Key Concepts and Principles of Learning and Memory

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W. M. Keck Center for the Neurobiology on Learning and Memory
1. What are the different types of memory?
2. Where in the brain is memory located?
3. How does memory work?
4. How can memory be enhanced?
Memory
  
Declarative (Explicit)
  
- Facts
  
- Events

Nondeclarative (Implicit)
  
- Skills and Habits
- Priming
- Simple Classical Conditioning
- Nonassociative Learning (Habituation, Sensitization)

- Emotional Responses
- Skeletal Musculature
Memory Test
Where in the brain is memory located?
Patient H. M.
Memory

Declarative (Explicit)
- Facts
  - Medial Temporal Lobe
    - Diencephalon
- Events
  - Striatum
  - Neocortex

Nondeclarative (Implicit)
- Skills and Habits
  - Simple Classical Conditioning
    - Emotional Responses
    - Skeletal Musculature
- Priming
  - Amygdala
  - Cerebellum
- Nonassociative Learning (Habituation, Sensitization)
  - Reflex Pathways
Mechanisms of Memory and How to Study Them
A

- Sensitizing Stimuli
- Test Site
- Tail
- Siphon

B

Protocol for Long-term Memory

- pre-test (5 trials, ISI = 20 min)
- 1 day post-test
- 5 days post-test
“…with any considerable number of repetitions a suitable distribution of them over a space of time is decidedly more advantageous than the massing of them at a single time.”

Memory Genes

Learning
Nerve Activity

Transcriptional Activators

CYTOPLASM

NUCLEUS

Time Domains
Early (0.5-2 h)
Intermediate (3-12 h)
Late (~24h)
Very Late (~48 h)

Genes

Proteins
+ C/EBP
+ CaM
+ PGK
+ apTBL-1
+ apCAM
+ Clathrin
+ Protein 3
+ apUCH
+ BiP
+ BiP
+ CaM
+ Calreticulin
+ Actin
+ IFP
Memory Enhancement
Transgenic Mice

Injection
memory gene

mouse eggs

Embryo implanted in uterus of surrogate mother

Offspring
Memory Test

Session 1:
- Novel sphere
- Novel block

Session 2:
- Same sphere
- Novel star

Graph:
- Y-axis: Memory (%)
- X-axis: Time (1 hour, 1 day, 3 days, 1 week)
- Normal mouse: Red line and markers
- Transgenic mouse: Blue line and markers
\[
\frac{d}{dt} \text{cAMP} = \lambda \frac{5-HT}{5-HT + K_{5HT}} - k_{b,\text{cAMP}} \text{cAMP}
\]

\[
\frac{d}{dt} \text{PKA}_R = k_{f,\text{PKA}} \text{PKA}_R \text{cAMP}^2 - k_{b,\text{PKA}} \text{PKA}_C \text{PKA}_R
\]

\[
\frac{d}{dt} \text{PKA}_C = k_{f,\text{PKA}} \text{PKA}_R \text{cAMP}^2 - k_{b,\text{PKA}} \text{PKA}_C \text{PKA}_R
\]

\[
\frac{d}{dt} \text{MEK} = \frac{k_{b,\text{MEK}} \text{MEK}^p}{\text{MEK}^p + K_{\text{MEK},2}} - \frac{k_{f,\text{MEK}} \text{Raf}^p \text{MEK}}{\text{MEK} + K_{\text{MEK},1}}
\]

\[
\frac{d}{dt} \text{MEK}^{pp} = \frac{k_{f,\text{MEK}} \text{Raf}^p \text{MEK}^p}{\text{MEK}^p + K_{\text{MEK},1}} - \frac{k_{b,\text{MEK}} \text{MEK}^{pp}}{\text{MEK}^{pp} + K_{\text{MEK},2}}
\]

\[
\frac{d}{dt} \text{ERK} = \frac{k_{b,\text{ERK}} \text{ERK}^p}{\text{ERK}^p + K_{\text{ERK},2}} - \frac{k_{f,\text{ERK}} \text{MEK}^{pp} \text{ERK}}{\text{ERK} + K_{\text{ERK},1}}
\]

\[
\frac{d}{dt} \text{ERK}^{pp} = \frac{k_{f,\text{ERK}} \text{MEK}^{pp} \text{ERK}^p}{\text{ERK}^p + K_{\text{ERK},1}} - \frac{k_{b,\text{ERK}} \text{ERK}^{pp}}{\text{ERK}^{pp} + K_{\text{ERK},2}}
\]

\[
\text{inducer} = k_{\text{inducer}} \text{PKA}_C \text{ERK}^{pp}
\]
A. Protocol 1  (ISIs = 5, 5, 5, & 5 min)

B. Protocol 10  (ISIs = 5, 5, 5, & 50 min)

C. Protocol 1,106  (ISIs = 10, 10, 5, & 30 min)

D. Protocol 3,334  (ISIs = 20, 20, 20, & 20 min)

E. Protocol 5,522  (ISIs = 30, 30, 15, & 10 min)

F. Protocol 10,000  (ISIs = 50, 50, 50, & 50 min)

Time (min)
**Schedule of Classes**

**NEUROSCI 161S NEUROBIO LEARNING/MEMORY**

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<tr>
<th>Course Code</th>
<th>Section</th>
<th>Type</th>
<th>Time</th>
<th>Location</th>
<th>Instructor</th>
<th>Seat Cap</th>
<th>Enrolled</th>
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<tbody>
<tr>
<td>4501 Sec. 01 SEM</td>
<td>MW</td>
<td>11:40 AM-12:55 PM</td>
<td>Perkins 2-059</td>
<td>Roberts, Craig D</td>
<td>Seat Cap: 6.00</td>
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**NEUROSCI 166 BEHAVIORAL NEUROIMMUNOLOGY (B)**

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<td>WF</td>
<td>10:05 AM-11:20 AM</td>
<td>Sociology/Psychology 129</td>
<td>Bilbo, Staci D</td>
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**NEUROSCI 167 NEURO APPROACHES TO SOC BEHAV**

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<td>02:50 PM-04:05 PM</td>
<td>To Be Announced</td>
<td>Harris, Lasana</td>
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**NEUROSCI 1/3L Functional Neuroanatomy**

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<td>L.S.R.C. B102</td>
<td>White, Leonard E</td>
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**NEUROSCI 233 ESSENTIALS PHARM/TOXICOL**

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