Lecture 13

Ergonomics and Human Factors for Interaction Techniques

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05-899A/05-499A

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Source: Maltron

User Modeling

Source: CMU

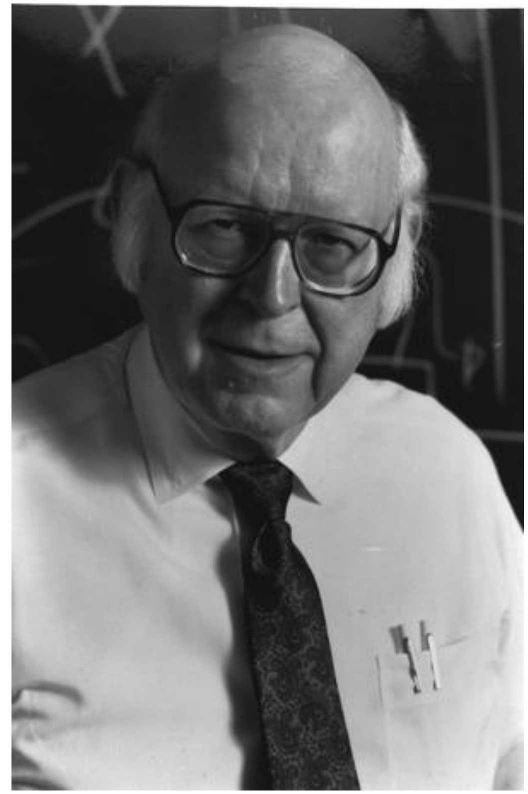
User Modeling

Even if we **can't perfectly simulate the human brain**, we can **approximate** it with **theories that match what we observe**, and **model** how it behaves. If we do it well, then the **models will match experiments**.

Keystroke Level Models

- Very, very low level
- Task-centered
- Provides timing data

- Find places to optimize
- Potential error cases



Source: nap.edu

Keystroke Level Models

- Make an ordered list of actions
  - Keys you press
  - Clicking the mouse
  - Scrolling, moving the mouse
  - User physical movements
  - User consideration, judgment, or thinking
  - System responses (does the user have to wait?)
- Assign and add up execution times for all the items in the list

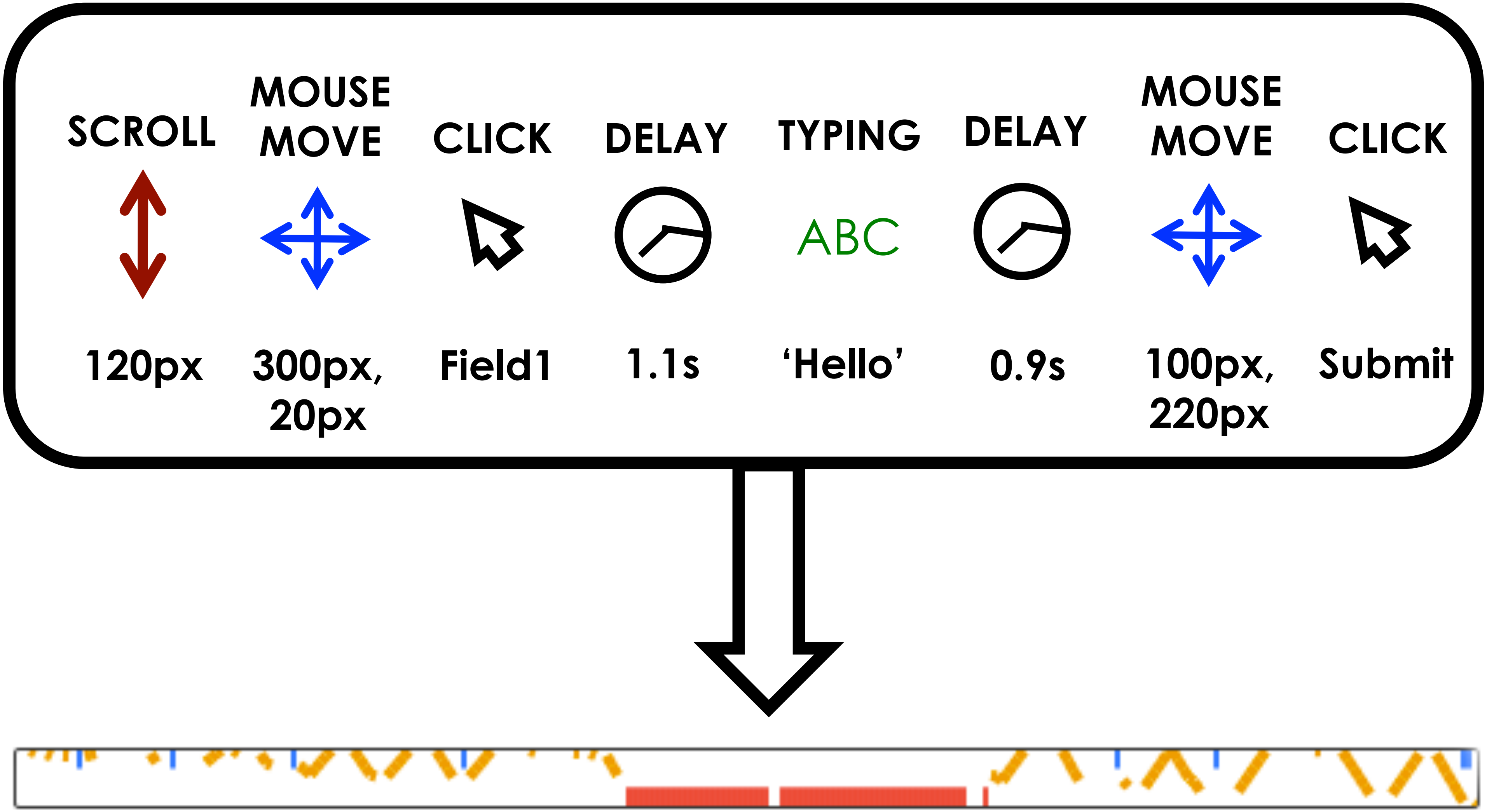
Keystroke Level Models

Description	Operation	Time (sec)
Reach for mouse	H[mouse]	0.40
Move pointer to "Replace" button	P[menu item]	1.10
Click on "Replace" command	K[mouse]	0.20
Home on keyboard	H[keyboard]	0.40
Specify word to be replaced	M4K[word]	2.15
Reach for mouse	H[mouse]	0.40
Point to correct field	P[field]	1.10
Click on field	K[mouse]	0.20
Home on keyboard	H[keyboard]	0.40
Type new word	M4K[word]	2.15
Reach for mouse	H[mouse]	0.40
Move pointer on Replace-all	P[replace-all]	1.10
Click on field	K[mouse]	0.20
Total		**10.2**

Source: Hochstein

Keystroke Level Models

- Different kinds of users?
- More than timing data?
- Complex tasks?
- Incorporating subtasks?



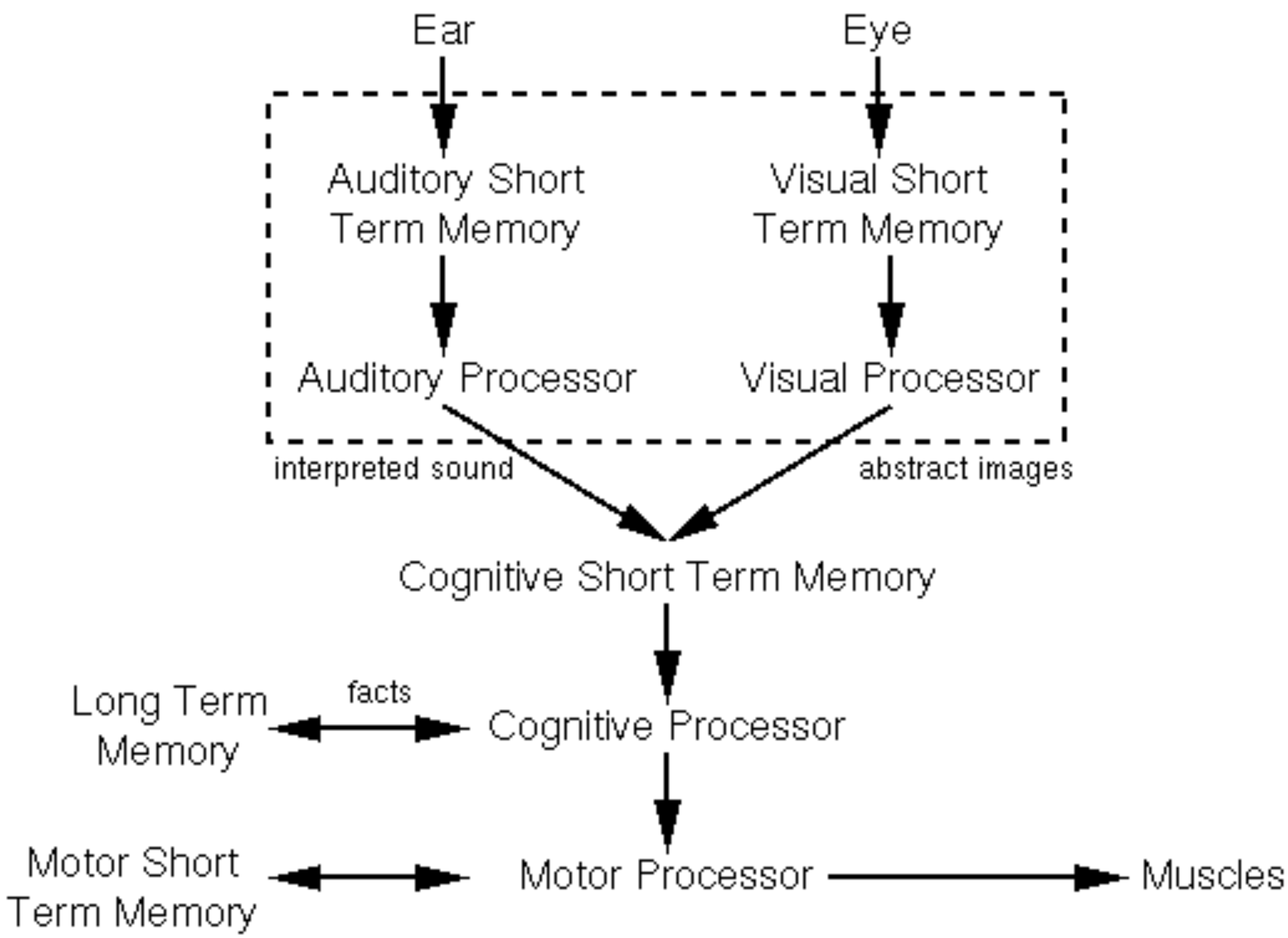
Check it out: [Rzeszotarski & Kittur, 2012]

GOMS

- High level
- More detailed than KLM

- Describe your tasks, (users), and interface elements
- Generate measurements

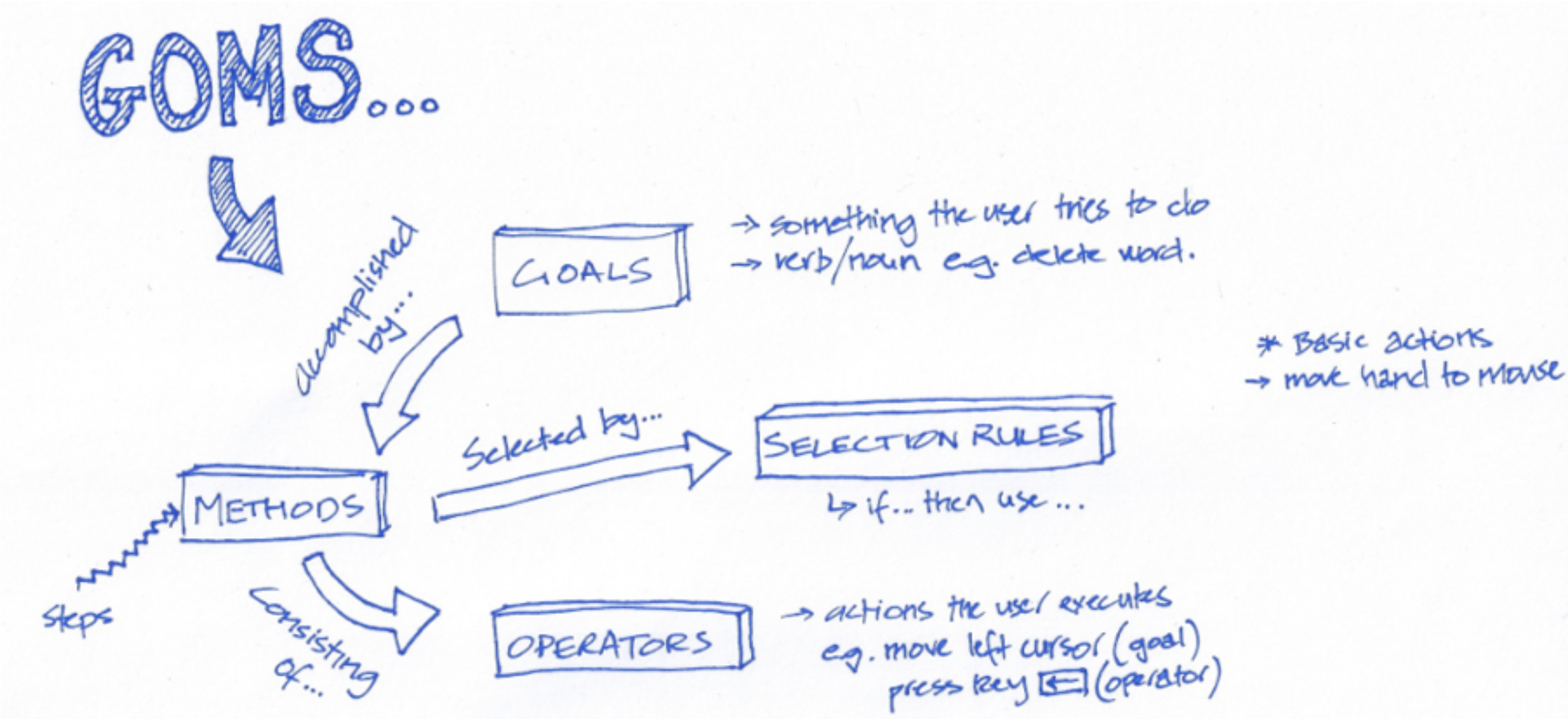
GOMS



Source: [Blustein]

GOMS

- Judge interface performance without user testing or experiments
- Compare designs / prototypes
- Study different user profiles
- Generate tutorials or resources
- (Evaluate learning and cognition)



Source: beheconomics.blogspot

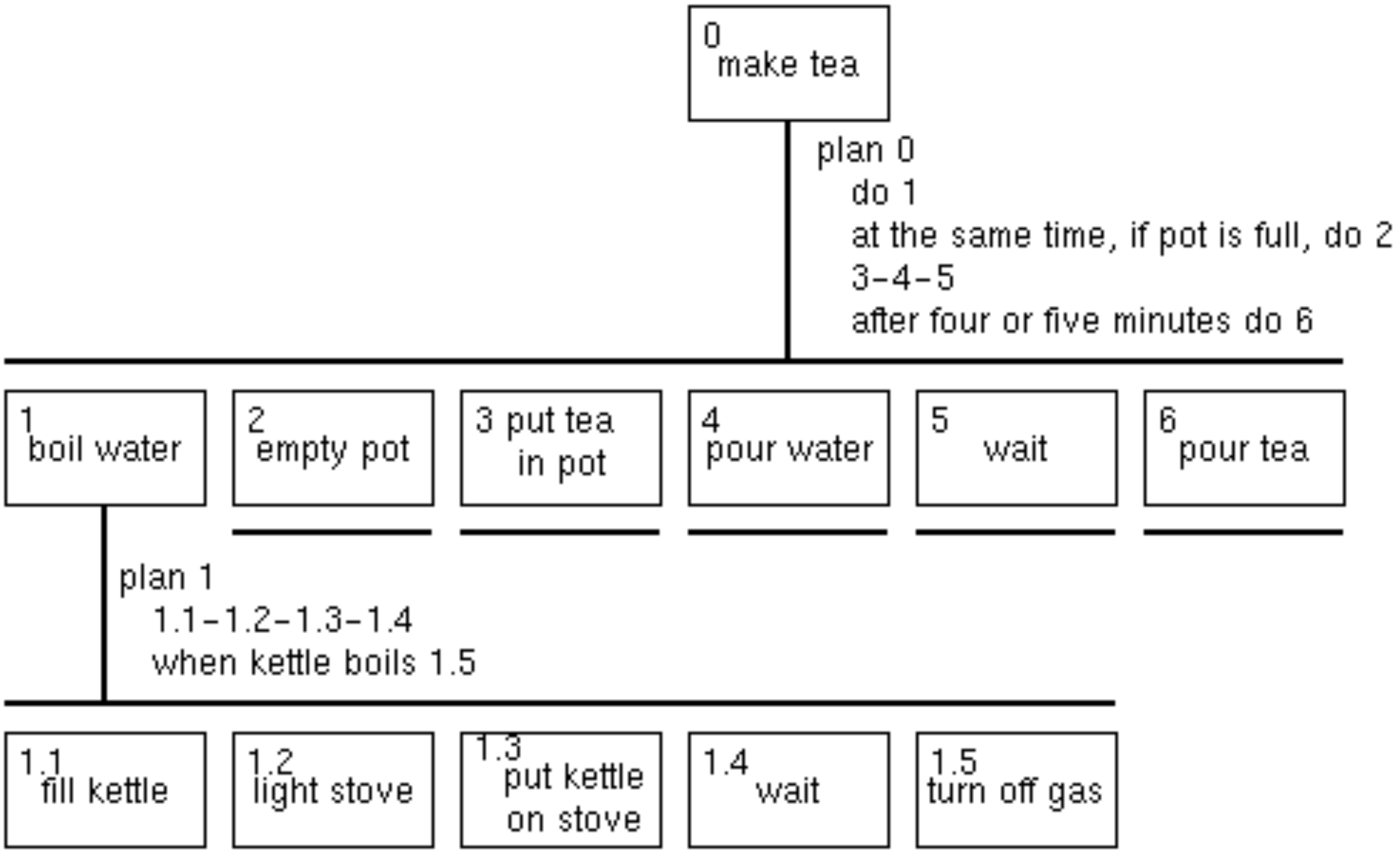
```
GOAL: MOVE-TEXT
.     GOAL: CUT-TEXT
.     .     GOAL: HIGHLIGHT-TEXT
.     .         .           [select**: GOAL: HIGHLIGHT-WORD
.     .         .                      .    MOVE-CURSOR-TO-WORD
.     .         .                      .    DOUBLE-CLICK-MOUSE-BUTTON
.     .         .                      .    VERIFY-HIGHLIGHT
.     .         .                      GOAL: HIGHLIGHT-ARBITRARY-TEXT
.     .         .                      .      MOVE-CURSOR-TO-BEGINNING       1.10
.     .         .                      .      CLICK-MOUSE-BUTTON             0.20
.     .         .                      .      MOVE-CURSOR-TO-END             1.10
.     .         .                      .      SHIFT-CLICK-MOUSE-BUTTON       0.48
.     .         .                      .      VERIFY-HIGHLIGHT]              1.35
.     .         GOAL: ISSUE-CUT-COMMAND
.     .         .     MOVE-CURSOR-TO-EDIT-MENU                               1.10
.     .         .     PRESS-MOUSE-BUTTON                                     0.10
.     .         .     MOVE-CURSOR-TO-CUT-ITEM                                1.10
.     .         .     VERIFY-HIGHLIGHT                                       1.35
.     .         .     RELEASE-MOUSE-BUTTON                                   0.10
.     GOAL: PASTE-TEXT
.     .     GOAL: POSITION-CURSOR-AT-INSERTION-POINT
.     .         MOVE-CURSOR-TO-INSERTION-POIONT                              1.10
.     .         CLICK-MOUSE-BUTTON                                           0.20
.     .         VERIFY-POSITION                                              1.35
.     .         GOAL: ISSUE-PASTE-COMMAND
.     .         .     MOVE-CURSOR-TO-EDIT-MENU                               1.10
.     .         .     PRESS-MOUSE-BUTTON                                     0.10
.     .         .     MOVE-MOUSE-TO-PASTE-ITEM                               1.10
.     .         .     VERIFY-HIGHLIGHT                                       1.35
.     .         .     RELEASE-MOUSE-BUTTON                                   0.10
                                        TOTAL TIME PREDICTED (SEC)          14.38
```

Source: [Hochstein]

GOMS

- vs User Studies
  - Sometimes faster, sometimes slower
  - More detailed feedback
- Requires a goal
  - What about browsing?
- Doesn’t evaluate design, human factors, social, or organizational impact

Other Task Analyses



Source: [Blustein]

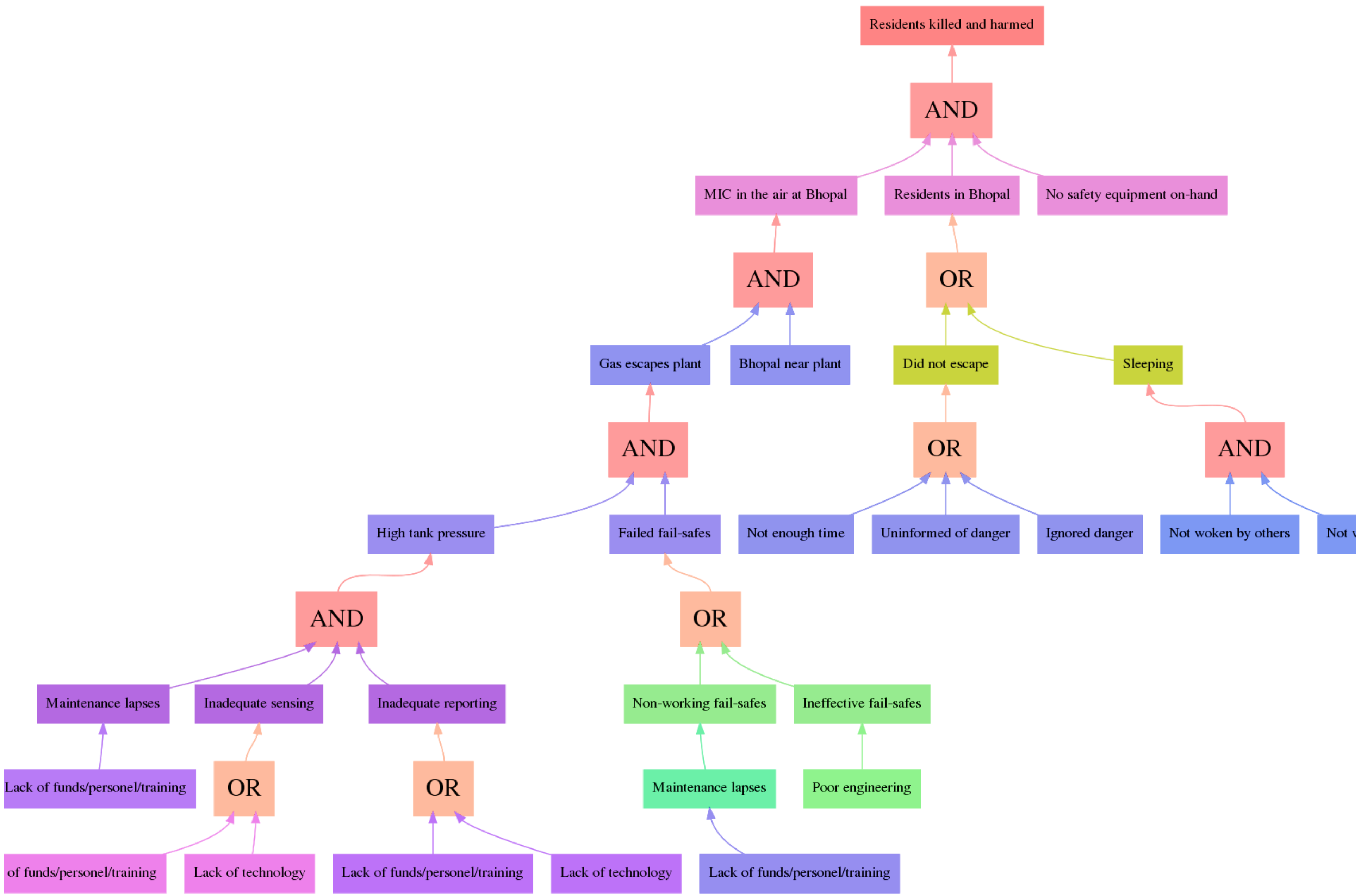
Human Factors & Ergonomics

Human factors is concerned with the understanding of **interactions among humans** and other **elements** of a **system**, and the profession that applies **theory**, principles, **data** and methods to design in order to **optimize human well-being** and overall **system performance**.

Human Factors

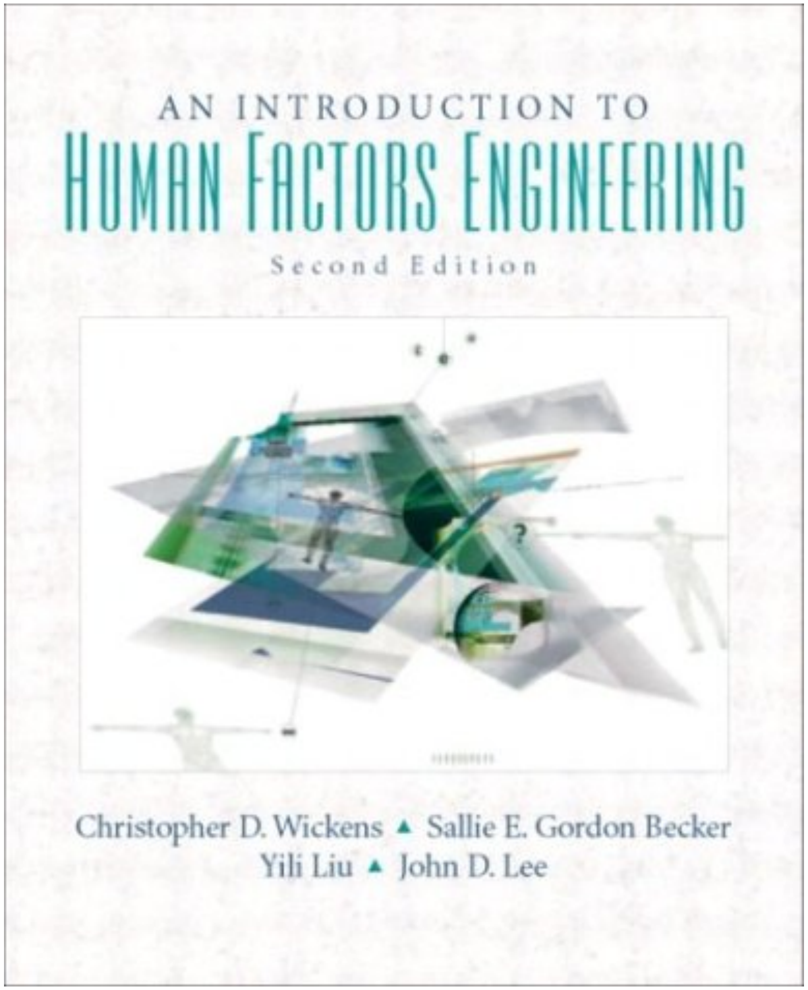
- Investigations of disasters / accidents
  - see Air Crash Investigation series for a demo of this process, or this Therac 25 report
- Understanding where errors may happen
- Designing new products or systems

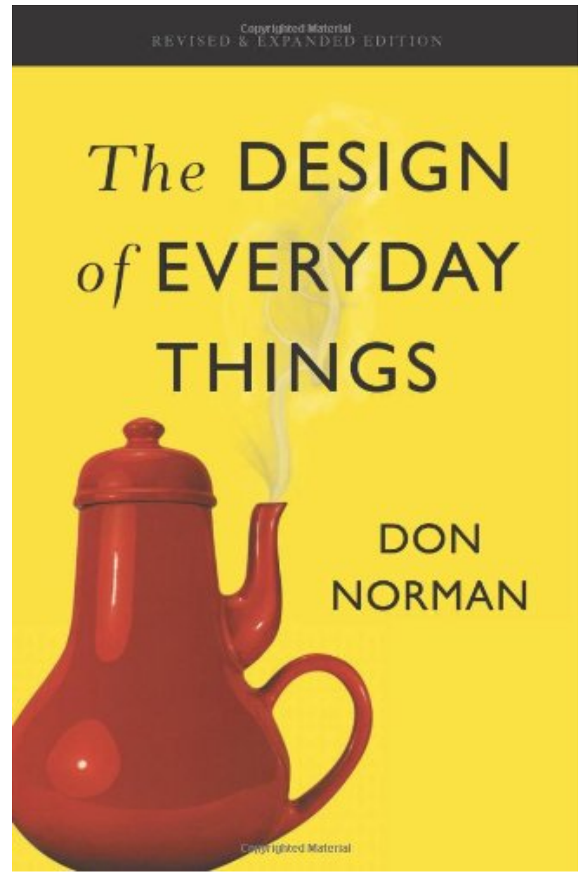
- Physiological, cognitive, behavioral, social, organizational, cultural, etc.



Residents killed and harmed
AND
MIC in the air at Bhopal
Residents in Bhopal
No safety equipment on-hand
AND
OR
Gas escapes plant
Bhopal near plant
Did not escape
Sleeping
AND
OR
AND
High tank pressure
Failed fail-safes
Not enough time
Uninformed of danger
Ignored danger
Not woken by others
AND
OR
Maintenance lapses
Inadequate sensing
Inadequate reporting
Non-working fail-safes
Ineffective fail-safes
Lack of funds/personel/training
OR
OR
Maintenance lapses
Poor engineering
of funds/personel/training
Lack of technology
Lack of funds/personel/training
Lack of technology
Lack of funds/personel/training

Human Factors





Time and Motion Studies

Time and Motion Studies

- Taylor, Gilbreth, Ford
- Improve worker performance through scientific practice – Scientific Management
- Observe experts, figure out why they perform well, make others like them

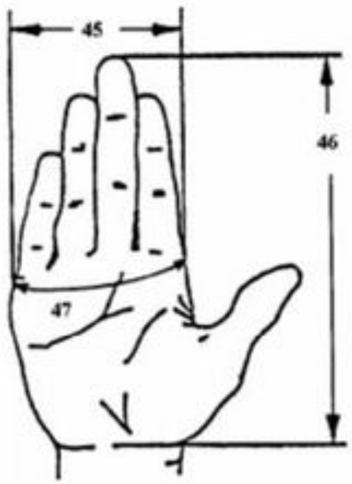
- Worker rights
- Injury and other human factors

Time and Motion Studies

Check out this instructional General Motors video from 1946 here

(pardon the dated, 40s depictions of gender, home, and society)

Anthropometry



45 Hand breadth. The breadth of the hand, measured across the ends of the metacarpal bones (metacarpal-phalangeal joints).

Sample			Percentiles 1st	5th	50th	95th	99th
A	Men	cm	8.1	8.4	9.0	9.8	10.0
		(in)	(3.2)	(3.3)	(3.5)	(3.9)	(3.9)
B	Women	cm	7.1	7.3	7.9	8.6	8.9
		(in)	(2.8)	(2.9)	(3.1)	(3.4)	(3.5)

46 Hand length. The distance from the base of the hand at the wrist crease to the tip of the middle finger.

Sample			Percentiles 1st	5th	50th	95th	99th
A	Men	cm	17.3	17.9	19.3	21.1	21.9
		(in)	(6.8)	(7.1)	(7.6)	(8.3)	(8.6)
B	Women	cm	15.9	16.5	18.0	19.7	20.5
		(in)	(6.3)	(6.5)	(7.1)	(7.8)	(8.1)

47 Hand circumference. The circumference of the hand, measured around the knuckles (metacarpal-phalangeal joints).

Sample			Percentiles 1st	5th	50th	95th	99th
A	Men	cm	19.2	19.9	21.3	23.0	23.7
		(in)	(7.6)	(7.8)	(8.4)	(9.1)	(9.3)
B	Women	cm	16.7	17.3	18.6	20.0	20.7
		(in)	(6.6)	(6.8)	(7.3)	(7.9)	(8.2)

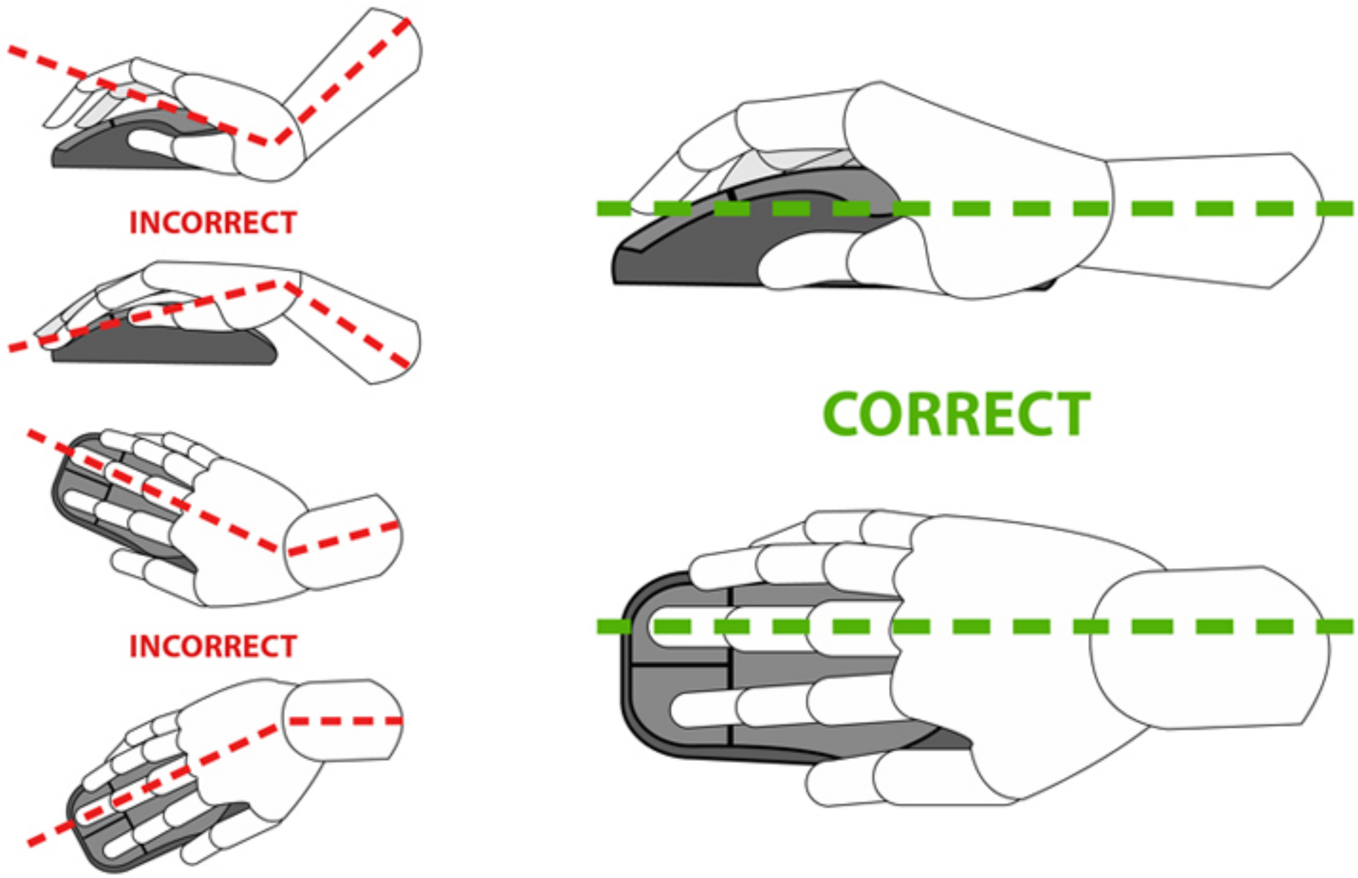
Anthropometry

- Measure populations to understand human body's structure
- Drive design to incorporate measurement and compatibility with variety of bodies

- Is there such a thing as an 'average' person in a population?
- Airplane seats vs. changing populations

Anthropometry

Physical Factors



“Ergonomics”

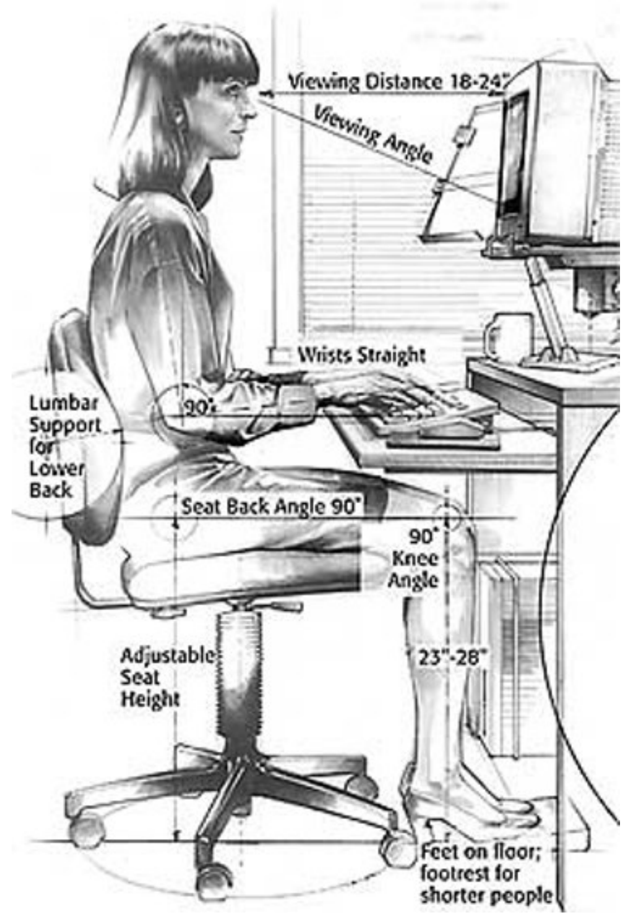
- Work-related injuries
  - OSHA
- Musculoskeletal injuries
  - Repetitive strain injuries
  - Vibration injuries
  - Fractures, sprains, and breaks
- Vision, hearing, or cognitive impairment
- Accidents

Human Decision Making

- Delayed gratification
  - Bias towards immediate gains
- Framing - cost vs. gain
  - Losses ‘worse’ than equal gains

Computer Posture

- Seating position
  - Erect posture
  - Back supported
  - Feet flat on ground
  - Eyes forward
  - 90 degree elbow
  - Wrist straightened
  - Adjustable chair
  - ’60 on, 15 off’



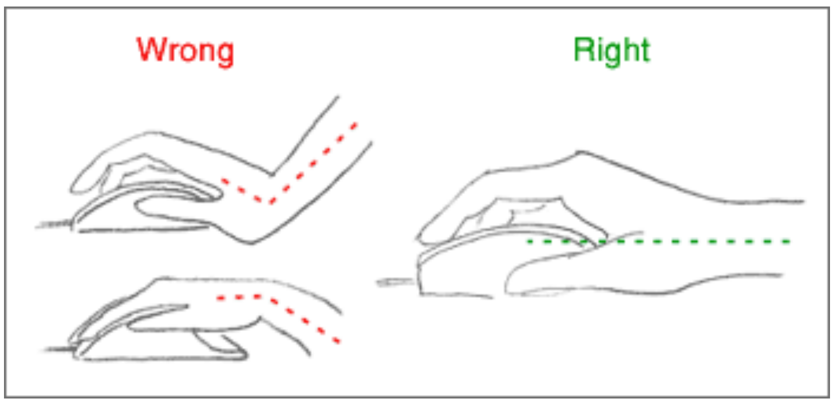
As physical or virtual interface designers, we <u>must</u> be proactive in preventing injuries

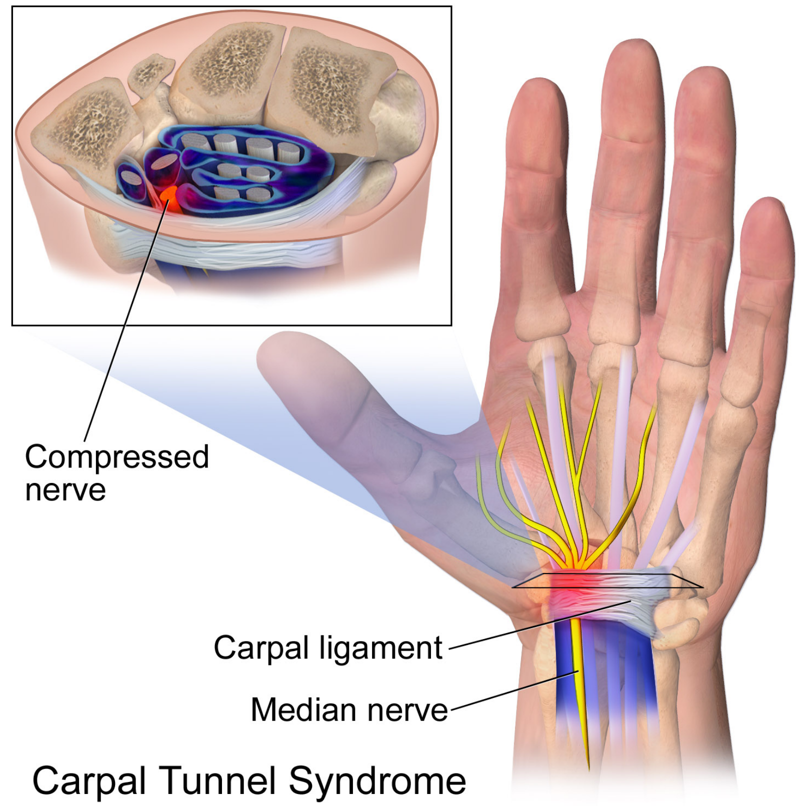
RSI

- Repetitive strain injuries
- Repetition of many physical actions over time, performed in an unsafe manner
  - Muscles in tension or nerves compressed
- No sudden onset – may take 5 years
- Permanent, irreversible damage

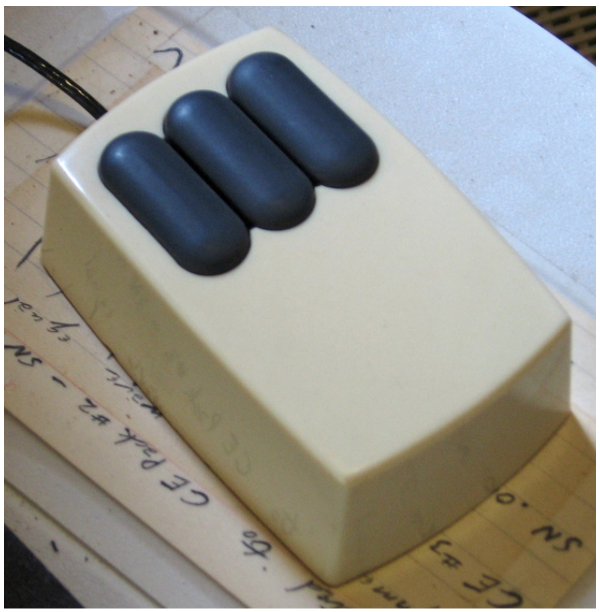
RSI

Pointing Device Injuries

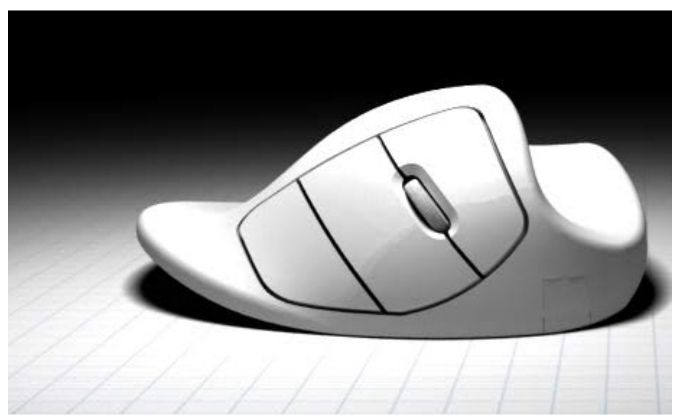




Pointing Device Injuries



Pointing Device Injuries



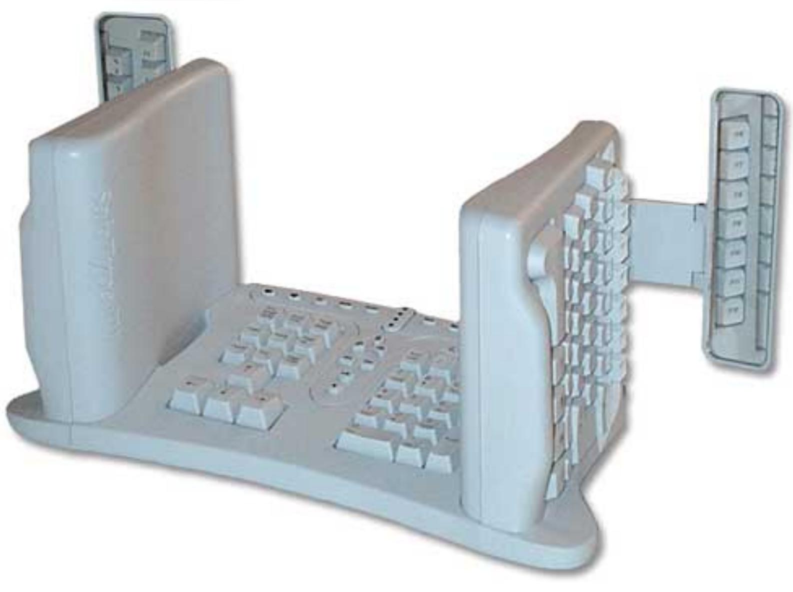
Pointing Device Injuries

vs

“Gorilla arm” Syndrome

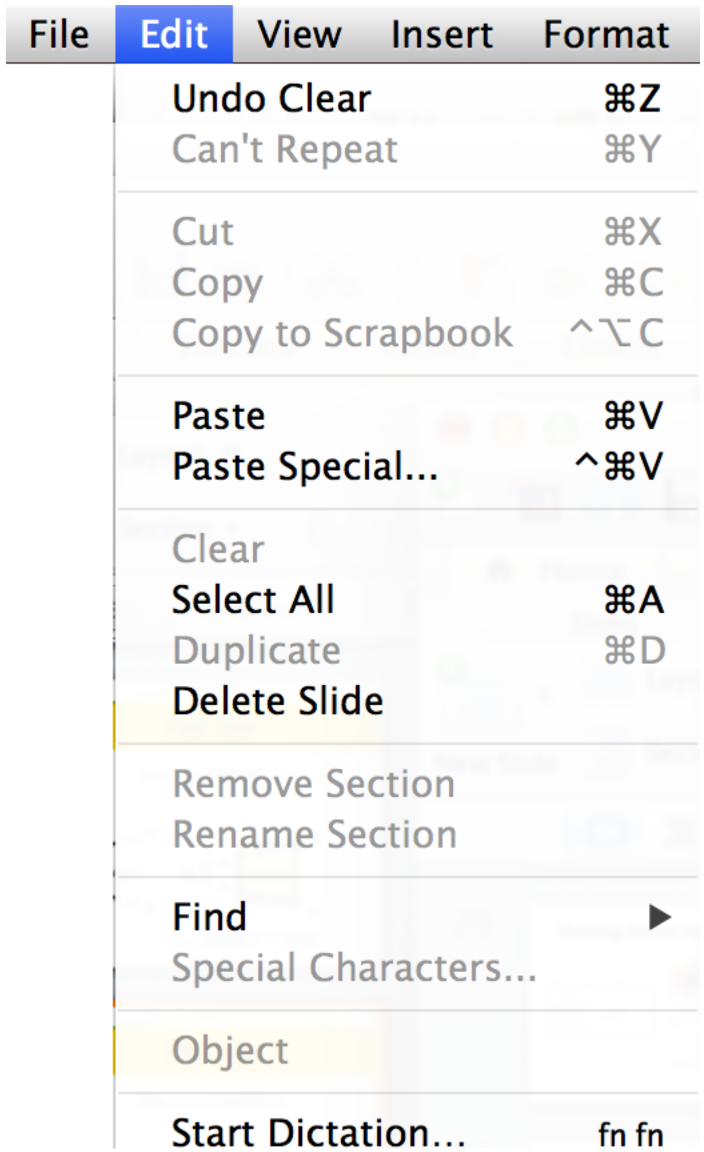
Text Entry Injuries

Text Entry Injuries

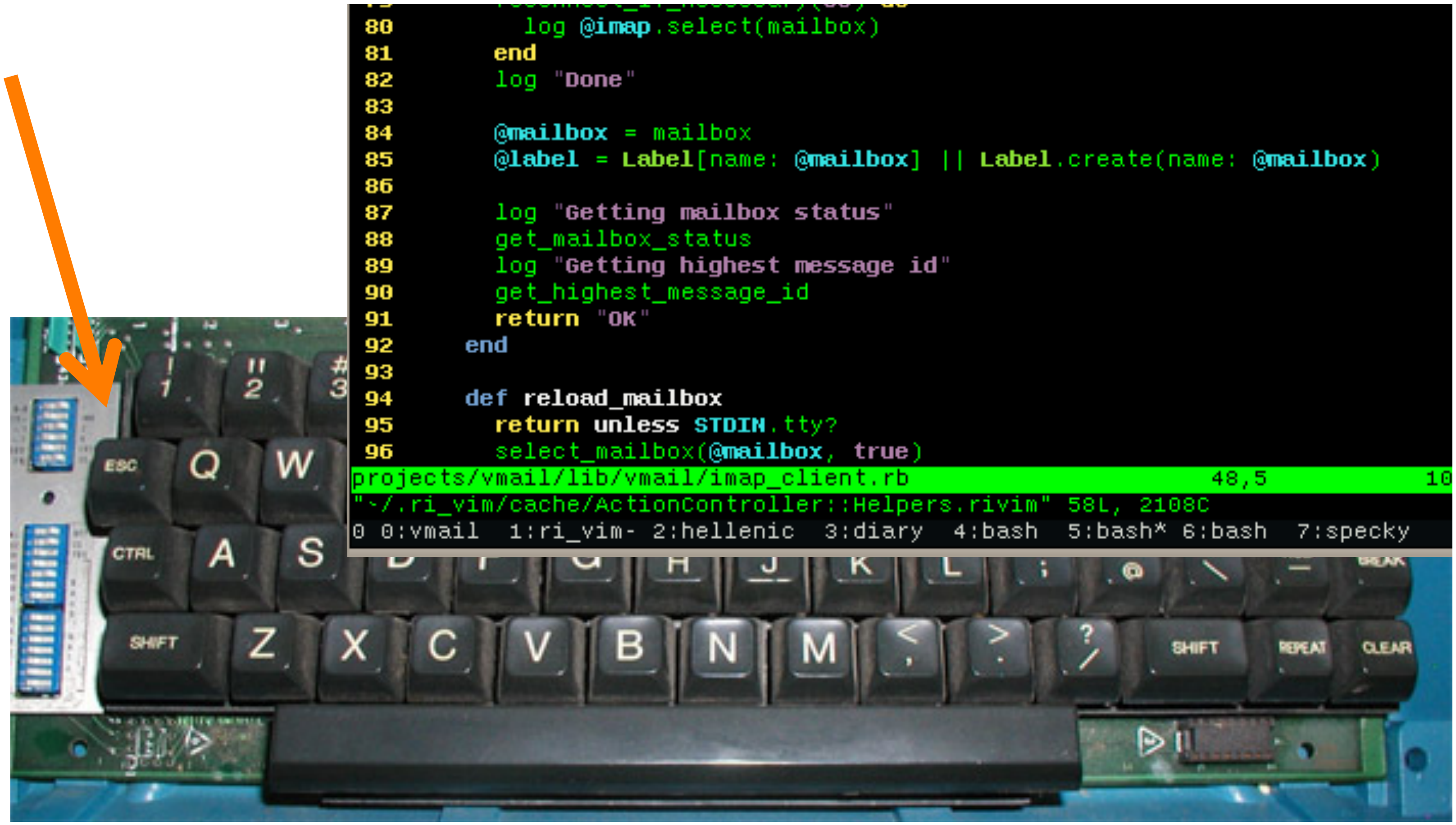


“Blackberry thumb” RSI

Strain from Interactions



Strain from Interactions



Strain from Interactions

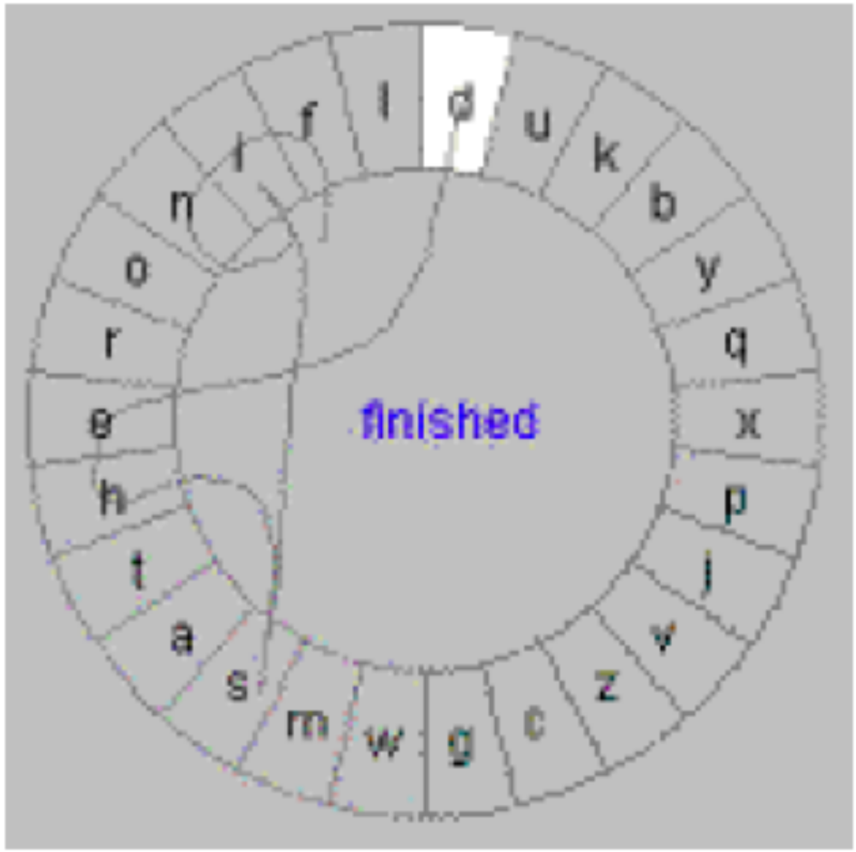


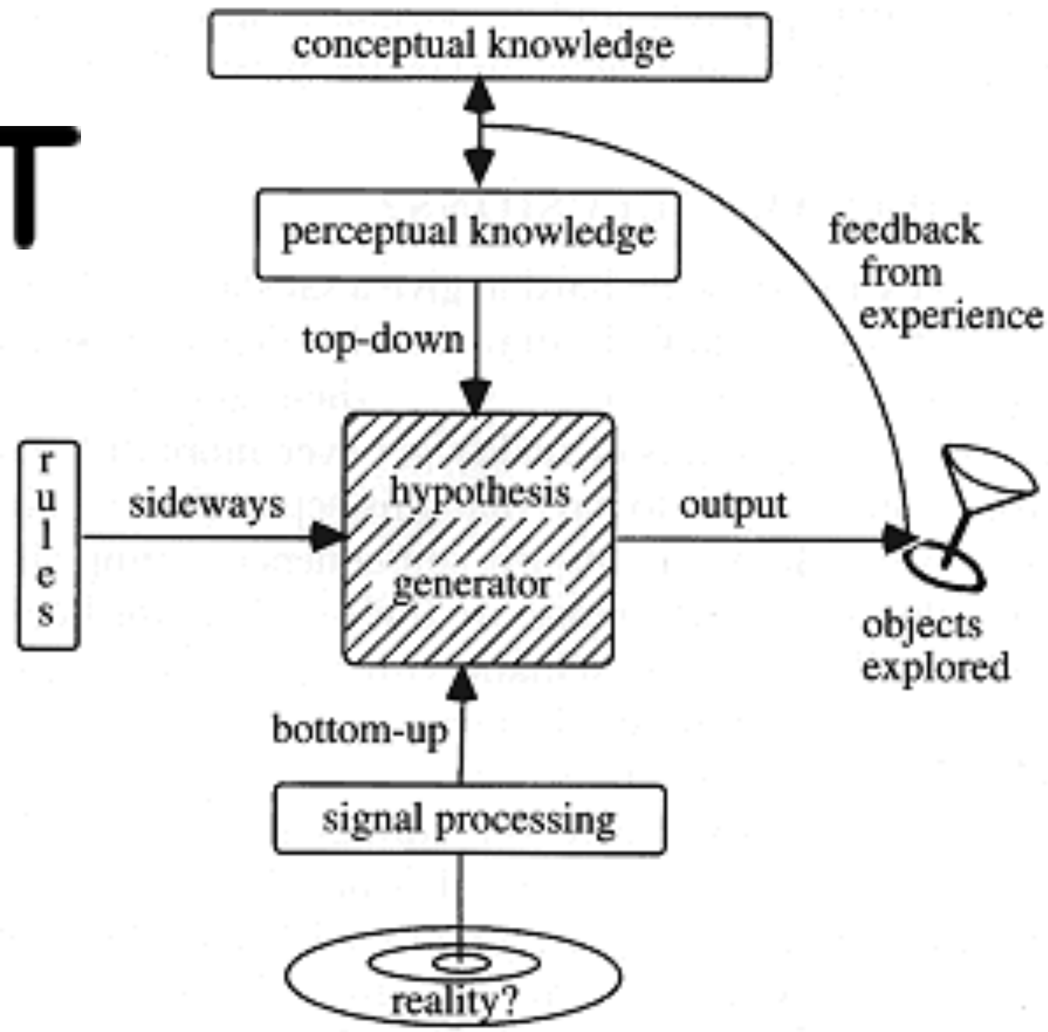
Figure 1: The word "finished" written on a circular, word-level soft keyboard.

Other Physical Issues

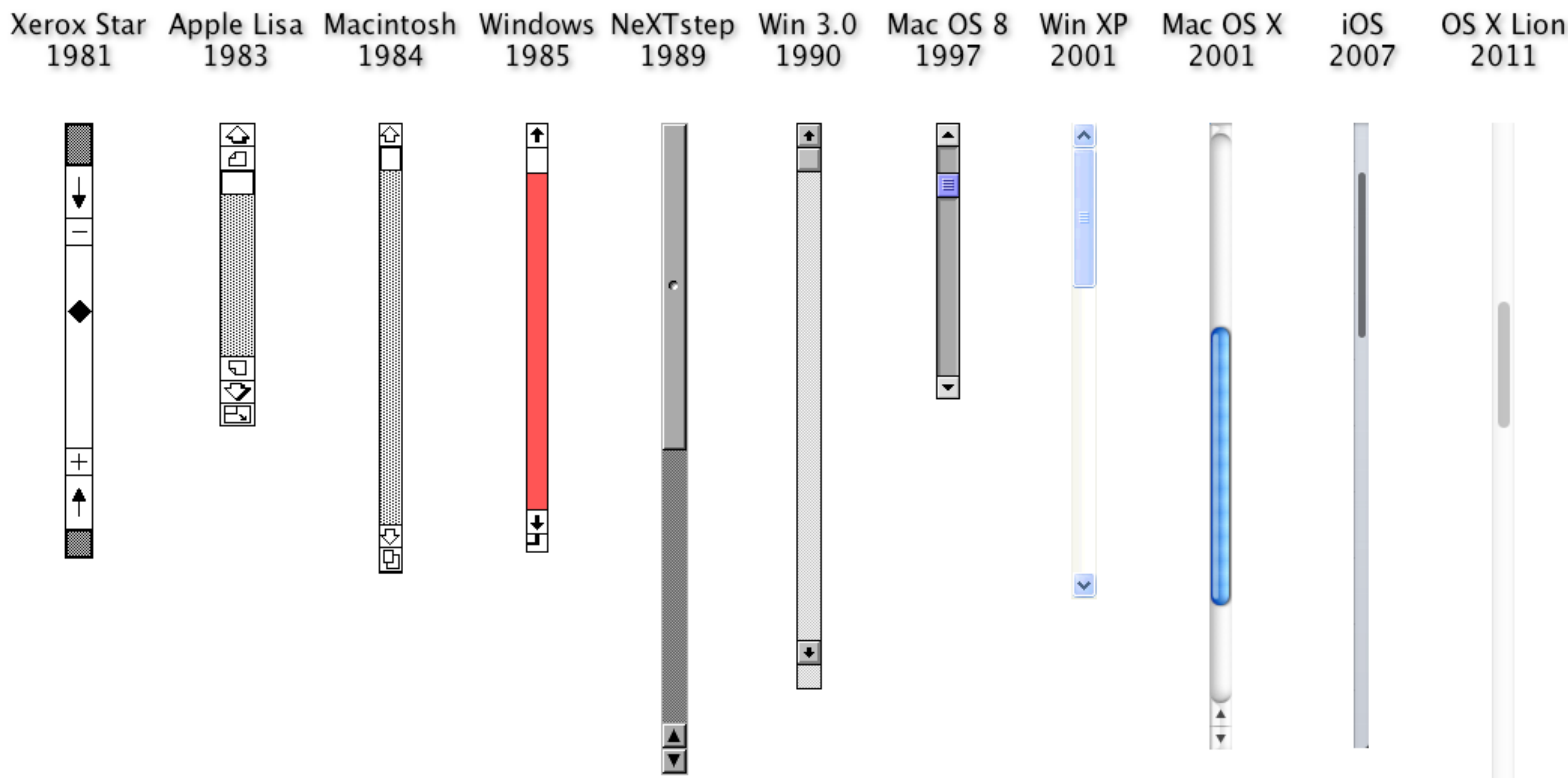
- Displays
  - Eye focus problems
  - Lighting vs. environment – flashing vision
    - “Watch in a well-lit room” warnings
- Noise – can’t close your ears
  - Deafness in Inuit hunters

Cognitive / Behavioral Factors

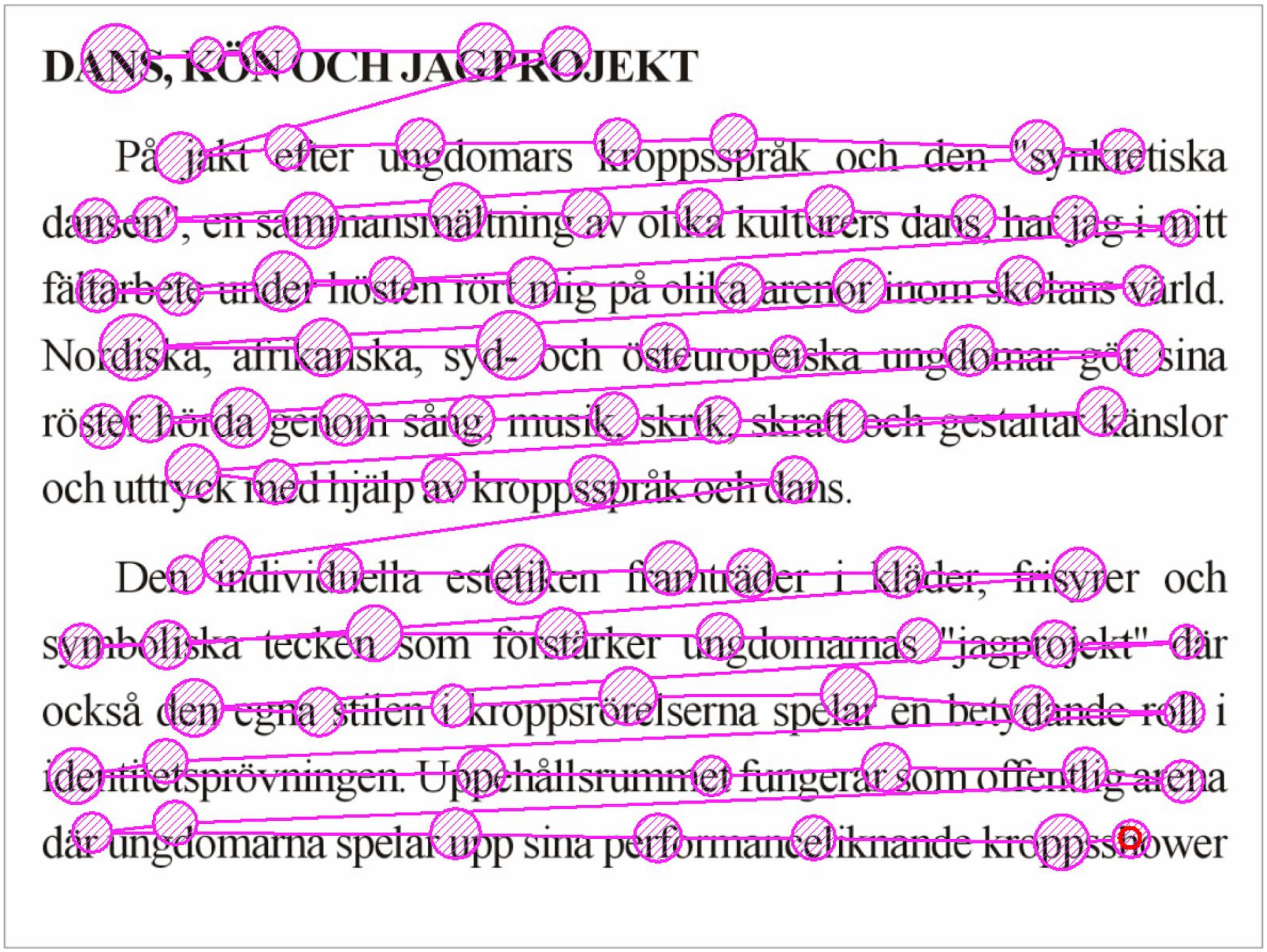
Top-down vs. Bottom-up Processing



Expectation Matching



Perceptual Factors



DANS, KÖN OCH JAGPROJEKT

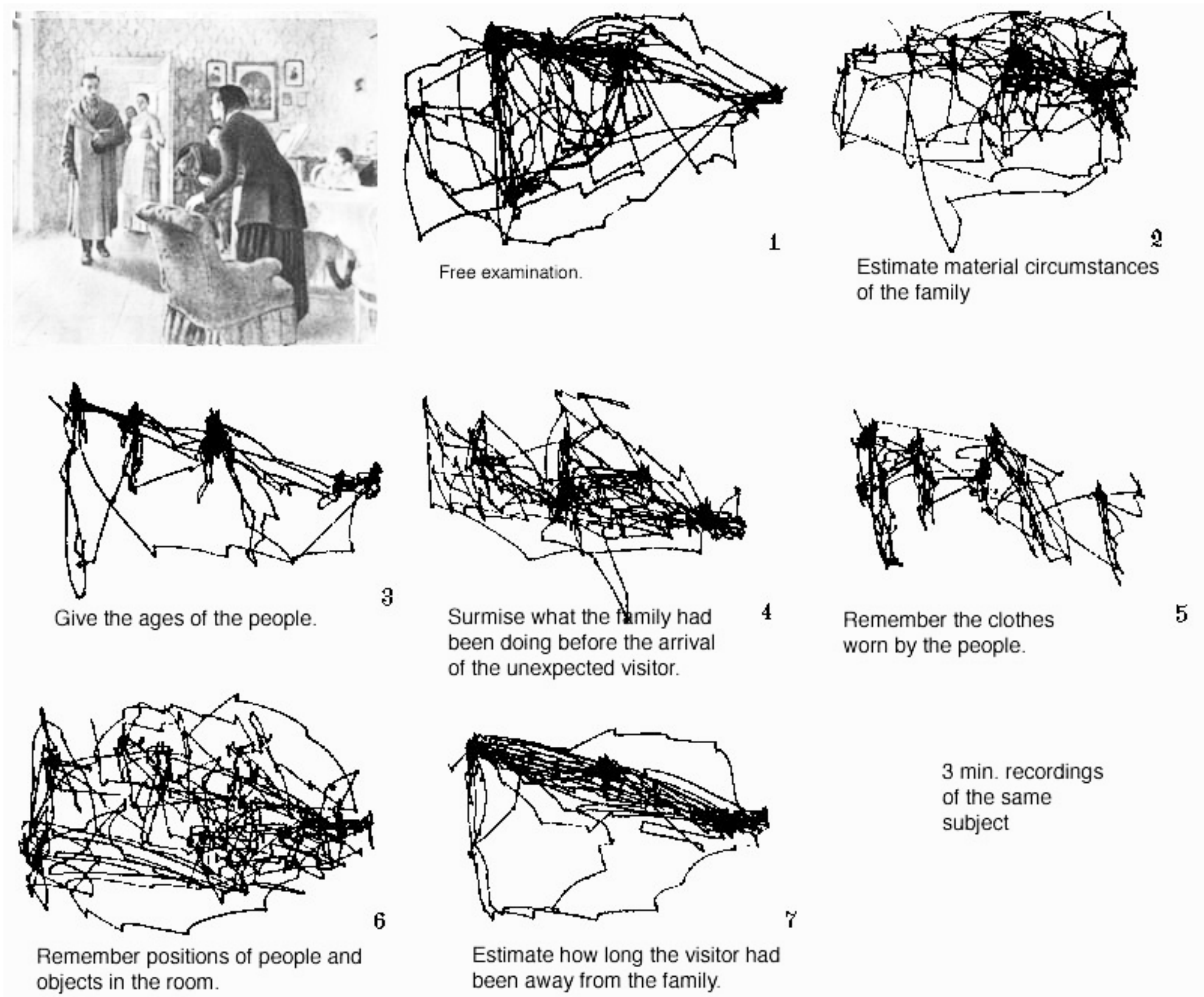
På jakt efter ungdomars kroppsspråk och den "synkretiska dansen", en sammansmältning av olika kulturers dans, har jag i mitt fältarbete under hösten rört mig på olika arenor inom skolans värld. Nordiska, afrikanska, syd- och östeuropeiska ungdomar gör sina röster hörda genom sång, musik, skrik, skratt och gestaltar känslor och uttryck med hjälp av kroppsspråk och dans.

Den individuella estetiken framträder i kläder, frisyrer och symboliska tecken som förstärker ungdomarnas "jagprojekt" där också den egna stilen i kroppsrörelserna spelar en betydande roll i identitetsprövningen. Uppehållsrummet fungerar som offentlig arena där ungdomarna spelar upp sina performanceliknande kroppsshower

Eye Movements

- Eye does <u>not</u> make smooth movements
  - *Saccades* – jumps from region to region
- Area of attention is not necessarily the precise center of eye focus
- Often a top-down process

Eye Tracking



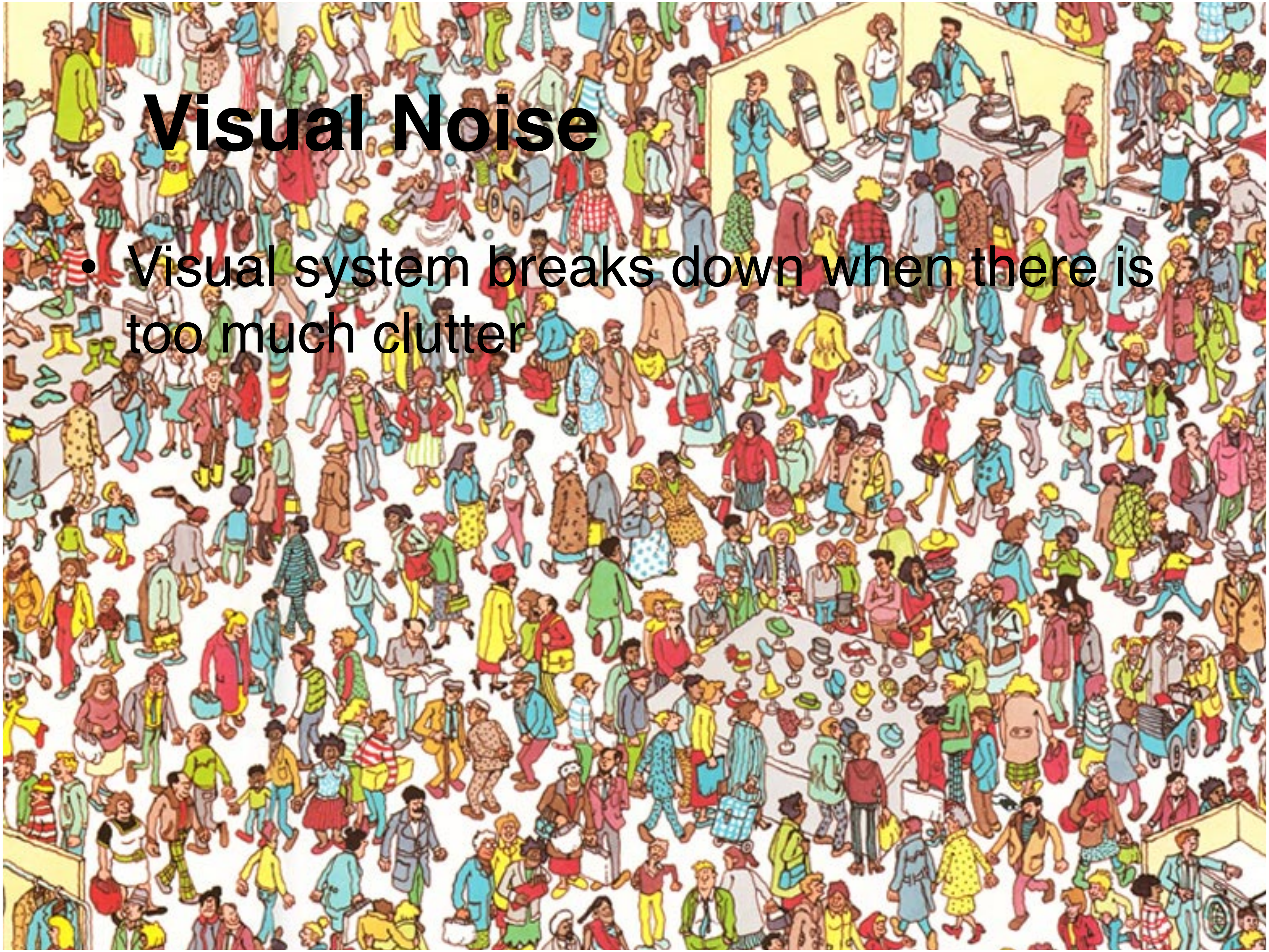
Eye Tracking

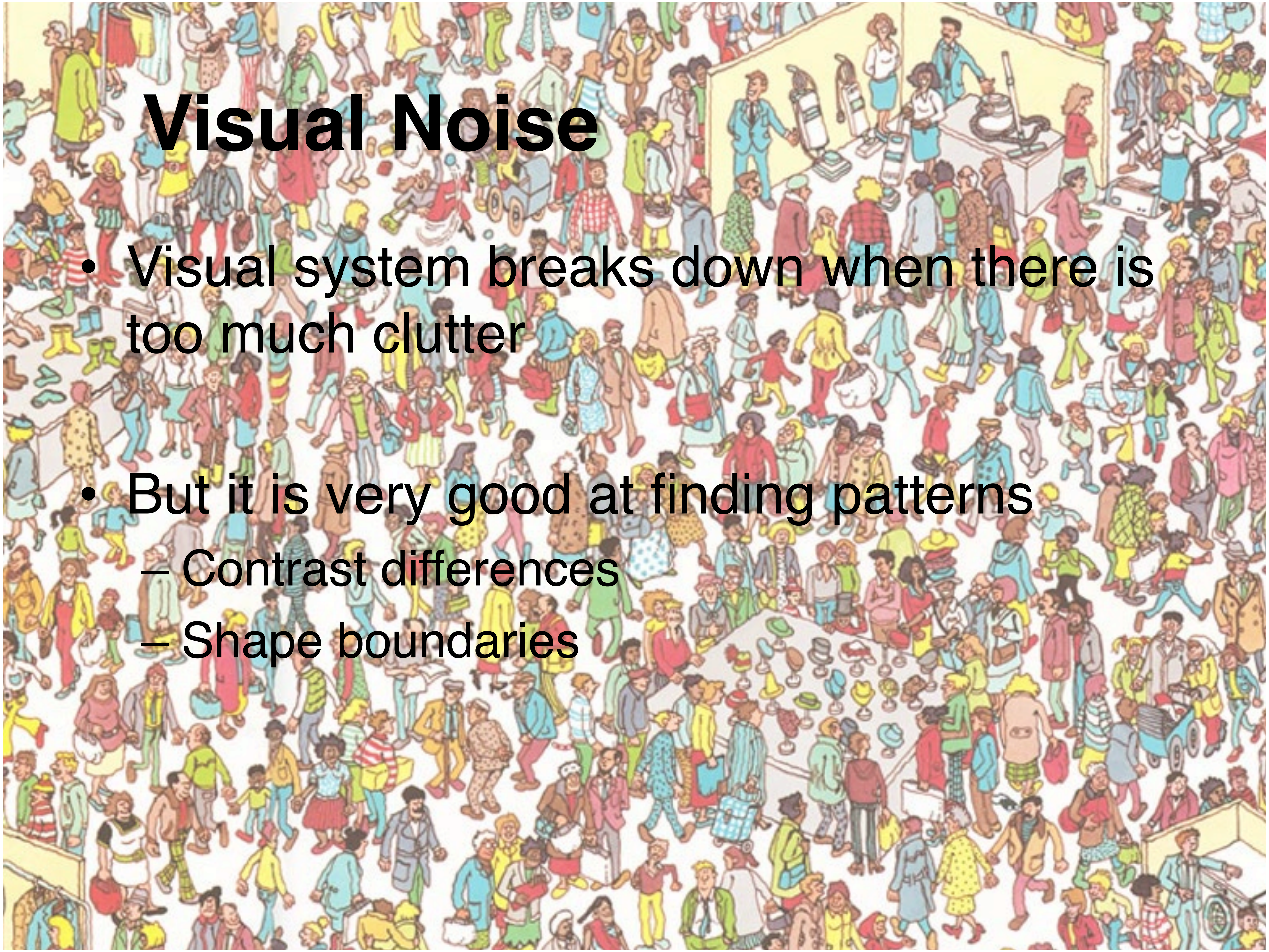
- *Why might eye tracking be hard to use as a pointing device?*

- *What about scrolling using eye tracking?*
  - "Midas problem"

Visual Noise

- Visual system breaks down when there is too much clutter



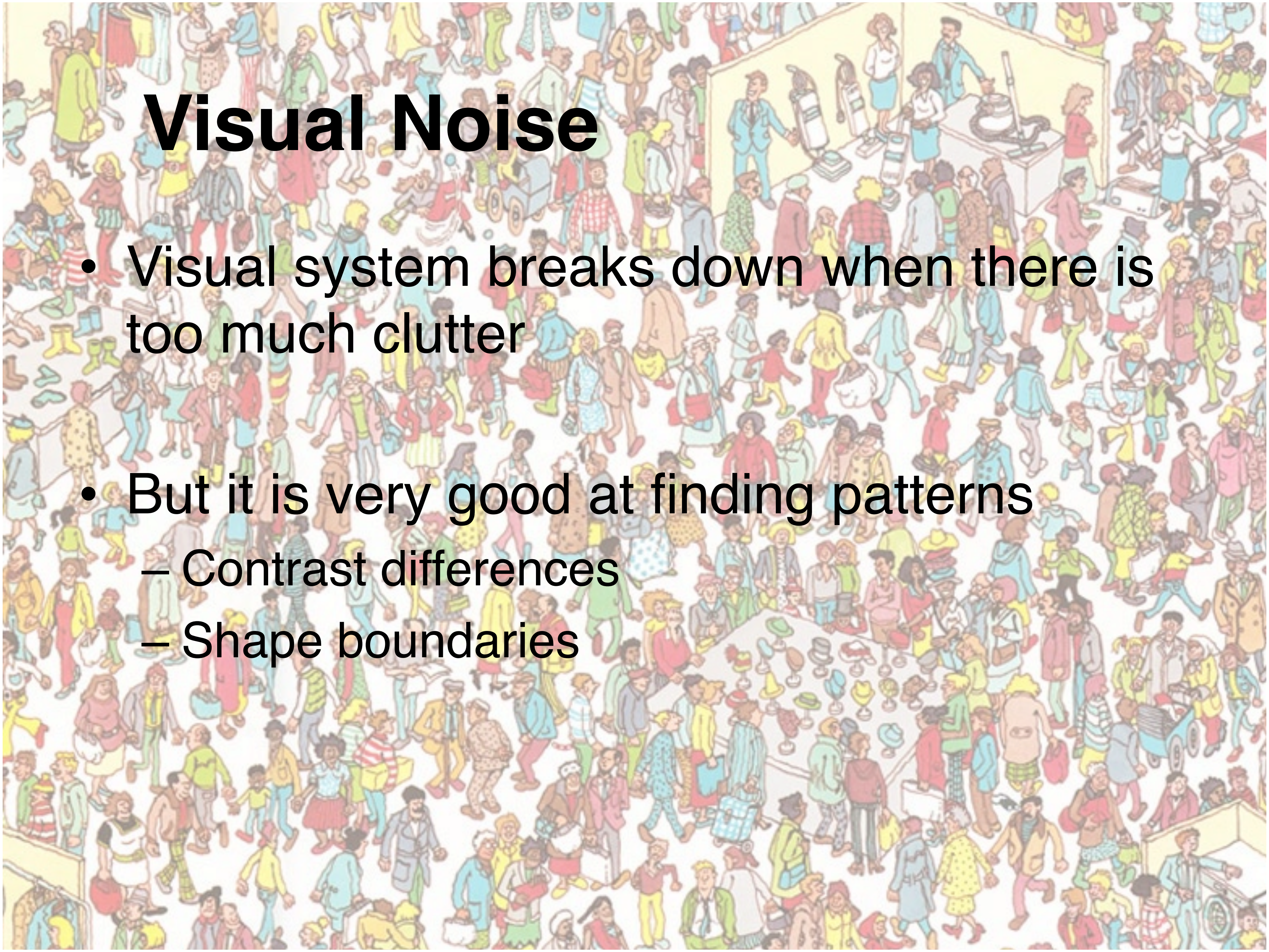


Visual Noise

- Visual system breaks down when there is too much clutter

- But it is very good at finding patterns
  - Contrast differences
  - Shape boundaries

Visual Noise



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Visual Noise

- Visual system breaks down when there is too much clutter

- But it is very good at finding patterns
  - Contrast differences
  - Shape boundaries

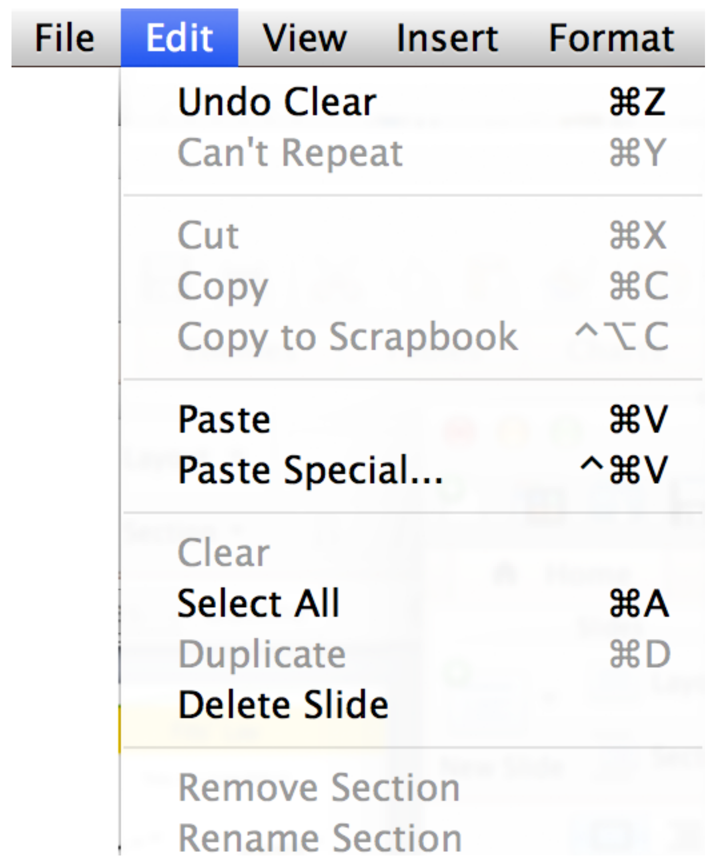
Searching vs. Browsing

- Visual search much, much faster

Find “Paste”

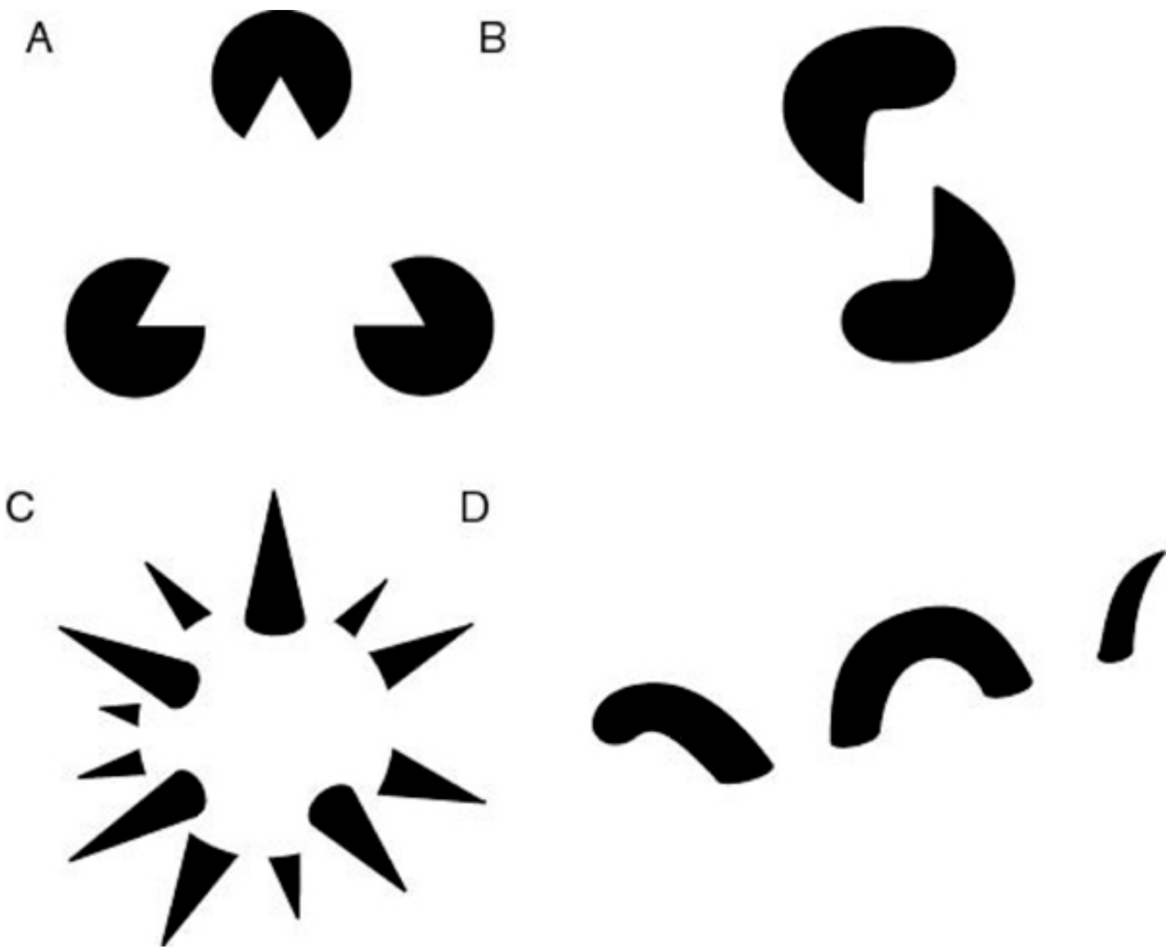
vs.

Is there a way to delete all selected text?



Gestalt Theory

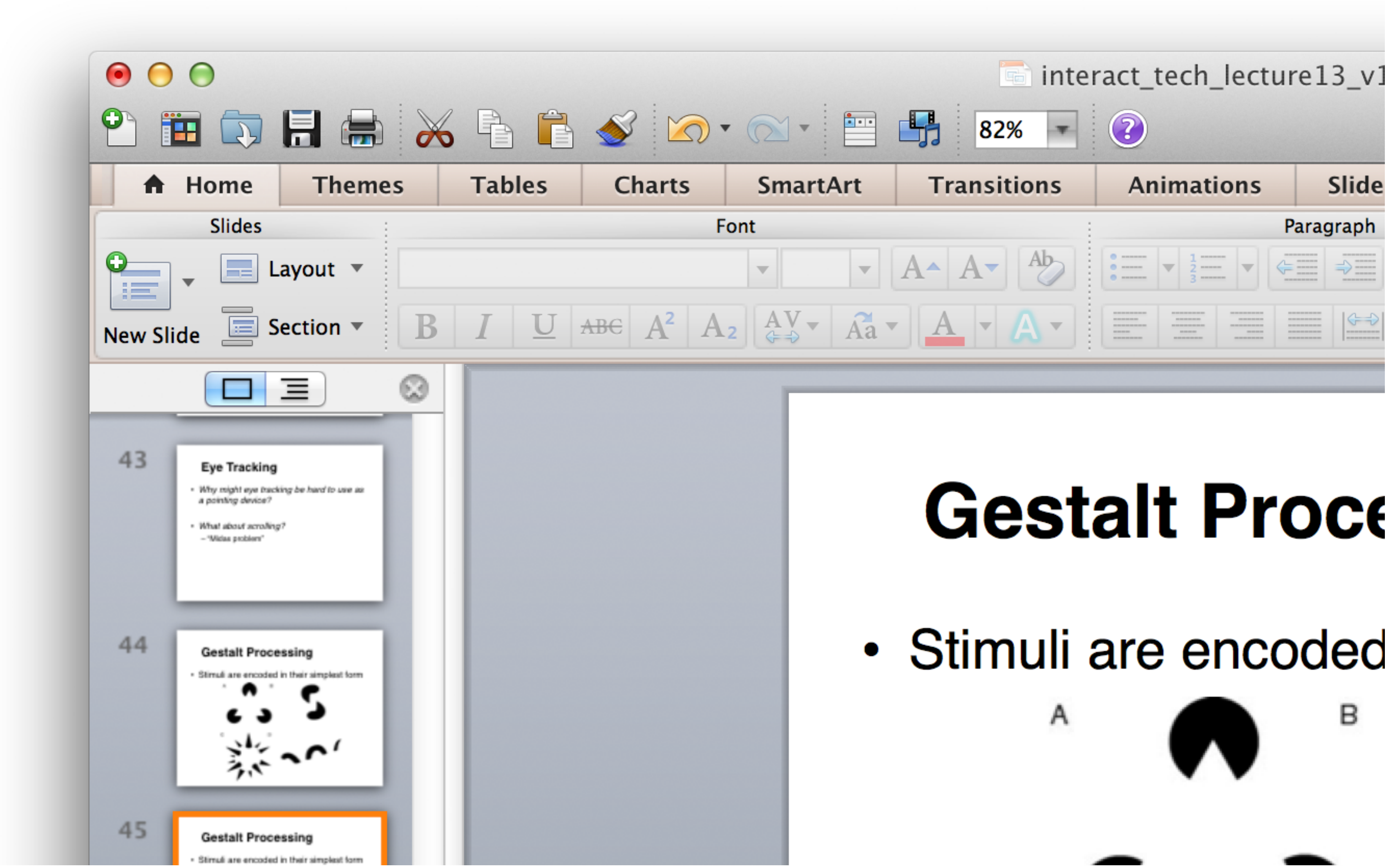
- Stimuli are encoded in their simplest form



Icons

- We can process images as/more rapidly than text
- Have to know what icon means
- Browsing goes faster if icons well designed

Window Overlap



Mobile Parallax

- See video [here]

Fisheye Menus

- We perceive larger things as more salient

Feedback

- Actions in the physical world have immediate feedback
- What about digital actions?

- Airplane throttle lag – accidents!
- Vibration on tap on smartphones
- Flashes in Windows and OSX

Feedback – Interface Latency

- Time delay in response or feedback for interface action
- Users may not realize that latency is the problem

Memory

Working Memory

Procedural Memory

Declarative Memory

Working Memory

- **4-7** units of information

- **Chunking** – we ‘package’ information rather than store as-is

Working Memory

N C I U F B S R S I A S A I A

Working Memory

Working Memory

C I A N S A I R S F B I U S A

Working Memory

Working Memory

Did you store those differently?

Working Memory

- Experts chunk information differently
  - Chess masters can look more moves ahead because they store more efficienty
  - Memory experts use advanced chunking techniques to memorize hundreds of digits

- Check out these articles

Working Memory

- You can help users chunk information in interfaces

- (412) 286-2000
- Menu hierarchies
- *Other examples?*

Working Memory - Menus

- *Norton suggests we use ‘broad’ menus rather than ‘deep’ ones. Why?*

- *How do you think we store what we’ve put into a clipboard?*

Procedural Memory

- How to accomplish a task
- Subconscious

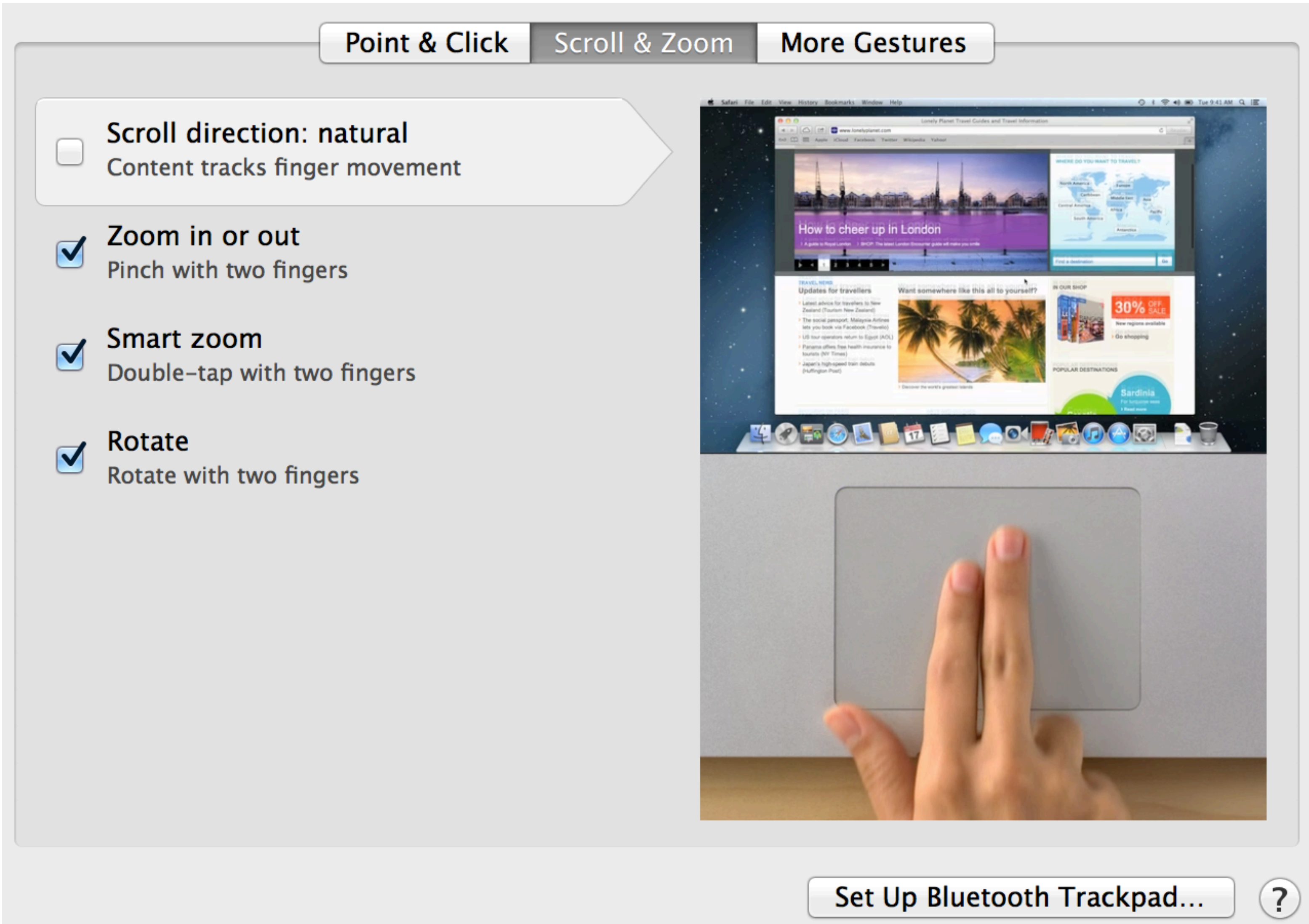
- Experienced driving, touch-typing, using keyboard accelerators

Procedural Memory

- Acquired during expertise development
- Process called "automatization"
- Automatized tasks don't require much attention to perform

- Can *interfere* if tasks are similar
  - Switching from QWERTY to Dvorak

Interference



Attention

- Finite pool of *attention resources*
- Multitasking divides the pool

- *Overload* - Insufficient resources cause mistakes or poor performance

Attention

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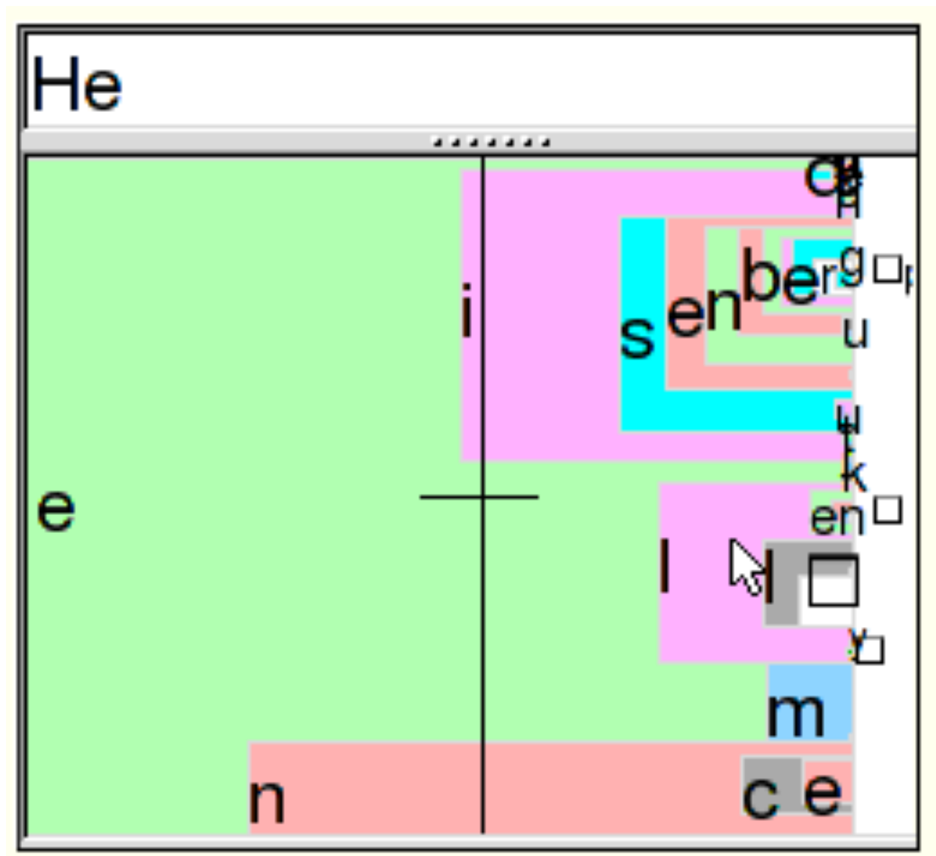
- Multitasking divides the pool

- *Overload* - Insufficient resources cause mistakes or poor performance


F-WWOW AJ-OM
F-WWOW AJ-OM

Attention

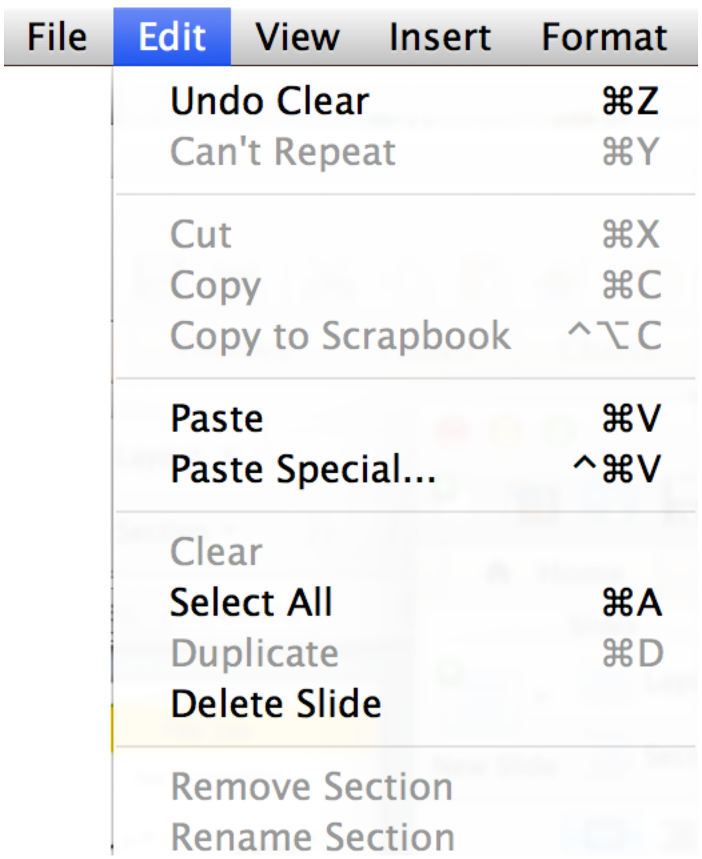
- *What tasks do you have to balance here, assuming you aren't an expert?*



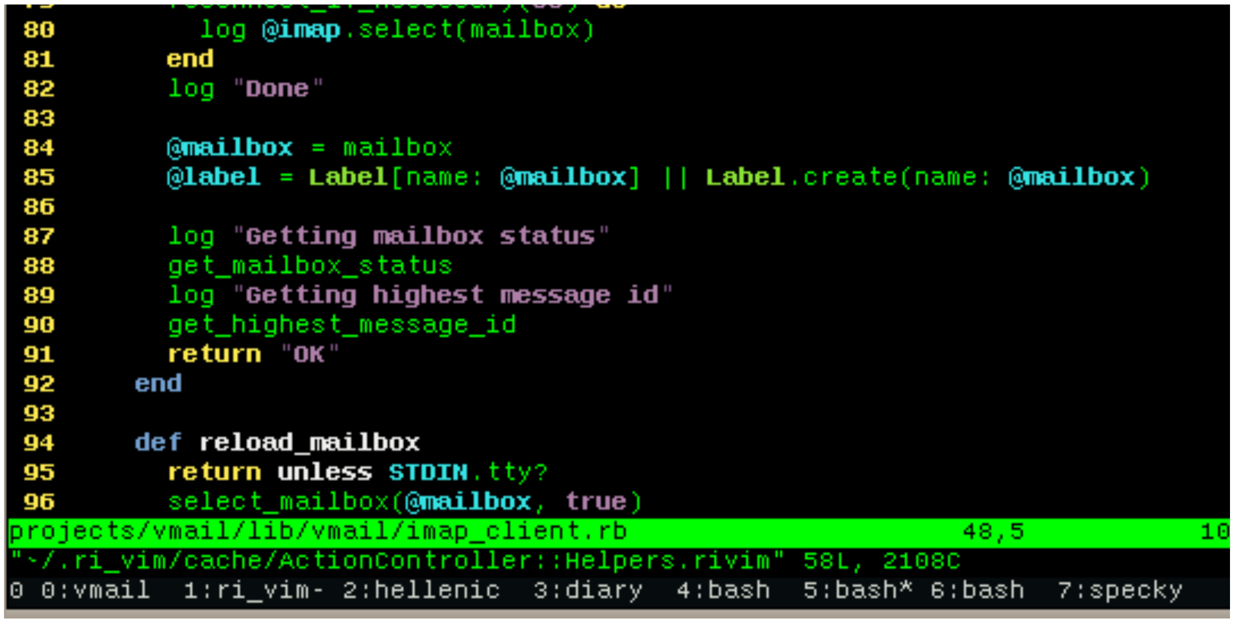
Attention

- Design to help both novice and ‘automatized’ users at once

- *Discoverability*



Case Study – Modal Interfaces



- *Are there human factors reasons for why modal interfaces aren't as common now?*

Case Study – Homework 3

ACBGEN. Application control block generation.

ACB name. (1) The name of an ACB macroinstruction. (2) A name specified e
Contrast with network name.

ACC. (1) Accumulate. (2) Accumulator. (3) Application control code.

acceleration time. That part of access time required to bring an auxiliary storage

accelerator. (1) In the AIXwindows program, a keyboard alternative to a mouse
the same way that a mouse button action does. Accelerators typically provide in
combination of keys that invokes an application-defined function.

********** **Next**

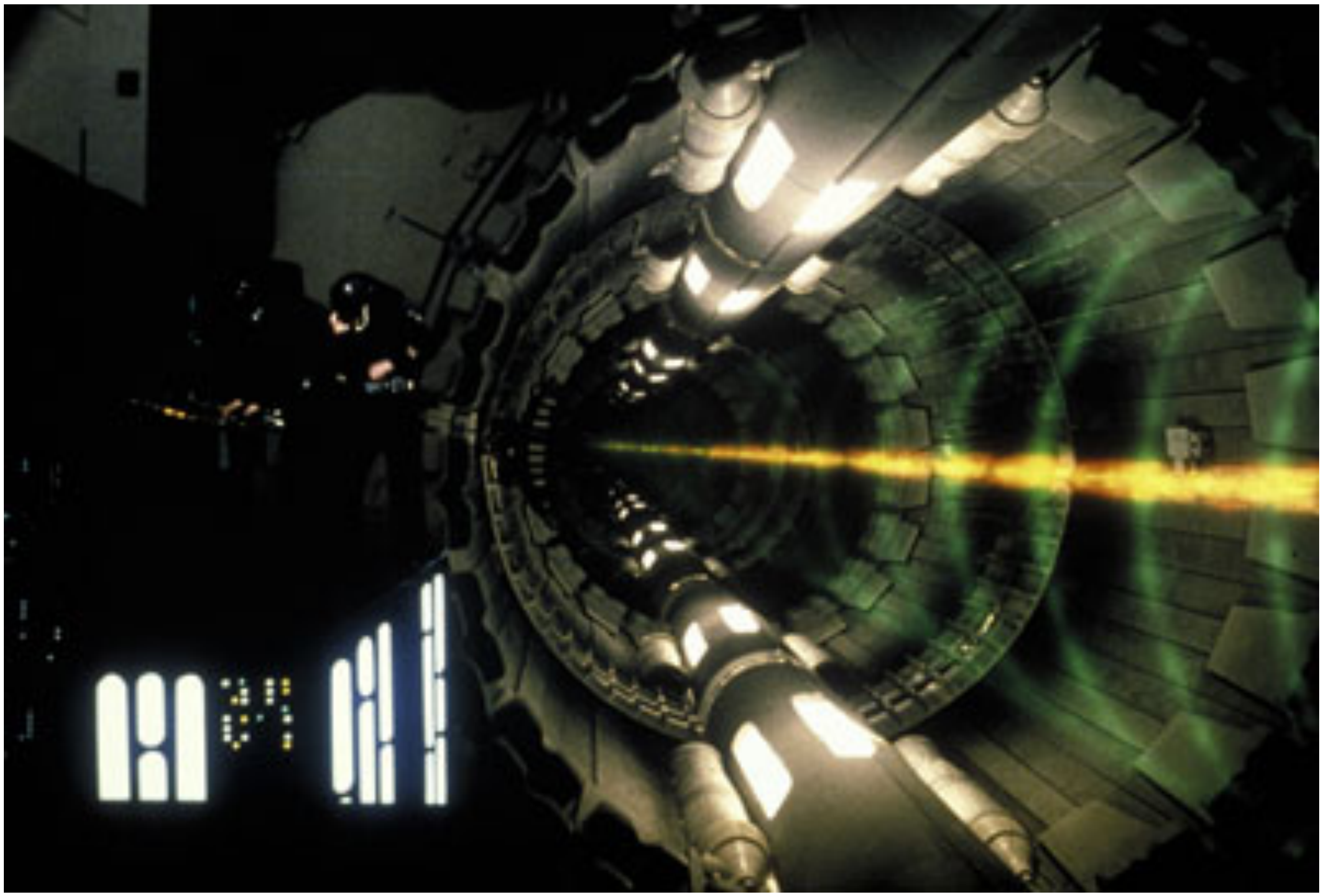
accept. (1) In a VTAM application program, to establish a session with a logica
request may begin when a terminal user logs on, a VTAM application program
moves distributed code and MVS-type programs to the distribution libraries.

- *What human factors principles do the two scrolling tasks use?*
- *What guidelines/principles does the testing software violation?*

Case Study – Laptops

- *Does anyone have a laptop that has egregious human factors problems?*

Case Study: Therac 25



Case Study: Therac 25

PATIENT NAME : TEST
TREATMENT MODE : FIX BEAM TYPE: X ENERGY (MeV): 25

	ACTUAL	PRESCRIBED	
UNIT RATE/MINUTE	0	200	
MONITOR UNITS	50 50	200	
TIME (MIN)	0.27	1.00	
GANTRY ROTATION (DEG)	0.0	0	VERIFIED
COLLIMATOR ROTATION (DEG)	359.2	359	VERIFIED
COLLIMATOR X (CM)	14.2	14.3	VERIFIED
COLLIMATOR Y (CM)	27.2	27.3	VERIFIED
WEDGE NUMBER	1	1	VERIFIED
ACCESSORY NUMBER	0	0	VERIFIED

DATE	: 84-OCT-26	SYSTEM	: BEAM READY	OP. MODE	: TREAT	AUTO
TIME	: 12:55: 8	TREAT	: TREAT PAUSE		X-RAY	173777
OPR ID	: T25V02-R03	REASON	: OPERATOR	COMMAND:		