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Learning and Memory

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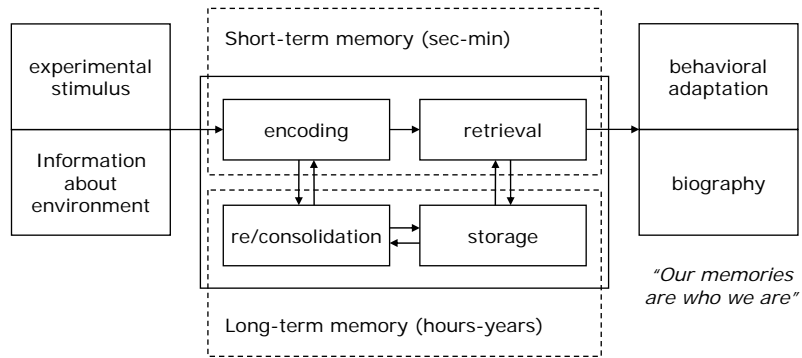
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Processes in learning and memory

experimental stimulus		behavioral adaptation
Information about environment		biography

Short-term memory (sec-min)

encoding	→	retrieval
re/consolidation	→	storage

Long-term memory (hours-years)

"Our memories are who we are"

Consolidation: memory fixation – reorganization (systems consolidation)

Declarative and nondeclarative memory
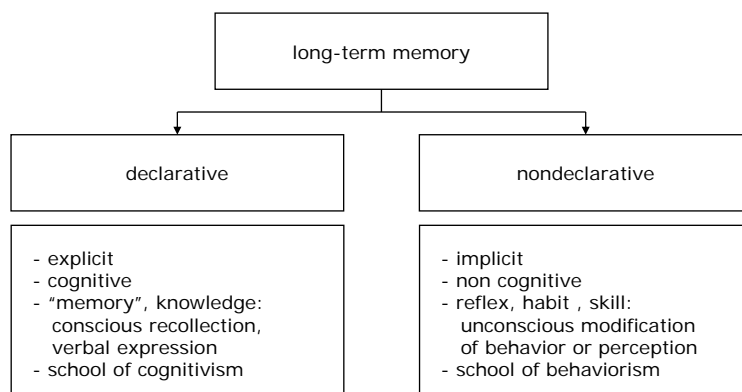
long-term memory

declarative	nondeclarative

- explicit
 - cognitive
 - "memory", knowledge:
   conscious recollection,
   verbal expression
 - school of cognitivism
	- implicit
	 - non cognitive
	 - reflex, habit , skill:
	   unconscious modification
	   of behavior or perception
	 - school of behaviorism

Often activated simultaneously!

Types of declarative memory

```
              ┌─────────────────────────┐
              │   declarative memory    │
              └─────────────────────────┘
                 │                   │
        ┌────────┘                   └────────┐
        ▼                                     ▼
┌─────────────────┐                 ┌─────────────────┐
│ episodic memory │                 │ semantic memory │
└─────────────────┘                 └─────────────────┘

┌─────────────────────────┐   ┌─────────────────────────────┐
│ - re-experienced events │   │ - acquired knowledge        │
│ - personal experiences  │   │ - general facts,            │
│   embedded in unique    │   │   independent of context of │
│   spatial and temporal  │   │   acquisition               │
│   context               │   │ - can be rehearsed          │
│ - "one trial"           │   │                             │
└─────────────────────────┘   └─────────────────────────────┘
```

Often activated simultaneously!

Types of nondeclarative memory

```
              ┌─────────────────────────┐
              │  nondeclarative memory  │
              └─────────────────────────┘
                 │                   │
        ┌────────┘                   └────────┐
        ▼                                     ▼
┌─────────────────┐                 ┌─────────────────┐
│   associative   │                 │  nonassociative │
└─────────────────┘                 └─────────────────┘

┌──────────────────────────────┐   ┌──────────────────────────┐
│ - classical conditioning      │   │ - sensory priming         │
│   (Pavlov: stimulus-stimulus) │   │ - habituation, sensitization │
│ - operant conditioning        │   │ - motor/skill learning    │
│   (Skinner: behavior-stimulus)│   │ - habit formation         │
└──────────────────────────────┘   └──────────────────────────┘
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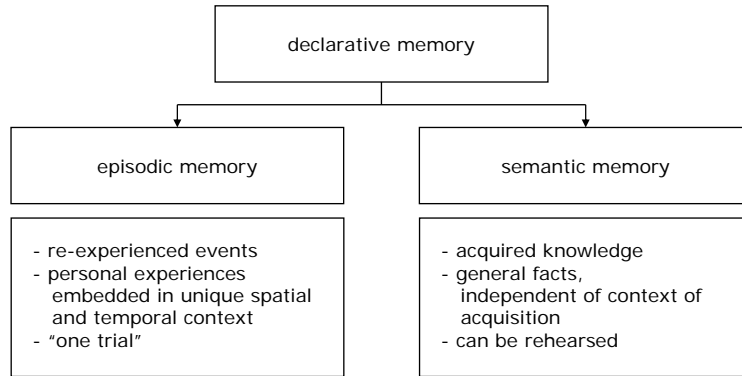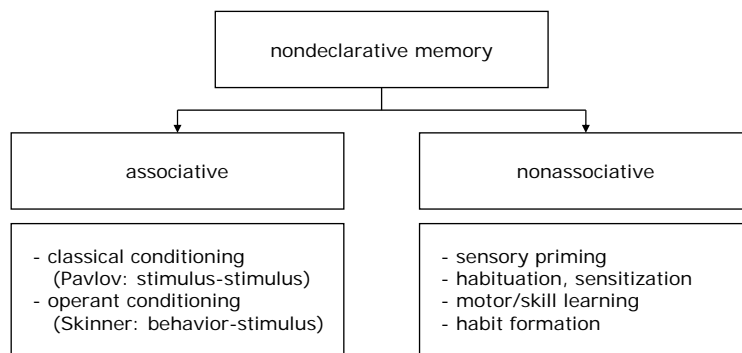
Often activated simultaneously!

Classical (Pavlovian) conditioning

CS — conditioned stimulus *neutral*

+

US — unconditioned stimulus *appetitive or aversive*

UR — unconditioned response

training

CS — conditioned stimulus *associated with US*

CR — conditioned response

testing
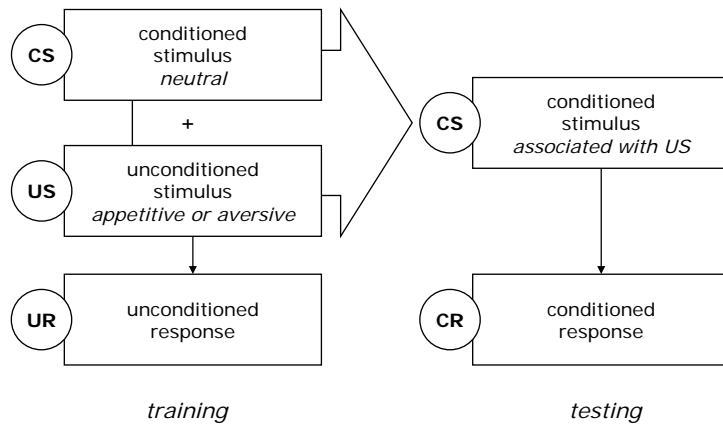
Amnesia

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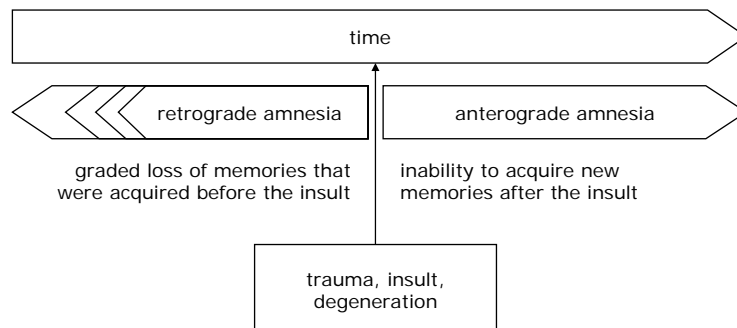
Patient H.M.
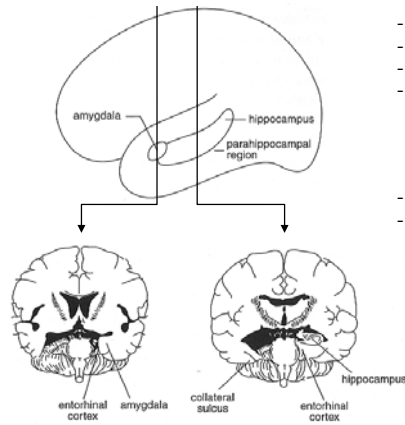
- born 1926
- 1933 knocked down by bicycle
- development of uncontrollable epilepsy
- 1953 bilateral medial temporal lobe resection
  by William Scoville

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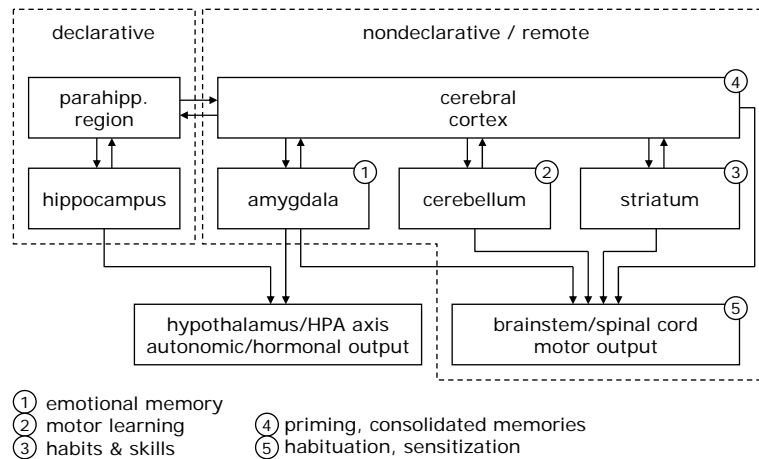
Cellular and molecular level
- Role of cellular processes: signaling cascades, protein phosphorylation,
  protein synthesis, gene expression, cell motility & proliferation
- Role of specific genes, proteins and their interactions

Simulation
- mathematical models, computer simulation
- electronic circuits, robots

Simplified anatomical framework for memory

1 emotional memory
2 motor learning   4 priming, consolidated memories
3 habits & skills   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)

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 conditioning (rat, mouse)
- trace eye blink conditioning (rabbit, 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)