Chapter 3 - Cognition

• Types of human memory
  – Short term memory and cognitive processes
  – Long term memory

• Learning

• Unlearning

• Attention

• Cognitive load
  – Working memory load
  – Multitasking
  – Measurement of cognitive load

• Decision making and time
Recap: Basic Model

Pattern Recognition

Sensory Registers
(visual, auditory, haptic, etc.)

Sensory Organs
(Eye, ear, etc.)

Stimuli

Long Term Memory (LTM)
declarative knowledge, procedural knowledge

Short Term Memory (STM)
= Working Memory
controlled cognitive processes
(e.g. decisions, memory search)

Motor Systems
(e.g. coordination of arm-hand-finger systems, eye movements, etc.)
Short Term Memory: *Recognize-Act Cycle*

Duration: approx. 30-100ms

Visual Register

LTM

STM

recognize

act

Based on Material by A. Butz & A. Krüger
Limitations of Short Term Memory

Once Upon a Time…

123 * 456 = ?

Source:
http://autoimg.frauenzimmer.de/
Chunks in Short Term Memory

• Capacity (in general): approx. 3 (2 to 4) chunks
  – for very short durations (2s) up to 7 (5 to 9) chunks

```
01000010 = 42 = B
```

<table>
<thead>
<tr>
<th>Dot</th>
<th>Dash</th>
<th>S</th>
<th>O</th>
<th>SOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>□□</td>
<td>□□□</td>
<td>□□□</td>
<td>□□□</td>
</tr>
</tbody>
</table>
Long Term Memory

- Declarative knowledge
- Procedural knowledge
  - motor knowledge vs. cognitive knowledge

Diagram:
- Animal
  - Bird
    - Penguin
  - Fish
    - Canary

Equation:
17784 ÷ 76 = 234
152
258
228
304
304
0
Recognition vs. Recall

• Of what brand is your bike?
  – Answer has to be produced
  – Example: `grep "recall" chapter??.tex`

• Is your bike of brand XYZ?
  – Yes/no decision only
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Evaluation of Learning Methods

- Control group: learns without method (trial & error)
- Transfer group: learns with new method (e.g. course)
- Measuring the time until a certain achievement is reached

Transfer group is learning

Transfer group is applying (doing)

Control group learns by doing

\[
\text{Transfer Performance} = \frac{\text{Time}_{\text{control group}} - \text{Time}_{\text{transfer group}}}{\text{Time}_{\text{control group}}} \times 100
\]

\[
\text{Transfer Efficiency} = \frac{\text{Time}_{\text{control group}} - \text{Time}_{\text{transfer group}}}{\text{Time}_{\text{new method}}} \times 100
\]

\[
\text{Training Cost Ratio} = \frac{\text{Training cost of new method (per time unit)}}{\text{Training cost of old method (per time unit)}}
\]
Learning by Examples

• Instructables
• YouTube
• Tutorials for lecture
Practical Exercise (Learning by Doing)
Training of Sub-Tasks

- (Steering + Balance) + Pedaling = Cycling

Based on Material by A. Butz & A. Krüger
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Trace Decay Theory

• Based on work by psychologist Hermann Ebbinghaus
• Experiment: Rehearsing non-sense syllables
  – Memory fades just by passage of time
  – Theory (Thorndike 1914): Memory trace (access path) decays

• More recent insights:
  – Not only time is relevant but also knowledge *activation*
  – When and how often the knowledge was accessed?

• Rarely used knowledge fades over time
Interference Theory

• New knowledge replaces old knowledge

• Example: Moving house, street names
• Example: Changing school, names of other pupils
• Example: Unused foreign language

• other examples??
Factors Slowing Down the Forgetting Process

• Strong emotions:
  – Associated knowledge is kept longer in memory

• Context:
  – Learning and recall within the same context (e.g. room)
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Based on Material by A. Butz & A. Krüger
Selective Attention

https://www.youtube.com/watch?v=mg11glSBW4Y
Cocktail Party Effect

- Selective hearing
- Organized conversation in presence of many different voices
- Irrelevant voices attenuated by up to 15dB
  – only perceived volume
  – not physically!
- Function of the human brain, currently not realizable by technology
Focussed Attention

http://www.youtube.com/watch?v=alwcN2VN-98

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» Download FLV « - 240p
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» Download MP4 « - 720p
» Download WEBM « - 360p
Shared Attention
Change Blindness

https://www.youtube.com/watch?v=ubNF9QNEQLA
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Working Memory Load / Cognitive Load in Learning

- **Extraneous Load**
  - created by form and design of presentation

- **Intrinsic Load**
  - created by the task itself

- **Germaine Load (Learning Load)**
  - necessary for finding and automatization of new schemata

Cognitive Load Theory (CLT) by John Sweller and Paul Chandler

Based on Material by A. Butz & A. Krüger
Cognitive Load in Multitasking
Performance Resource Function

Resources vs. Performance

Simple Task

Hard Task

1 2 3
Measurement of Cognitive Load

- Primary task
- Secondary task

Secondary task measured
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Hick-Hyman Law

\[ DT = k + z \ast H_5 = k + z \ast \log_2(N) \]
Example for Hick-Hyman Law (or not?)


http://www.photosophic.com/iphone_screen
Hick’s Law, explained for a different audience