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ZNZ Introductory Course in Neuroscience
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Learning and Memory

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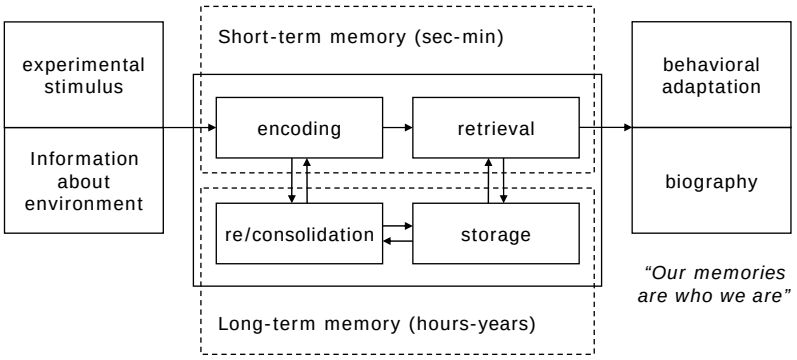
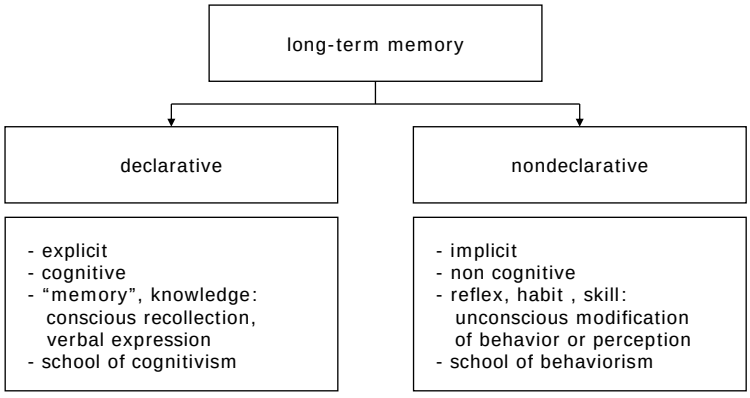
Processes in learning and memory



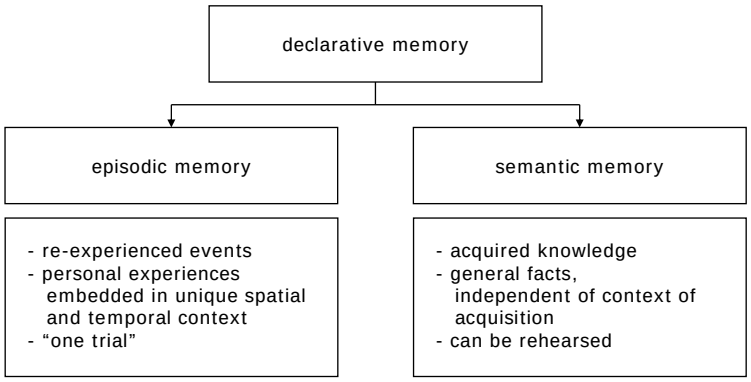
Consolidation: memory fixation – reorganization (systems consolidation)

Declarative and nondeclarative memory



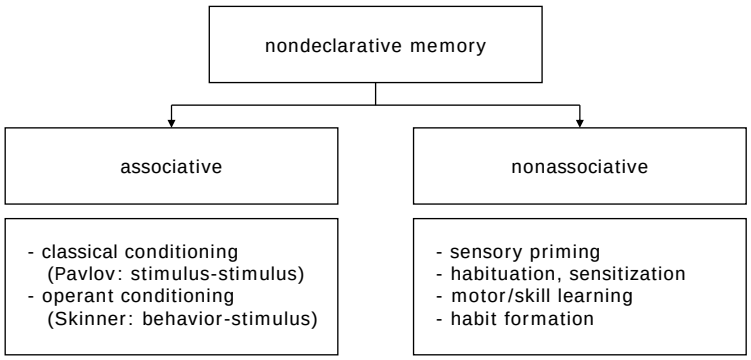
Often activated simultaneously!

Types of declarative memory



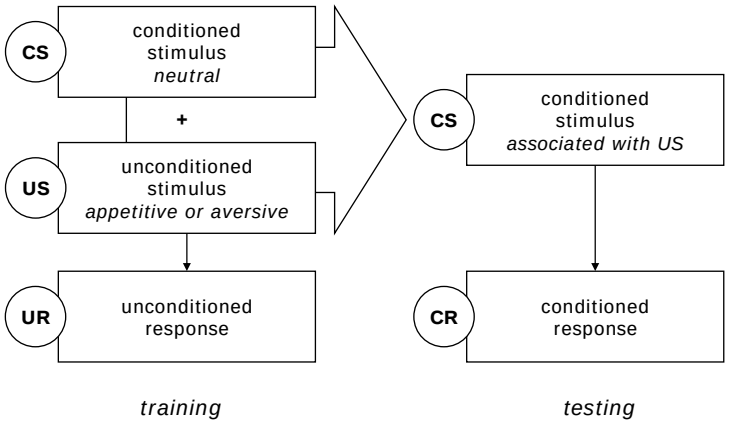
Often activated simultaneously!

Types of nondeclarative memory



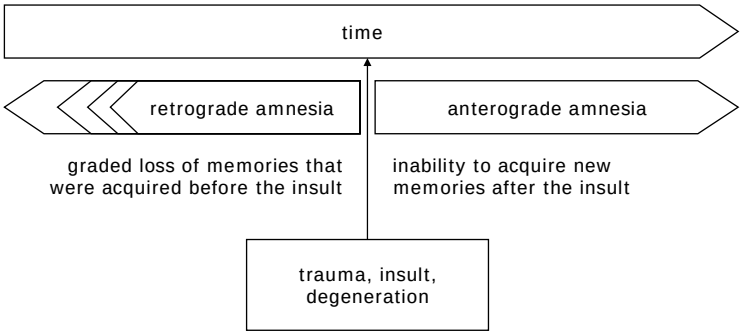
Often activated simultaneously!

Classical (Pavlovian) conditioning

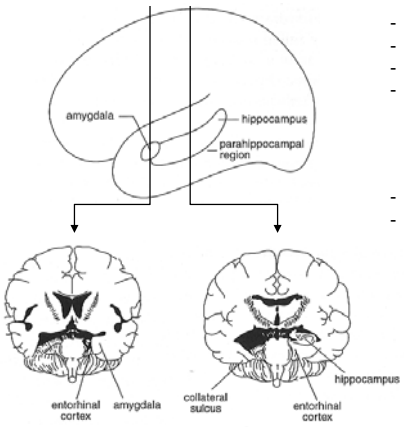


Amnesia

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



Patient H.M.



- born 1926
- 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

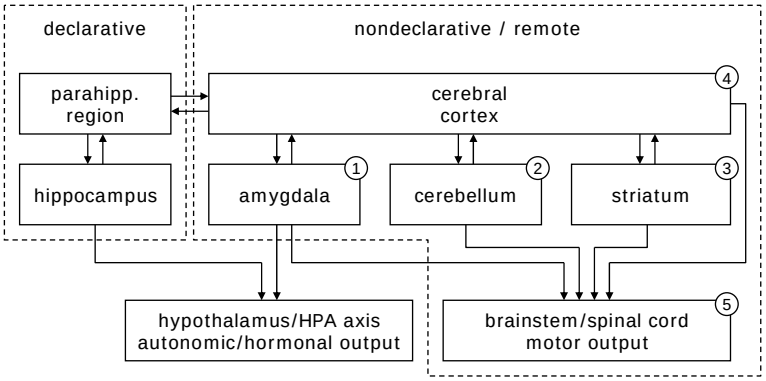
Cellular and molecular level

- 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



① emotional memory
② motor learning
③ habits & skills
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)
- habit learning
  - dry land and water mazes (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)