CS 4249 - Phenomena and Theories
Capstone 1

Kan Min-Yen
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?

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
- 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

Sensory Store → Short-term Memory → Long-term Memory

lack of rehearsal leads to decay and forgetting

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 change 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
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)

Visuo Spatial Sketchpad
- Inner Eye
  - Remembering an image that you’ve just seen
- Stroop (1955) Effect

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.
Models of Memory

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

2. Not a passive process
   - Changes can occur

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
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.

*declarative memory is stored in the temporal lobe
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 store...
   - Generally agreed that memory involves both short- and long-term storage.

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?
Levels of Processing & Seven Stages of Actions

Forming the Goal
- Forming the Intention
- Specifying the action
- Executing the action

Evaluating the outcome
- Interpreting the state of the world
- Perceiving the state of the world

Shallow/Deep Processing
Shallow/Deep Processing
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).
Models of Attention

Two strands of theories:
- Selective Attention
- Divided Attention (Multitasking)
The Spotlight

Margin

Fringe

Focus

noch der Neben
Selective Attention

Visual Scene

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

pic.twitter.com/MghepH73
Models of 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.

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

- Alan Kay on Learning and Computer Science

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.
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.”
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.
Visual Perception

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

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

*works on all mammals*
Visual Perception

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

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

*works on all mammals
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
Color Perception

- 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.

From visionweb.com
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

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

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 it is appropriate to use Fitts' law and what modifications you have to make for other scenarios.
Keystroke Level Model

Fitts’ Law predicts time to complete a pointing operation. But it is just one of many possible (human) operations in a computer system.

KLM puts these together by defining a set of different operators, where each operator is given a time estimate to complete.

To find out a task completion time, one decomposes a task to its set of keystroke-level operators, and sum up the time for all of the operations.

We’re now done with our lecture on human abilities.

For you to think about:
- How do the models we discussed apply to mobile phone applications?
- How can we apply the varying types of perception we have to best support HCI (cf Guiard’s Model of Bimanual Skill)
**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.

<table>
<thead>
<tr>
<th>Description</th>
<th>Operation</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach for mouse</td>
<td>H [mouse]</td>
<td>0.40</td>
</tr>
<tr>
<td>Move pointer to “Replace” button</td>
<td>P [menu item]</td>
<td>1.10</td>
</tr>
<tr>
<td>Click on “Replace” command</td>
<td>K [mouse]</td>
<td>0.20</td>
</tr>
<tr>
<td>Home on keyboard</td>
<td>H [keyboard]</td>
<td>0.40</td>
</tr>
<tr>
<td>Specify word to be replaced</td>
<td>M4K [word]</td>
<td>2.15</td>
</tr>
<tr>
<td>Reach for mouse</td>
<td>H [mouse]</td>
<td>0.40</td>
</tr>
<tr>
<td>Point to correct field</td>
<td>P [field]</td>
<td>1.10</td>
</tr>
<tr>
<td>Click on field</td>
<td>K [mouse]</td>
<td>0.20</td>
</tr>
<tr>
<td>Home on keyboard</td>
<td>H [keyboard]</td>
<td>0.40</td>
</tr>
<tr>
<td>Type new word</td>
<td>M4K [word]</td>
<td>2.15</td>
</tr>
<tr>
<td>Reach for mouse</td>
<td>H [mouse]</td>
<td>0.40</td>
</tr>
<tr>
<td>Move pointer on Replace-all</td>
<td>P [replace-all]</td>
<td>1.10</td>
</tr>
<tr>
<td>Click on field</td>
<td>K [mouse]</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Total** 10.2
Keystroke Level Model

Fitts’ Law predicts time to complete a pointing operation. But it is just one of many possible (human) operations in a computer system.

KLM puts these together by defining a set of different operators, where each operator is given a time estimate to complete.

To find out a task completion time, one decomposes a task to its set of keystroke-level operators, and sum up the time for all of the operations.

We’re now done with our lecture on human abilities.

For you to think about:
- How do the models we discussed apply to mobile phone applications?
- How can we apply the varying types of perception we have to best support HCI (cf Guiard’s Model of Bimanual Skill)