





**CS 4249 - Phenomena and Theories
Capstone 1**

Kan Min-Yen

Crowdsourcing



Health

- Human-Computer Interaction
- Memory and Attention
- Human Factors
- Cognitive Health

Search Algorithms and Metrics

- HCI design involves understanding both computers and humans
- System requirements have and not given for user requirements (often in HCI)
- We need and think about being clear (often together so that they better understand each other)

Search Engines

Phenomena	Phenomena
- How do people use it?	- How do people use it?
- What observations can we make about search?	- What observations can we make about search?
What can be learned from search engines?	What can be learned from search engines?

Foundations: phenomena and theories

- HCI design requires understanding both computers and humans
- Student presentations have and will present the basic component theories in HCI
- This week and Week 10 will bring these theories together so that we'll better understand ourselves

Human Factors

Phenomena

- How do people ...?
- What observations can we make about people?

Leads us to:

- Guidelines, frameworks and heuristics for useability

Theories

- Our explanations for the phenomena
- Surprisingly, less agreement than we might expect
- Ties into psychology, cognitive sciences, ergonomics

Outline

- Human Information Processing
 - Memory and Attention
 - Human Abilities
- Cognitive Models
- Social, Emotional and Affective Factors
- Navigation and Wayfinding



Goals of Theories

- Descriptive
- Explanatory
- Prescriptive
- Predictive

How does GOMS relate to HCI?

Classification

Predictive

Descriptive

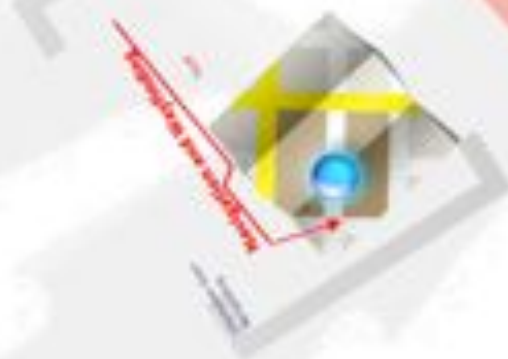
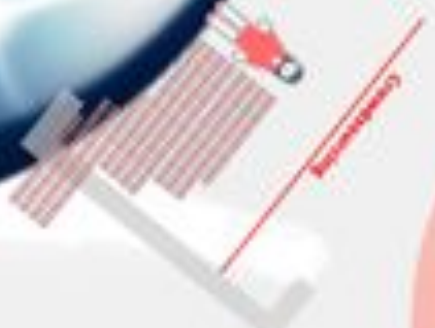
Prescriptive

Influence

A Predictive Model

- Used to predict **time to perform tasks** under analysis

Developer must come up with **time estimates** for operators involved



Human Processing and Abilities



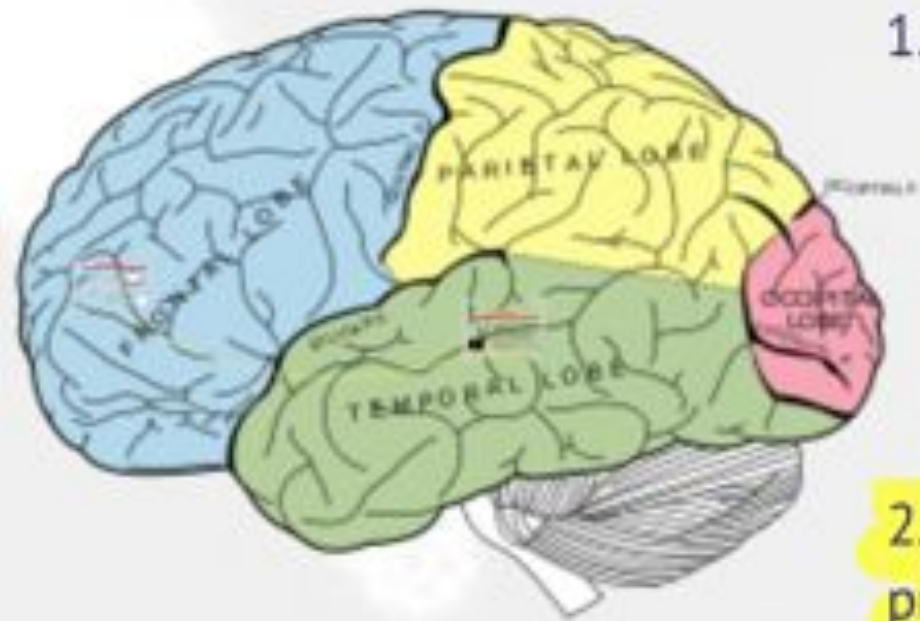
- Memory
- Attention

- Perception
 - Visual
 - Auditory
 - Haptics

- Motor Skills



Models of Memory



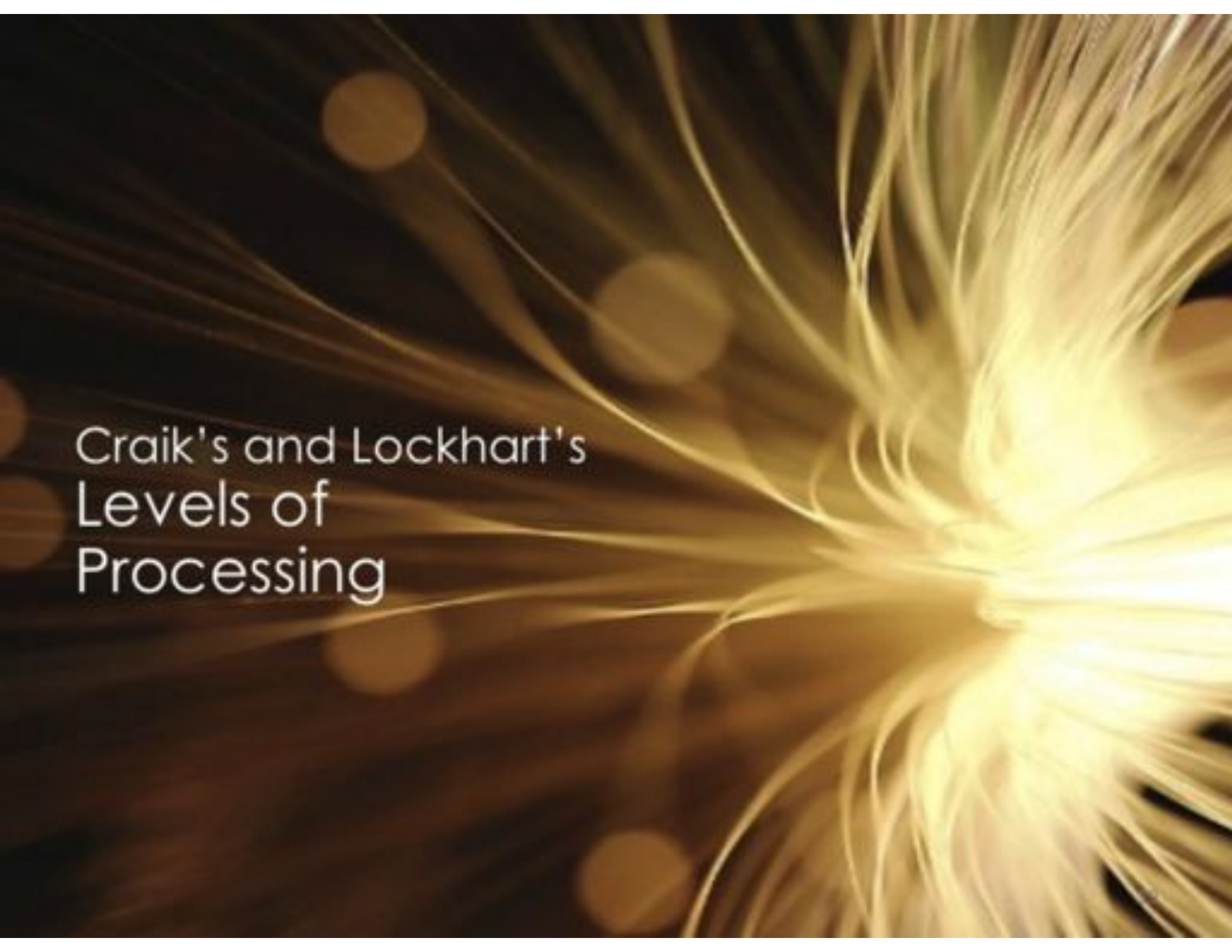
1. Not a simple information store
 - Generally agreed that it has a short- and long-term division



2. Not a passive repository. Active processes changes its structure.

3. Not unaffected by the type of material to be stored.





Craik's and Lockhart's
Levels of
Processing

MULTI STORE LEVEL

- Proposed by Atkinson-Shiffrin in 1968
- Human memory has 3 stages:
 - Sensory memory (SM)
 - Short-term memory (STM) / Short-term store (STS)
 - Long-term memory (LTM) / Long-term store (STS)

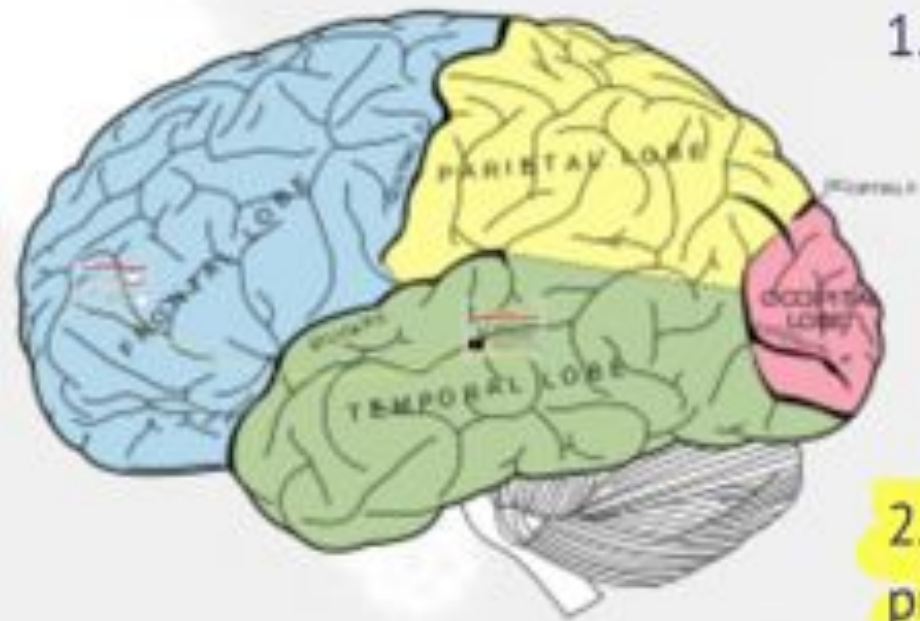
ATKINSON-SHIFFRIN MEMORY MODEL

MULTI STORE LEVEL



Source: <http://www.psychologistworld.com/memory/multistore.php>

Models of Memory



1. Not a simple information store
 - Generally agreed that it has a short- and long-term division



2. Not a passive repository. Active processes changes its structure.

3. Not unaffected by the type of material to be stored.



Memory Stores and Processes

1. Sensory Stores:

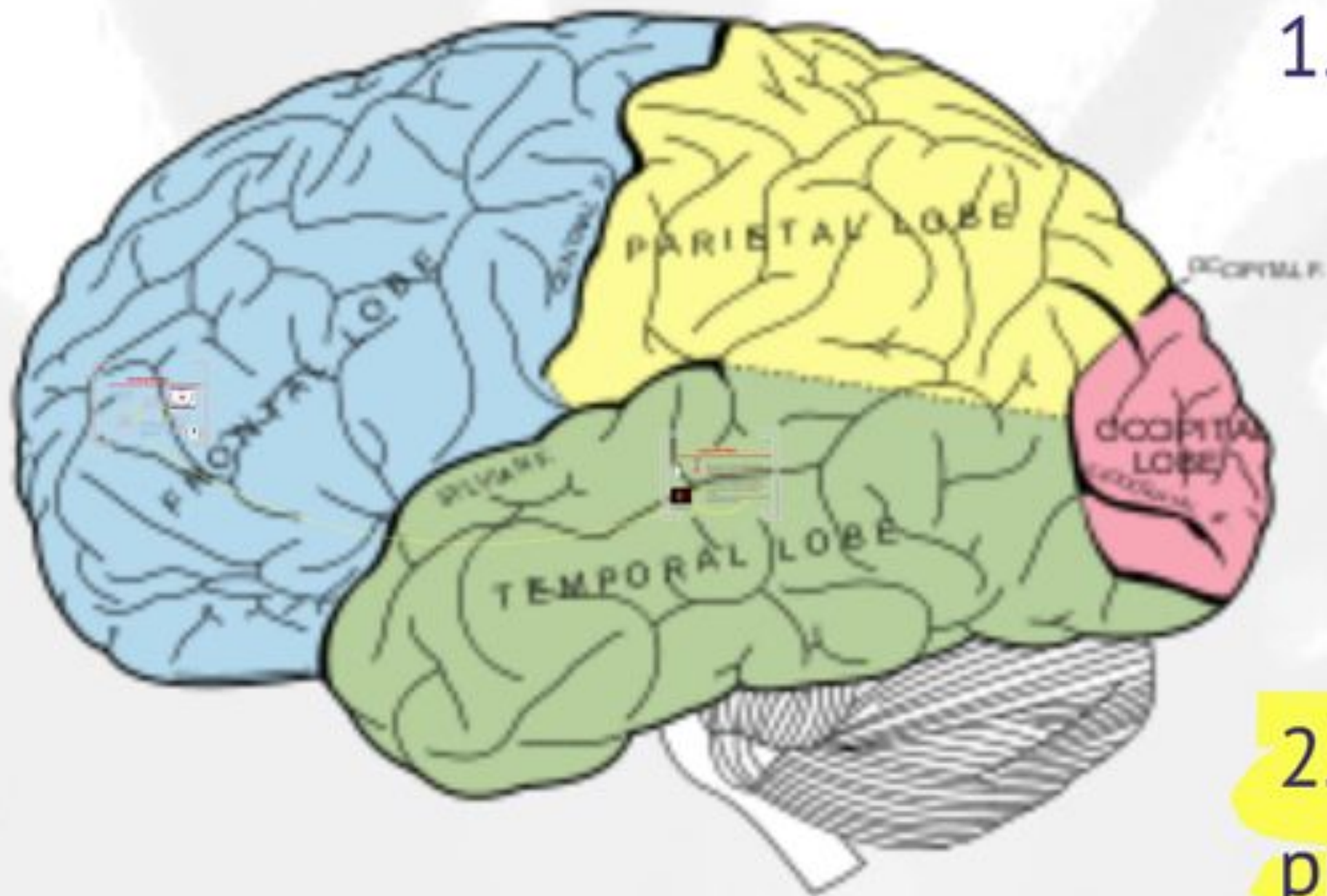
- Iconic
- Echoic

2. Short Term / Working Memory:

- Central Executive
- Articulatory Loop
- Visuo-spatial Sketchpad

3. Long Term Memory:

- Semantic Memory
- Procedural Memory
- Biographical Memory
- Permastore



1.

2.

pl

Working Memory

Rehearsal keeps things in short term memory
Decay or Displacement pushes information out of the WM

Central Executive

Assigns processing to the two slave modules

Articulatory Loop

Inner Ear (~2 secs) and Inner Voice (Repeating to yourself to remember)

Miller's 7 ± 2 is perhaps the most famous fact about WM. And it is often misapplied by HCI designers. Why?

Also there's been some evidence that in today's generation the number is closer to 4 ± 1 (Cowan, 2002). Think about why.



Working Memory Model revision tutorial

Visuo Spatial Sketchpad

- Inner Eye - Remembering an image that you've just seen
- Snoop (1955) Effect

Test



Test Yourself

Models of Memory



1. Not a simple process
 - Generally involves both short- and long-term memory



2. Not a passive process; involves active processes that change the stored information
3. Not unaffected by the type of material to be stored.

Memory Storage and Processes

- 1. Sensory Memory
- 2. Short-Term Memory
- 3. Long-Term Memory

Forgetting

- 1. Transience: you can't retrieve the stored memory
- 2. Interference: this suggests that other information is interfering with the retrieval of the stored memory
- 3. Repression: this suggests that you don't want to retrieve the memory
- 4. Amnesia: this suggests that you've lost the ability to retrieve the memory

Memory Stores and Processes

1. Sensory Stores:

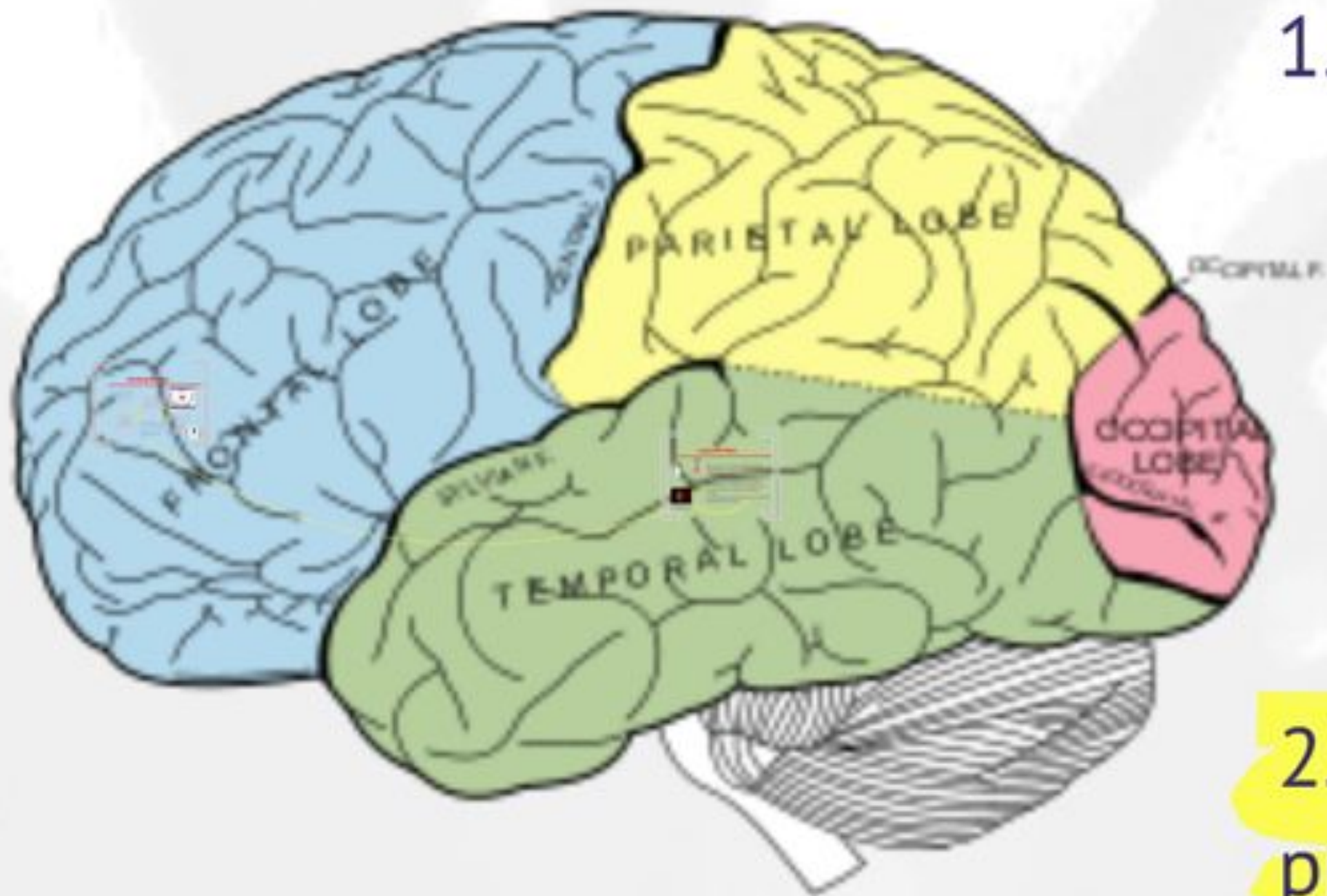
- Iconic
- Echoic

2. Short Term / Working Memory:

- Central Executive
- Articulatory Loop
- Visuo-spatial Sketchpad

3. Long Term Memory:

- Semantic Memory
- Procedural Memory
- Biographical Memory
- Permastore



Long Term Store



- Studies place LT memory in different places depending on whether it is **declarative*** or **nondeclarative (implicit)**.
- The synthesis of proteins allows neurons to form the pathways that encode our LT memory.
 - This process is called **encoding** or **storage**
- **Retrieval** is then the process of recalling memory.
- The active process of **elaboration** can change the effectiveness of retrieval.



Andrew Park: Memory systems suggest that the
 cortex for declarative memory is distributed throughout
 the cortex for why the brain's memory for 2 is changing



Joshua Foer: Feats of memory anyone can do

Listen for Joshua's description of distributed cognition.

Listen to why he thinks Miller's 7 ± 2 is changing.

Models of Memory



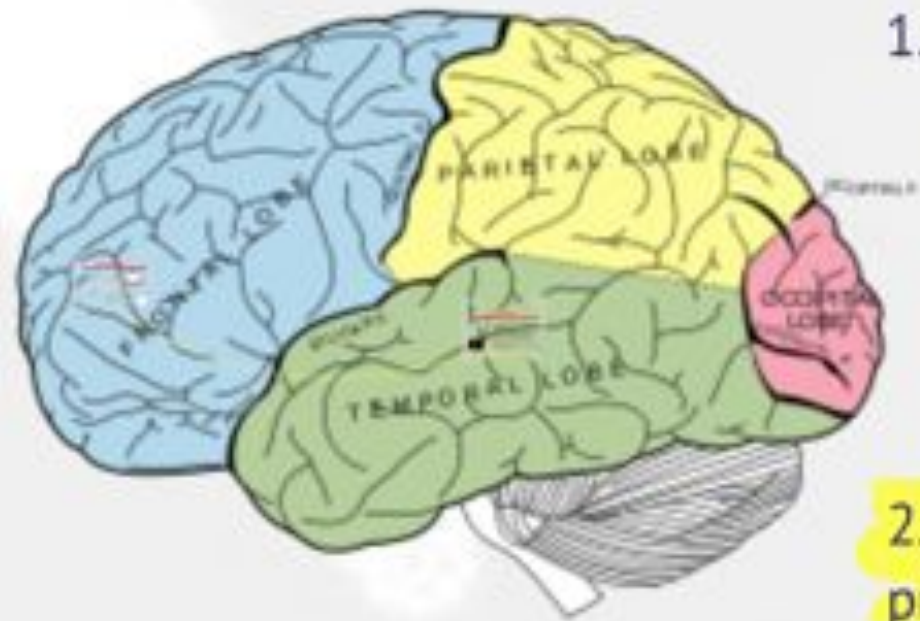
1. Not a simple information storage system
 - Generally agreed that memory is divided into short- and long-term



2. Not a passive repository; processes changes its structure
3. Not unaffected by the type of material to be stored.



Models of Memory



1. Not a simple information store
 - Generally agreed that it has a short- and long-term division



2. Not a passive repository. Active processes changes its structure.

3. Not unaffected by the type of material to be stored.



Levels of Processing



Instead of looking at the structure of memory, **Levels of Processing** proposed that memory is simply the by-product of analysis done by us to interpret the world.

- The more complex the analysis, the stronger and more durable the memory trace (cf long term memory, and the Foer video on elaboration).

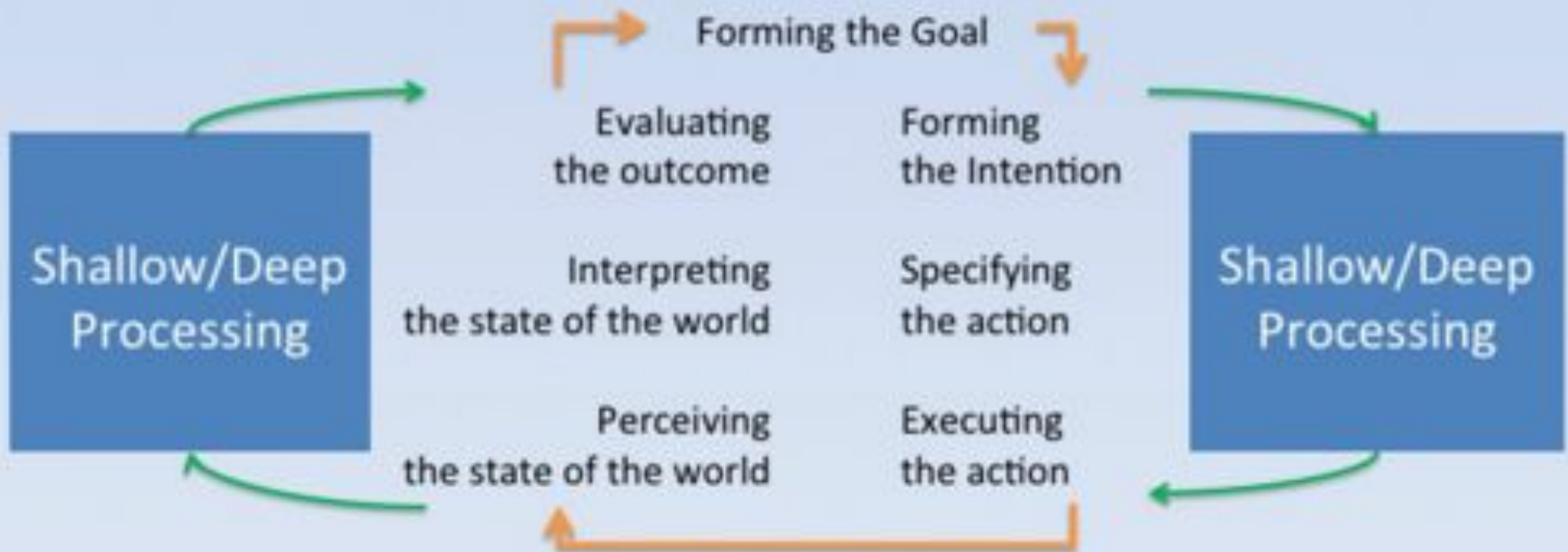


Why is this important? If we want a person to remember something, LoP asserts that we need them to think more deeply (semantically, again elaborate) about the subject.

Your turn: In some ways, this contradicts the HCI principle of lowering the cognitive load of the user. What do you think?

RELATION

Levels of Processing & Seven Stages of Actions



Forgetting

- Accessibility: can we retrieve the stored memory
- Availability: is the memory actually stored in our brain?
- **Hebbian Theory** suggest we forget when we don't use our memories.
- **Interference Theory** suggests that other acts of remembering or learning can supplant retrieval cues for the original memory.
- **Retrieval Failure Theory** suggests we can't retrieve things when the wrong retrieval cue is employed (cf **elaboration**).

"Cells that fire together, wire together"

Basis for some (recent) A.I. theories of learning

Models of Attention



Selective Attention

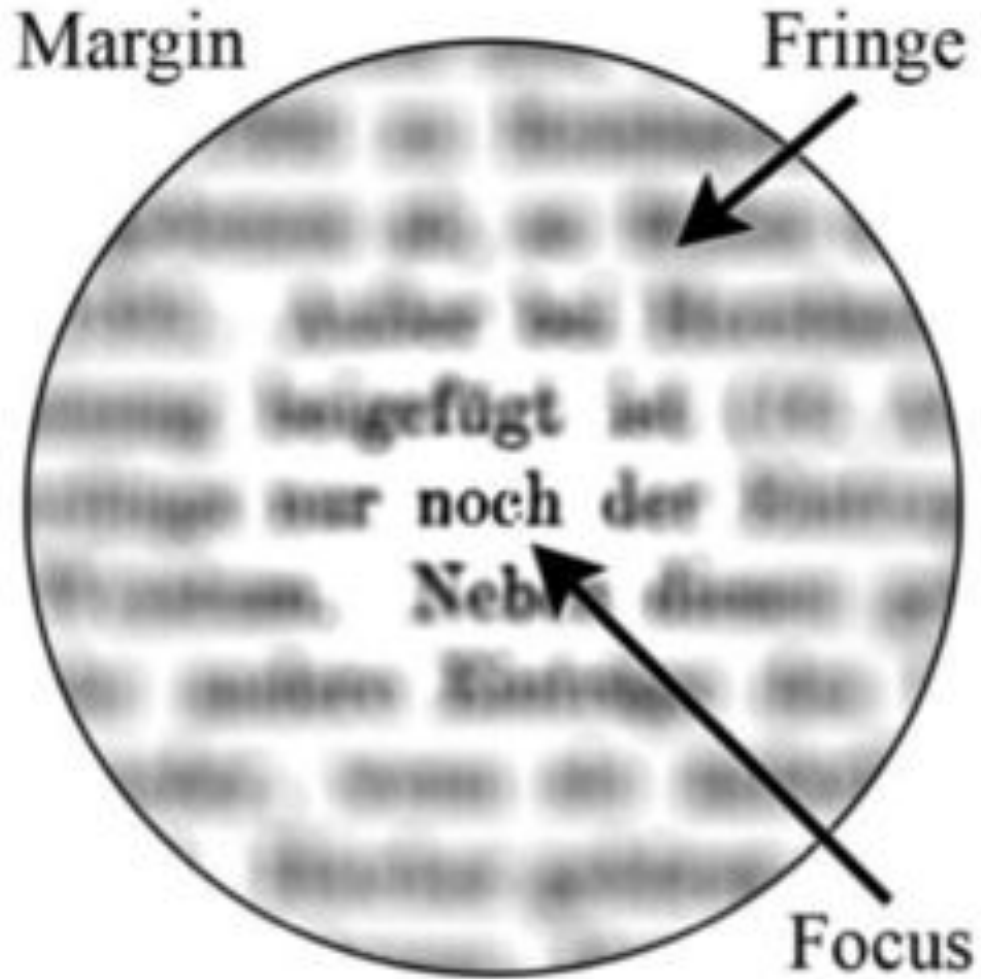


Two strands of theories:

- Selective Attention
- Divided Attention (Multitasking)



The Spotlight



Selective Attention

Visual Scene

- Contains objects for information processing
- But not everything can be processed!
- Exclude certain objects from processing



Models of Attention



Selective Attention



Two strands of theories:

- Selective Attention
- Divided Attention (Multitasking)



Divided Attention

As capacity allocation

Depends on the nature of the tasks and how much attention each demands



Automatic vs. Controlled Processing

- Tasks that we find easy require less attention and we employ **automatic processing**
- Tasks that are complex or novel require **controlled processing**
- **Practice** allows us to convert controlled processing to automatic ones



As capacity allocation

Depends on the nature of the tasks
and how much attention each
demands



*Kahneman's (1973)
capacity allocation model*

Automatic vs. Controlled Processing

- Tasks that we find easy require less attention and we employ **automatic processing**
- Tasks that are complex or novel require **controlled processing**
- **Practice** allows us to convert controlled processing to automatic ones



Why are these models important?

- Models of working memory tells us why certain abilities are impaired: we don't process both verbal and visual information in parallel very well. Our understanding of multitasking and cognitive load support these findings.
- As HCI practitioners, it's likely that we'll want to use one channel as the **primary channel** and use another channel to reinforce it.
- Design to promote **recognition** rather than **recall**.
- Provide users with different methods for **encoding** information and procedures.

Tangent: Alan Kay and Tim Gallwey

For HCI and problem solving:
Representations matter.
Use the appropriate channel.



Inner Game of Tennis (Tim Gallwey method)

Alan Kay also cites Tim Gallwey's "The Inner Game of Tennis" - you can learn tennis in an afternoon if you don't try to hard.



Alan Kay on Learning and Computer Science

"The best way to predict the future is to invent it."



YouTube

Tangent: Alan Kay and Tim Gallwey

For HCI and problem solving:
Representations matter.
Use the appropriate channel.



Inner Game of Tennis (Tim Gallwey method)



Alan Kay on Learning and Computer Science

"The best way to predict
the future is to invent it."

Alan Kay also cites Tim Gallwey's "The Inner Game of Tennis" - you can learn tennis in an afternoon if you don't try to hard.



YouTube

Human Processing and Abilities



- Memory
- Attention

- Perception
 - Visual
 - Auditory
 - Haptics

- Motor Skills



Visual Perception

We construct meaning and recognition from sensory store.

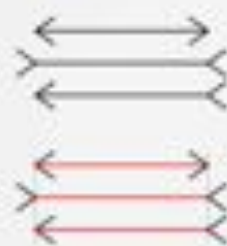
Normally sighted people perceive stable, 3D color world. Thus we have constancy in these same dimensions. Violating these we get surprising illusions.



Red car by night



Red car by day



Müller-Lyer Illusion



Necker Cube

Visual Perception

As humans, we are particularly sensitive to motion and human likeliness.



Due to Alan Kay

*works on all mammals

The phenomenon of Mori's **Uncanny Valley** can be seen as one manifestation of this.



Images from Wikipedia

m
M
W

Due to Alan Kay



Visual Perception

As humans, we are particularly sensitive to motion and human likeliness.



Due to Alan Kay

*works on all mammals

The phenomenon of Mori's **Uncanny Valley** can be seen as one manifestation of this.



Images from Wikipedia

Depth Perception

Perceiving* depth is based on a number of recognized cues.

- Primary cues - are largely based on **optic image received by eyes** and **muscle control**.
- Secondary cues - are based on only a single image (i.e., one eye).
 - Light and Shade
 - Linear Perspective (e.g., Müller-Lyer arrows)
 - Motion Parallax, Texture Gradient
 - Overlap
 - Relative Size



Gestalt Perception

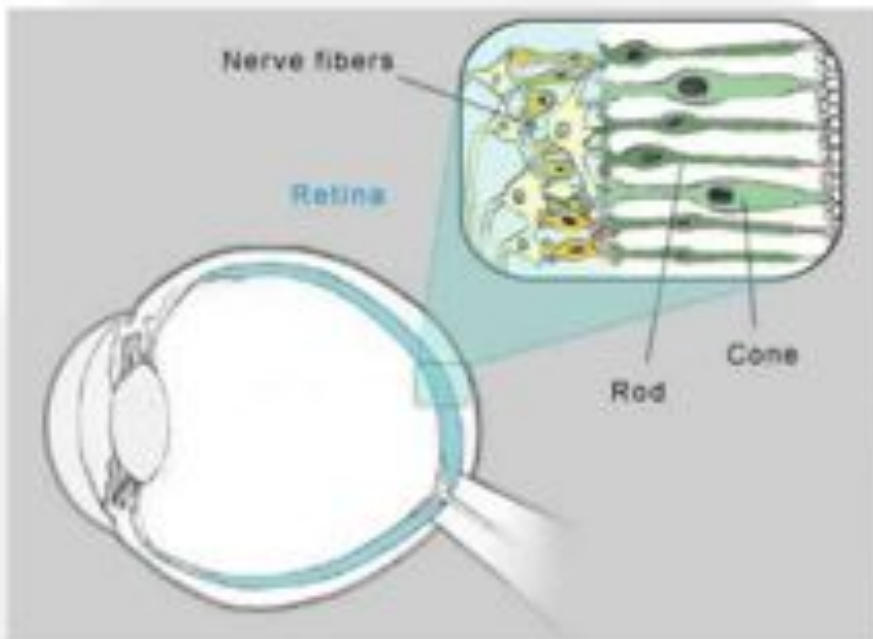
Were a group of psychologist working to look at perception of wholes from parts* (cf. holistic cognitive models)

- Proximity
- Continuity
- Similarity
- Closure



*Applies to other things aside from vision

Color Perception



From visionweb.com

- Rods are more numerous, and highly sensitive but cannot see color .
- Cones are wavelength specific, and detail-oriented but need lots of lights
- Visual attention orients the cone-rich portion of the retina

Auditory Perception

Loudness is measured in (deci)bels

Bel scale is logarithmic: 40 dB is 10 times louder than 30 dB

We hear better at lower pitches (frequencies)

Normal conversation goes from 100 Hz - 4 KHz

But humans can hear up to 22 KHz

Auditory Perception

The one and same Claude Shannon of information theory

Nyquist-Shannon law tells us that we need to sample at twice the frequency to store a sample perfectly.


The sampling rate for CDs (44.1 KHz) reflects this.

Haptic Perception and Kinaesthetics

Haptics refers to touch, whereas kinaesthetics refers to our sense of our body's position.

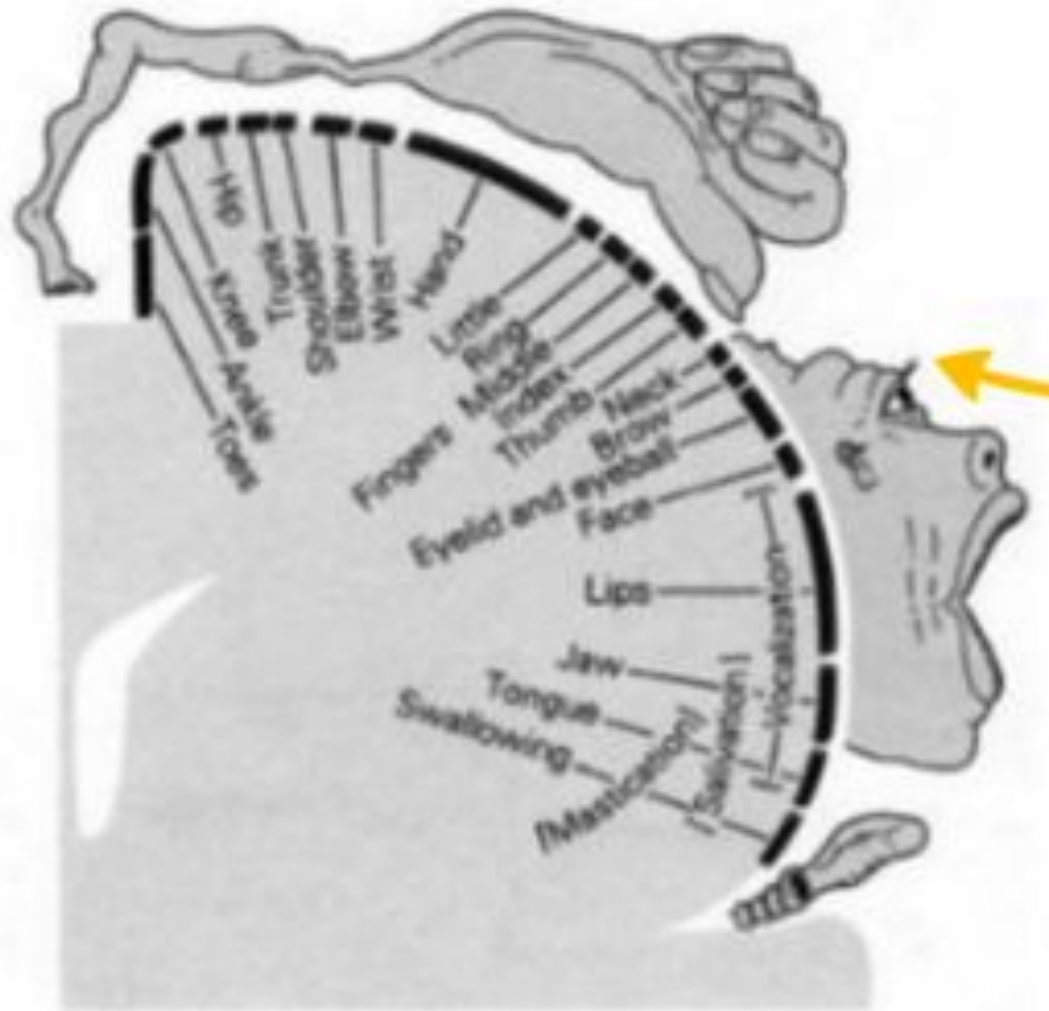
Force feedback and vibration are newer methods of interaction

We are much more sensitive to sensation in certain body parts





l: sensory homunculus



r: Penfield's motor homunculus

Human Processing and Abilities



- Memory
- Attention

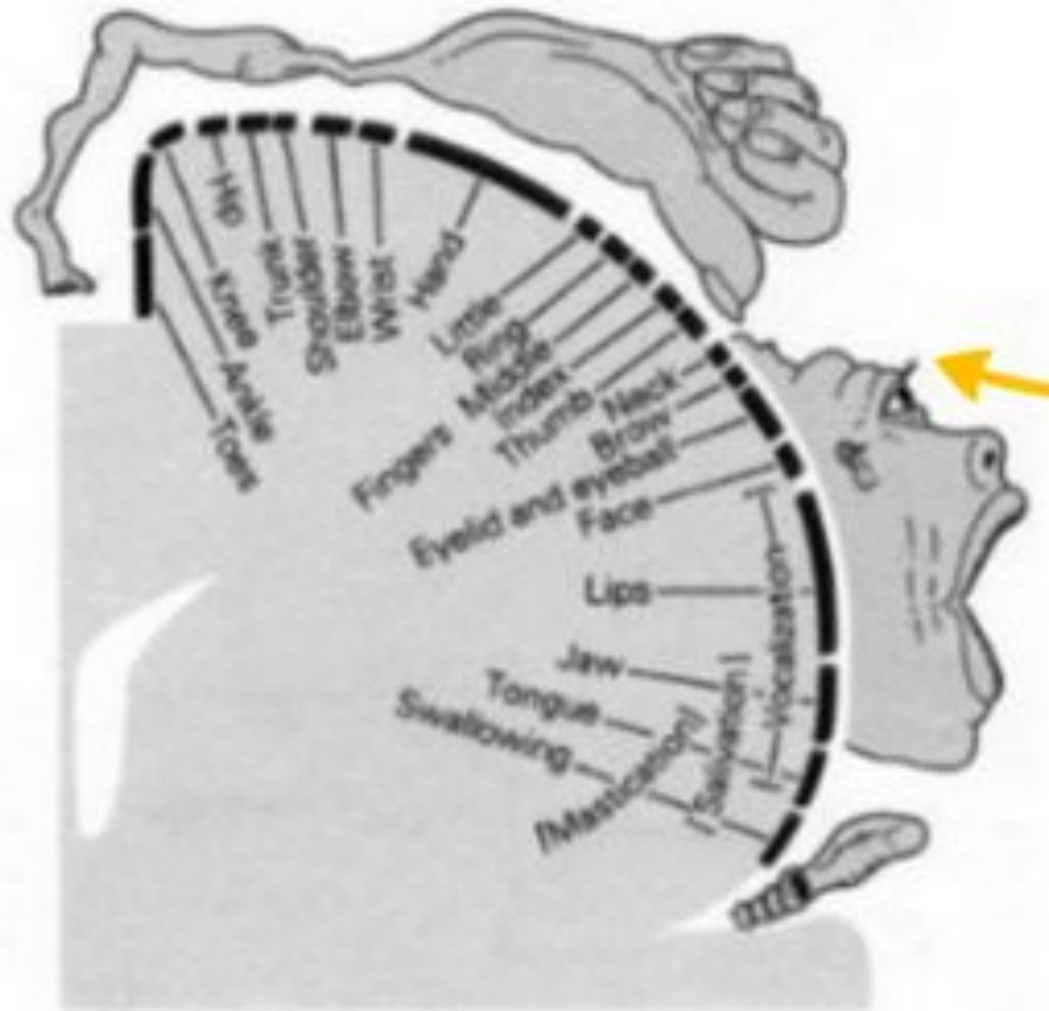
- Perception
 - Visual
 - Auditory
 - Haptics

- Motor Skills





l: sensory homunculus



r: Penfield's motor homunculus

Motor Ability

In studies of physiology and psychology there are actually two homunculi: one for describing **sensing** and another to describe our **motor control**.

In our class, we've explored **Fitts' Laws** and the **Keystroke Level Model** as examples of predictive laws for motor ability.



Fitts' Law, revisited

Time Taken to Reach Target in Fitts' Law

$$T = a + b \log_2 \left(2 \frac{D}{W} \right)$$

(Note: This is a simplified version of the equation. The original equation is more complex and includes a constant 'a' and a multiplier 'b'. The original equation is: $T = a + b \log_2 \left(1 + \frac{2D}{W} \right)$)

Fitts' Law Applied

- The larger the ratio, the longer it takes to reach the target.
- The larger the target, the shorter it takes to reach the target.



We've already seen what Fitts' "law" is: a model to predict how long it will take for a pointing action to take place.

It is a ratio between the distance covered (D) and the width of the target (W). The larger the ratio, the longer it takes.

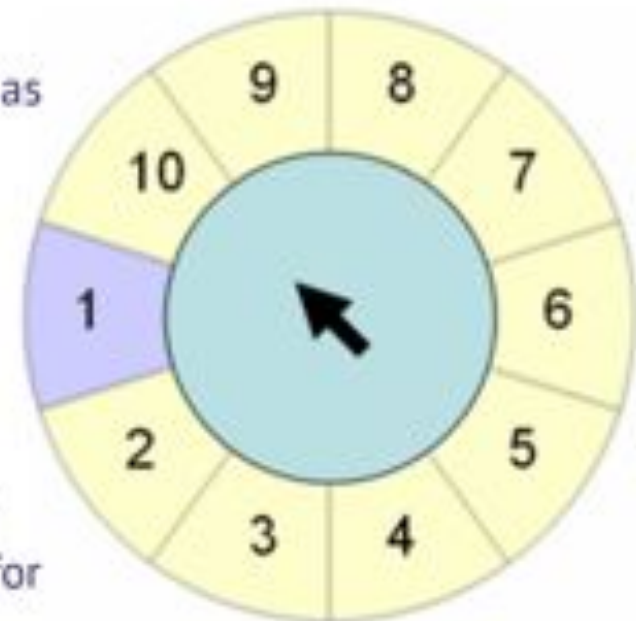


Fitts' Law, revisited

It is a one-dimensional measure that doesn't account for the "height" or "depth" of a target (in 2D or 3D space).

Since distance is a large factor in Fitts' law, it has been a justification in developing pie menus

Think about when is it appropriate to use Fitts' law and what modifications you have to make for other scenarios.



KEYSTROKE-LEVEL MODEL

Consider the text editing task of searching a Microsoft Word document for all occurrences of a four-letter word, and replacing it with another four-letter word.

Overview

KLM Operators

Levels of Abstraction

Example

CMN-GOMS vs. KLM

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	M&K [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	M&K [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

Crowdsourcing



Health

- Human-Computer Interaction
- Memory and Attention
- Human Factors

Logistics Health

Search Algorithms and Theories

- HCI design involves understanding both computers and humans
- System requirements have and not given for user requirements (often in HCI)
- We need and think about being there together so that each better understand another

Search Theory

Phenomena	Theory
- How do people...?	- How explanations...
- What observations...	- For the phenomena...
- and why do they...	- (concepts, but...
- present?	- sometimes they are...
	- right context
	- How do...
	- Testable...
	- (empirical, cognitive science,...
	- engineering)