2 Physiological and Psychological Foundations

2.1 Human Nervous System
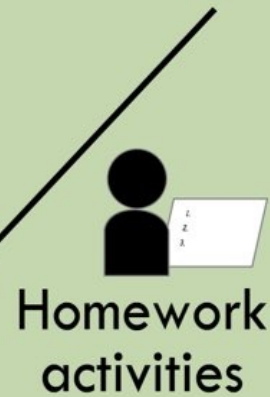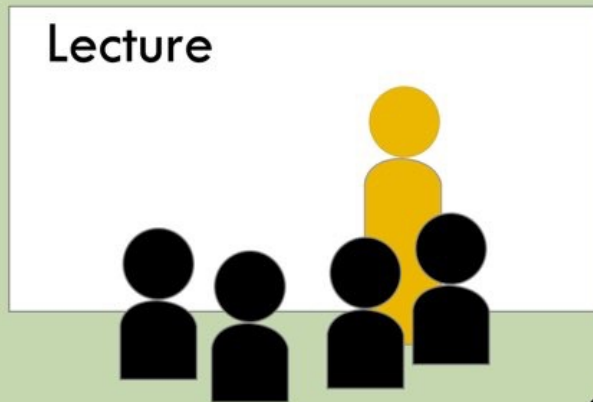
2.2 Human Brain

2.3 Human Memory

2.4 Remembering and Forgetting

About This Class: Flipped Classroom

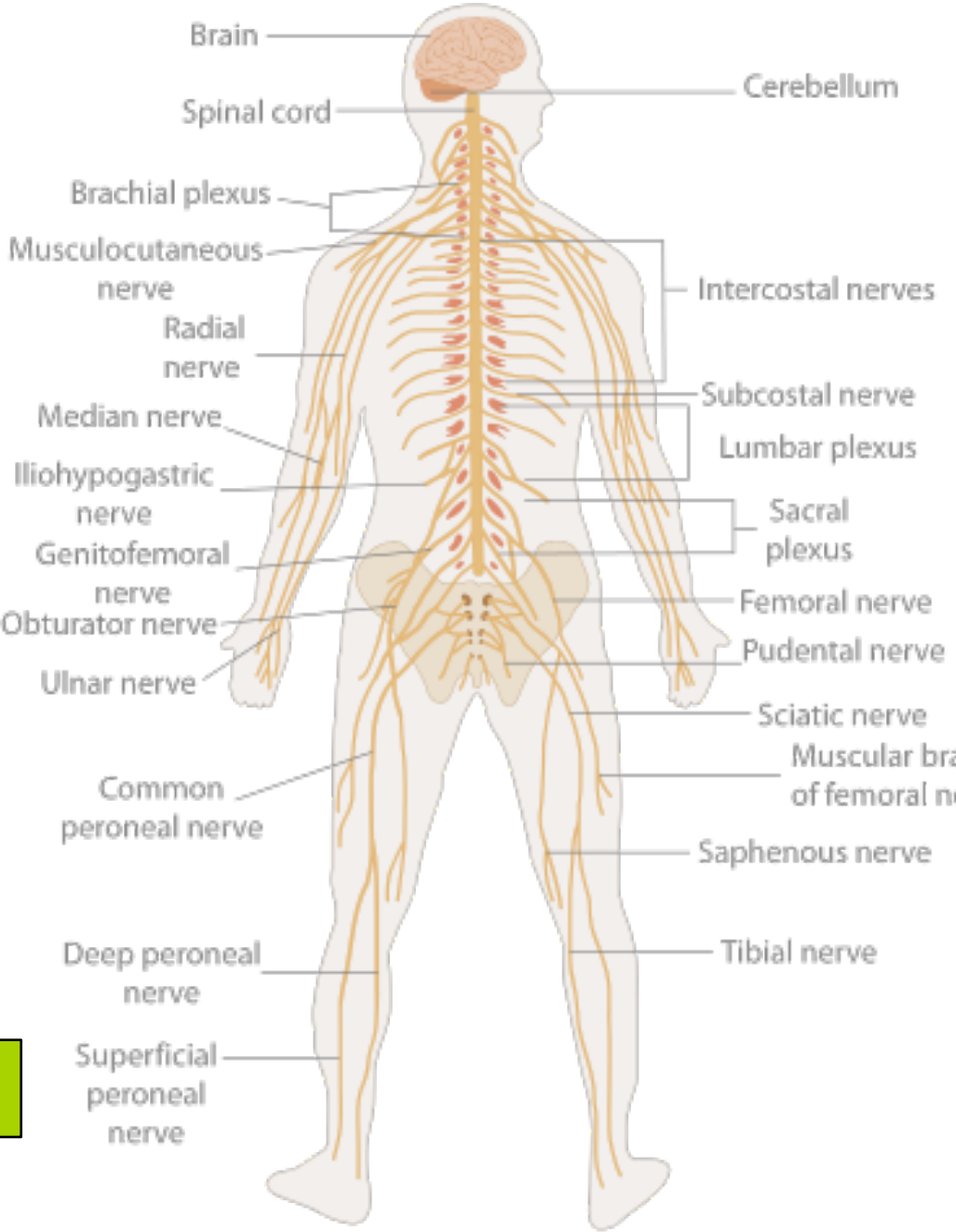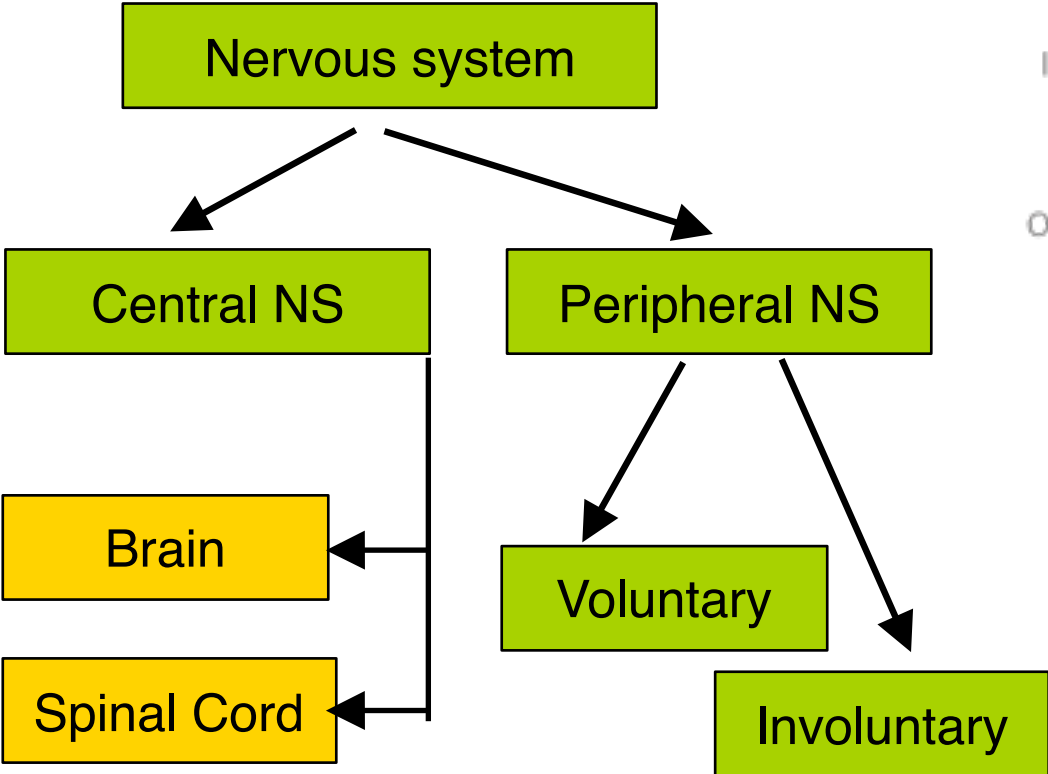

Source: washington.edu

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

Nervous System

- Mesh of special cells (neurons)

Nervous system
↓
Central NS ← Peripheral NS
Brain
Spinal Cord
Voluntary
Involuntary
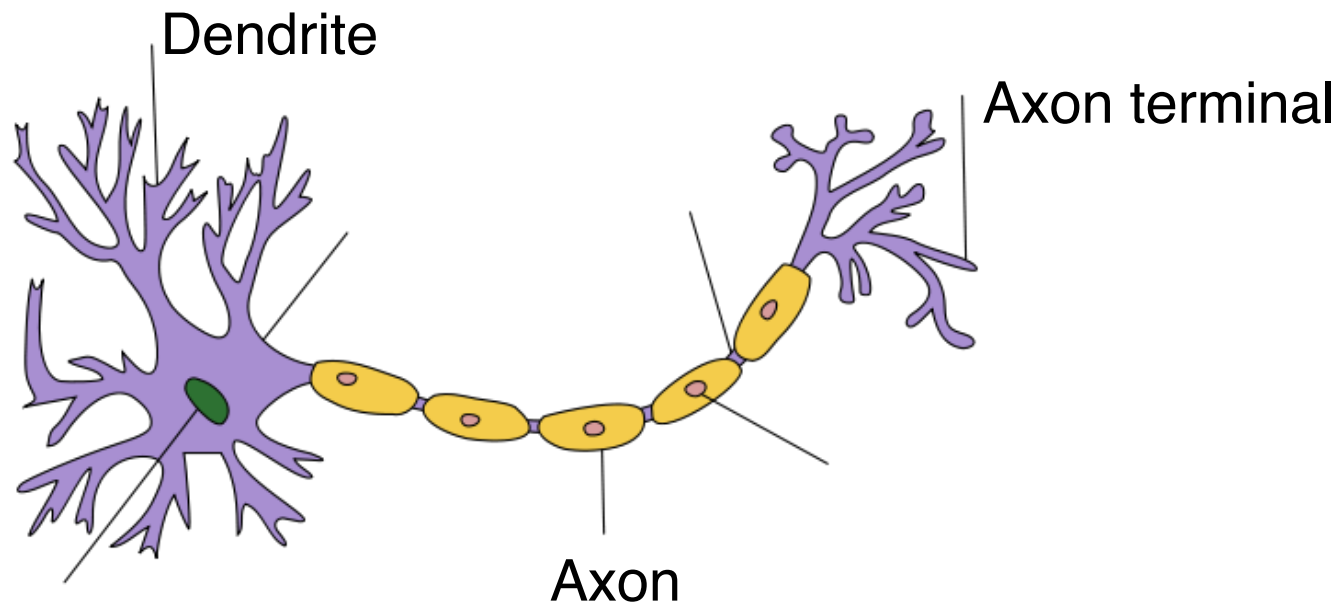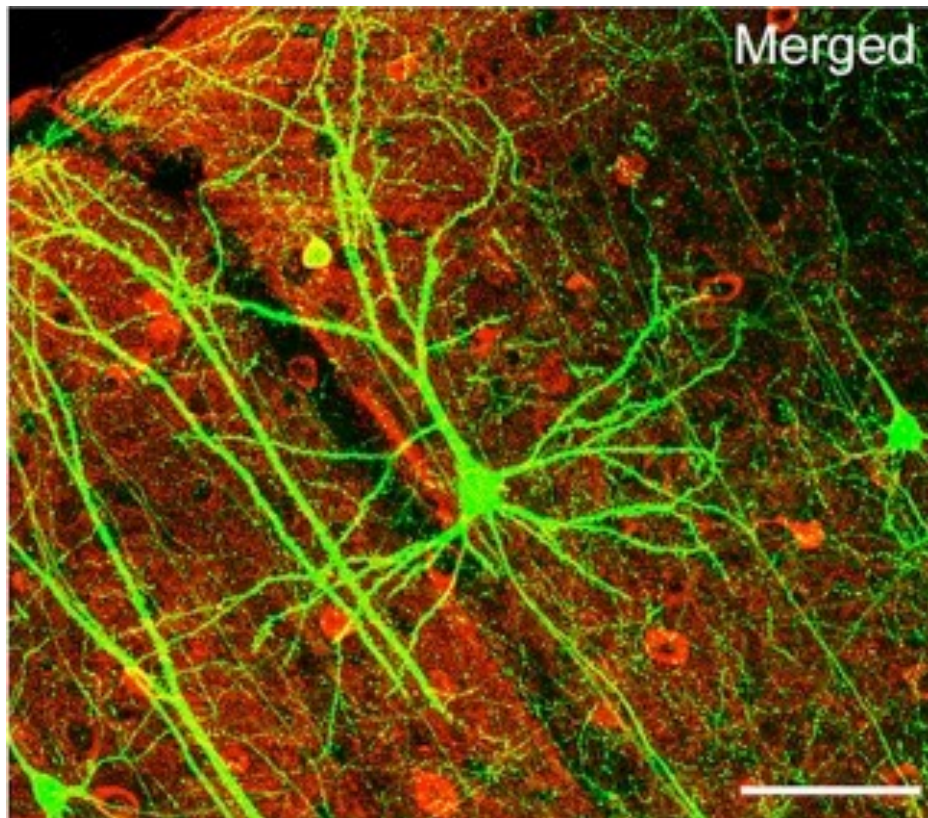

Sources: Wikipedia

Neuron

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

Dendrite

Axon terminal

Axon

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
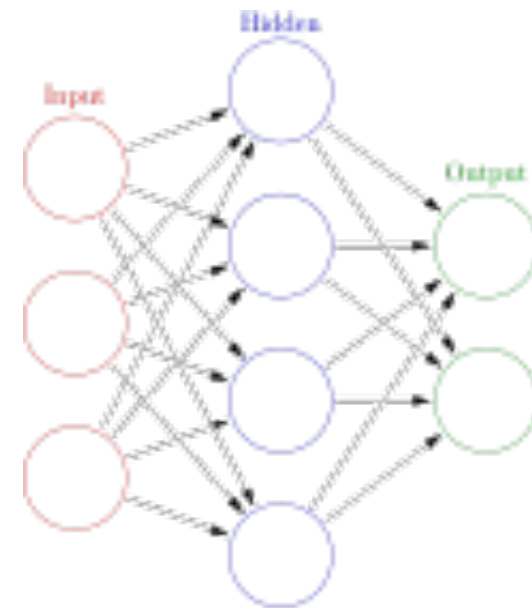 - 10 % for input/output, 90 % for internal connections

Cerebral cortex of a mouse

Scale: 100 μm

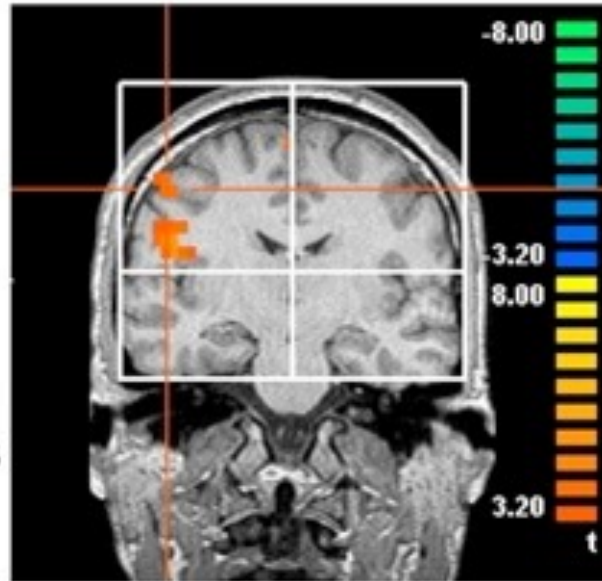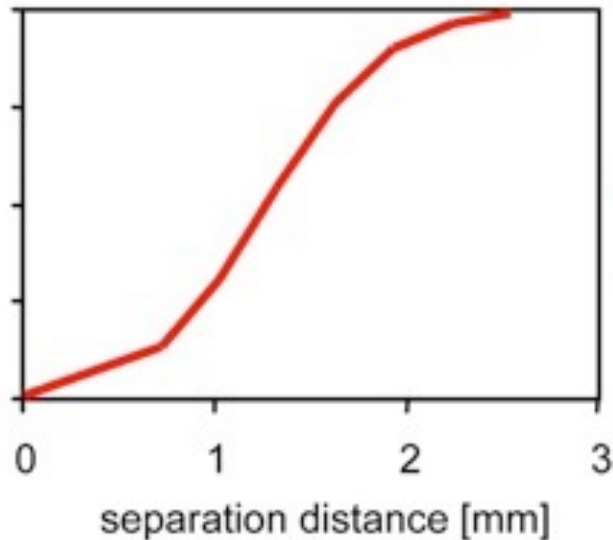Source: Lee/Huang/Feng/Sanes/Brown/So/Nedivi. PLoS Biology

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

glosser.ca/Wikipedia

Learning as Training of Neural Connections

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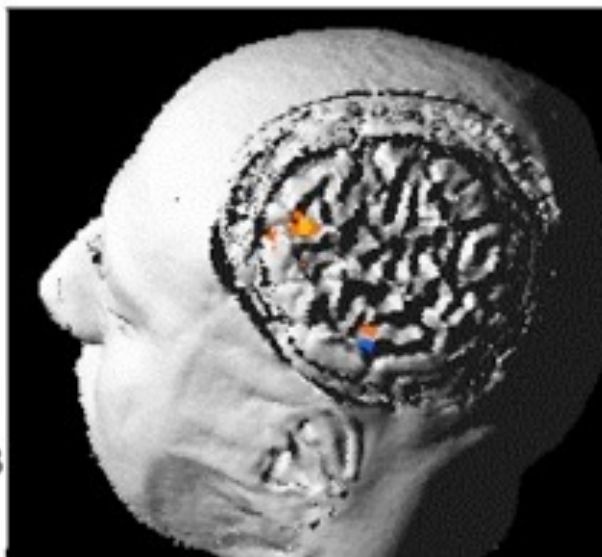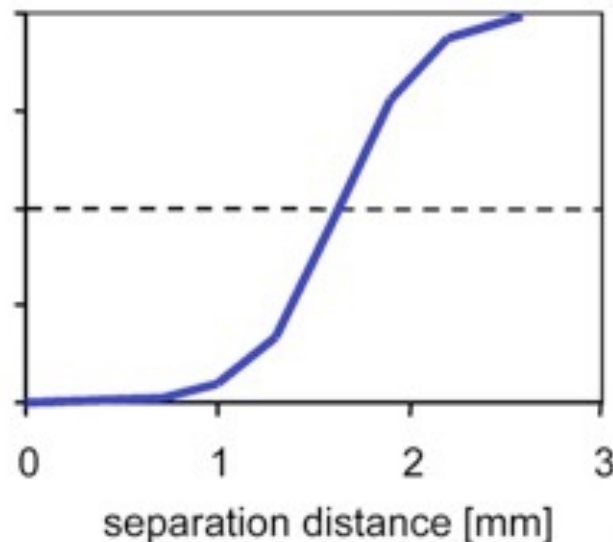Distinguish points on fingertip which are located close to each other

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

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Parts of the Human Brain

Cerebrum
(Forebrain)

Brainstem

Cerebellum
(Hindbrain)

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

Figure AB-20: Diencephalon

Diencephalon = Thalamus + Hypothalamus + MFB

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)

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

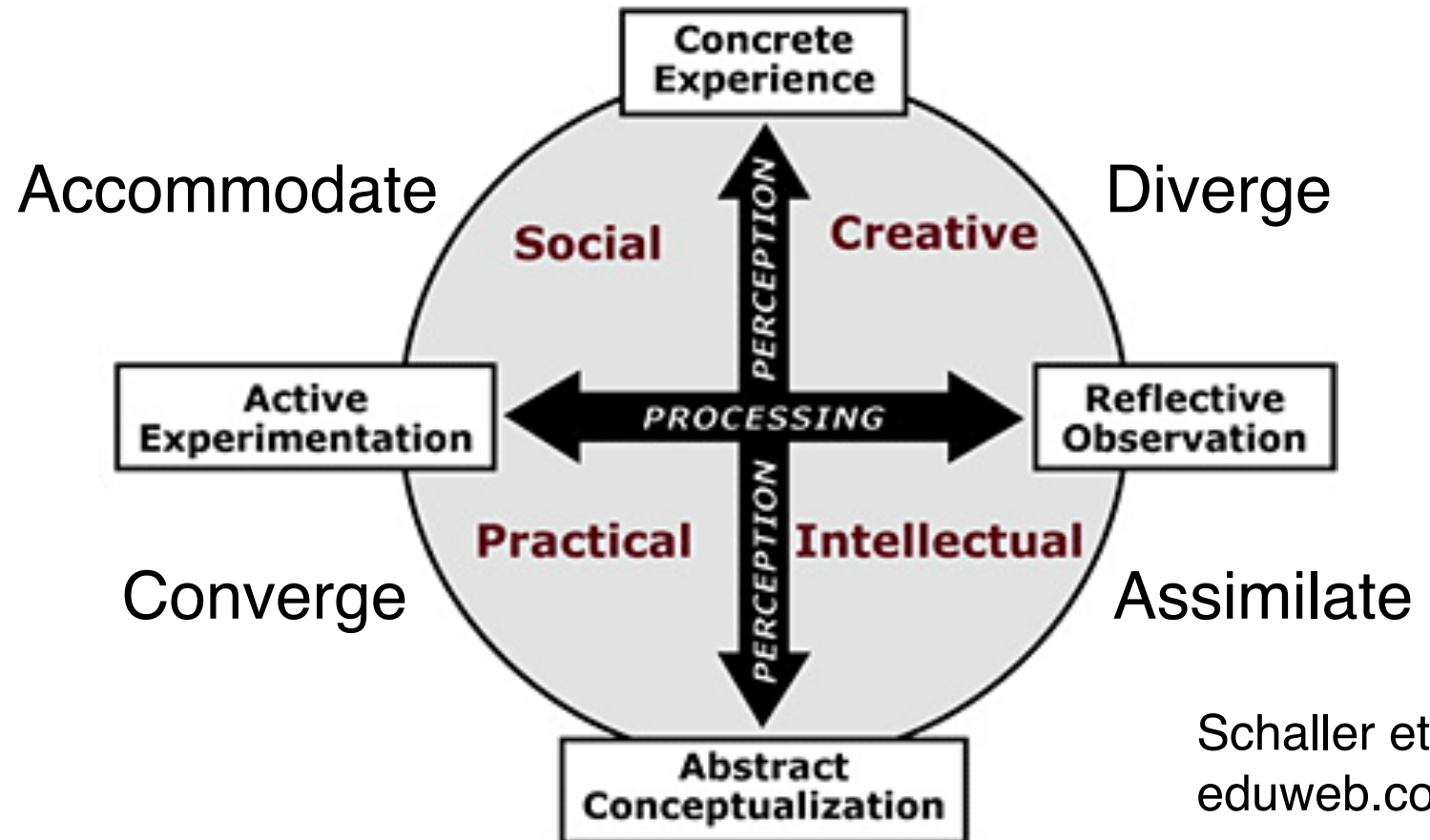# Learning Modalities

- Barbe/Swassing/Milone 1979: Three Learning Modalities
  - Visualizing
  - Auditory
  - Tactile / Kinesthetic
- See e.g. http://web.cortland.edu/andersmd/learning/Modalities.htm

Visual	Kinesthetic	Auditory
Picture	Gestures	Listening
Shape	Body Movements	Rhythms
Sculpture	Object Manipulation	Tone
Paintings	Positioning	Chants

Kolb's Learning Styles

Kolb's Experiential Learning Theory

Accommodate

Diverge

Converge

Assimilate

Concrete Experience

Social   Creative

Active Experimentation

PERCEPTION

PROCESSING

Reflective Observation

Practical   Intellectual

PERCEPTION

Abstract Conceptualization

Schaller et al.
eduweb.com

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

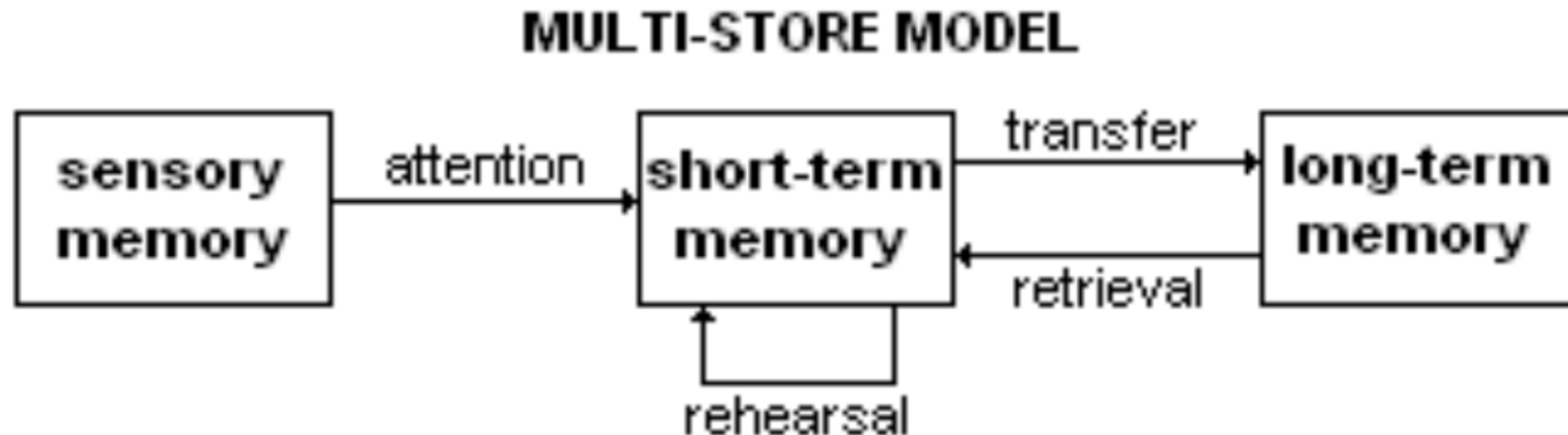# 2   Physiological and Psychological Foundations

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Atkinson/Shiffrin Memory Model

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

MULTI-STORE MODEL

Sensory memory:
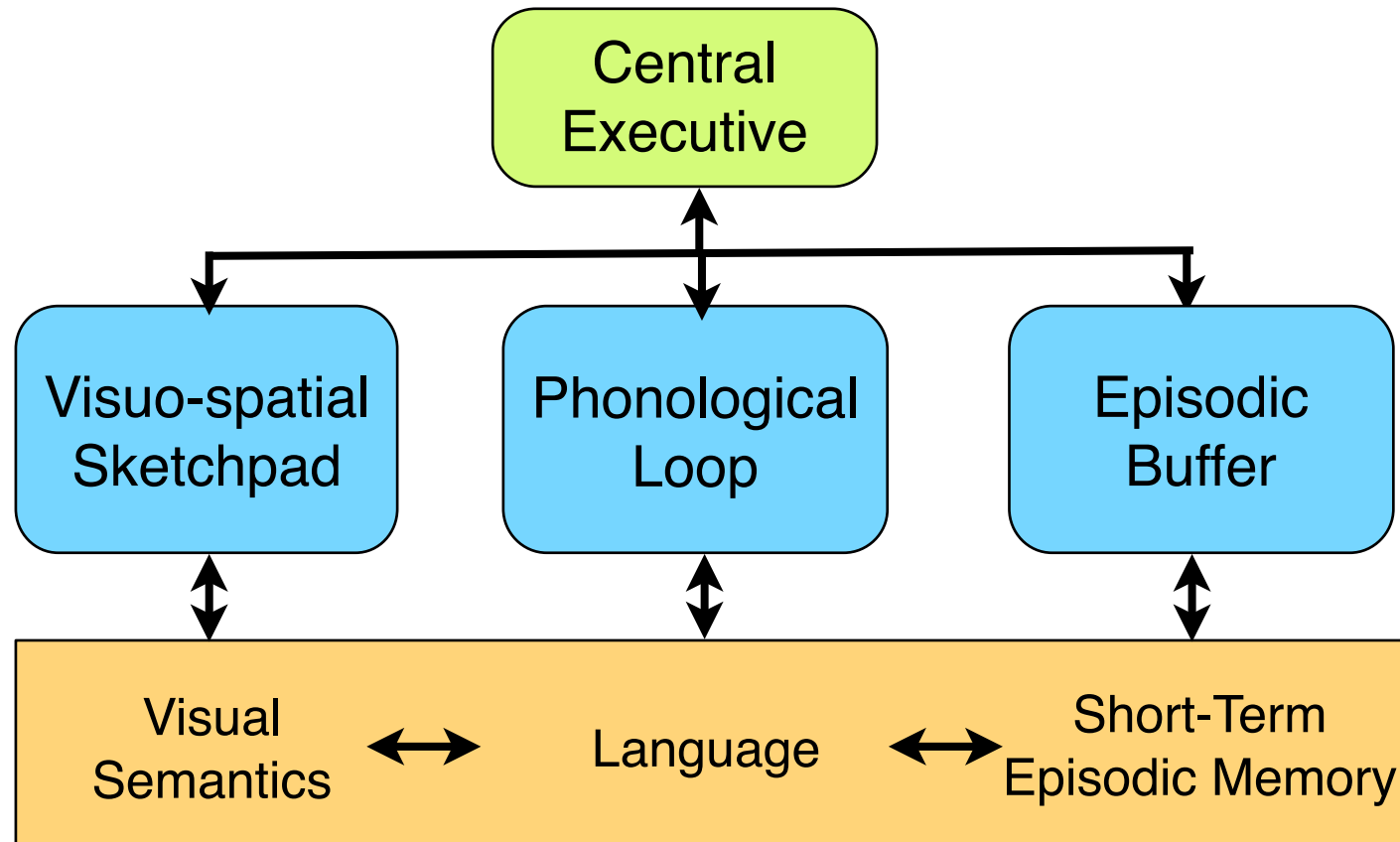   Raw data, fast decay (less than 1 sec)
Long-term memory:
    Almost unlimited in capacity and storage time

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
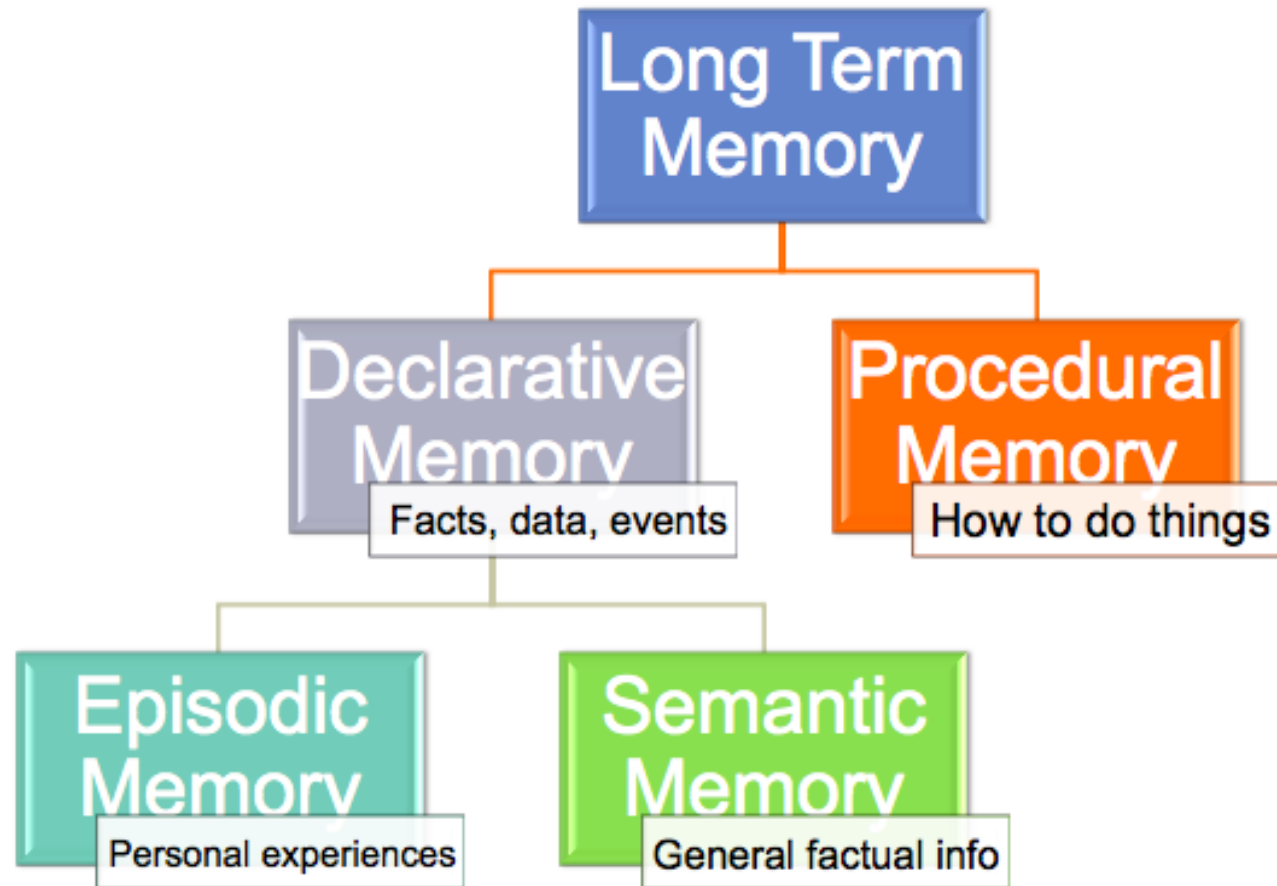
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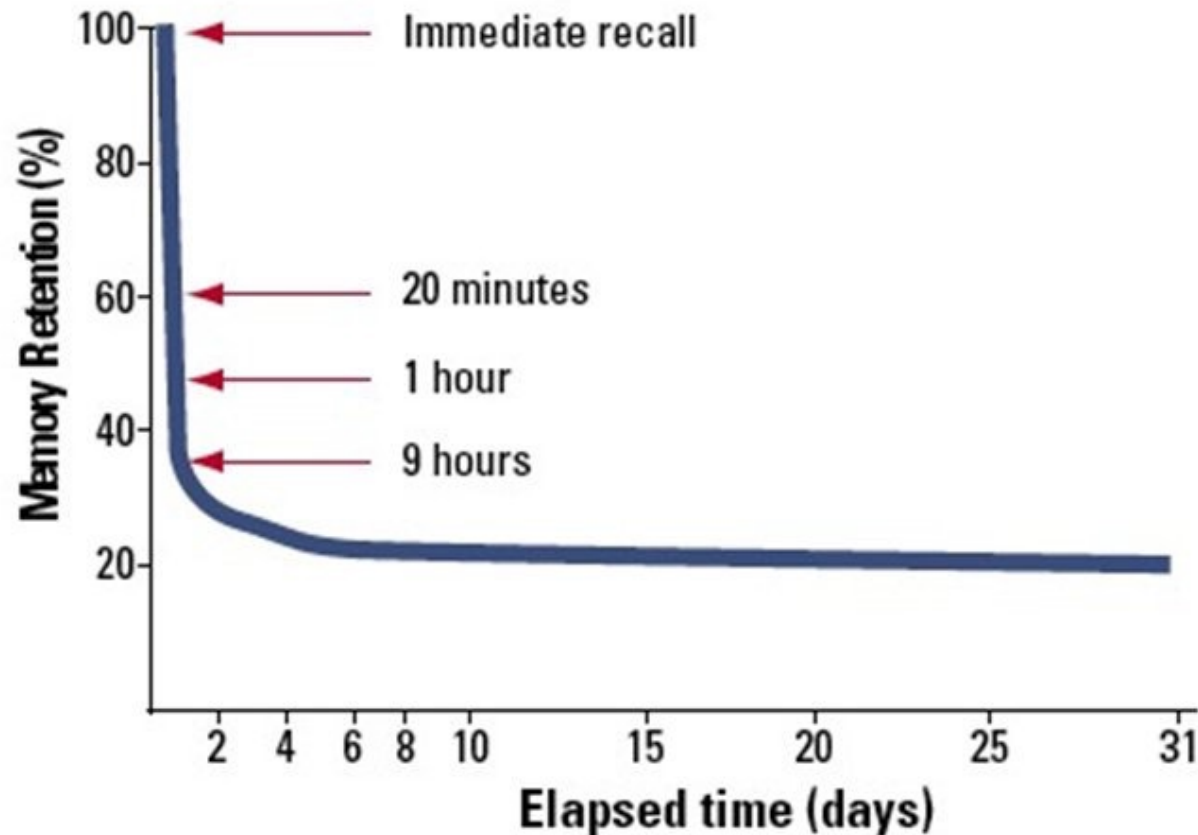2.4 Remembering and Forgetting

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