2 Physiological and Psychological Foundations

2.1 Human Nervous System
2.2 Human Brain
2.3 Human Memory
2.4 Remembering and Forgetting
About This Class: Flipped Classroom

- Four short clips of recorded lecture
- Interactive work
- Discussion

Source: washington.edu
Nervous System

- Mesh of special cells (neurons)

Sources: Wikipedia
Neuron

- Functions of a neuron:
  - Accepting information from sensory cells
  - Controlling muscular cells
  - Transmitting information
  - Connected to other cells via switched connections (synapses)

Source: Quasar Jarosz at en.wikipedia
Neuron Mesh

- Each neuron has many connections to other neurons
  - Up to $10^{15}$ neuronal connections in human brain
  - 10% for input/output, 90% for internal connections

Cerebral cortex of a mouse

Scale: 100 µm

Source: Lee/Huang/Feng/Sanes/Brown/So/Nedivi. PLoS Biology
Hebbian Theory

• Donald O. Hebb, 1949 ("The Organization of Behaviour"):  
  "When an axon of cell A is near enough to excite a cell B and repeatedly or  
  persistently takes part in firing it, some growth process or metabolic change  
  takes place in one or both cells such that A’s efficiency, as one of the cells  
  firing B, is increased."

• Behaviour on axon/synapse level is dynamic over time
• Learning = training of connections in nervous system?
• Learning appears to physically change the brain  
  (brain plasticity)
• Technical simulation: „Artificial Neural Network"
  • Statistical learning algorithm for machine learning
Learning as Training of Neural Connections

Task:
Distinguish points on fingertip which are located close to each other

Training leads to better precision in distinction

Functional magnetic resonance imaging shows increase of active area in brain

http://www.pm.ruhr-uni-bochum.de/pm2003/msg00333.htm
2 Physiological and Psychological Foundations

2.1 Human Nervous System
2.2 Human Brain
2.3 Human Memory
2.4 Remembering and Forgetting
Parts of the Human Brain

Brainstem (Stammhirn): 
"reptile brain"
basic body functions
not relevant for learning

Cerebellum (Kleinhirn): 
Coordination, muscle tonus
motor memory

Cerebrum (Großhirn): 
Information processing,
memory, consciousness
Diencephalon (Zwischenhirn) and Limbic System (Limbisches System)

- Source (& Demo): The HOPES Brain Tutorial
  http://www.stanford.edu/group/hopes/basics/braintut/ab0.html

Between brain stem and cerebrum

Said to be related to emotions, drives, and also olfaction

Assumed to be highly involved in recognition processes
  (e.g. Eichenbaum 2007)

= Hypophyse

Diencephalon = Thalamus + Hypothalamus + MFB
Human Perception as Information Processing

- Perception of "reality" involves many regions of the brain
- Perception depends strongly on previous knowledge (learning)
- Examples from visual perception:
  - Brain adapts to serious changes in optical system (e.g. flipping image upside-down)
  - Eyes are moving in saccades, brain works as if it was a still image
  - Shadows of blood vessels in retina are not perceived as image
Learning Modalities

- Barbe/Swassing/Milone 1979: Three Learning Modalities
  - Visualizing
  - Auditory
  - Tactile / Kinesthetic

- See e.g. http://web.cortland.edu/andersmd/learning/Modalities.htm

<table>
<thead>
<tr>
<th>Visual</th>
<th>Kinesthetic</th>
<th>Auditory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture</td>
<td>Gestures</td>
<td>Listening</td>
</tr>
<tr>
<td>Shape</td>
<td>Body Movements</td>
<td>Rhythms</td>
</tr>
<tr>
<td>Sculpture</td>
<td>Object Manipulation</td>
<td>Tone</td>
</tr>
<tr>
<td>Paintings</td>
<td>Positioning</td>
<td>Chants</td>
</tr>
</tbody>
</table>
Kolb's Learning Styles

Kolb's Experiential Learning Theory

Accommodate  Diverge

Converge  Assimilate

David A. Kolb, 1985
D. A. Kolb: Learning Style Inventory, Hayes 1981
S. A. Santo; Relationships Between Learning Styles and Online Learning, *Performance Improvement Quarterly* 19(3) 2006

Schaller et al. eduweb.com
2 Physiological and Psychological Foundations

2.1 Human Nervous System
2.2 Human Brain
2.3 Human Memory
2.4 Remembering and Forgetting
Atkinson/Shiffrin Memory Model

- R.C. Atkinson, R. M. Shiffrin (1968):
  - Multi-store model of human memory

Sensory memory:
  Raw data, fast decay (less than 1 sec)

Long-term memory:
  Almost unlimited in capacity and storage time
Short Term Memory / Working Memory

• Stored for seconds up to a few minutes
  – Decays if not transferred into long-term memory
• Capacity: Approx. 7 "chunks"
  – Miller (1956): "The magical number seven - plus or minus two"
  – Recent work (Cowan 2001): Lower number, at least 4
• Chunks:
  – Differ depending on previous knowledge
  – Examples:
    » Word in known or unknown language
    » 149162536496481
    » 19501955196019651970
• Repetition helps for transfer to long-term memory
• Shock may block transfer to long-term memory
Structure of Working Memory (Baddeley)

- Baddeley 2000:
  - Phonological loop
  - Visuospatial sketchpad
  - Episodic buffer
2 Physiological and Psychological Foundations

2.1 Human Nervous System
2.2 Human Brain
2.3 Human Memory
2.4 Remembering and Forgetting
Types of Long-Term Memory

Source: study.com
Theories of Forgetting

• Trace decay theory
• Interference theory
  – Retroactive: Freshly learnt material disturbs earlier material
  – Proactive: Previously learnt material disturbs new learning
• Recall stimulus (context):
  – Can make "forgotten" information accessible
  – Tip-of-the-tongue (TOT) blocking
Forgetting Curve, Ebbinghaus (1885)

- Decay of memory, if nothing is done to keep the memory alive
- Exponential function!

Source: peakmemory.me
Strategies Against Forgetting

- "Overlearning": Massive repetition after learning
  - Not the most efficient method
- Rhythmical repetition:
  - Change between inactive phases and repetition
  - Refresh up to "100% recall"
  - Increasing time interval between repetitions

Source: matt.me