University of Zurich UZH | ETH Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ZNZ Introductory Course in Neuroscience
Mon 14.12.2015
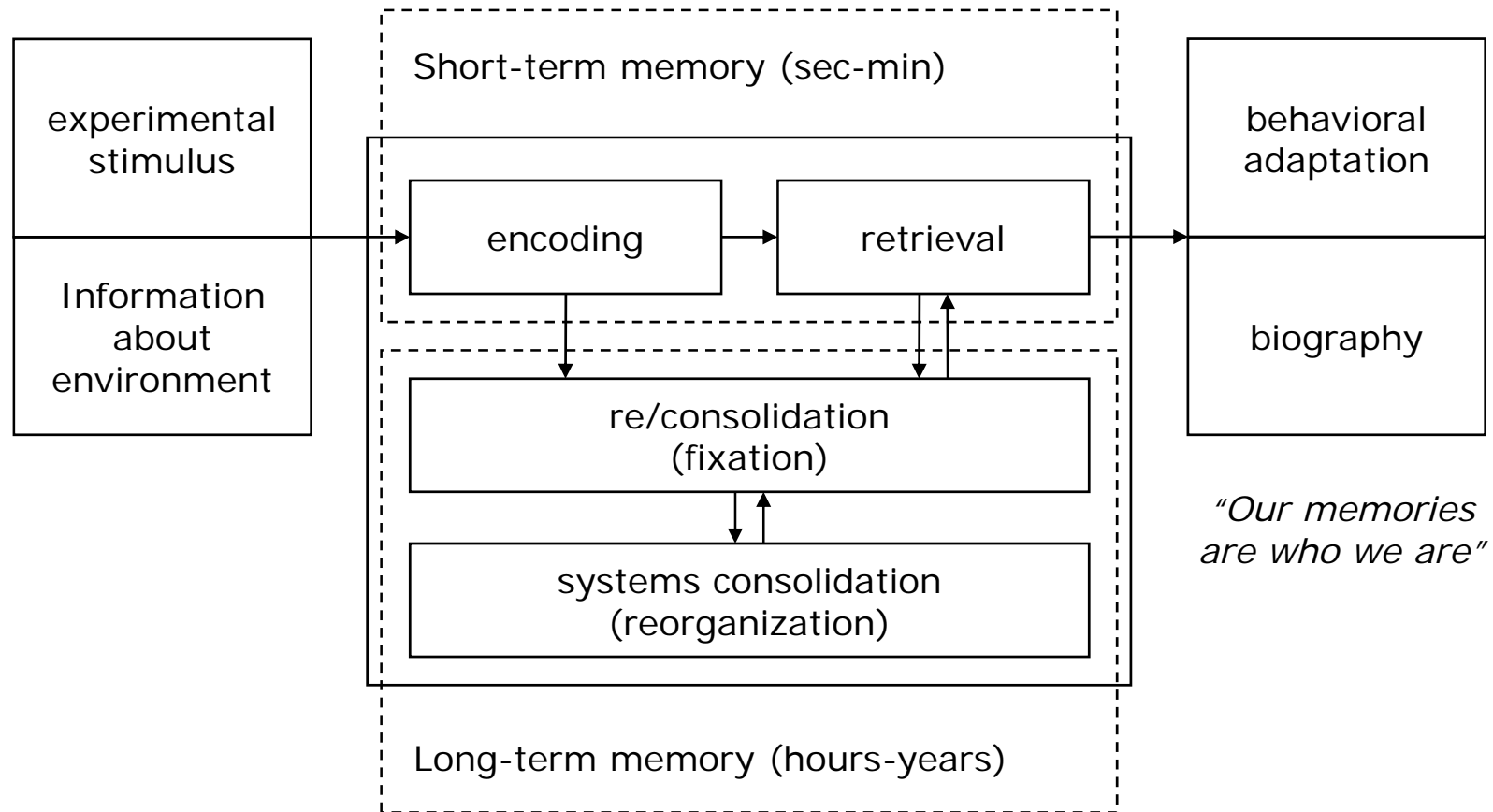# Learning and Memory, mice and human

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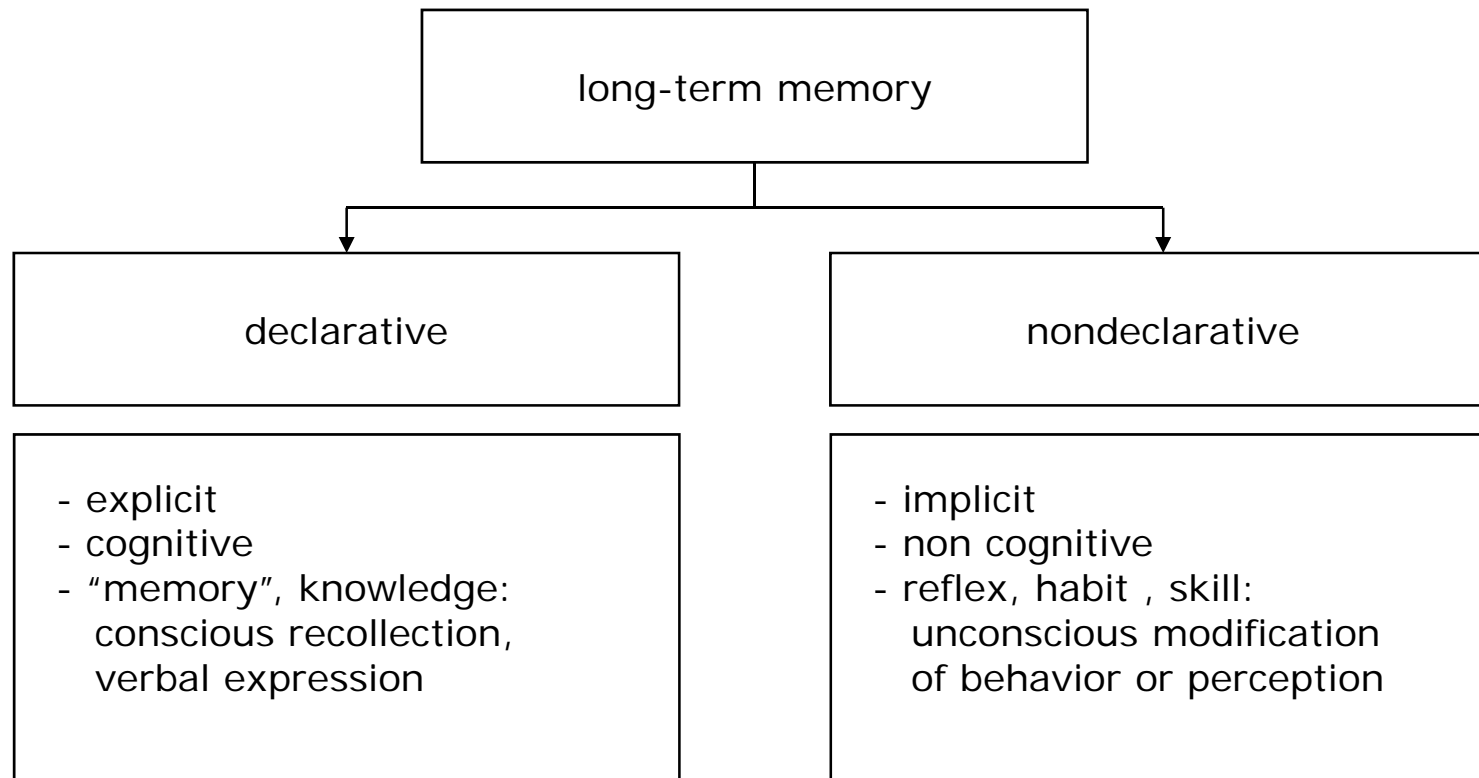http://www.dpwolfer.ch
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Contents

Processes in learning and memory

Declarative and nondeclarative memory

long-term memory

declarative

nondeclarative

- explicit
- cognitive
- "memory", knowledge:
  conscious recollection,
  verbal expression

- implicit
- non cognitive
- reflex, habit , skill:
  unconscious modification
  of behavior or perception
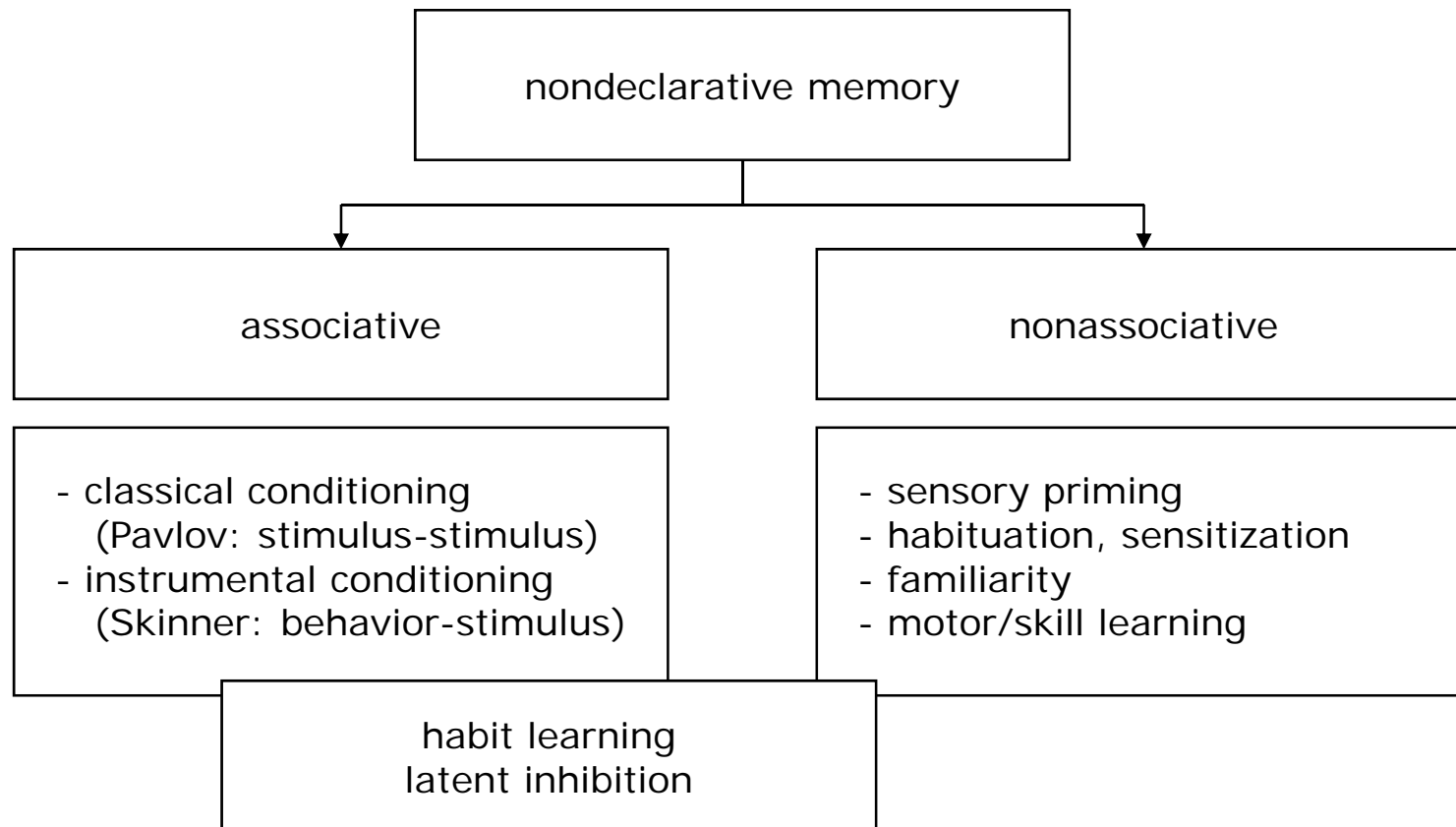
Often activated simultaneously!

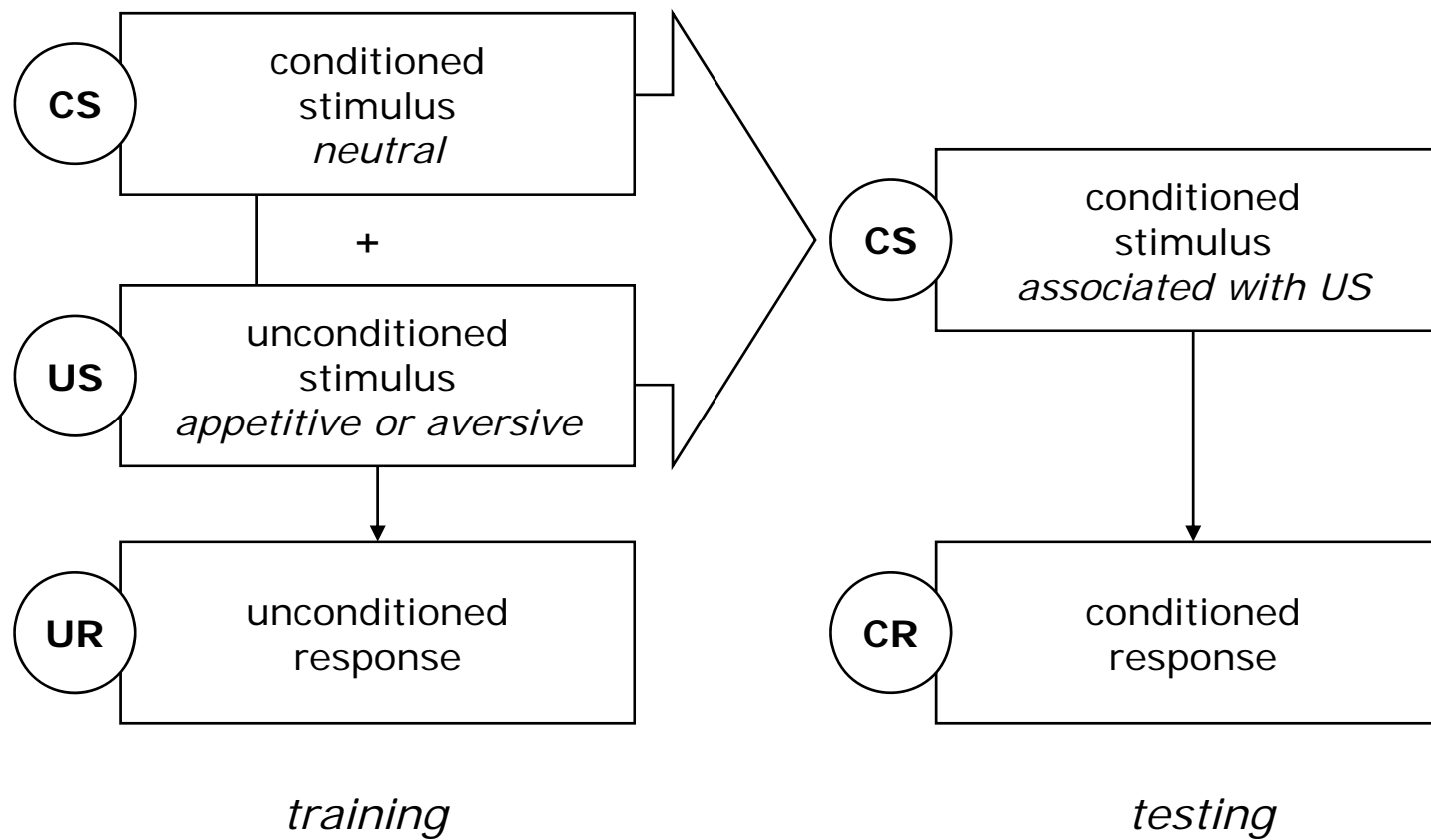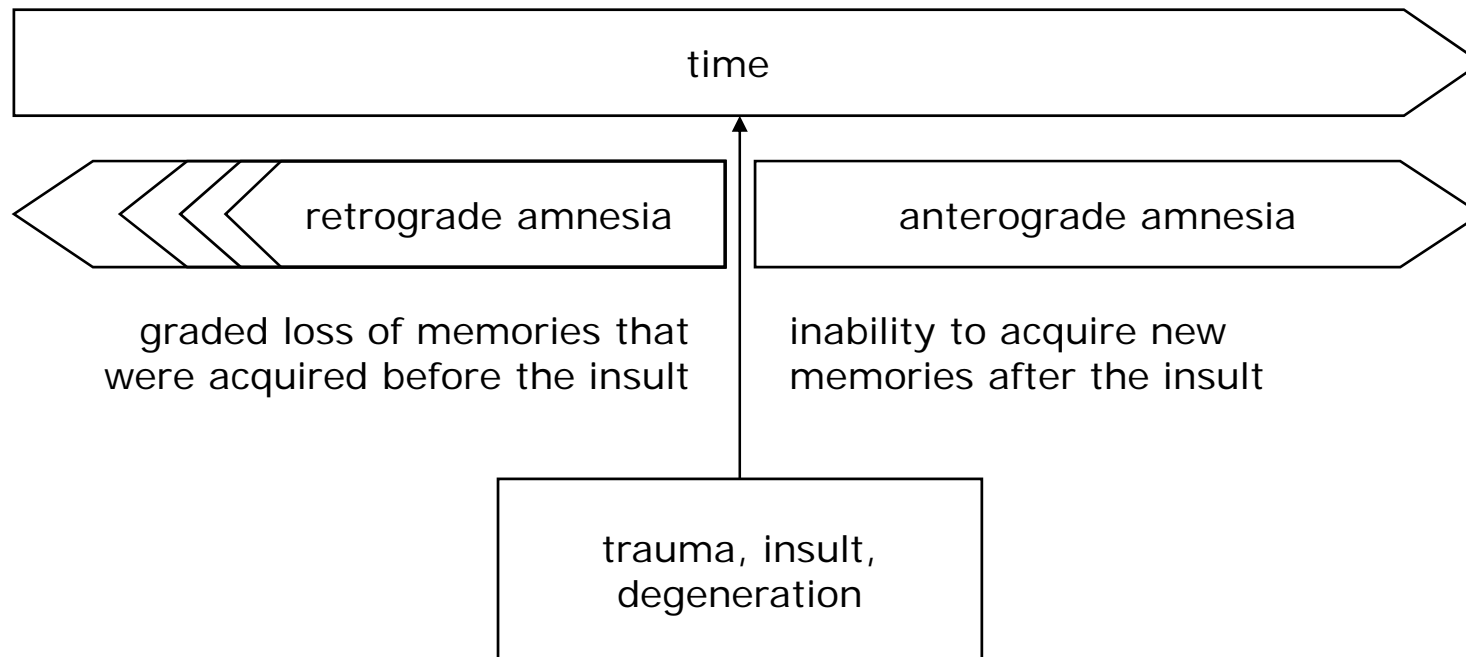# Types of declarative memory
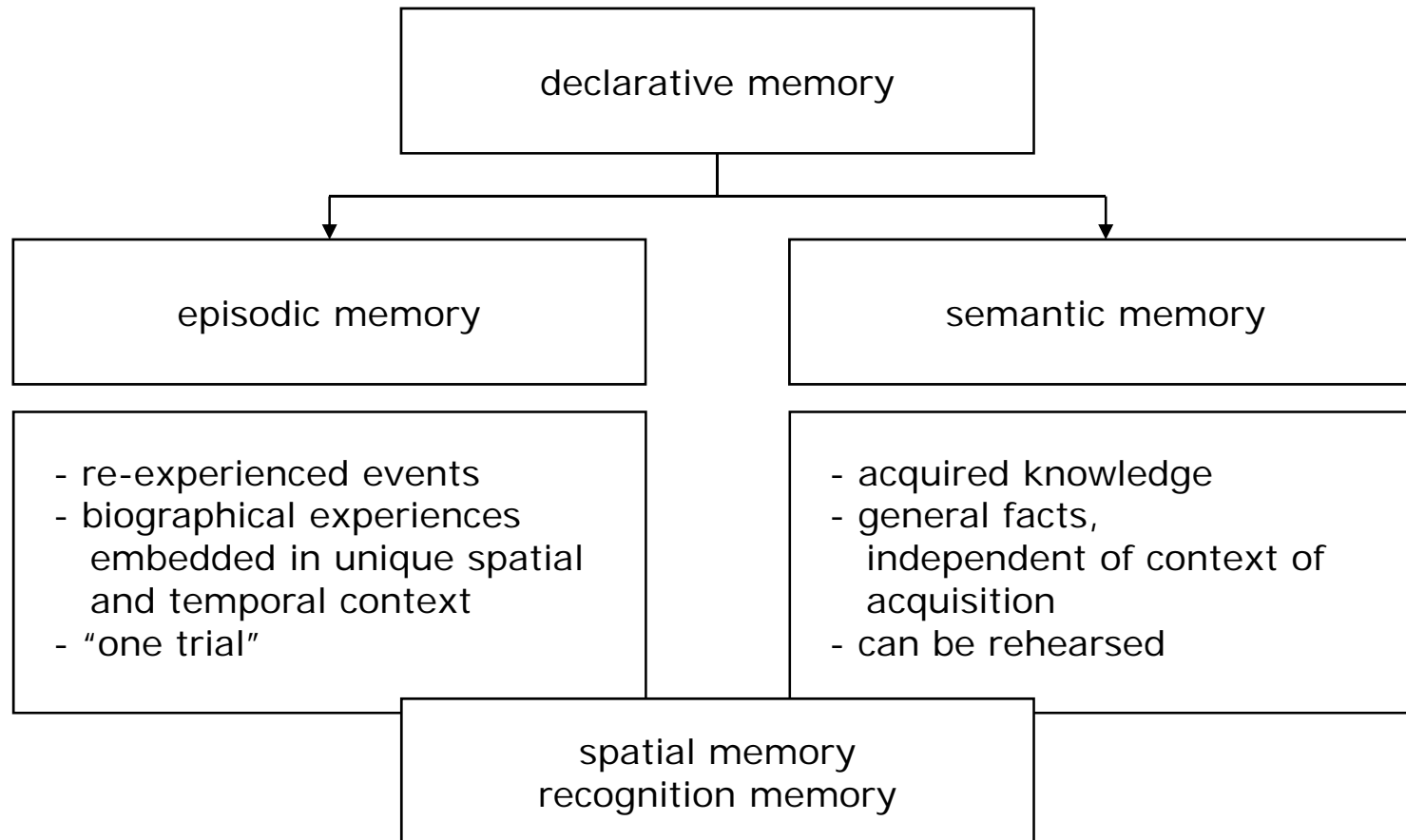
Types of nondeclarative memory

Classical (Pavlovian) conditioning

Amnestic syndrome

*= loss of declarative memory function,
  with preserved short-term and nondeclarative memory*

time

retrograde amnesia | anterograde amnesia

graded loss of memories that
were acquired before the insult

inability to acquire new
memories after the insult

trauma, insult,
degeneration

Patient H.M.
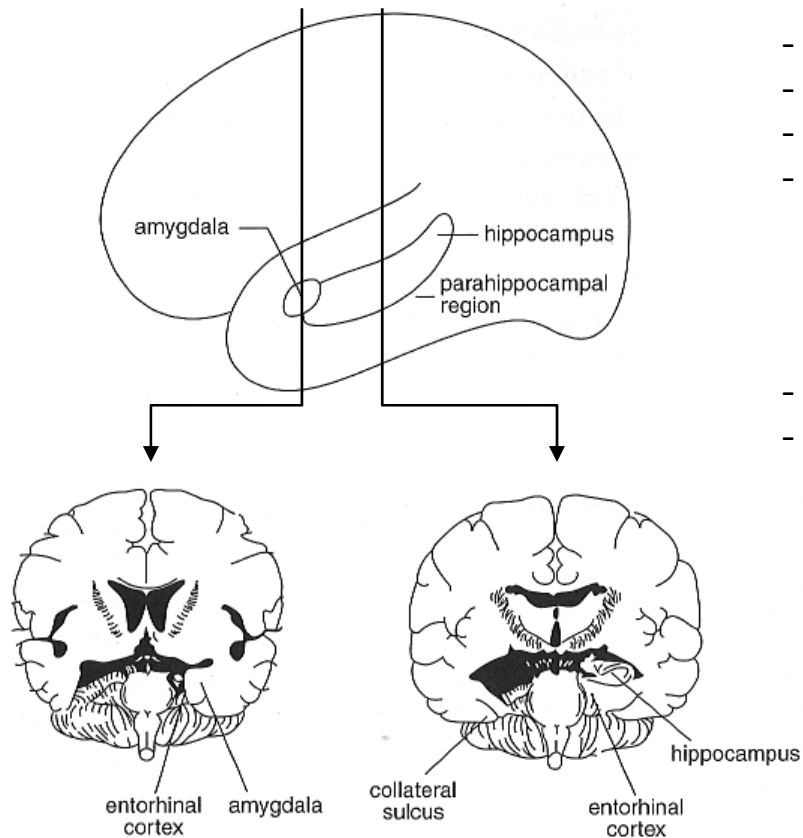
- 1926-2008
- 1933 knocked down by bicycle
- development of uncontrollable epilepsy
- 1953 bilateral medial temporal lobe resection
  by William Scoville

Result:

- Seizures less frequent and controllable
- Severe amnesic syndrome:
  - complete anterograde amnesia
  - retrograde for <15y before surgery
  - nondeclarative memory spared
  - short-term memory spared
  - IQ and language normal
  - cooperative, very placid temper

Levels of analysis

Psychological level

    - distinction und definition of various types of memory
    - description of their properties, formalization
    - models and learning theories, subject as „black box"

Systemic level

    - compartmentalization and localization to different brain areas
    - role of particular cell populations, fiber tracts, transmitters
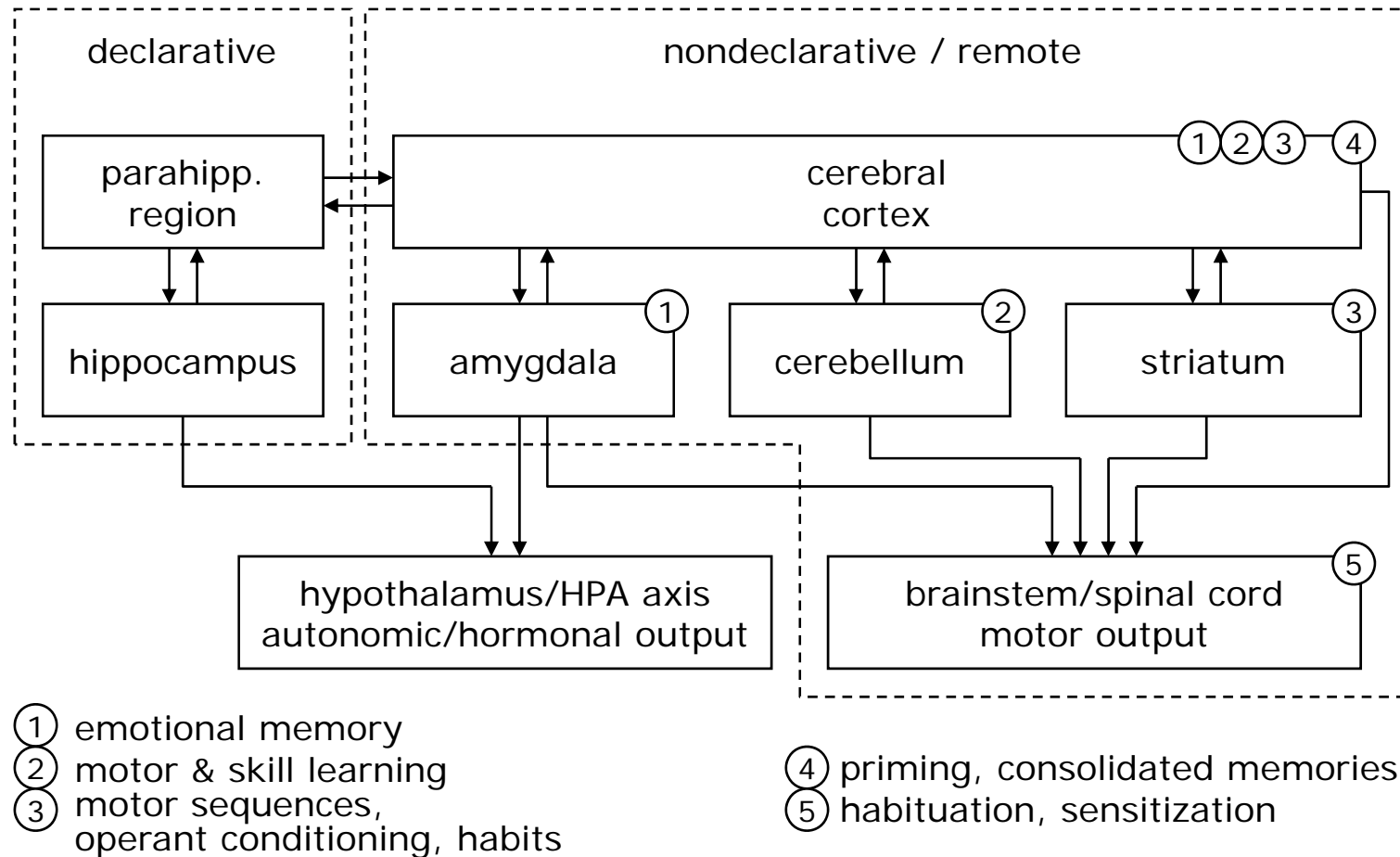
Cellular and molecular level

    - Role of cellular processes: signaling cascades, protein phosphorylation,
      protein synthesis, gene expression, cell motility & proliferation
    - Role of specific genes, proteins and their interactions

Simulation

    - mathematical models, computer simulation
    - electronic circuits, robots

Simplified anatomical framework for memory

declarative

nondeclarative / remote

parahipp. region

cerebral cortex ① ② ③ ④

hippocampus

amygdala ①

cerebellum ②

striatum ③

hypothalamus/HPA axis
autonomic/hormonal output

brainstem/spinal cord
motor output ⑤

① emotional memory
② motor & skill learning
③ motor sequences,
  operant conditioning, habits

④ priming, consolidated memories
⑤ habituation, sensitization

Animal models of nondeclarative memory

Associative

- classical conditioning:
  - fear conditioning (rats, mice - amygdala)
  - conditioned taste aversion (rats, mice – amygdala, cortex)
  - eye blink conditioning (rabbits, mice - cerebellum)

- operant conditioning
  - Skinner box (primates, birds, rats, mice - striatum)
  - Home cage testing environments (mice)

Nonassociative

- motor skill learning
  - rotarod, beam walking (rats, mice - cerebellum, striatum, cortex)

- habit learning
  - dry & water mazes, Skinner boxes (rats, mice - striatum)

- habituation, sensitization
  - startle reflex (rats, mice - brainstem)

Animal models of declarative memory

- species differences! lack of language in animals!
- declarative memory defined indirectly through dependence on hippocampus
- no fully established model of episodic memory: "episodic-like" memory

Spatial memory

- place navigation in water-maze (rat, mouse)
- 8-arm radial maze (rat, mouse)
- T-maze alternation (rat, mouse)

Modified conditioning models

- contextual fear conditioning (rat, mouse)
- trace fear or eye blink conditioning (rabbit, rat, mouse)
- home cage testing environments (mouse)

Other models

- object recognition, D(N)MS = delayed (non) matching to sample (rat, primate)
- social recognition, social transmission of food preferences (rat, mouse)
- paired-associate tasks (rat, primates)