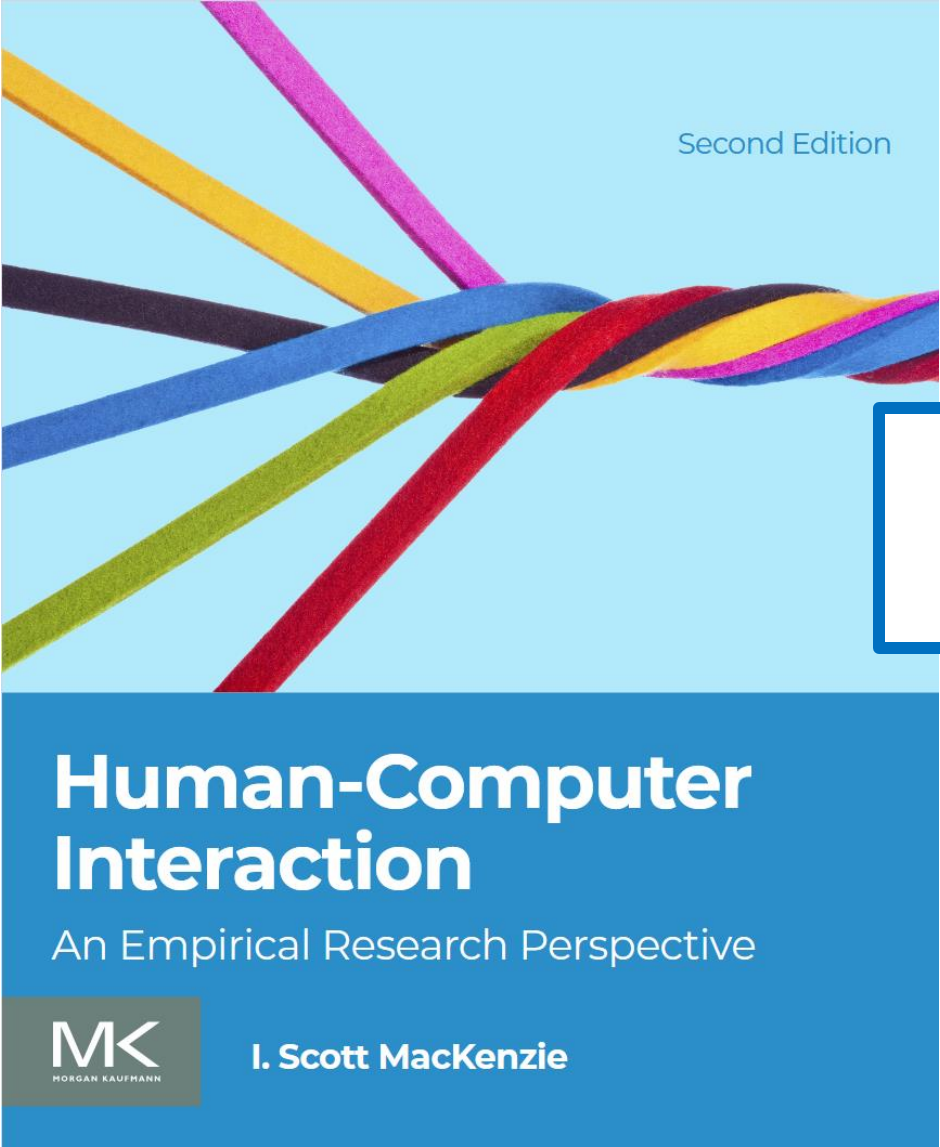




Second Edition

Chapter 2 The Human Factor

Human-Computer Interaction

An Empirical Research Perspective



I. Scott MacKenzie

Models of the Human

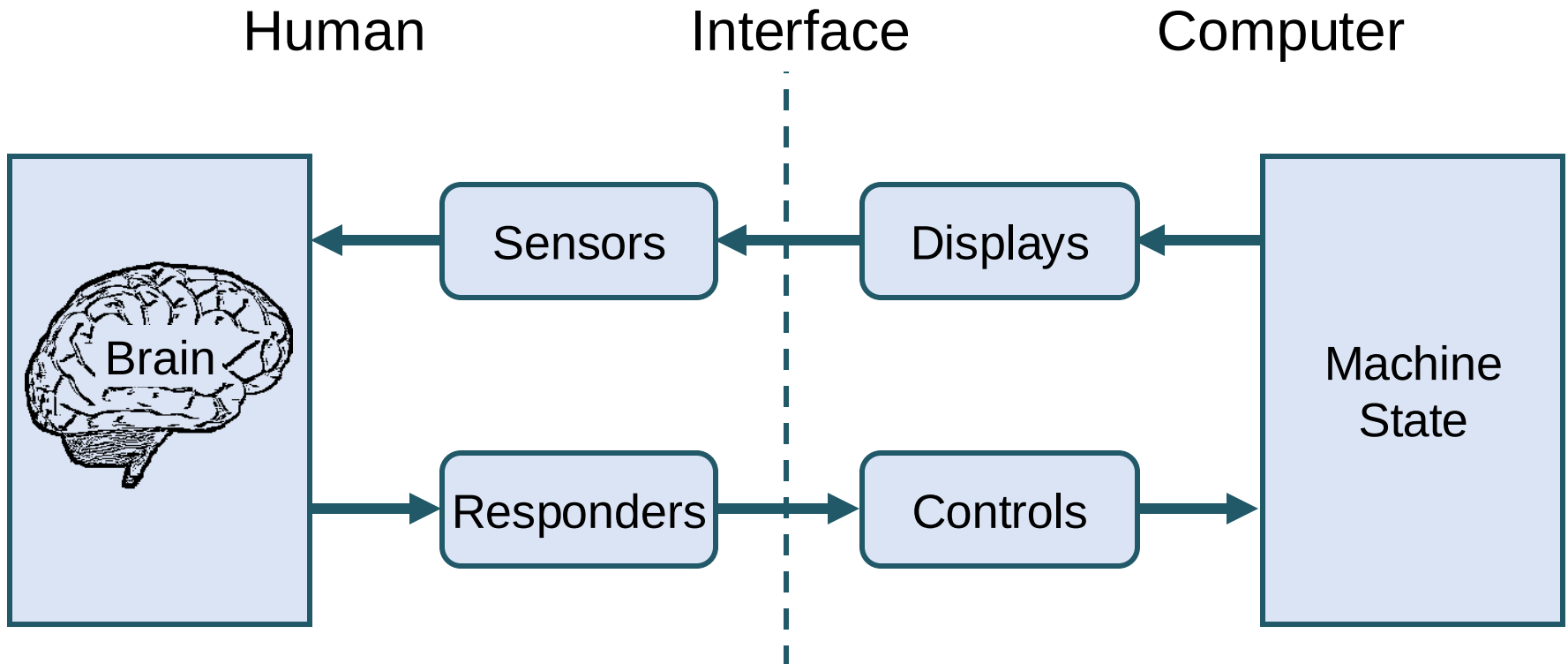
- Descriptive models are tools for thinking (see Chapter 7)
- It would be useful to have a descriptive model for the human
- In fact, there are many (e.g., Model Human Processor, Chapter 1)
- We begin with two useful models for the human...

Newell's Time Scale of Human Action¹

Scale (seconds)	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 s	Unit Task	COGNITIVE BAND
10^0	1 s	Operations	
10^{-1}	100 ms	Deliberate act	
10^{-2}	10 ms	Neural circuit	BIOLOGICAL BAND
10^{-3}	1 ms	Neuron	
10^{-4}	100 μ s	Organelle	

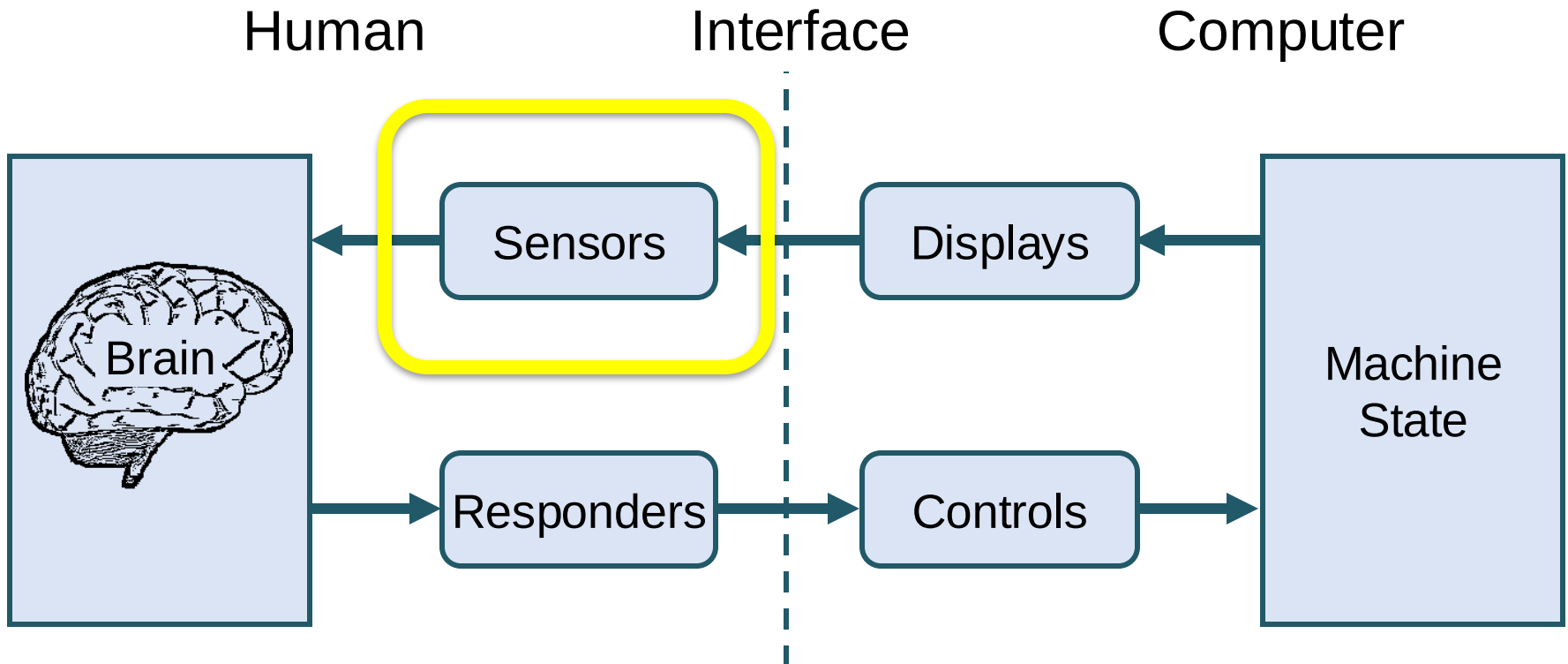
¹ A. Newell, Unified Theories of Cognition, Harvard University Press, Cambridge, MA, 1990.

Human Factors Model¹



¹ B.H. Kantowitz, R.D. Sorkin, Human Factors: Understanding People-System Relationships, Wiley, New York, 1983.

Human Factors Model¹



¹ B.H. Kantowitz, R.D. Sorkin, Human Factors: Understanding People-System Relationships, Wiley, New York, 1983.

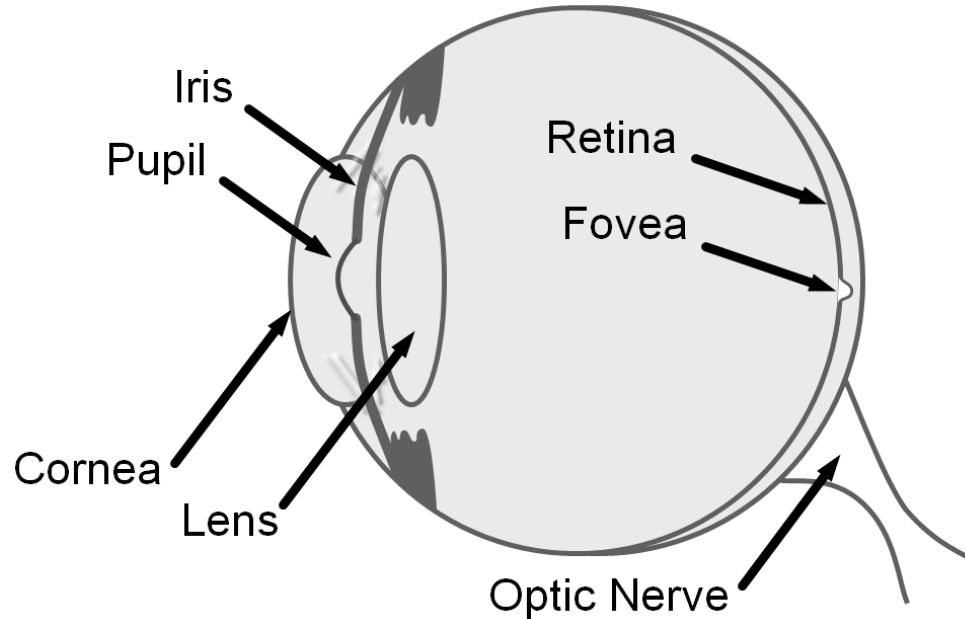
Human Senses

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

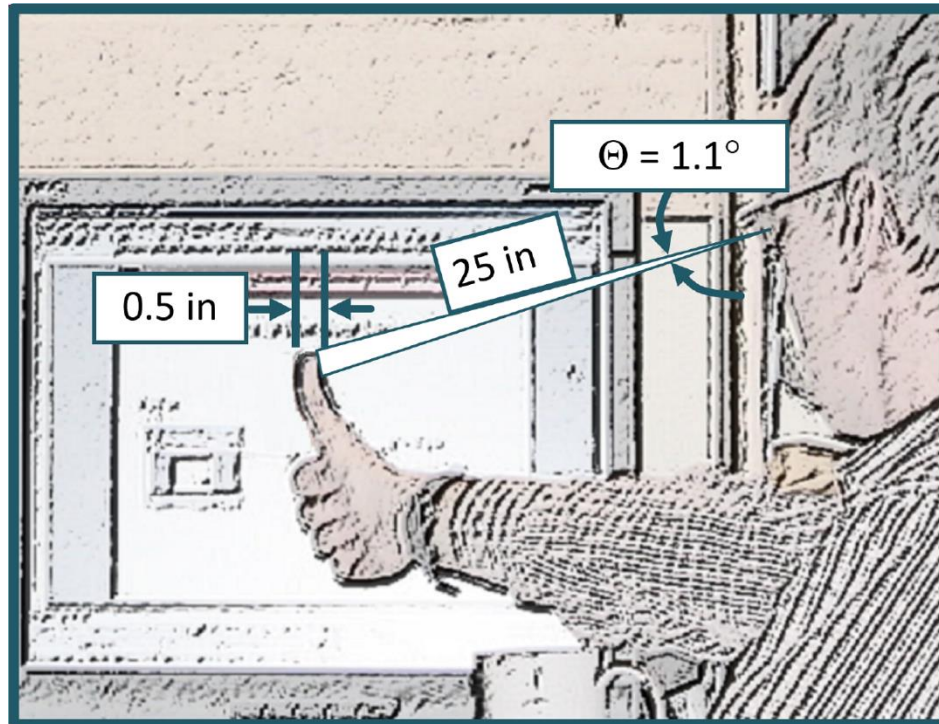
Vision (The Eye)

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



Fovea Image

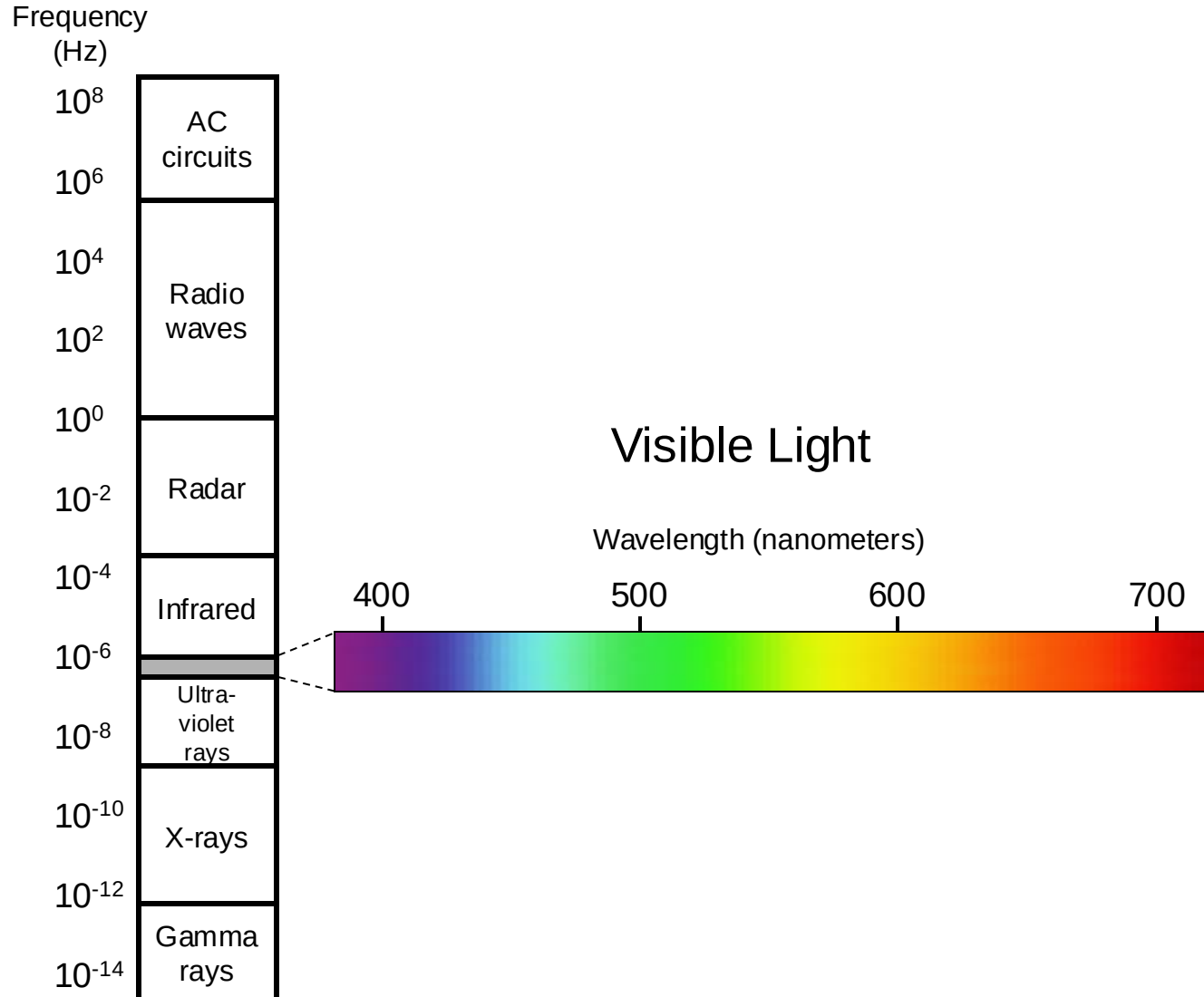
- Sharp central vision
- 1% of retina, 50% of visual cortex
- Fovea image is $\approx 1^\circ$ of visual angle:



Visual Stimulus

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

Colour Spectrum

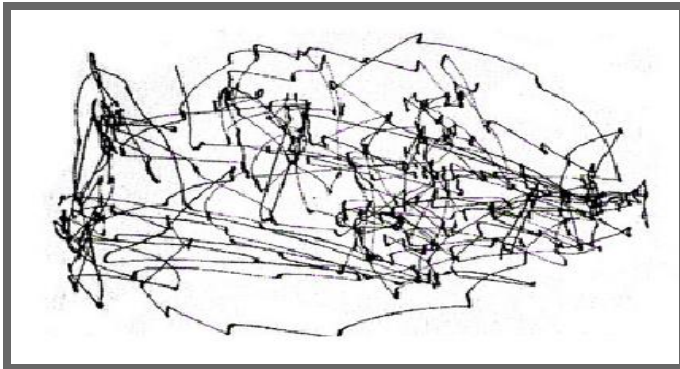


Fixations and Saccades

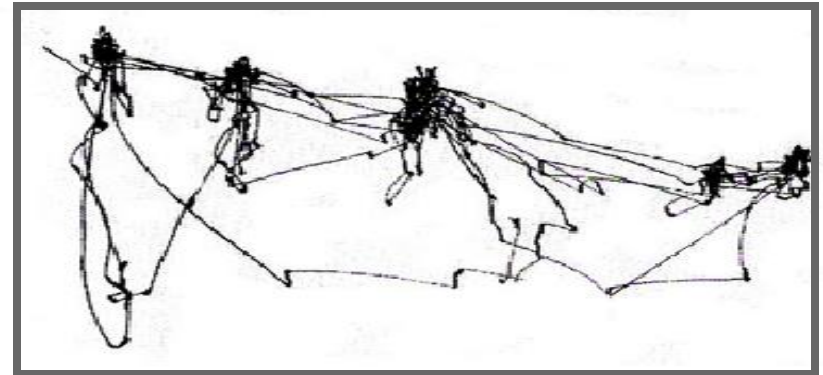
- Fixation
 - Eyes are stationary (dwell)
 - Take in visual detail from the environment
 - Long or short, but typically at least 200 ms
- Saccade
 - Rapid repositioning of the eye to fixate on a new location
 - Quick: $\approx 30\text{-}120$ ms

Yarbus' Eye Tracking Research (1965)¹

- Participants were given instructions and asked to view a scene; example →
- Eye movements (fixations and saccades) were recorded and plotted for a variety of tasks



Task: Remember the position of people and objects in the room



Task: Estimate the ages of the people

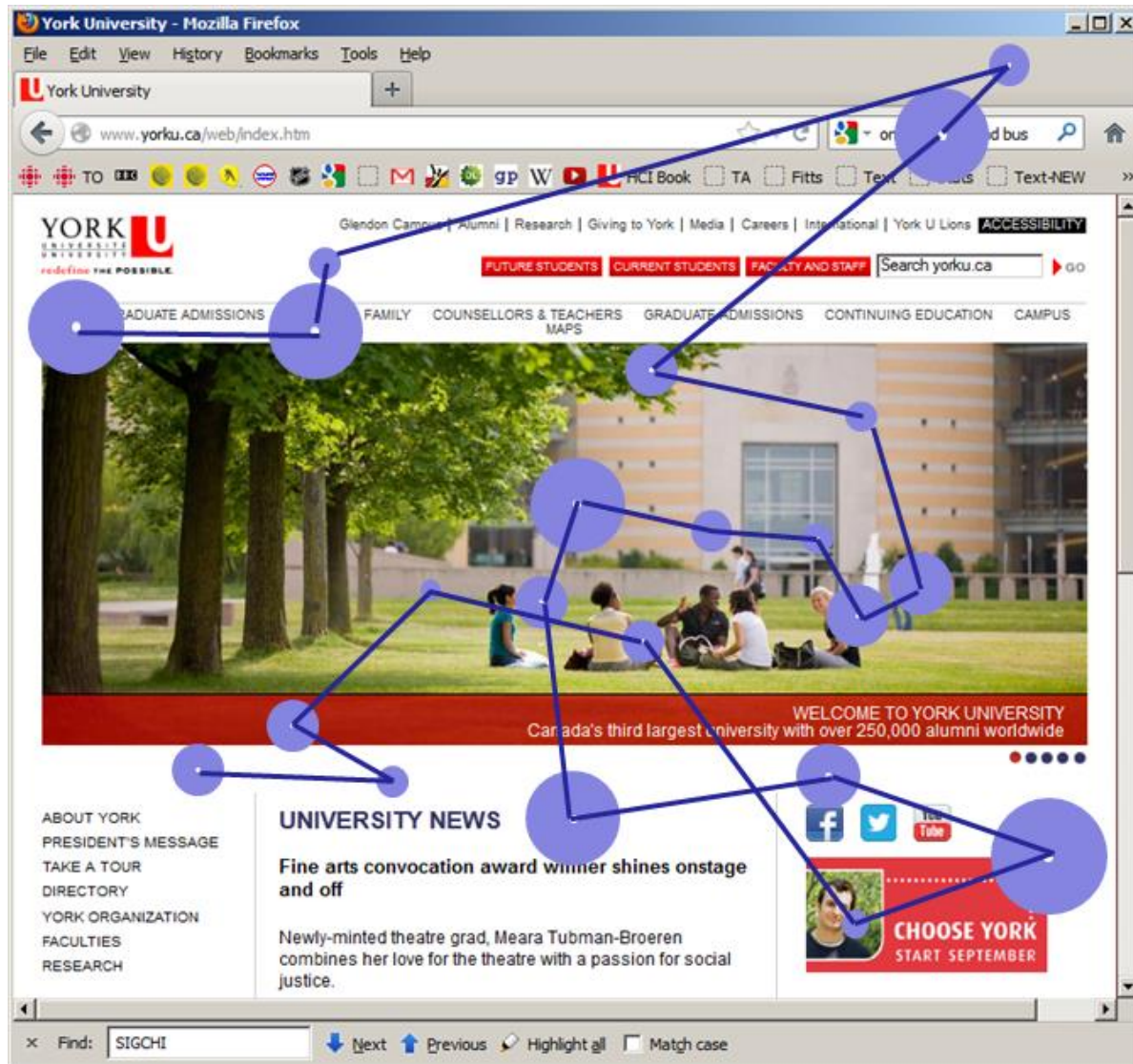
¹ B.W. Tatler, N.J. Wade, H. Kwan, J.M. Findlay, B.M. Velichkovsky, Yarbus, eye movements, and vision, *i-Perception* 1 (1) (2010) 7–27.

² *The Unwanted Visitor* by Ilya Repin (1844-1930)

Scan Paths

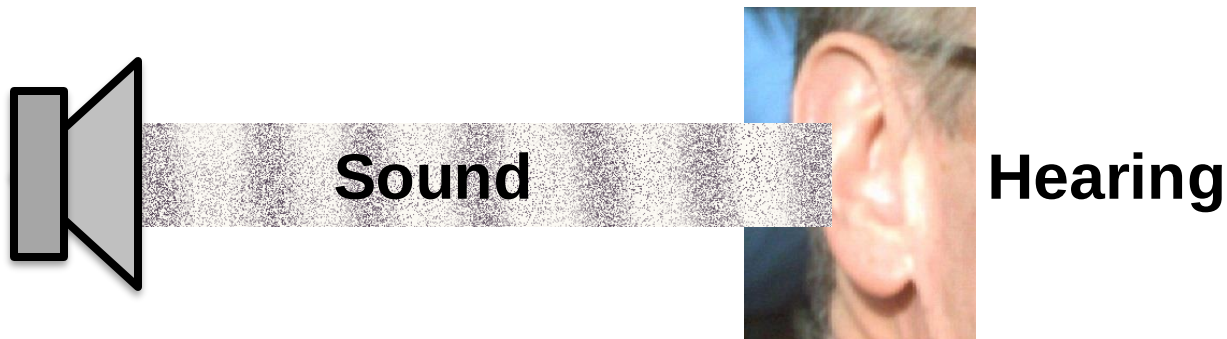
- Visual depiction of saccades and fixations
- Saccades → straight lines
- Fixations → circles
 - Diameter of circle $\approx$ duration of fixation
- Applications
 - User behaviour research (e.g., reading patterns)
 - Marketing research (e.g., ad placement)

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

Corresponds to ...
- Subjective properties of hearing...
 - Pitch
 - Loudness

Properties of Sounds

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

Loudness & Pitch

- Human hearing begins with sounds of 0-10 dB. Conversational speech is about 50-70 dB in loudness. Pain sets in when humans are exposed to sounds of approximately 120-140 dB.
- Humans can perceive sounds in the frequency range of about 20 Hz to 20,000 Hz (20 kHz). The speech of typical adults has frequency range from about 85 to 155 Hz for males and 165 to 255 Hz for females.

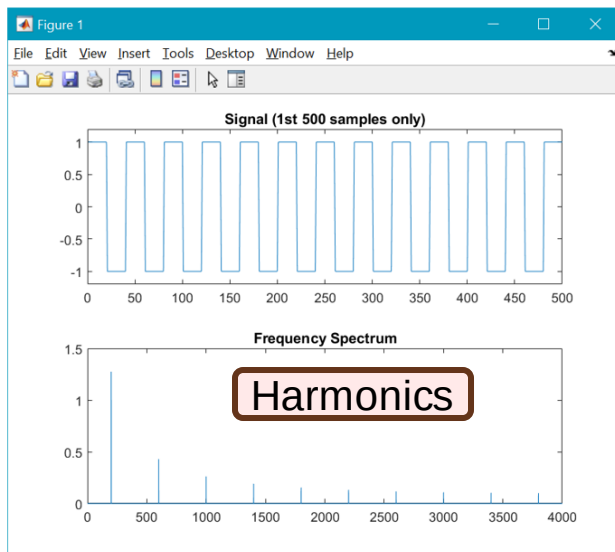
Timbre

- 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.
 - The relative amplitudes of the harmonics create the subjective sense of timbre.
- Notes of the same frequency from different instruments are distinguished, in part, due to timbre



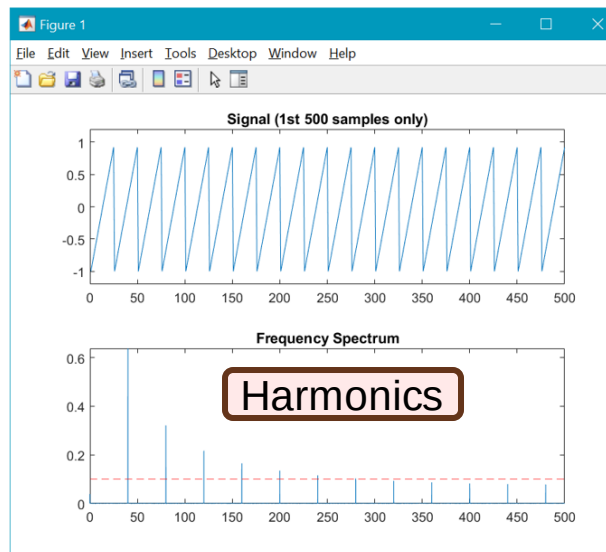
Examples

Square Wave



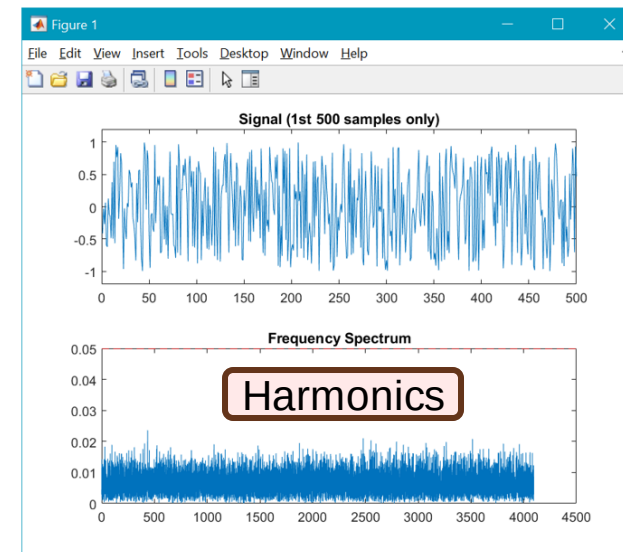
practice070_fft_square_wave.m

Sawtooth Wave



practice070_fft_sawtooth.m

Noise

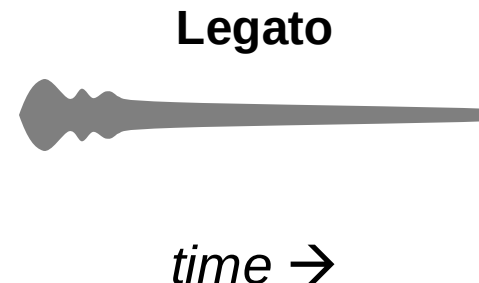
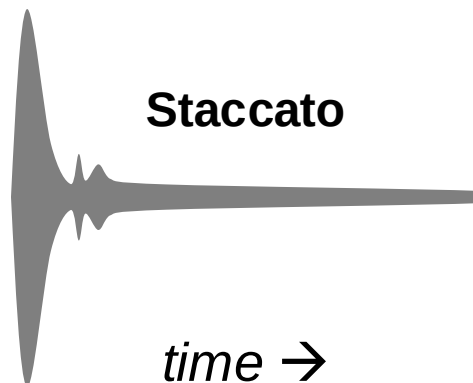


practice070_fft_noise.m

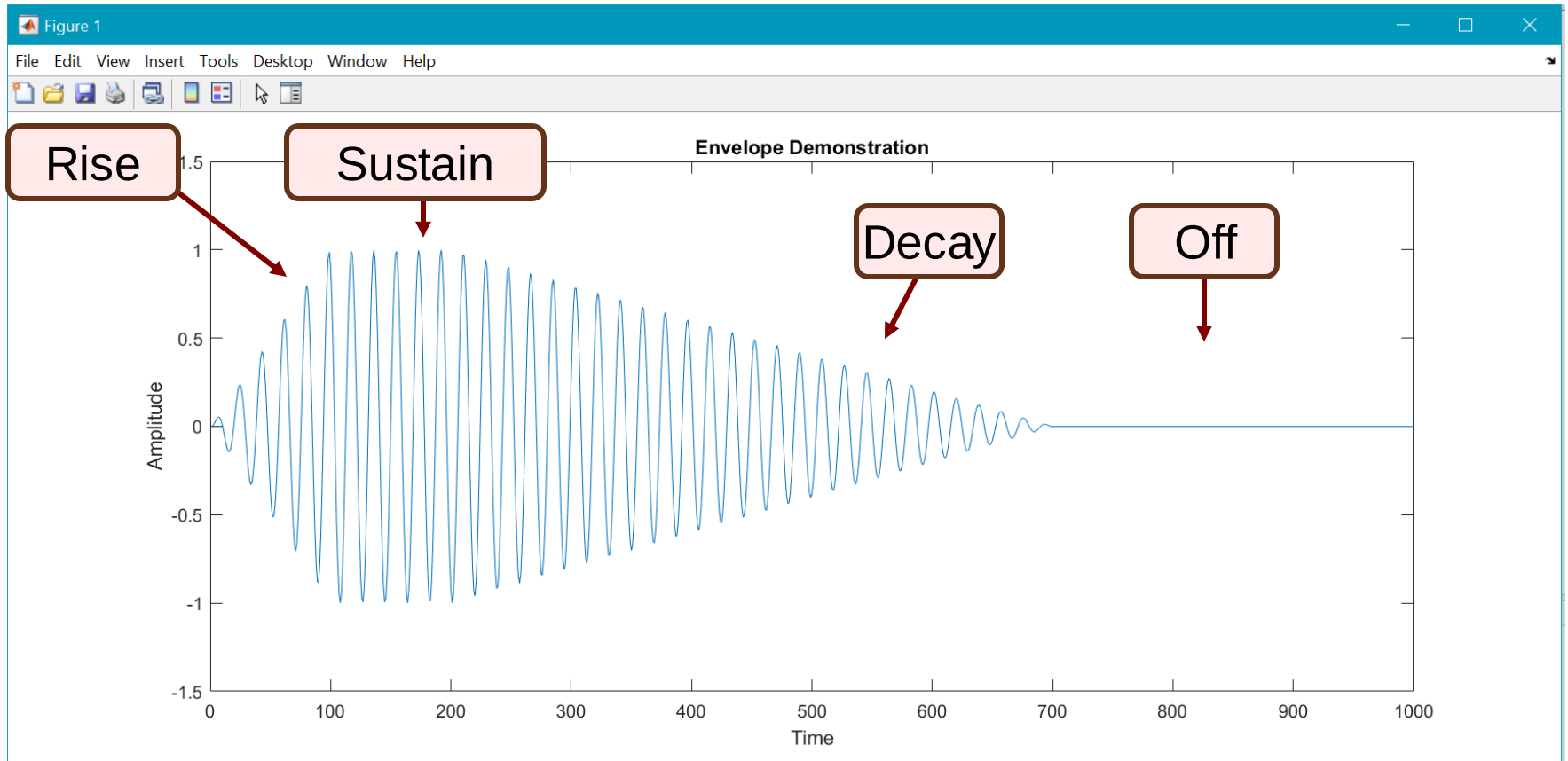


Attack

- 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 envelope
- Assists in distinguishing notes of the same pitch coming from different instruments
- Onset envelope created through articulation (e.g., legato, staccato)



Example



practice061_sound_envelope.m

Eyes (seeing) vs. Ears (hearing)

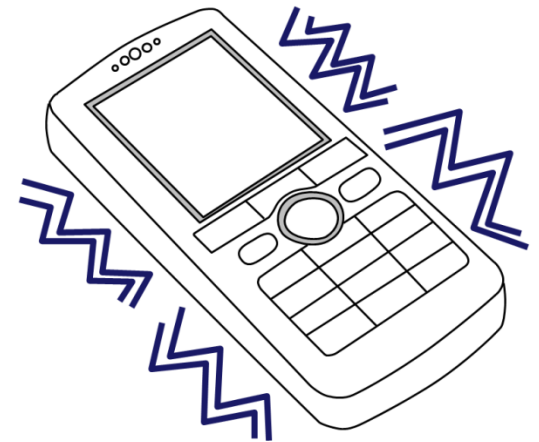
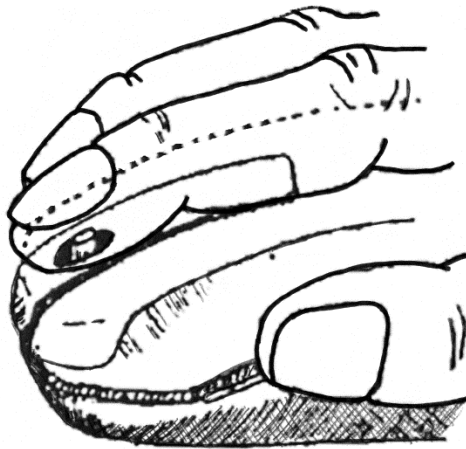
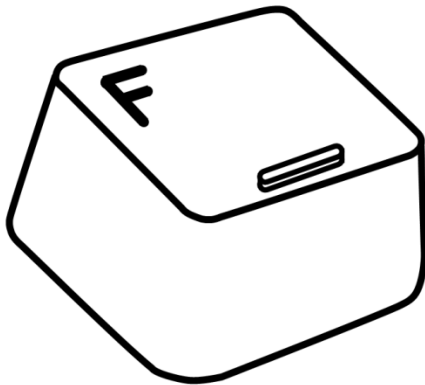
1

Quality/Ability	Eyes	Ears
Frequency sensitivity	$(4 \text{ to } 7.2) \times 10^{14} \text{ Hz}$	20 to 20,000 Hz
Wavelength sensitivity	$(4 \text{ to } 7.6) \times 10^{-7} \text{ meters}$	16.5 mm to 16.5 meters
Speed of light/sound	300,000,000 m/s	343 m/s
Can distinguish ratios	No	Yes
Primary brain processing	Intellectual, reason	Emotional, intuition
Focus	Narrow, pointed	Broad, omnidirectional
Open or closed	Either	Only open
Habitat	Space	Time
Transmission	Time	Space

¹ D. Sonnenschein, Sound design: The expressive power of music, voice, and sound effects in cinema, Michael Weiser Productions, Studio City, CA, ISBN 0-941188-26-4, 2001.

Touch (Tactition)

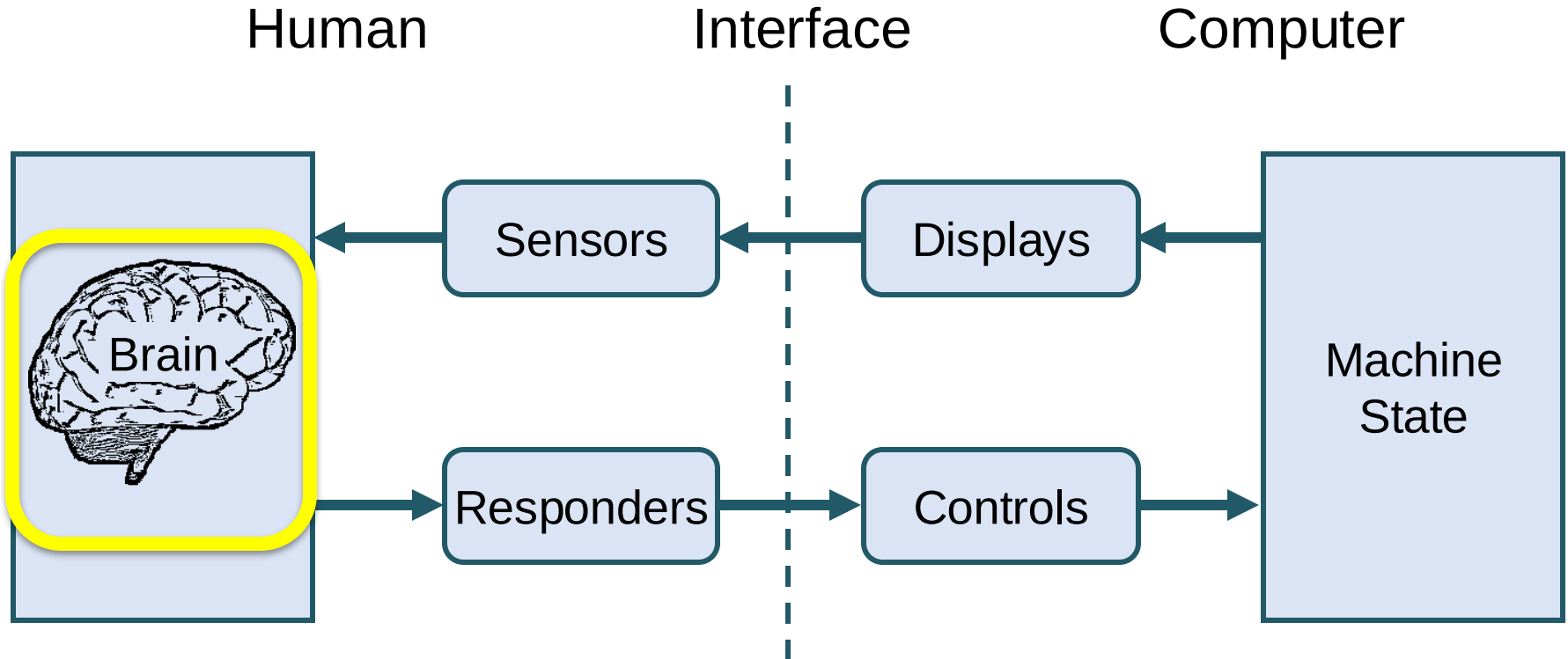
- Part of somatosensory system, with...
- Receptors in skin, muscles, joints, bones
 - Sense of touch, pain, temperature, position, shape, texture, resistance, etc.
- Tactile feedback examples:



Smell and Taste

- Smell (olfaction)
 - Ability to perceive odors
 - Occurs through sensory cells in nasal cavity
- Taste (gustation)
 - Chemical reception of sweet, salty, bitter, and sour sensations
- Flavor
 - 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



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

Perception

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

Human Uniqueness

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

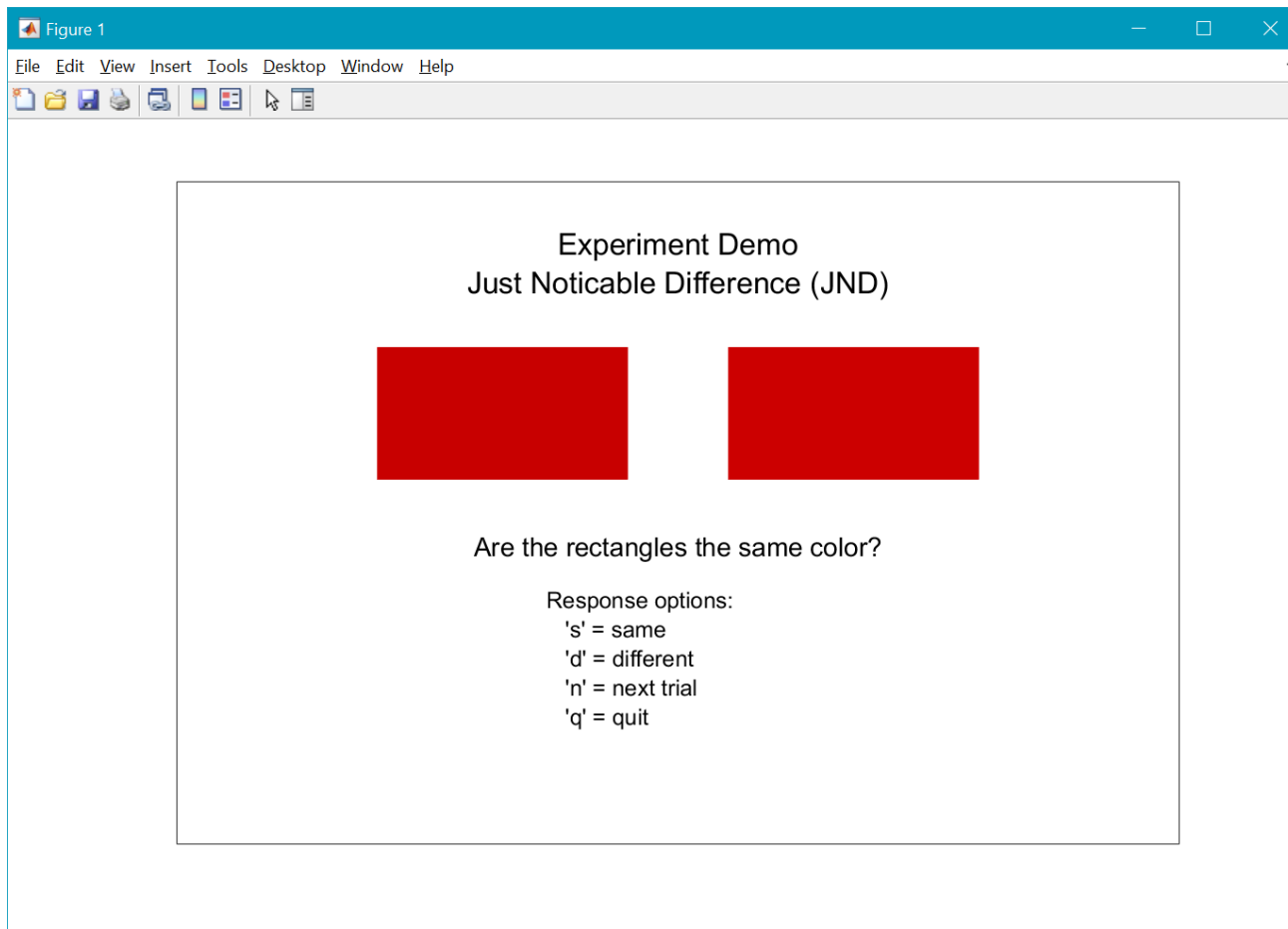
People excel at perception, at creativity, at the ability to go beyond the information given, making sense of otherwise chaotic events. We often have to interpret events far beyond the information available, and our ability to do this efficiently and effortlessly, usually without even being aware that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

¹ D.A. Norman, The Design of Everyday Things, Basic Books, New York, 1988.

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)

Example

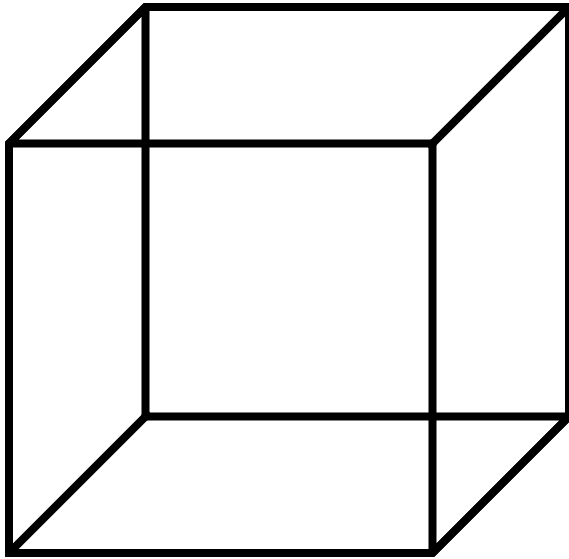


practice042d_jnd_experiment.m



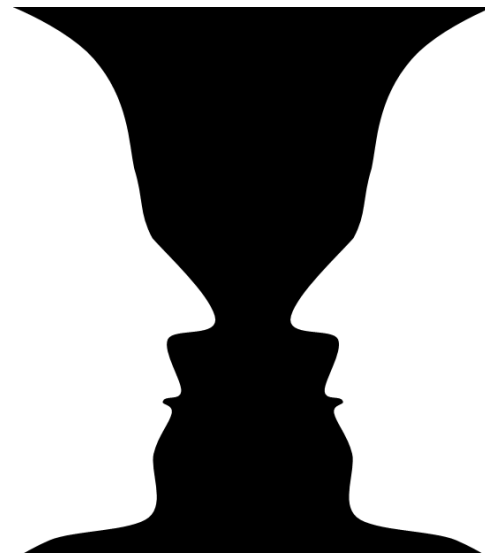
Ambiguity

Necker cube



Which surface is at the front?

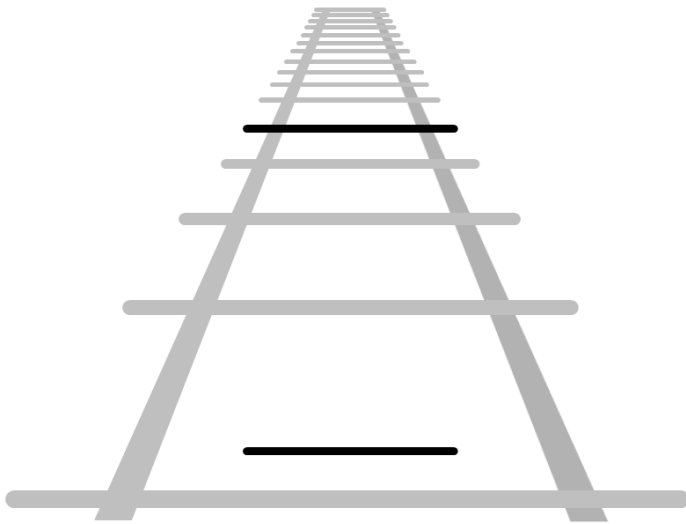
Rubin vase



Wine goblet or two faces?

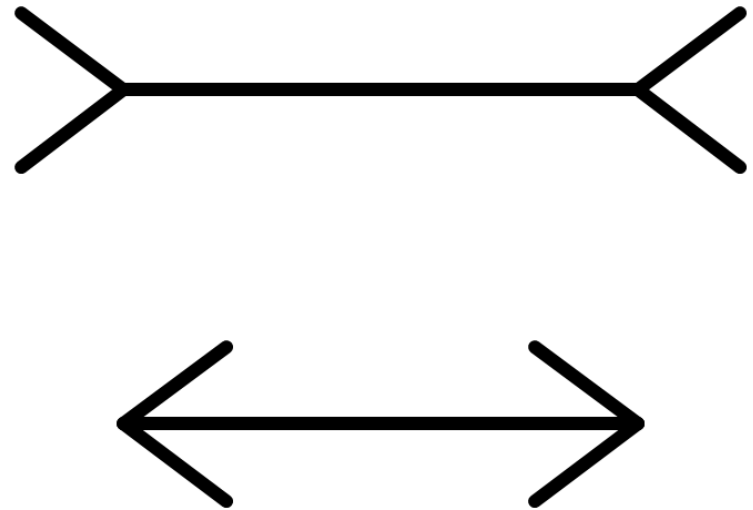
Illusion (length)

Ponzo lines



Which black line is longer?

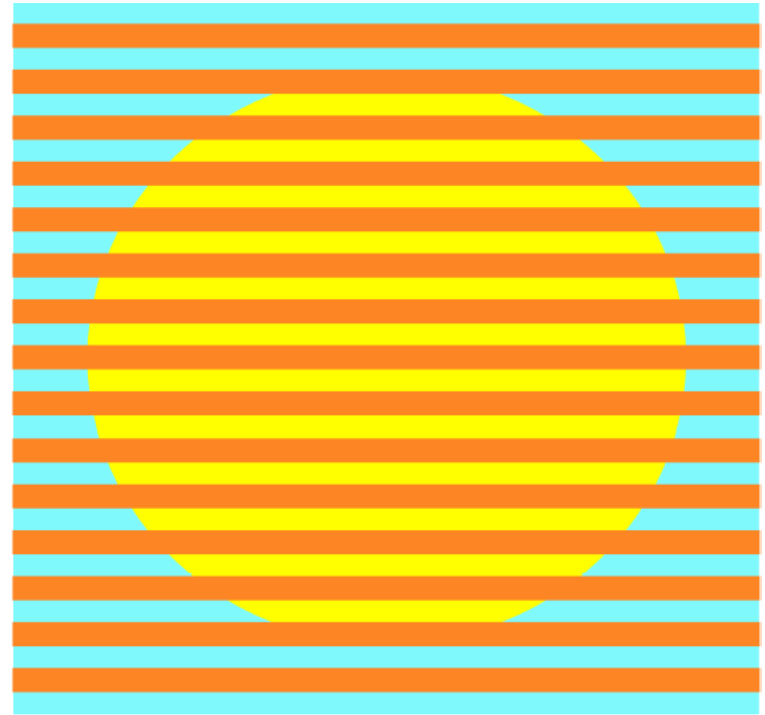
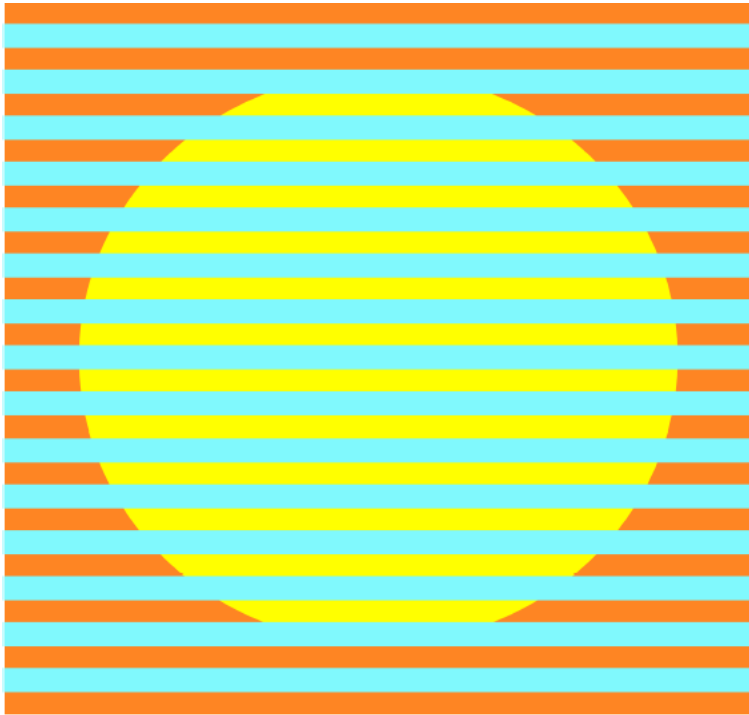
Müller-Lyer arrows



Which horizontal line is longer?

Illusion (color)

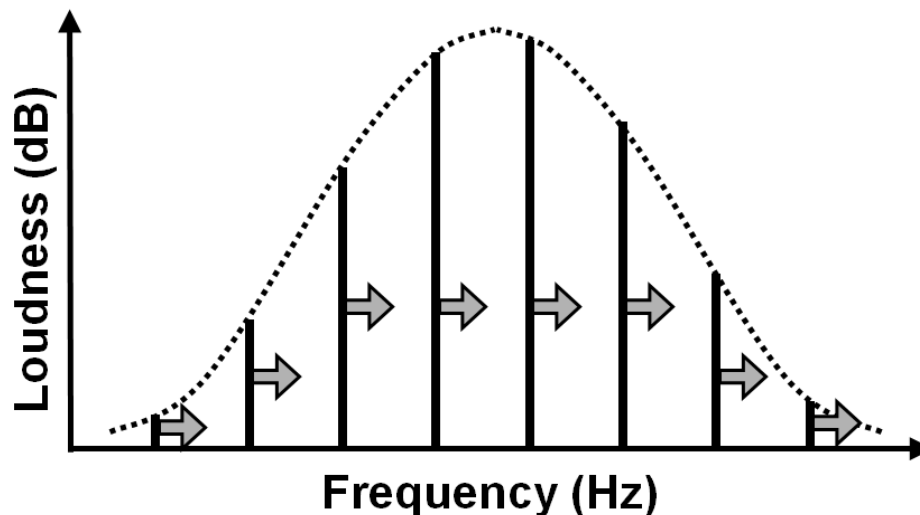
Munker illusion



The two circles are the same color.

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: Sheppard-Risset glissando
 - Visit *YouTube* for examples



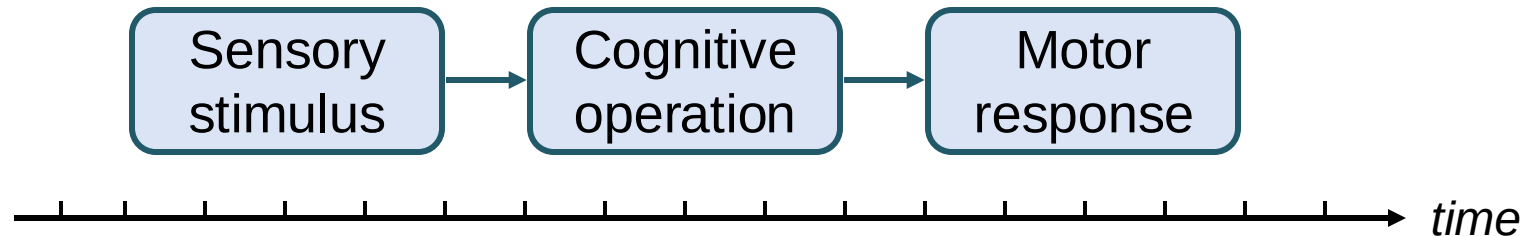
Cognition

- Cognition is the human process of conscious intellectual activity
 - Thinking, reasoning, deciding, etc.
- Spans many fields
 - Neurology, linguistics, anthropology, etc.
- 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!

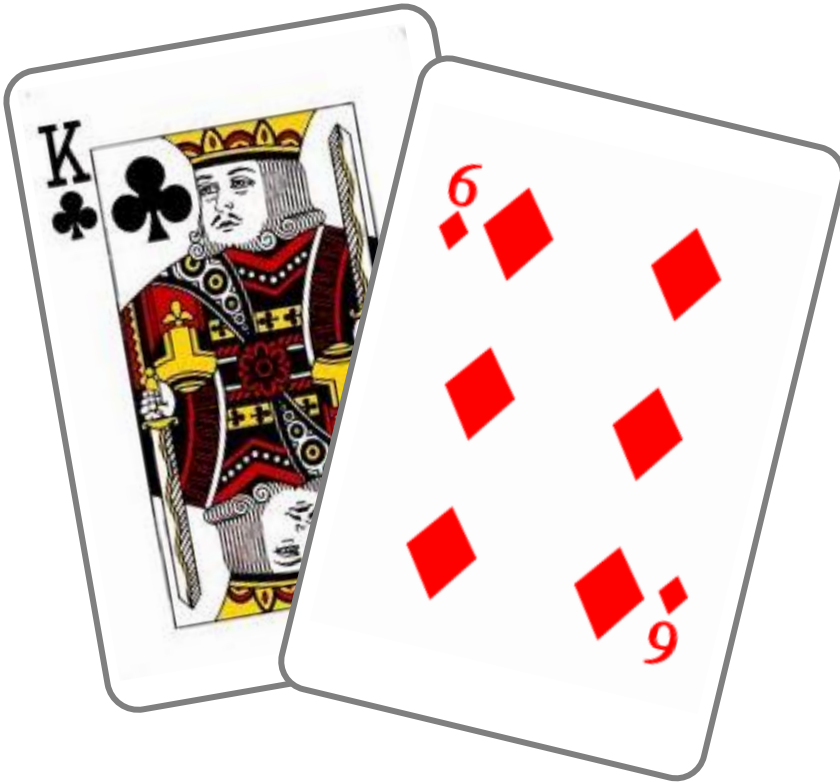


Examples of Simple Decisions

- 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?
Remember dealt
cards?
(dealer has 17)

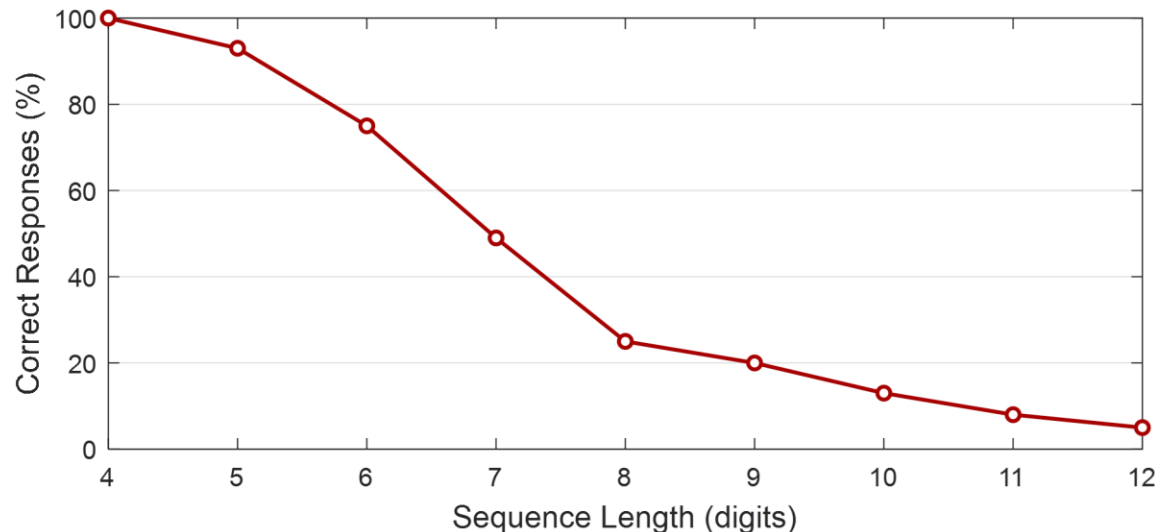
Memory

- 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 chunks¹

¹ G.A. Miller, The magical number seven plus or minus two: some limits on our capacity for processing information, *Psychological Review* 63 (2) (1956) 81–97.

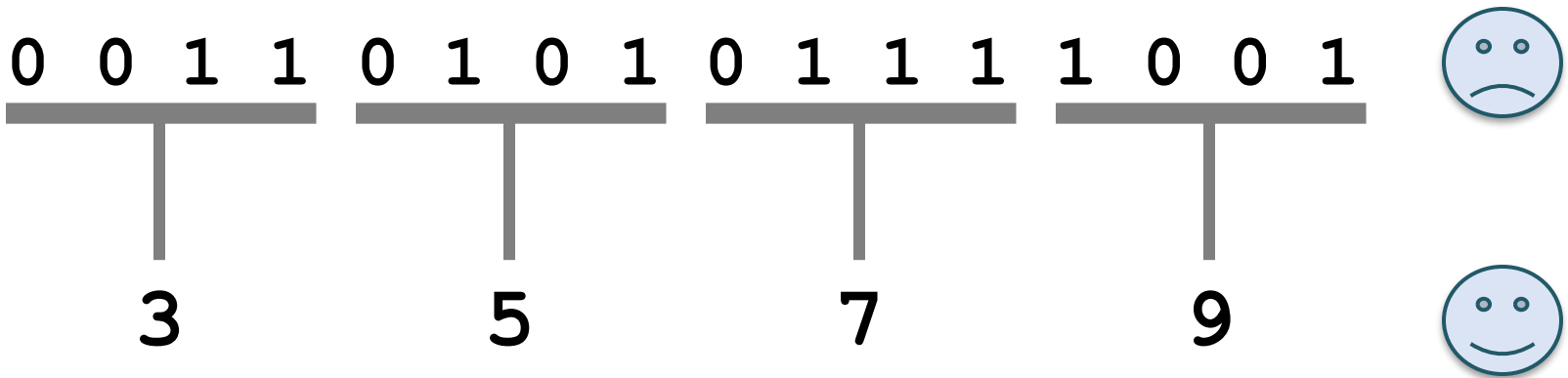
Short Term Memory Experiment

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

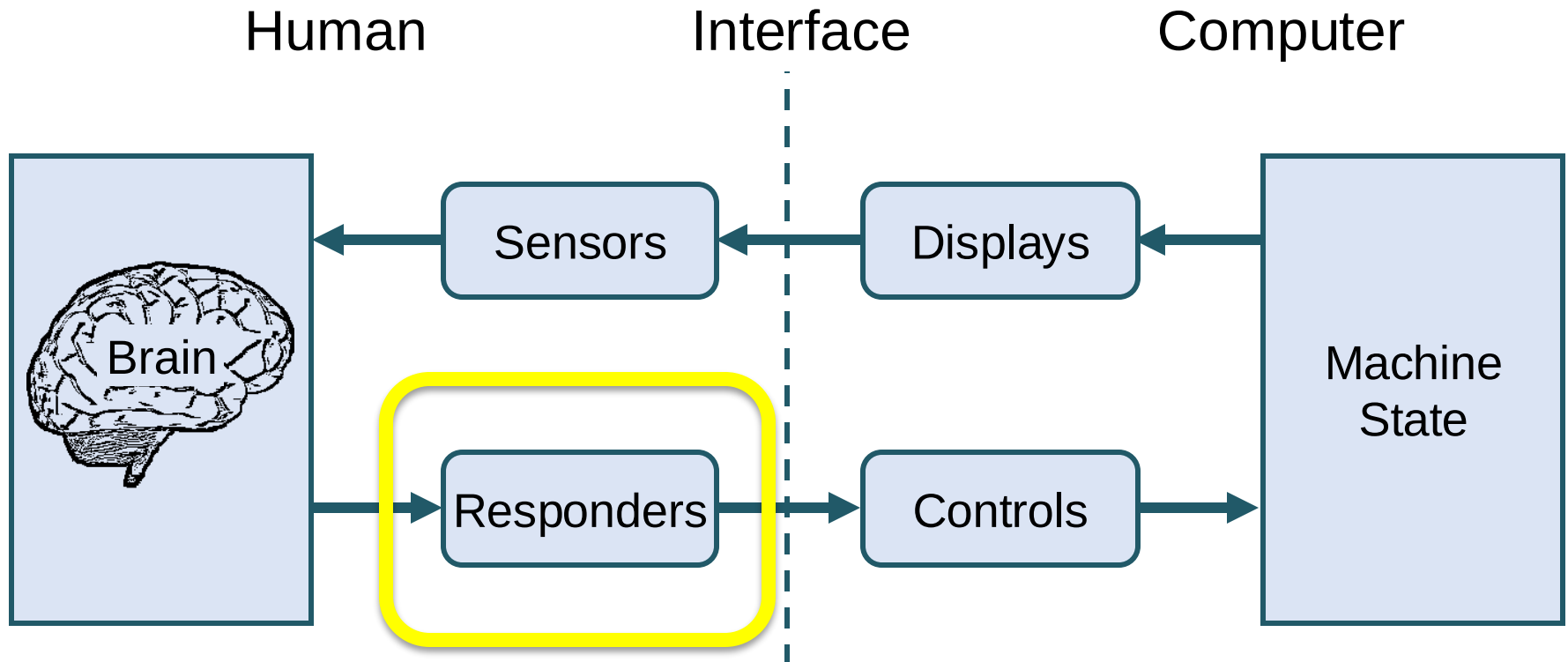


Chunking

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



Human Factors Model

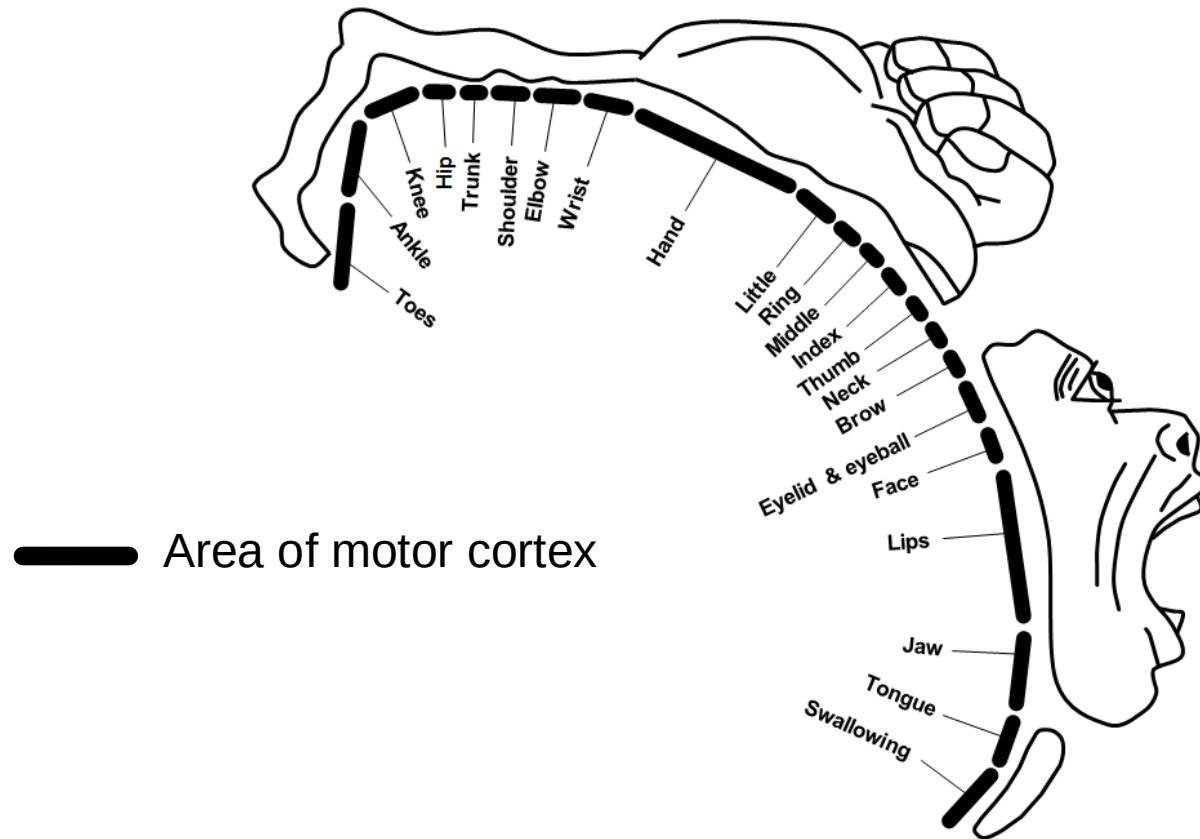


Responders

- Humans control their environment through responders, for example...
 - A finger to 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:

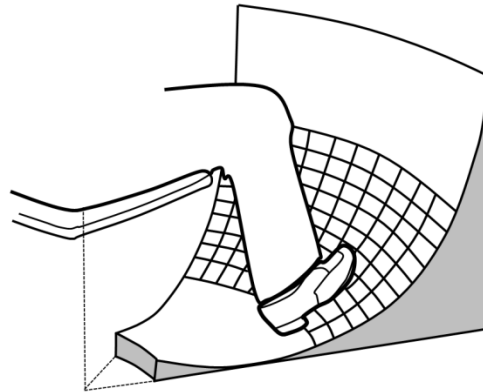
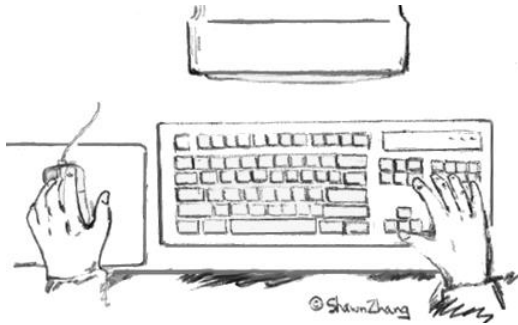


Motor Homunculus¹



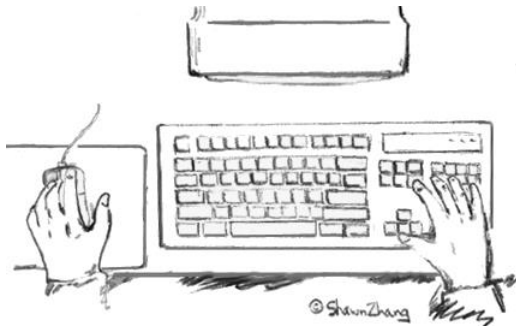
¹ W. Penfield, T. Rasmussen, The Cerebral Cortex of Man: A Clinical Study of Localization of Function, Macmillan, New York, 1990.

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 Handedness¹

	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 R.C. Oldfield, The assessment and analysis of handedness: the Edinburgh inventory, Neuropsychologia 9 (1) (1971) 97–113.

Hand/Finger Size – Measuring

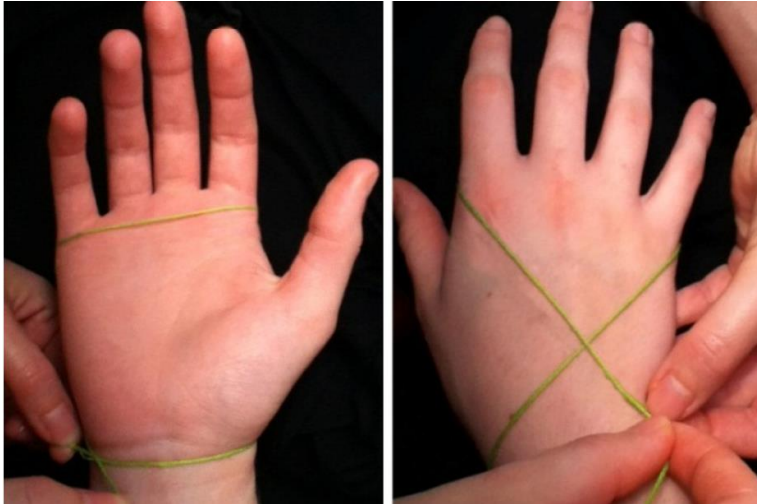
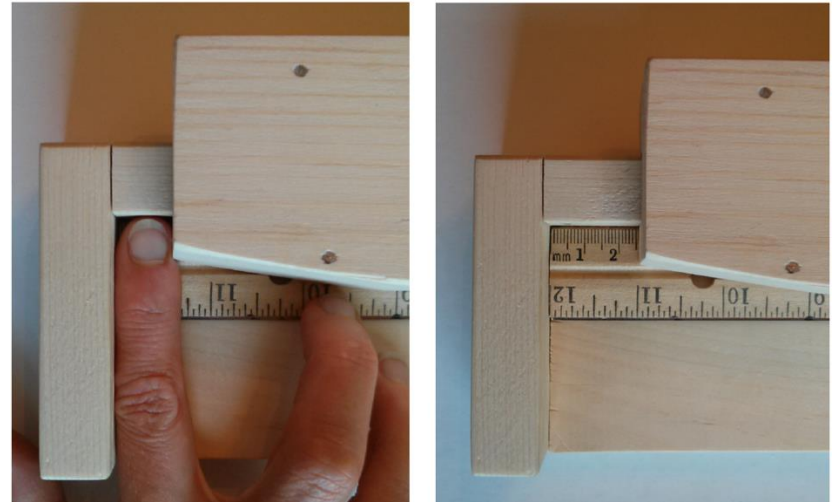


Figure-of-eight method¹



Caliper²

12-16.5 mm ($M=14$, $SD=1.4$)

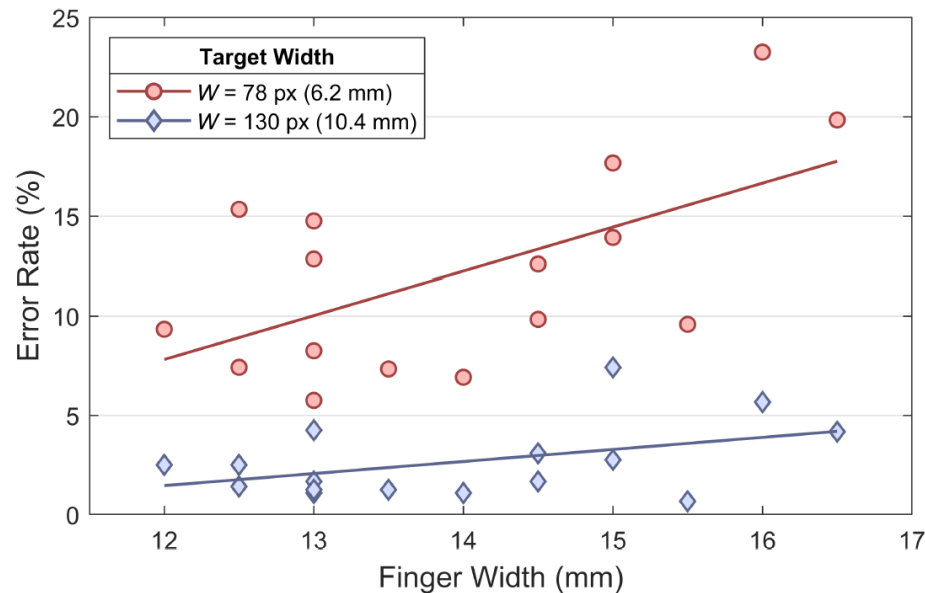
¹ M.A. Brown, I.S. MacKenzie, Evaluating video game controller usability as related to user hand size, in: Proc MHCI '13, ASET, Ottawa, Canada, 2013, pp. 114.1–114.8.

² I.S. MacKenzie, Fitts' throughput and the remarkable case of touch-based target selection, in: Proc HCII '15 (LNCS 9170), Springer, Berlin, 2015, pp. 238–249.

Finger Size – Performance Issues



Finger size vs. target width



Error rate vs. finger width and target width

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 Example¹

- NVVI = non-verbal voice interaction

	Key 1	Key 2	Key 3	Key 4	BACK
SET 1					
SET 2					
SET 3					
SET 4					

Four sets were compared in an evaluation with five disabled participants. Set 1 was preferred by four participants, set 4 by one participant.

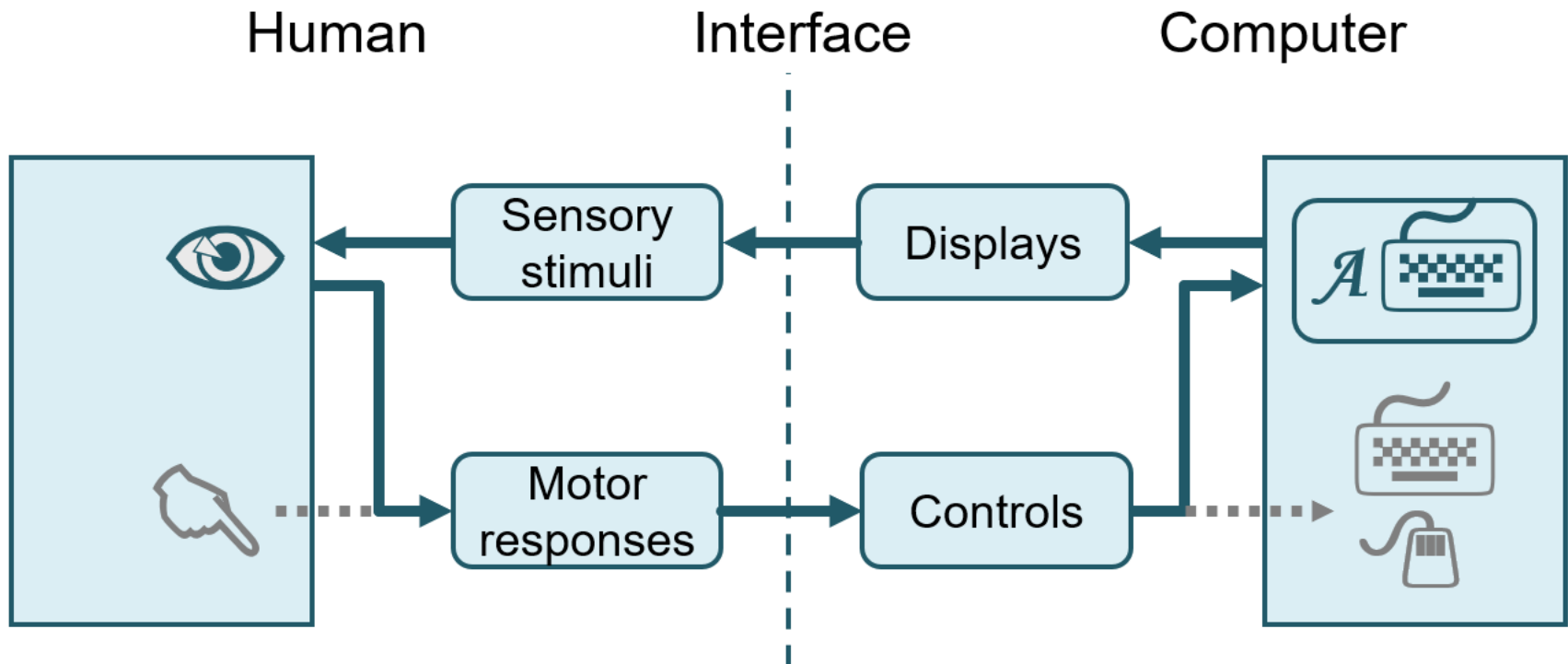
¹ A.J. Sporka, T. Felzer, S.H. Kurniawan, P. Ondrej, P. Haiduk, I.S. MacKenzie, CHANTI: predictive text entry using non-verbal vocal input, in: Proc CHI '11, ACM, New York, 2011, pp. 2463–2472. 53

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
- This suggests a modification to the human factors model presented earlier (next slide)

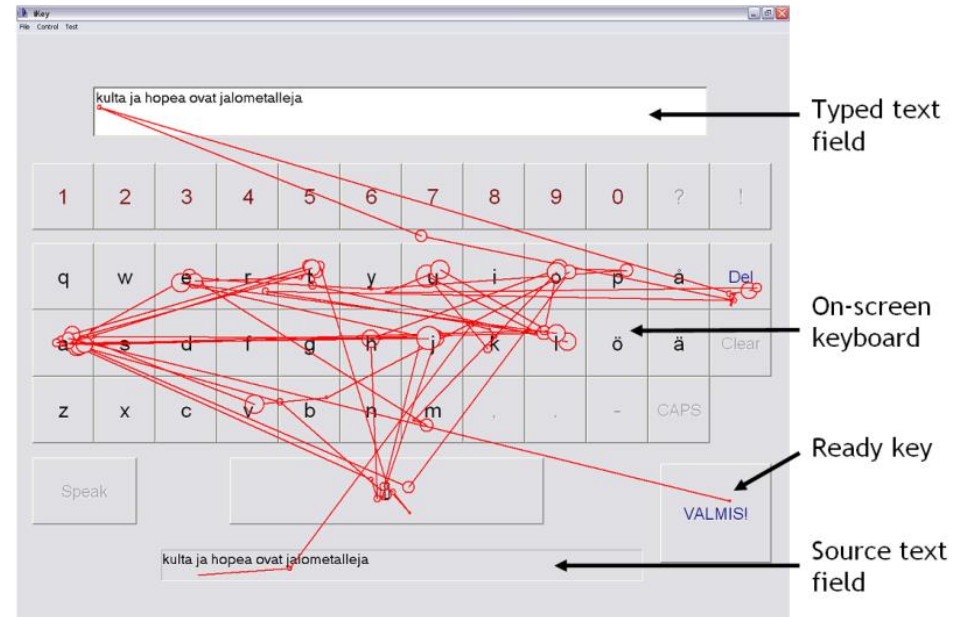
Modified Human Factors Model¹

(as eye tracker for input)



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

Example - Eye Typing¹



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

Eye Tracking as Input

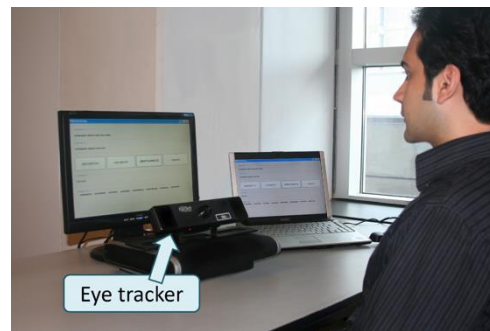
- An eye tracker is often configured to emulate a computer mouse by using “look-select,” and thereby activate soft controls, such as buttons, icons, links, or text (e.g., [551]).
- Selecting with the eye is by fixating, or dwelling, on a selectable target for a predetermined period of time, such as 700 ms.
- A widely noted downside to dwell-time selection is inadvertent selections which occur if the user casually looks at a selectable on-screen object. This is known as the “**Midas touch problem**”

Blinking

- Blinking is an eye response that can be used for computer control:

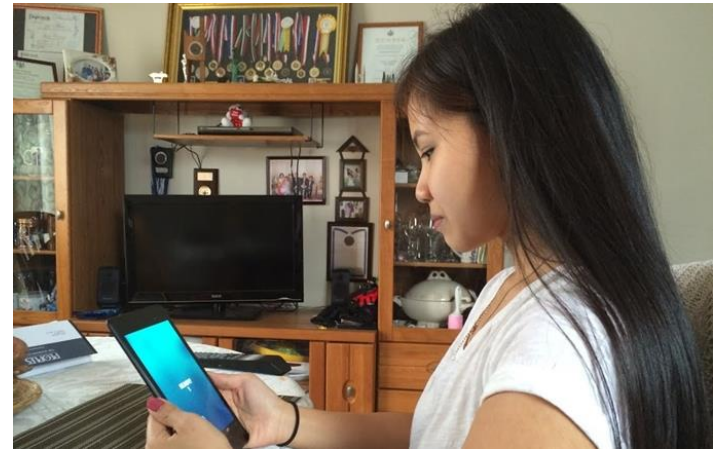
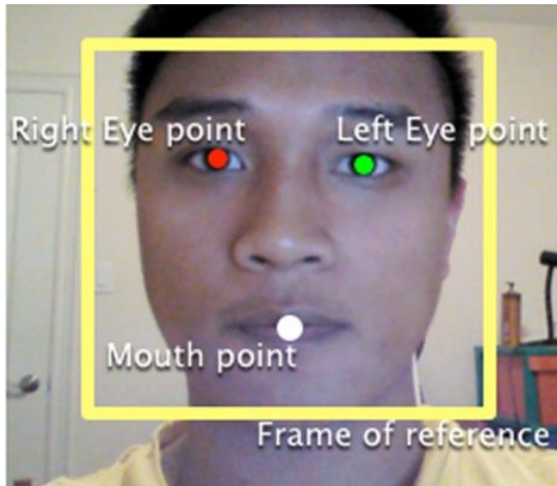


- E.g., BlinkWrite:



(click image to view video)

Face Tracking



Note: The Jellyfish is moved horizontally either by device tilt or by face tracking

¹ J. Cuaresma, J., & I.S. MacKenzie, A comparison between tilt-input and facial tracking as input methods for mobile games. Proc IEEE-GEM 2014, New York: IEEE, 2014, pp. 70-76.

Brain as Responder

- The goal of BCI is to use signals generated by the brain to control a user interface
- One approach is “motor imagery,” whereby the user consciously thinks of certain actions, such as clenching a fist or raising a foot, while the signals emitted by the brain coincident with that action are measured and identified

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 P.T. Daniels, W. Bright, The World's Writing Systems, Oxford University Press, New York, 1996.

Corpus

- One way to characterize 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 space¹
- Example:

The *paint* is dry. (noun)

Children *paint* with passion. (verb)

¹ J. Gong, P. Tarasewich, I.S. MacKenzie, Improved word list ordering for text entry on ambiguous keyboards, in: Proc NordiCHI '08, ACM, New York, 2008, pp. 152–161.

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?

smmr → 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 scent 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 tricks¹
- Examples
 - Sound:
 - th@s → that's
 - gr8 → great
 - Invented acronyms:
 - w → with
 - gf → girlfriend
 - x → times

¹ R. Grinter, M. Eldridge, Wan2tlk? Everyday text messaging, in: Proc CHI '03, ACM, New York, 2003, pp. 441–448.

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 experiment¹
 - Subject shown text with letters blocked
 - Subject guesses letters one at a time
 - Letters revealed as guessing proceeds:
 - Incorrect guess → show correct letter
 - Correct guess → show “-”

(next slide)

¹ C.E. Shannon, Prediction and entropy of printed English, Bell System Technical Journal 30 (1) (1951) 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--O-

POLISHED WOOD BUT LESS ON THE SHABBY RED CARPET

P-L-S-----O---BU--L-S--O-----SH---RE--C-----

Letter Guessing Experiment (2)



Letter Guessing Experiment

Setup

Parameters

Participant code

Block number

Number of phrases

Phrases file

☒ Beep on error

Mode

☒ One guess per letter

☐ Guess until correct

Letter Guessing Experiment

movie about a nutty pro*****

movie-----nu-----

Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	
Z	X	C	V	B	N	M			

Use software from the book's web site:

<http://www.yorku.ca/mack/HCIbook2e/>

Letter Guessing Experiment (3)

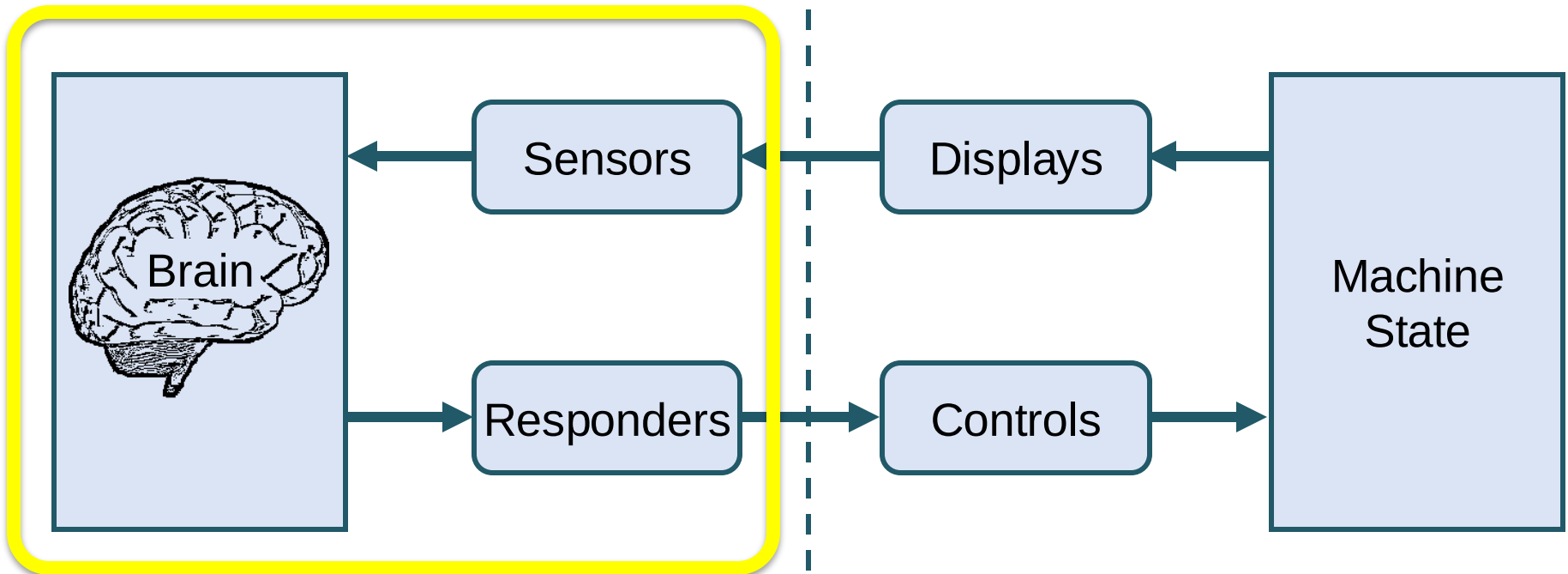
- Observations:
 - Errors most common at beginning of words
 - Errors less common as a word progresses
 - Errors even less common as a phrase progresses
- Entropy discussion:
 - The two phrases (original and “reduced”) contain the same information
 - With a good statistical model, the original text can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

Human Factors Model

Human

Interface

Computer



Human Performance
Skilled Behavior
Attention
Human Error

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 smartphone

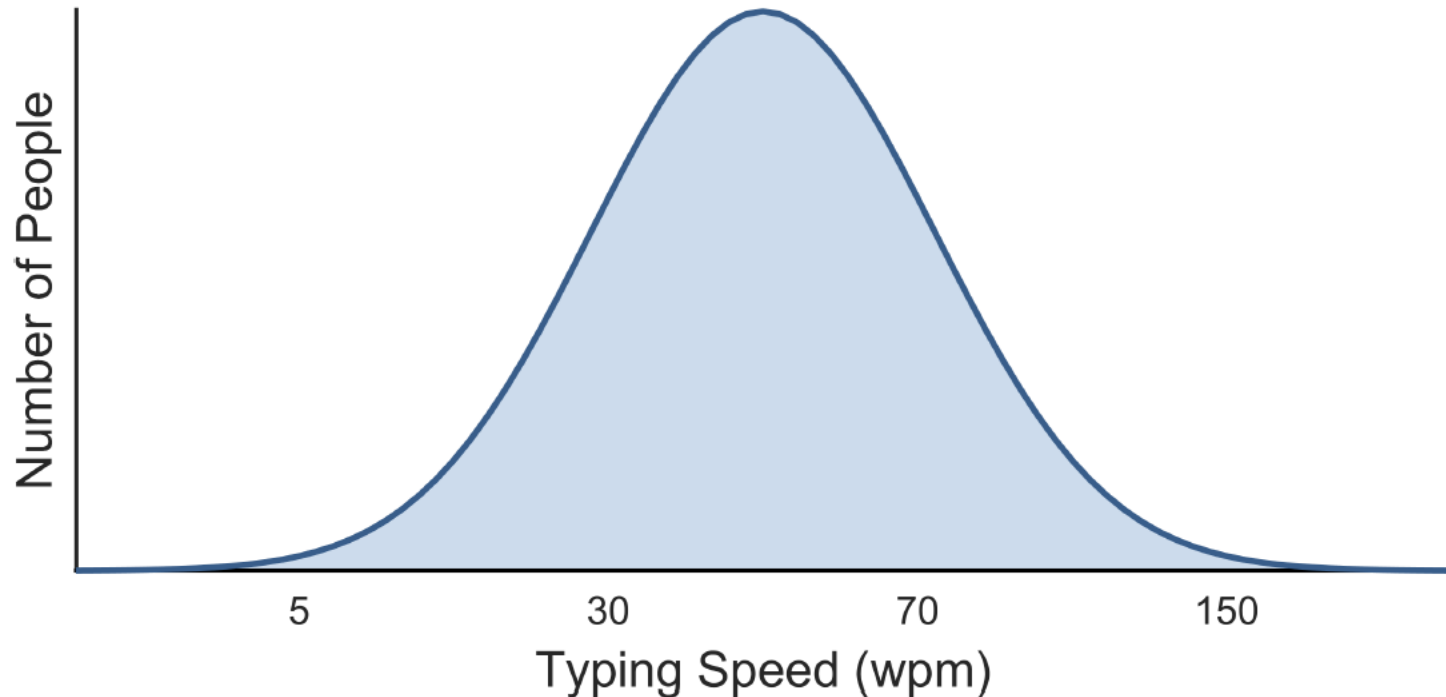
Speed-accuracy Trade-off

- 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 or grandmother?

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!)?

Typing Test Experiment



Configure TypingTestExperiment

Setup

Parameters

Participant code

Condition code

Session code

Number of phrases

Phrases file

☒ Show presented text during input

Typing Test Experiment

Presented text:

Transcribed text:

DATA COLLECTED:

Presented: the rationale behind the decision
Transcribed: the rationale behindd the decision
Keystrokes: 38
Characters: 34 (6.8 words)
Time: 6.58 s (0.11 minutes)
MSD: 1

PARTICIPANT PERFORMANCE:

Entry Speed: 62.02 wpm
Error rate: 2.94%
KSPC: 1.1176

Use software from book's web site:

<http://www.yorku.ca/mack/HCIbook2e/>

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 it¹
- Example: pressing a button in response to the onset of a stimulus light

¹ P.M. Fitts, M.I. Posner, Human Performance, Brooks/Cole Publishing Company, Belmont, CA, 1968.

Sensory Stimuli and Reaction Time

- Delay time varies by type of sensory stimuli

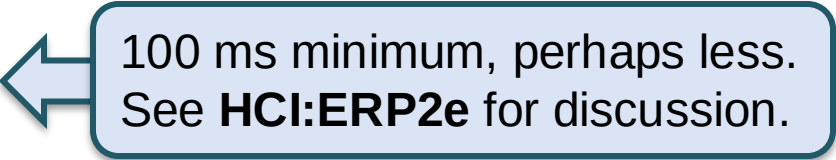
- Approximate values^{1,2}

- Auditory → 150 ms

- Visual → 200 ms

- Smell → 300 ms

- Pain → 380 ms

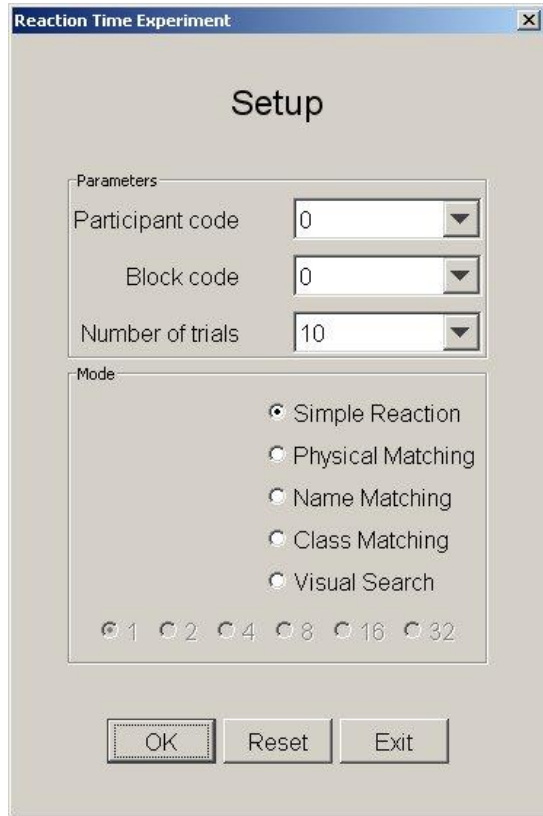


100 ms minimum, perhaps less.
See **HCI:ERP2e** for discussion.

¹ R.W. Bailey, Human Performance Engineering: Designing High Quality, Professional User Interfaces for Computer Products, Applications, and Systems, 3rd ed. Edition, Prentice Hall, Upper Saddle River, NJ, ISBN 978-0131496347, 1996.

² M. Ploner, J. Gross, L. Timmermann, A. Schnitzler, Pain processing is faster than tactile processing in the human brain, Journal of Neuroscience 26 (42) (2006) 10879–10882,

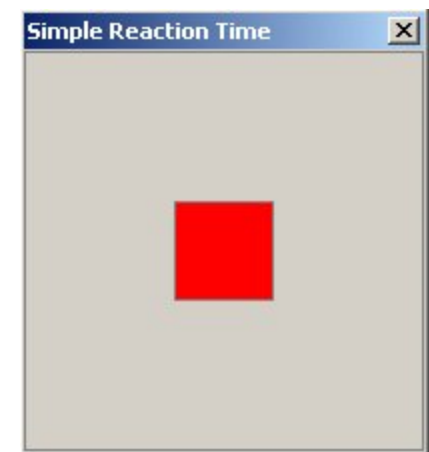
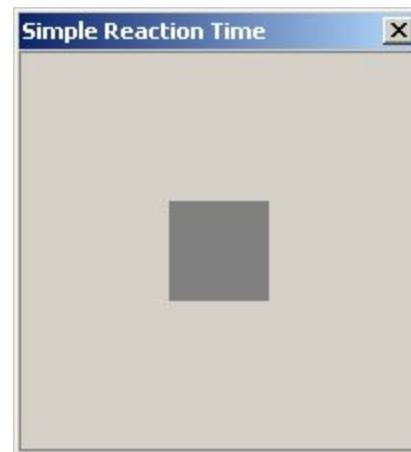
Reaction Time Experiment



The screenshot shows a window titled "Reaction Time Experiment" with a "Setup" section. It contains three input fields for "Participant code", "Block code", and "Number of trials", all set to "0". Below these is a "Mode" section with five radio buttons: "Simple Reaction" (selected), "Physical Matching", "Name Matching", "Class Matching", and "Visual Search". At the bottom of the mode section are six radio buttons labeled "1", "2", "4", "8", "16", and "32". At the very bottom are three buttons: "OK", "Reset", and "Exit".



Simple Reaction Time

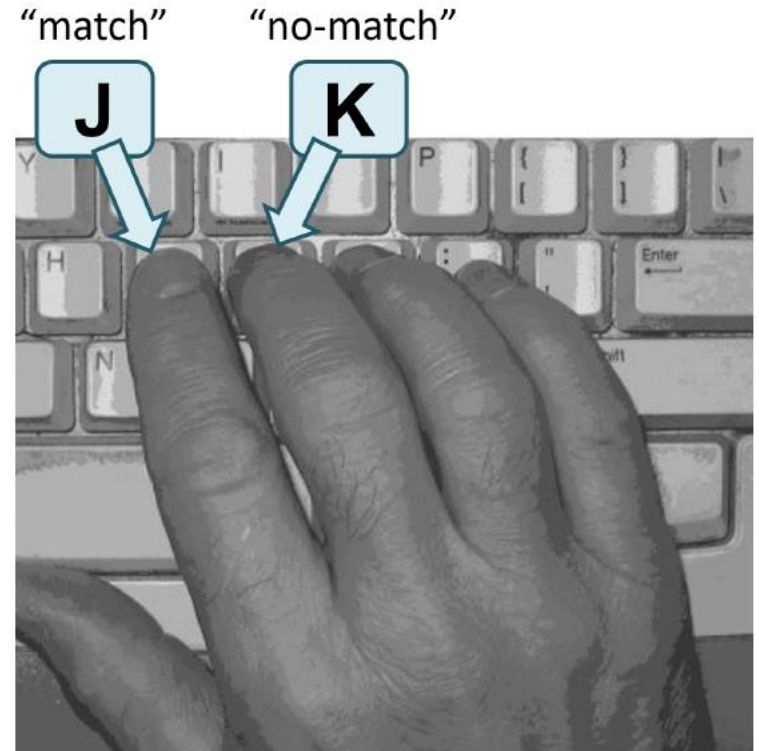


Use software from the book's web site:

<http://www.yorku.ca/mack/HCIbook2e/>

Reaction Time Experiment (2)

Physical Matching

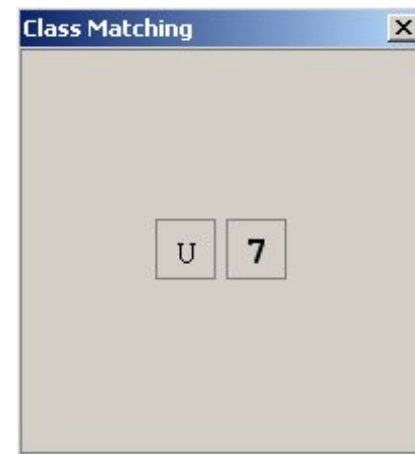


Reaction Time Experiment (3)

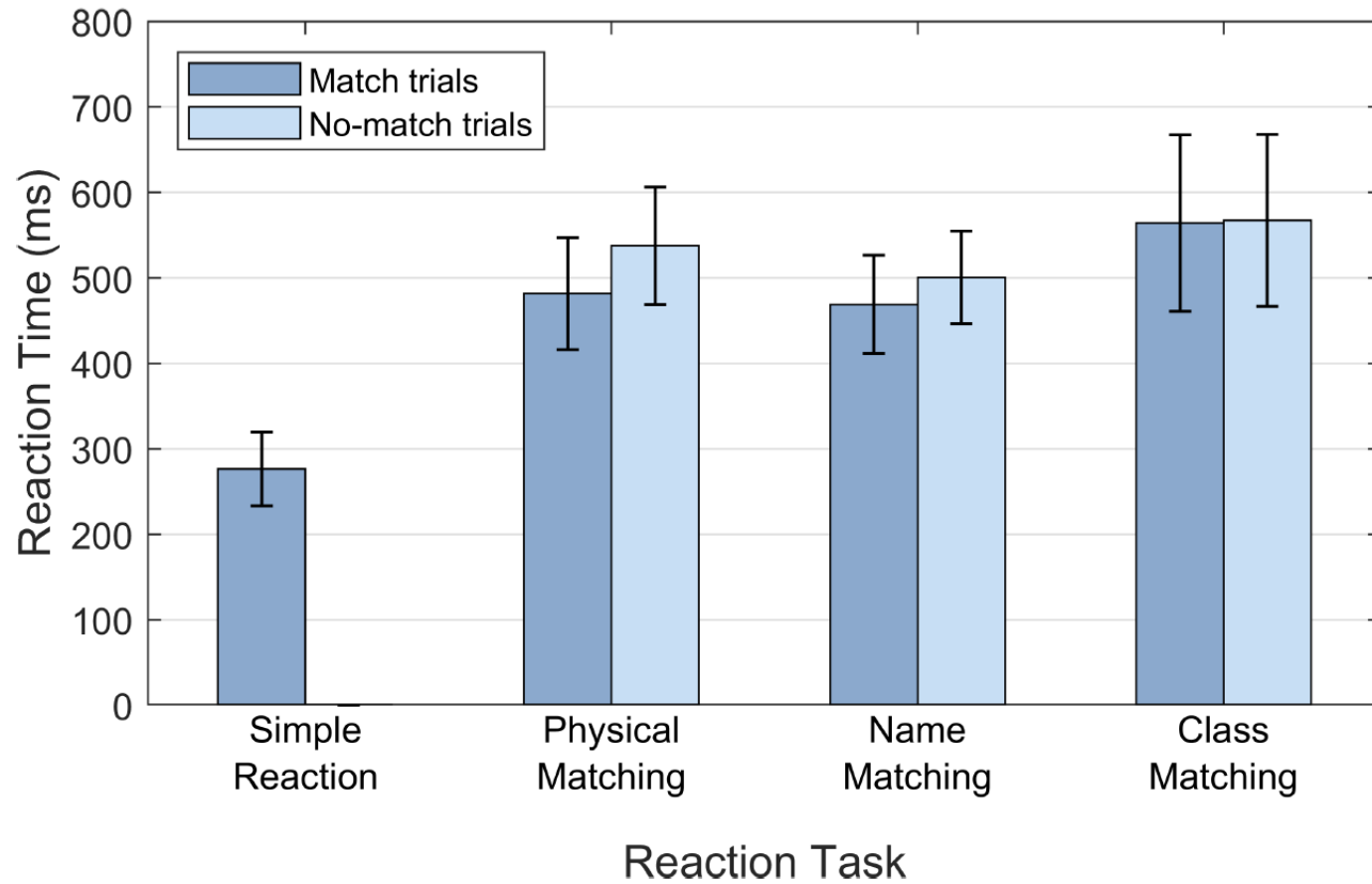
Name Matching



Class Matching

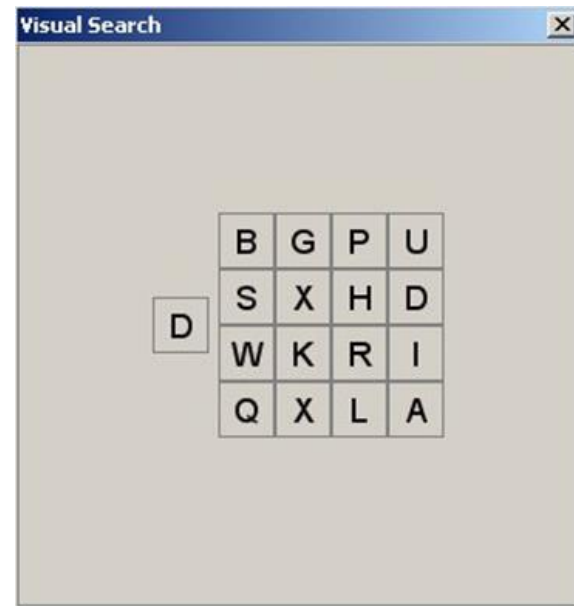
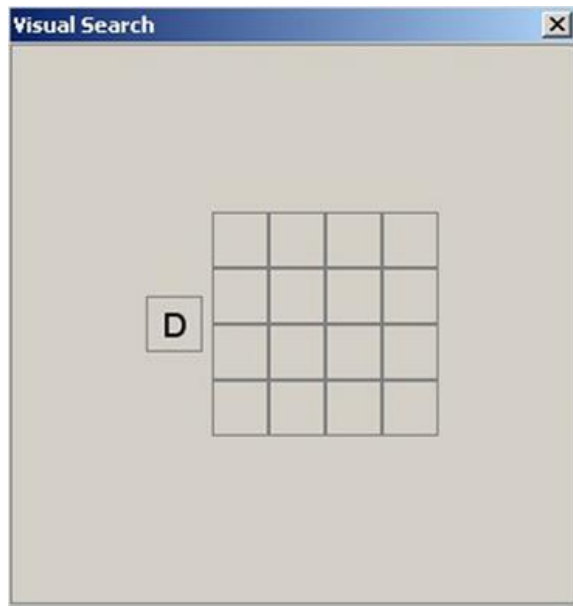


Experiment Results

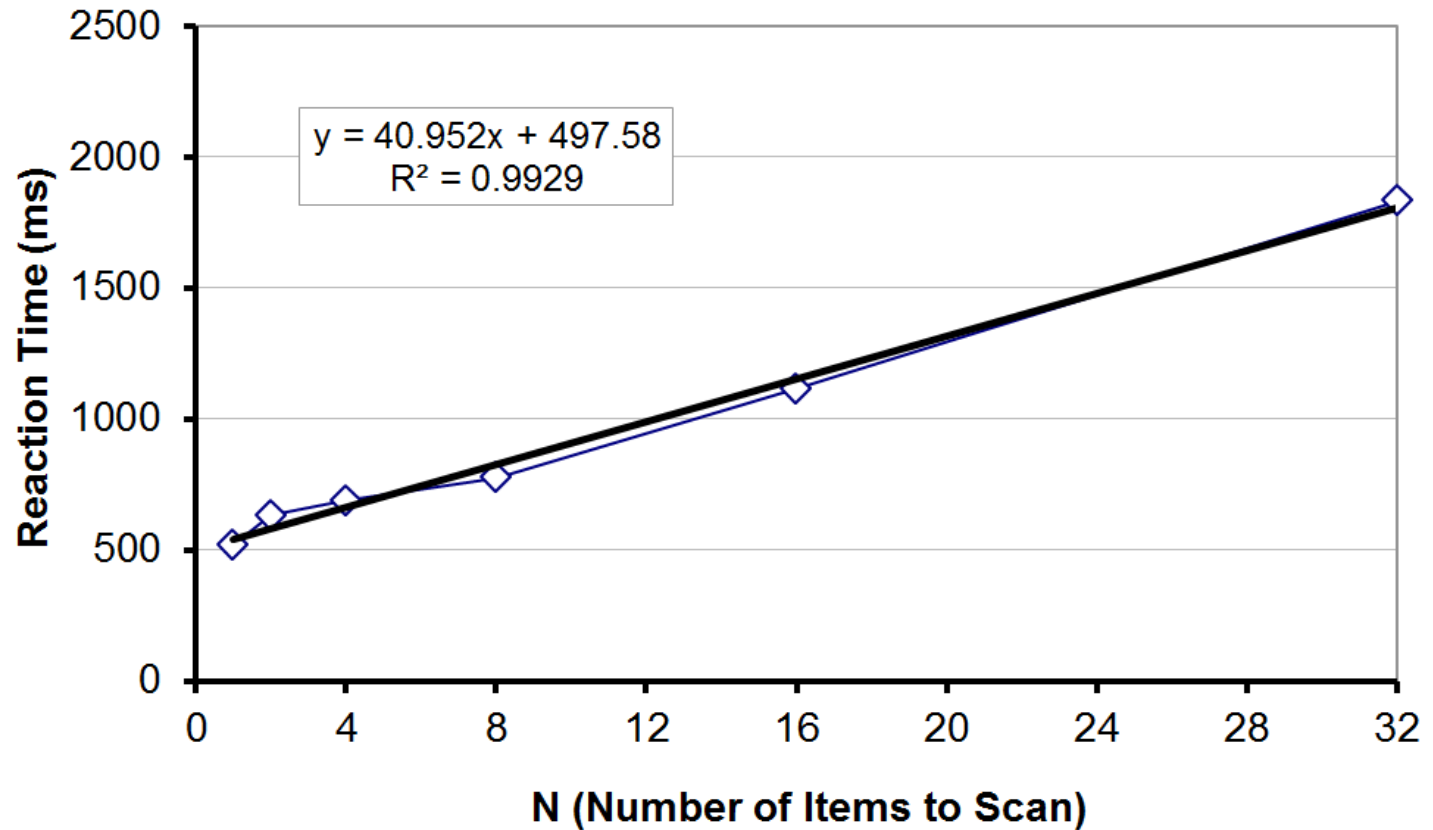


Visual Search

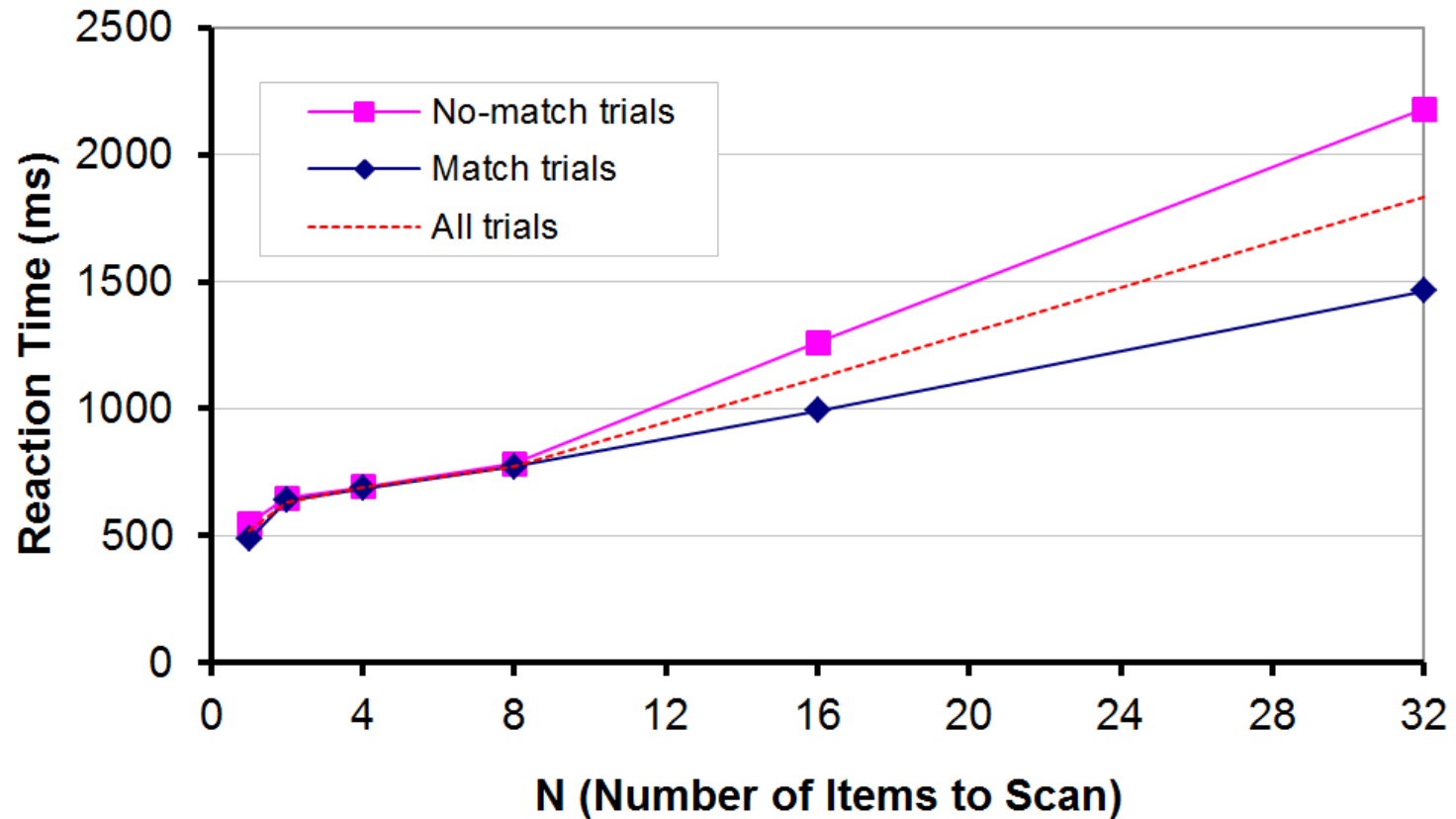
- A variation on simple reaction time
- User scans a collection of items looking for desired item
- Time increases with the number of items to scan
- Included in the demo software with $N = 1, 2, 4, 8, 16$, or 32 items



Experiment Results (1)



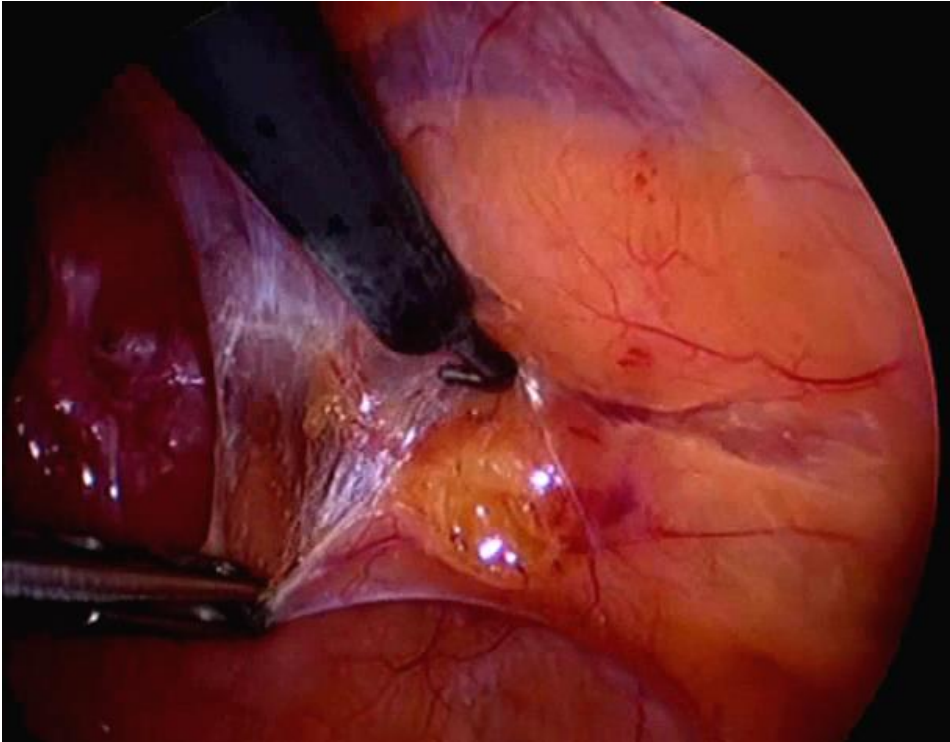
Experiment Results (2)



Skilled Behavior

- For many tasks, human performance improves considerably and continuously with practice
- (Note: Very little improvement with practice in 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 require a lot of both (next slide)

Laparoscopic Surgery¹



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, distractions
 - 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)

Selected Attention Example

- The Stroop Effect¹
 - The user is asked to name the colour of a word stimulus
 - The words are colours, but are not necessarily set in the colour suggested by the word (e.g., **RED** vs. **GREEN**)
 - The response takes longer when there is a mismatch
 - The primary task (attend to the colour) is affected by the secondary task (ignore the meaning of the word)

Stimulus 1: Purple Brown Red Blue Green

Stimulus 2: Brown Green Blue Green

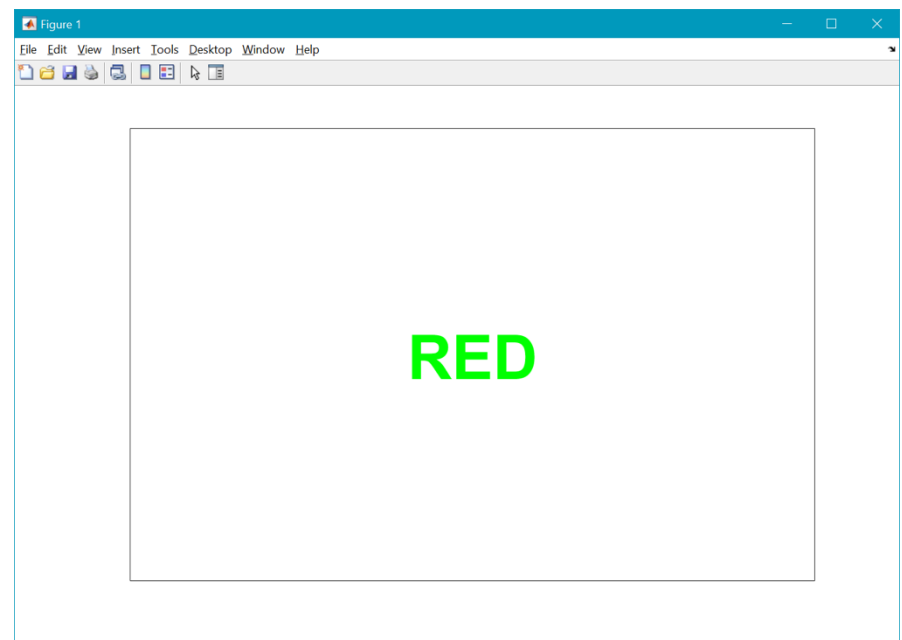
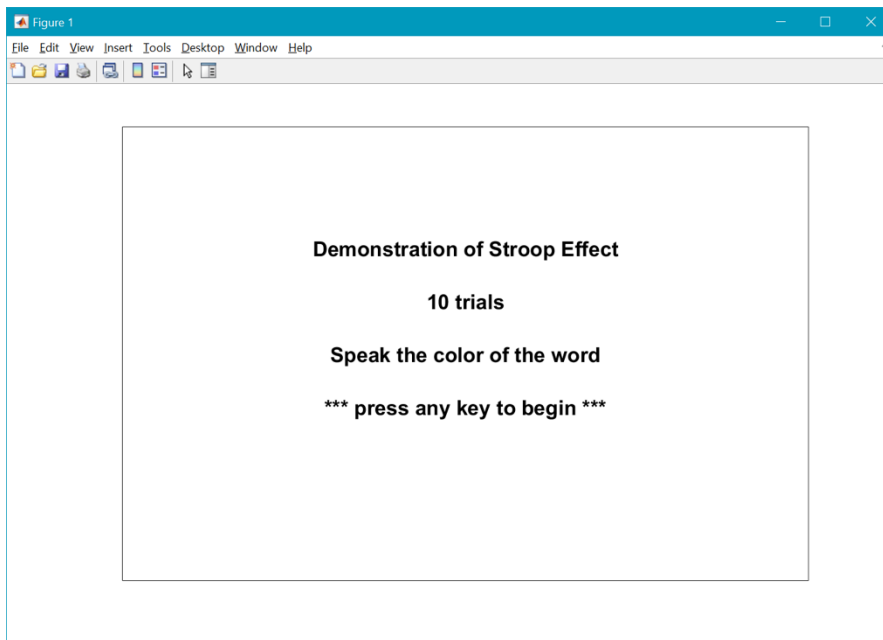
Stimulus 3: ■■■■■■ ■■■■■■ ■■■■■■ ■■■■■■

Examples of the three stimuli and colors used for each of the activities of the original Stroop article.

¹ https://en.wikipedia.org/wiki/Stroop_effect

Example (1)

- Stroop Effect¹



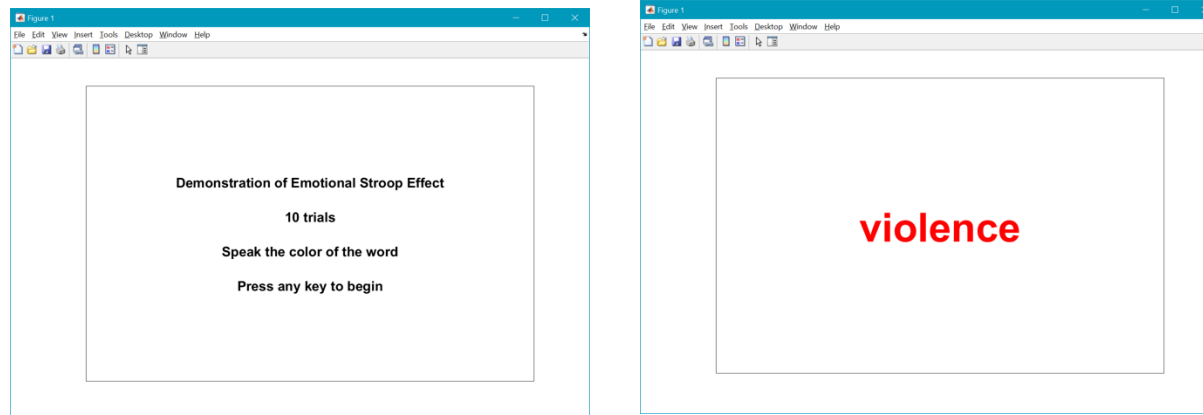
practice043a_stroop_effect_demo.m

Note: Created in MATLAB 

¹ https://en.wikipedia.org/wiki/Emotional_Stroop_test

Example (2)

- Emotional Stroop Effect¹
 - Same task: speak the colour of the word
 - Words are neutral (e.g., house, beaver) or emotional (e.g., disease, murder)
 - RT for emotional words is longer for depressed people



practice043b_stroop_effect_demo.m

Note: Created in MATLAB

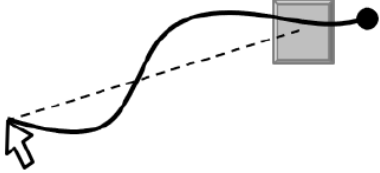
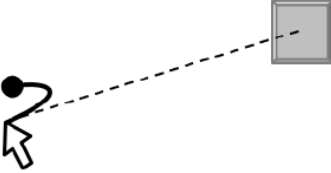


¹ https://en.wikipedia.org/wiki/Emotional_Stroop_test

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 in error are often at least partly correct (next slide)

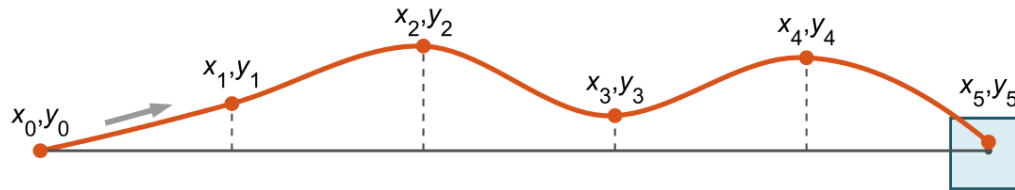
Variability and Error

Outcome	Task	
	Target Selection	Text Entry
Correct		quickly
Corrected		quicz←kly
Incorrect		qucehkly
Outlier		xq

What went wrong and why?

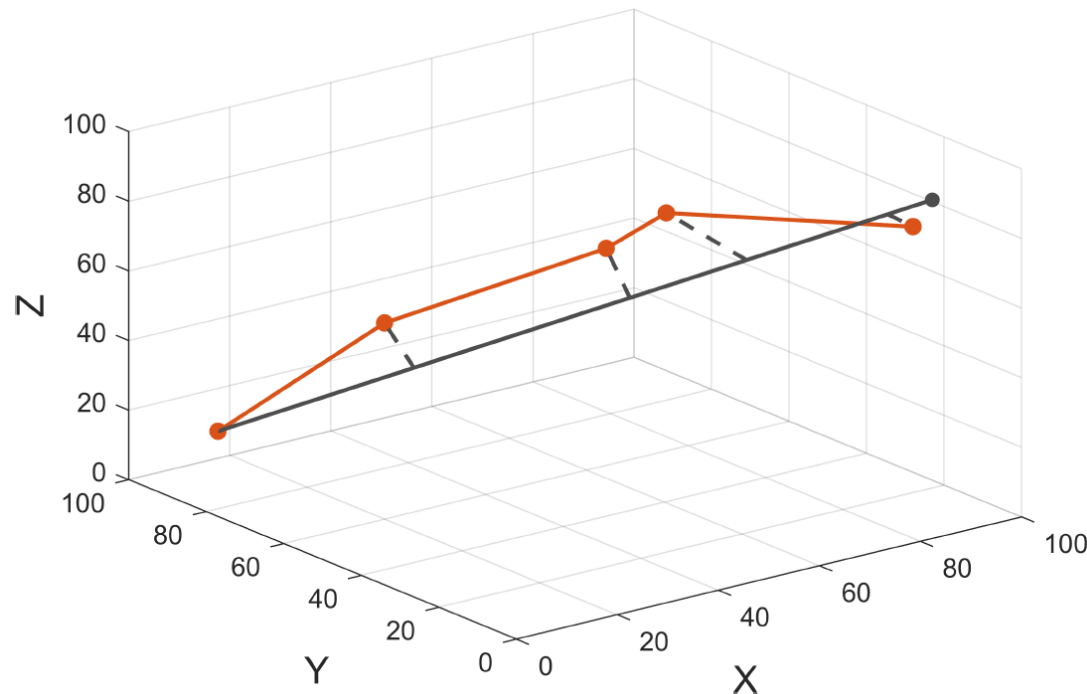
Pointer Movement Variability

- 2D



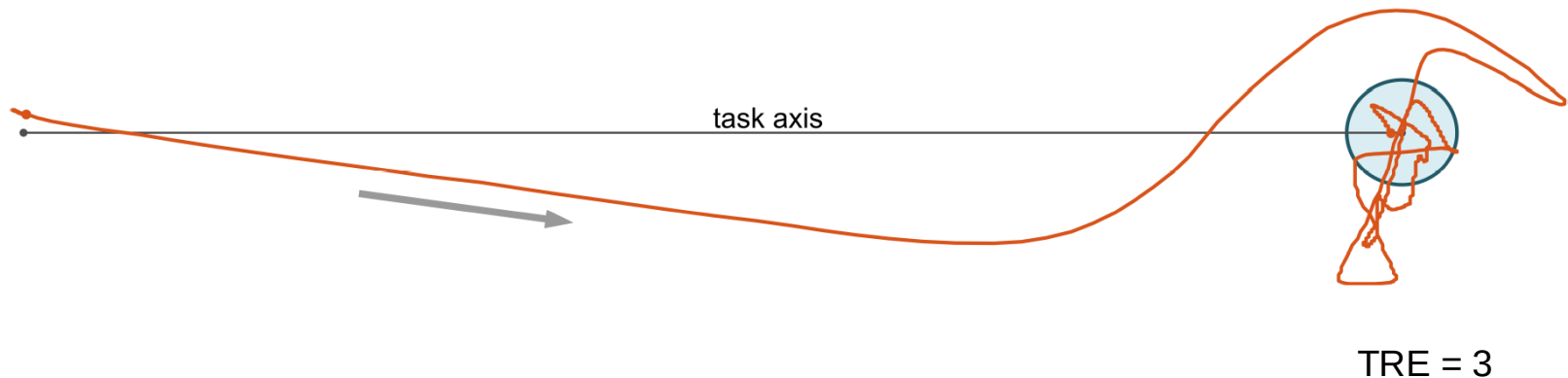
$$MV = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n - 1}}$$

- 3D



Other Performance Measures

- TRE (target re-entries)¹



- See **HCI:ERP2e** for additional measures for pointer path accuracy

¹ I.S. MacKenzie, T. Kauppinen, M. Silfverberg, Accuracy measures for evaluating computer pointing devices, in: Proc CHI '01, ACM, New York, 2001, pp. 9–16.

Text Entry Metrics

- Keystrokes per character (KSPC)

$$\text{KSPC} = \frac{\text{len}(\text{quicz} < \text{kly})}{\text{len}(\text{quickly})} = \frac{9}{7} = 1.286$$

- MSD Error rate

Types of errors:

- Substitution
- Deletion
- Insertion

	q	u	c	e	h	k	l	y
0	1	2	3	4	5	6	7	8
q	1	0	1	2	3	4	5	6
u	2	1	0	1	2	3	4	5
i	3	2	1	1	2	3	4	5
c	4	3	2	1	2	3	4	5
k	5	4	3	2	2	3	3	4
l	6	5	4	3	3	3	4	3
y	7	6	5	4	4	4	4	3

Minimum String Distance

MSD

Alignments

quic--kly
qu-cehkly

quic-kly
qucehkly

qui-ckly
qucehkly

qu-ickly
qucehkly

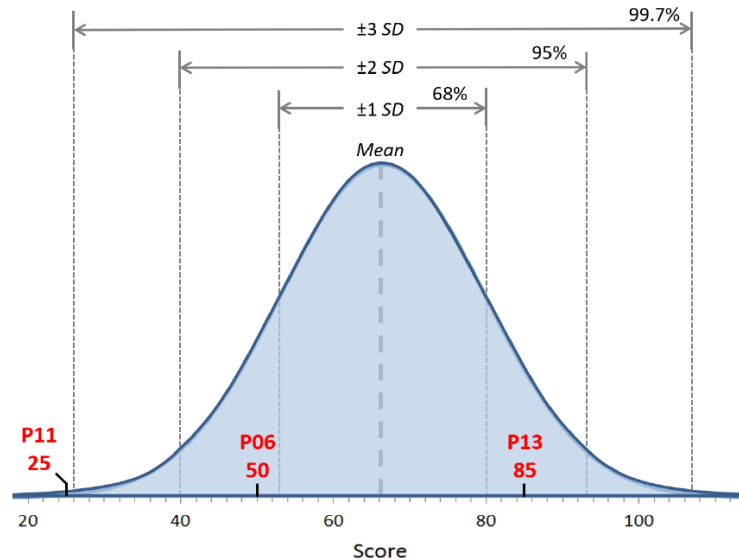
$$\text{ER} = \frac{\text{MSD}(A, B)}{\max(\text{len}(A), \text{len}(B))} = \frac{3}{8} = 0.125 = 12.5\%$$

Outliers

- Wildly deviate scores may be classified as outliers and possibly removed from analyses
- May apply to individual trials, blocks of trials, or participants
- Must have a criterion (quantitative) and a rationale (qualitative)

Outlier Example

Participant	Score
P01	71
P02	70
P03	69
P04	67
P05	70
P06	50
P07	71
P08	69
P09	71
P10	67
P11	25
P12	67
P13	85
P14	75
P15	69
Mean	66.4
SD	13.4

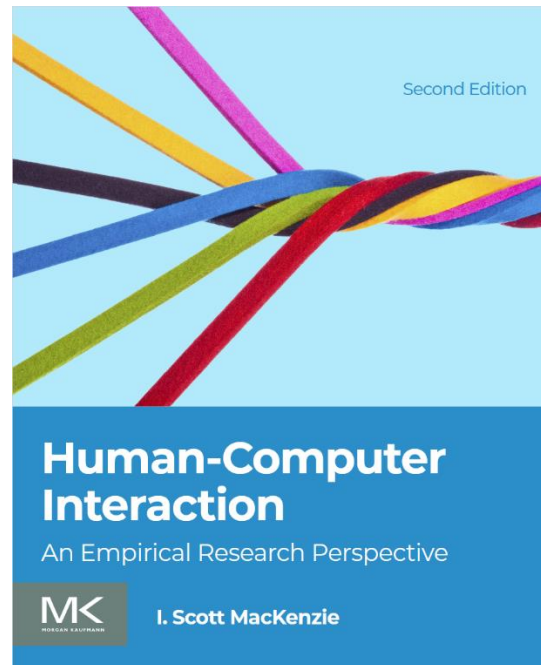


- Perhaps remove data for P11 (outlier)
 - Criterion: score $> \pm 3 SD$ from mean
 - Rationale: participant distracted, participant didn't understand, etc.

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



<https://www.yorku.ca/mack/HCIbook2e/>