The Neuroscience of Learning

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Key Information

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Course Outline

Week One: How We Learn
- Topic 1. Repetition and Hebbian Learning
- Topic 2. Feedback and Types of Learning

Week Two; How We Learn
- Topic 1. Long Term Potentiation and Synaptic Plasticity
- Topic 2. Dopamine and the Basal Ganglia

Week Three: What We Learn
- Topic 1. Explicit Memory
- Topic 2. Implicit Memory

Week Four: What We Learn
- Topic 1. Neural Basis of Memory
- Topic 2. Internal Models

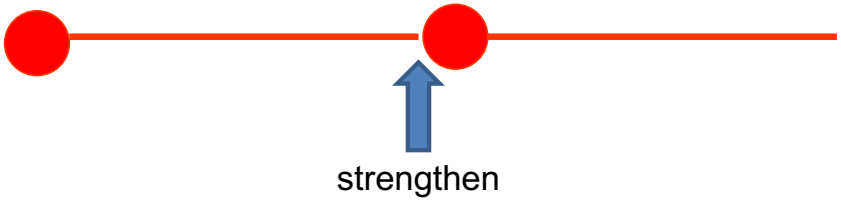
Week Five: How We Can Improve Learning
- Topic 1. Distributed Practice, Random Practice, Variable Practice
- Topic 2. Specificity of Practice, Part-Whole Practice, Mental Imagery

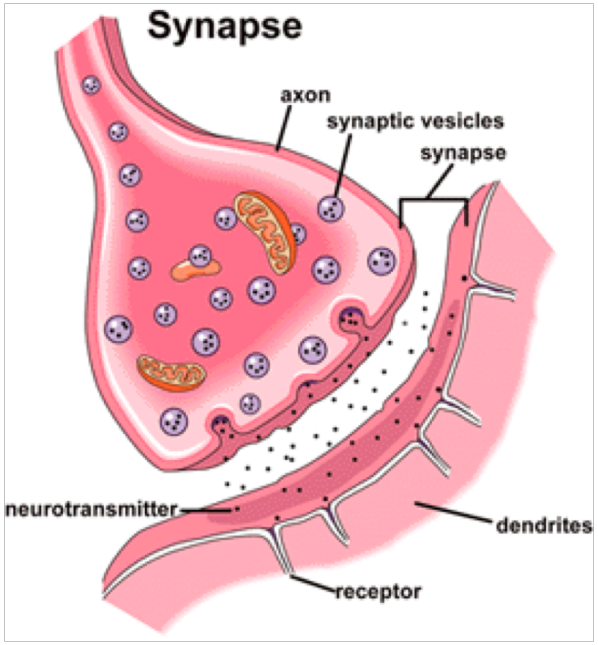
Week Six: How We Can Improve Learning
- Topic 1. Sleep, Diet, and Exercise
- Topic 2. Age, Learning Disorders

How do we learn?

REPETITION and FEEDBACK

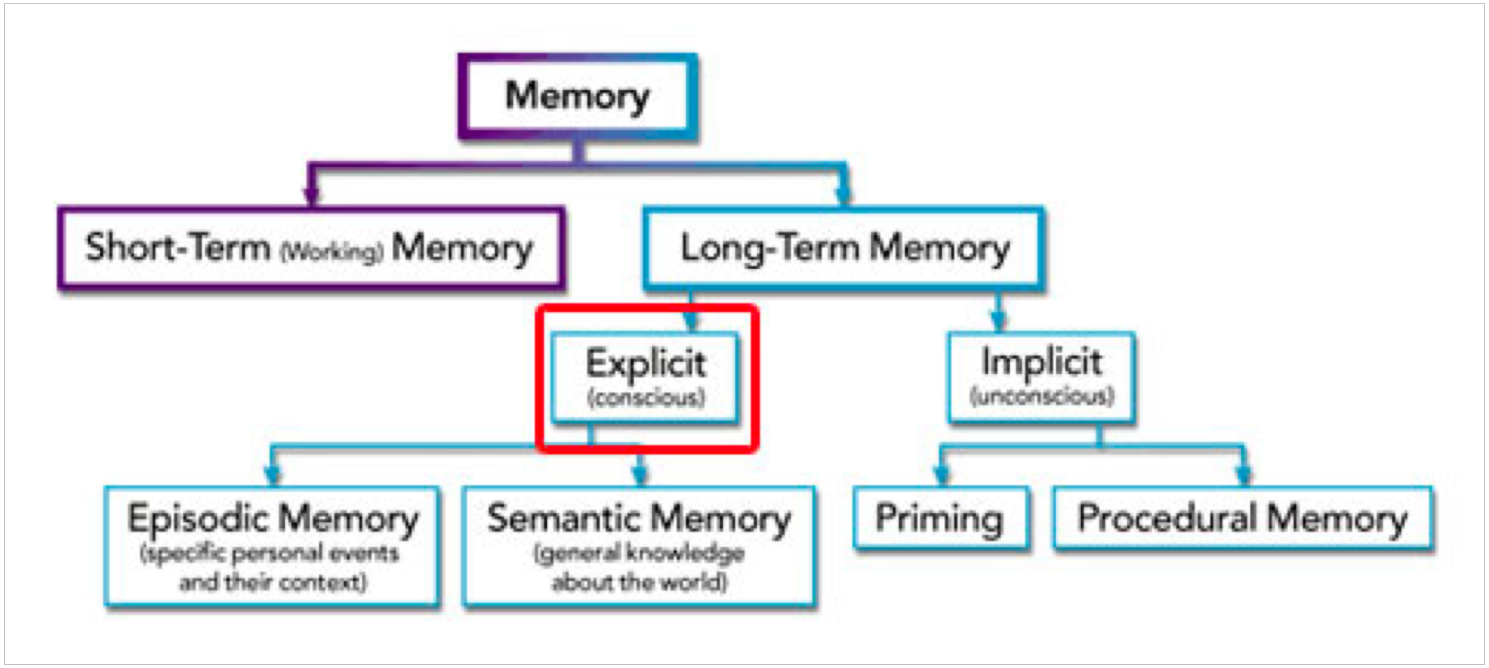
But what do we learn?





HOW?

Increased neurotransmitter release
Increase receptors
Structural changes


Memory
Short-Term (Working) Memory
Long-Term Memory
Explicit
(conscious)
Implicit
(unconscious)
Episodic Memory
(specific personal events
and their context)
Semantic Memory
(general knowledge
about the world)
Priming
Procedural Memory

Episodic Memories

- “I remember”
- Tagged with spatial and temporal context
- Learned in a single exposure

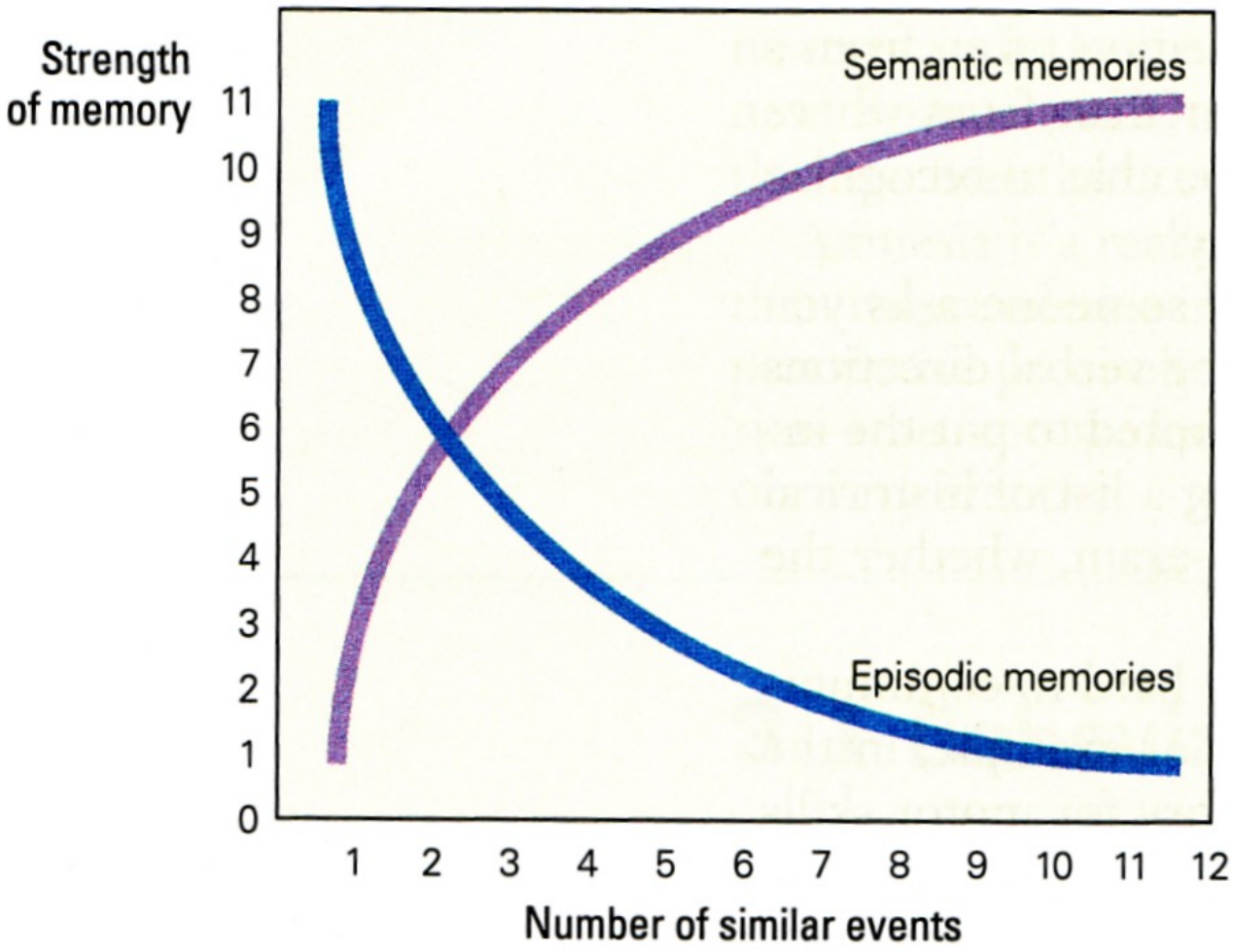
Semantic Memories

- “I know”
- Does not have to have spatial and temporal context
- Learned in a single exposure, but strengthened with repetition

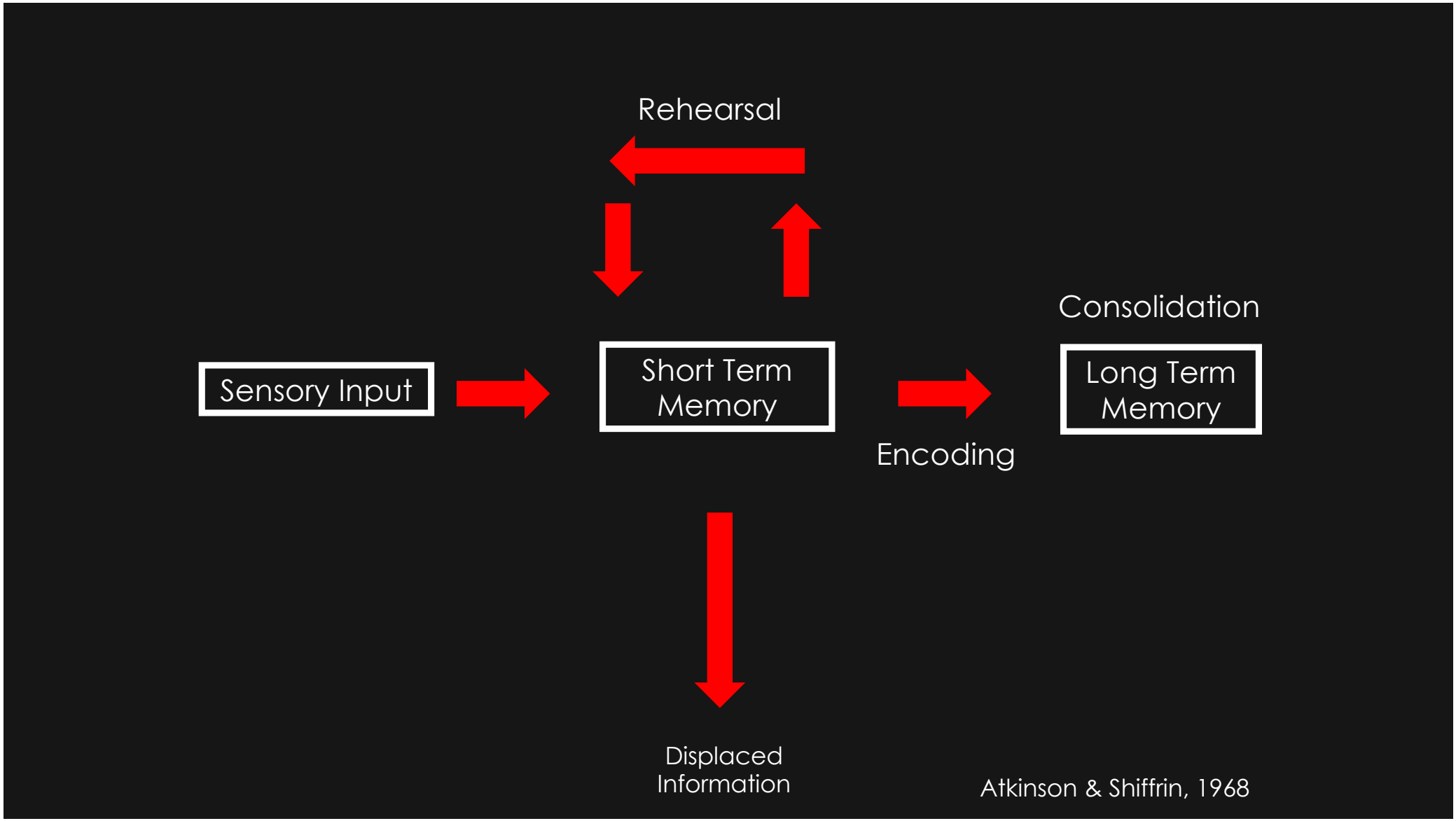
Episodic and Semantic Memories

- Can be communicated flexibly in a format other than they were acquired

- Consciously accessible


Strength of memory
11
10
9
8
7
6
5
4
3
2
1
0
Semantic memories
Episodic memories
1
2
3
4
5
6
7
8
9
10
11
12
Number of similar events

Stages of Memory


Rehearsal
Consolidation
Sensory Input
Short Term Memory
Long Term Memory
Encoding
Displaced Information
Atkinson & Shiffrin, 1968

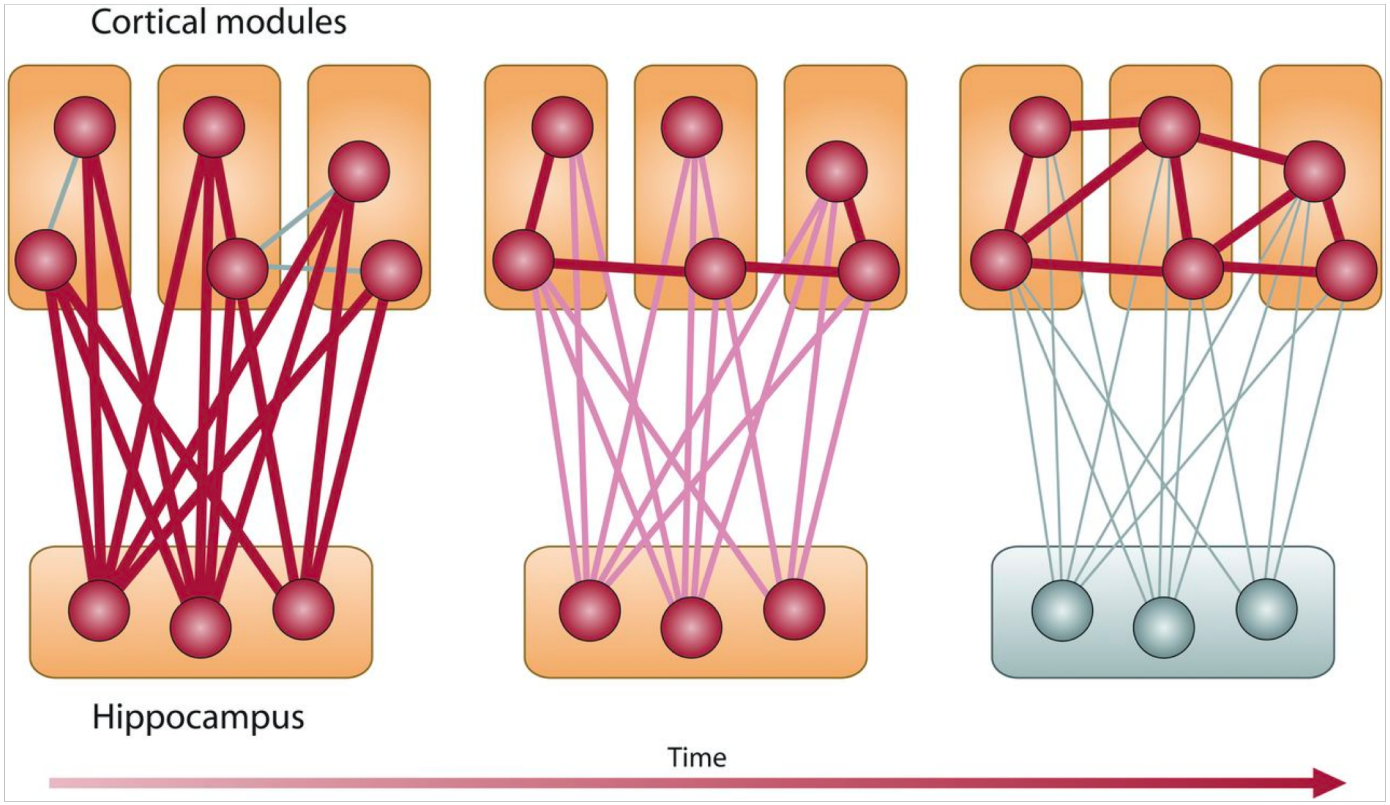
Stages of Memory Formation

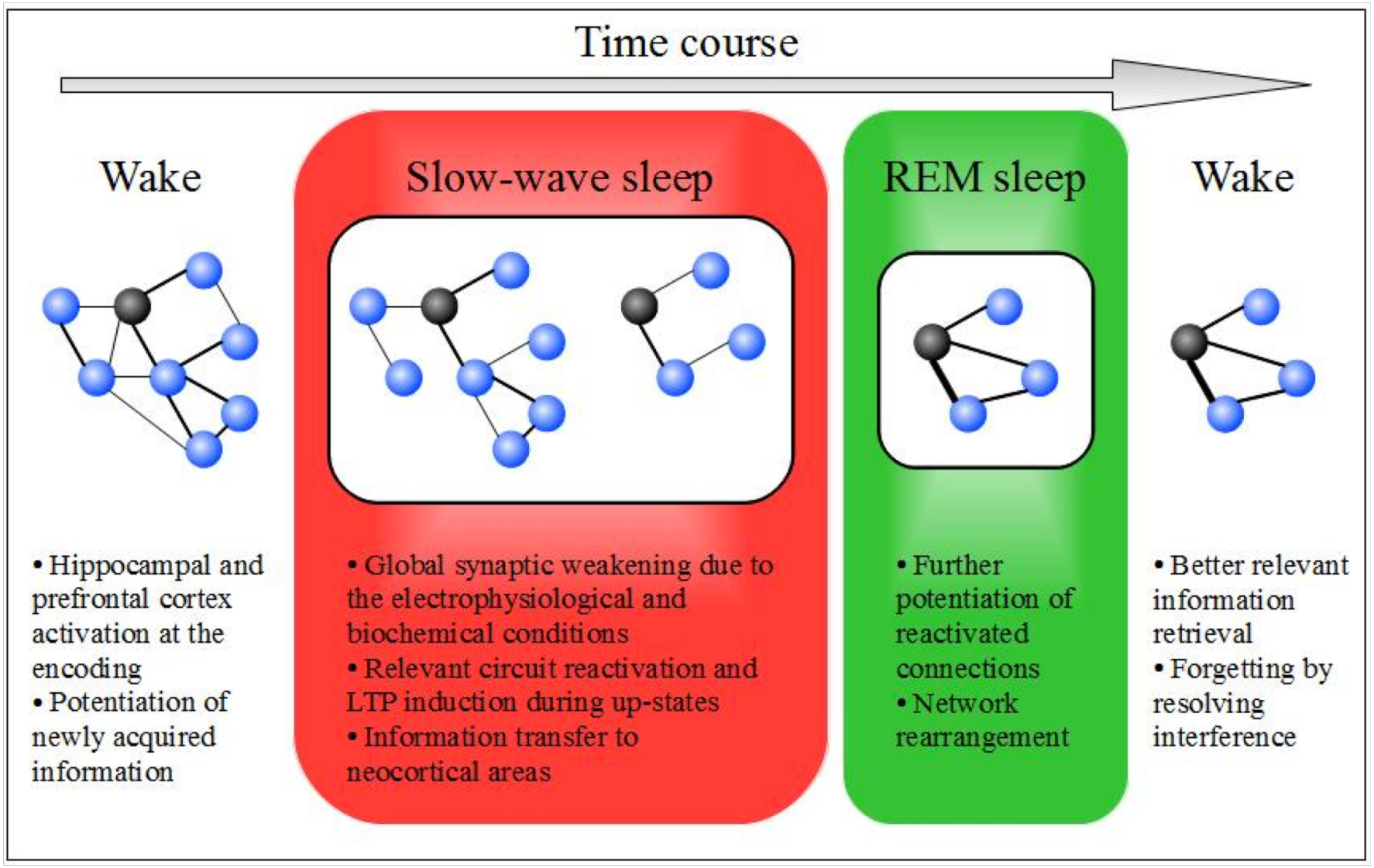
1. Encoding
2. Consolidation
3. Retention
4. Retrieval

Stages of Memory - Encoding Storage and Retrieval

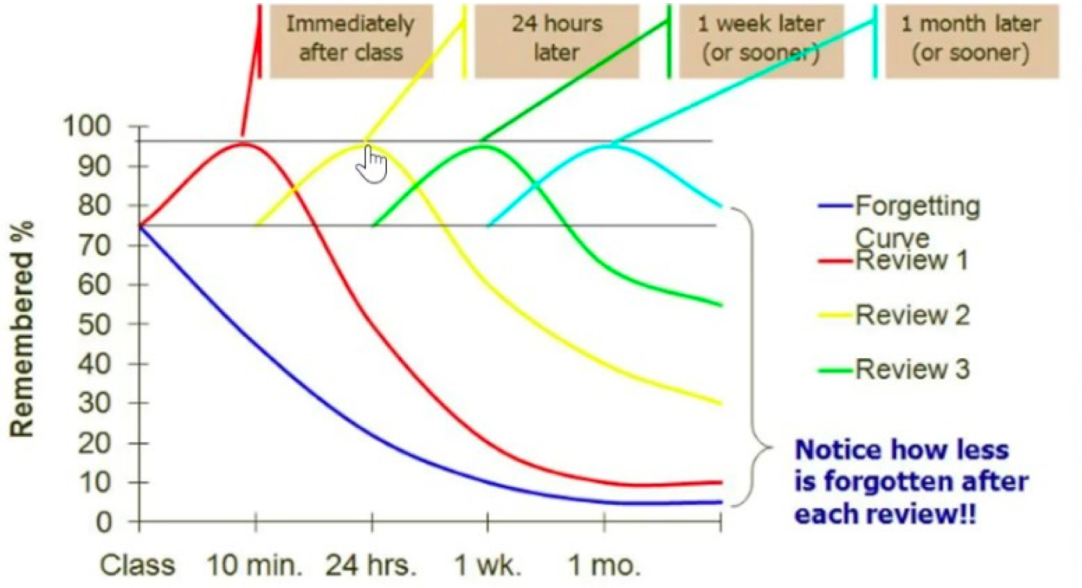
- For psychologists the term memory covers three important aspects of information processing:
- **1. Memory Encoding**
- When information comes into our memory system (from sensory input), it needs to be changed into a form that the system can cope with, so that it can be stored.
  - Think of this as similar to changing your money into a different currency when you travel from one country to another.
  - For example, a word which is seen (in a book) may be stored if it is changed (encoded) into a sound or a meaning (i.e. semantic processing).
- There are three main ways in which information can be encoded (changed):
  - **1. Visual (picture)**
  - **2. Acoustic (sound)**
  - **3. Semantic (meaning)**
- For example, how do you remember a telephone number you have looked up in the phone book?
  - If you can see it then you are using visual coding, but if you are repeating it to yourself you are using acoustic coding (by sound).

Consolidation



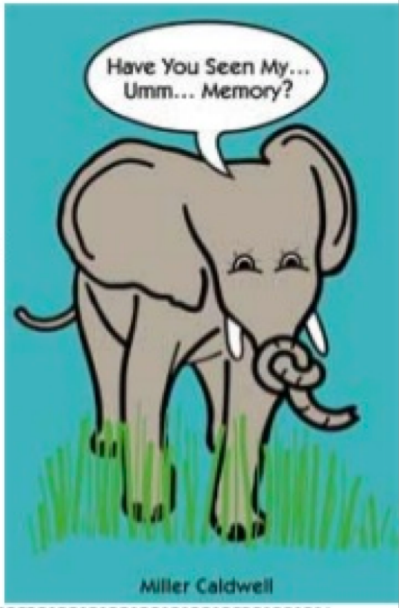

Time course
Wake
Slow-wave sleep
REM sleep
Wake
• Hippocampal and prefrontal cortex activation at the encoding
• Potentiation of newly acquired information
• Global synaptic weakening due to the electrophysiological and biochemical conditions
• Relevant circuit reactivation and LTP induction during up-states
• Information transfer to neocortical areas
• Further potentiation of reactivated connections
• Network rearrangement
• Better relevant information retrieval
• Forgetting by resolving interference

Retention


Immediately after class
24 hours later
1 week later (or sooner)
1 month later (or sooner)
Remembered %
100
90
80
70
60
50
40
30
20
10
0
Class
10 min.
24 hrs.
1 wk.
1 mo.
Forgetting Curve
Review 1
Review 2
Review 3
Notice how less is forgotten after each review!!

Retrieval: Accessing information from the semantic network

- **Retrieval Failures**
  - Decay: Weakening of nodes or links over time
    - Sleeper effect: remember the message, but not the source
  - Interference: Signals getting mixed up
    - E.g. similar ads
  - Primacy and Recency Effects
    - Greater memory for information that comes first or last in a sequence
- **Retrieval Errors**
  - Memory is subject to distortion and confusion



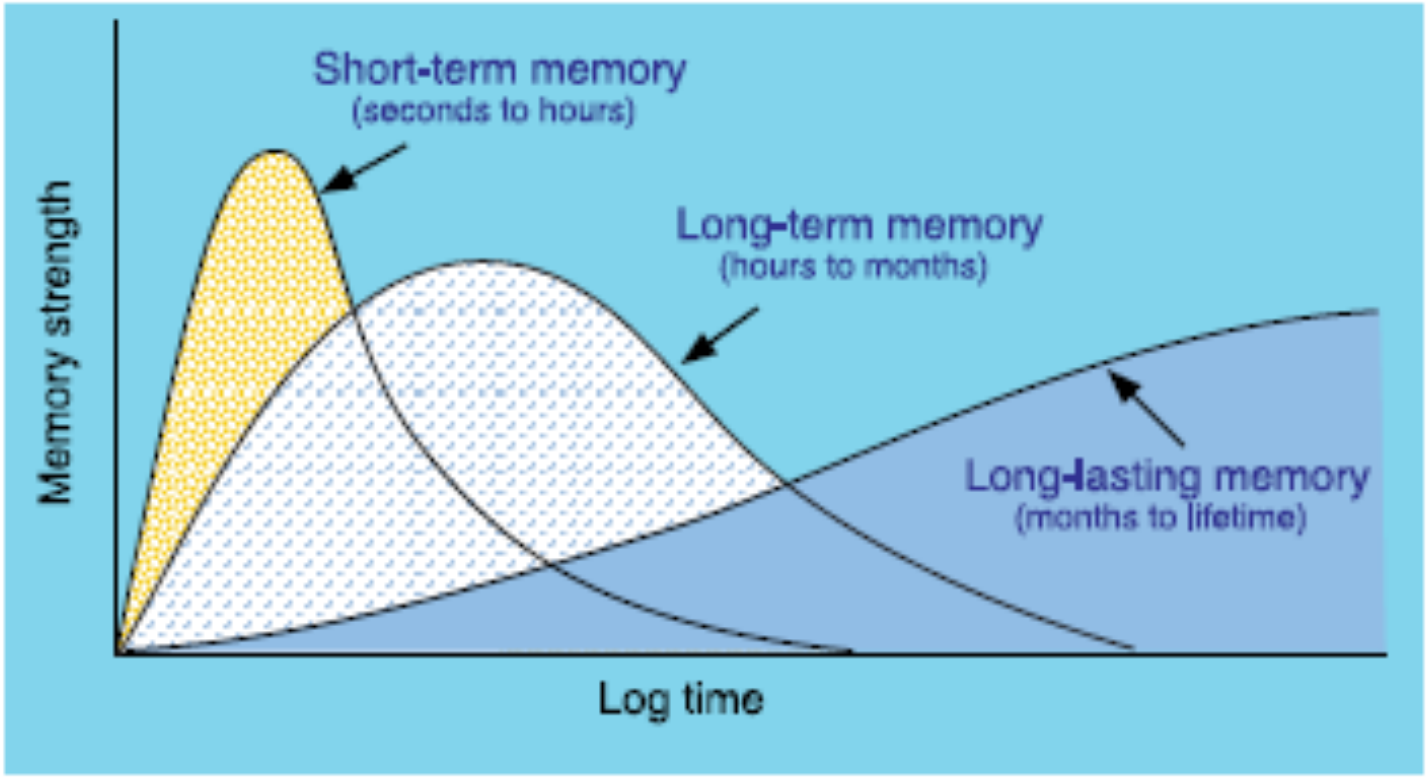
So what is stored?

Trace Levels

- Sensory Trace (< 1 s)
- Short Term Trace (develops within seconds or minutes and last for hours)
- Long Term Trace
- Long Lasting Trace

Class Discussion

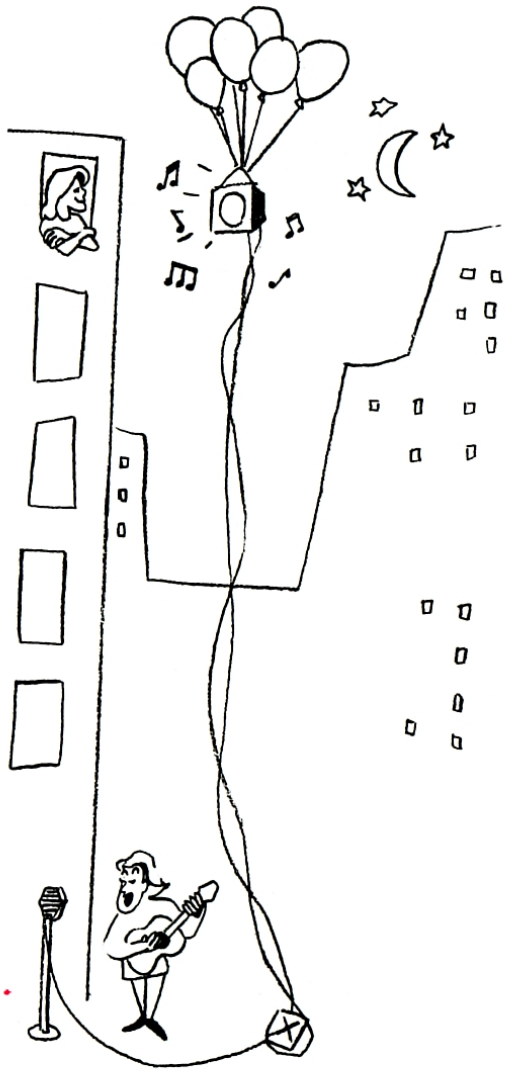
- What is a memory trace?


Short-term memory
(seconds to hours)
Long-term memory
(hours to months)
Long-lasting memory
(months to lifetime)
Memory strength
Log time

Factors which influence semantic and episodic memory formation

Context

If the balloons popped, the sound wouldn't be able to carry, since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying, since most buildings tend to be well-insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face-to-face contact, the least number of things could go wrong.



(b)

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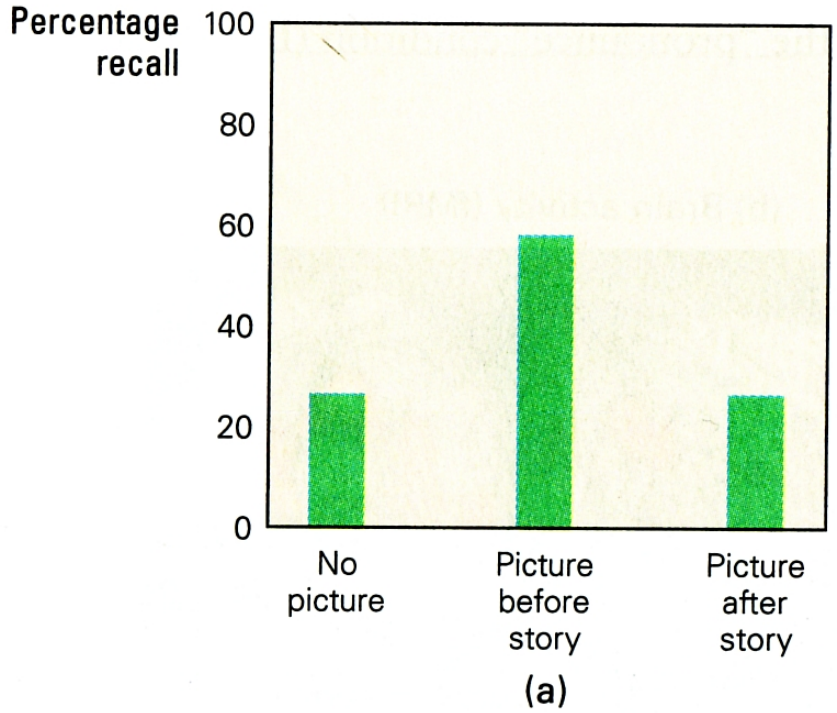
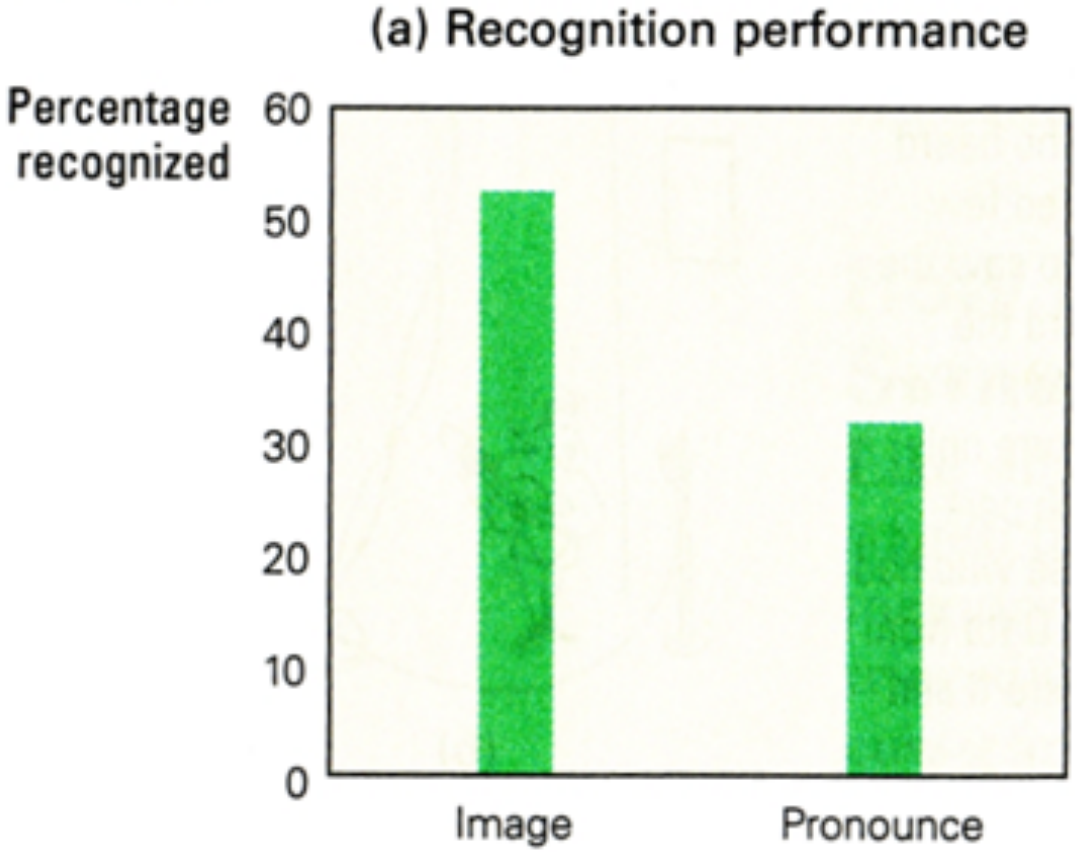


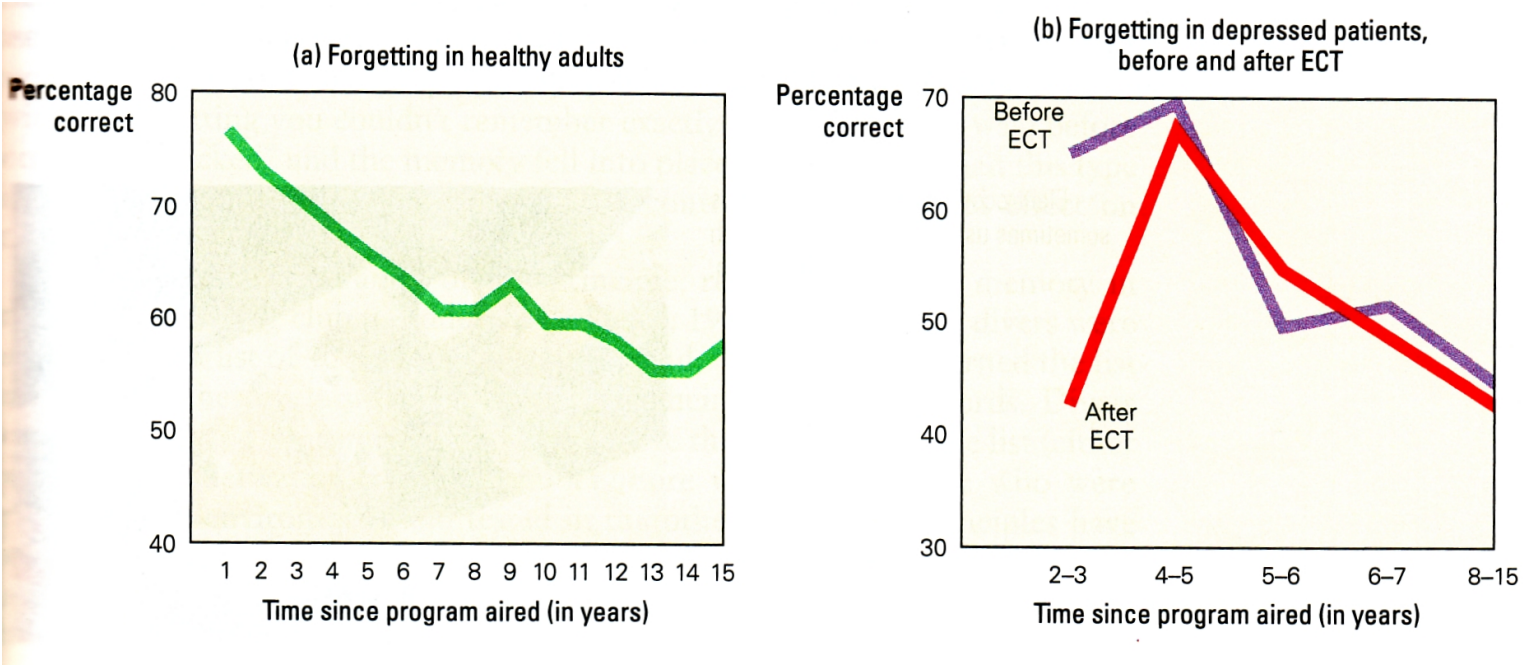
Figure 3.3 The effects of organization on memory An experimenter read aloud to participants a paragraph describing a scene. (a) Participants who heard the paragraph alone recalled few items; but participants who saw the picture in (b) and then heard the paragraph recalled more items. Participants who saw the picture only after hearing the paragraph performed no better than those who had never seen the picture. (a) Data from and (b) adapted from Bransford and Johnson, 1972.

Depth of Processing

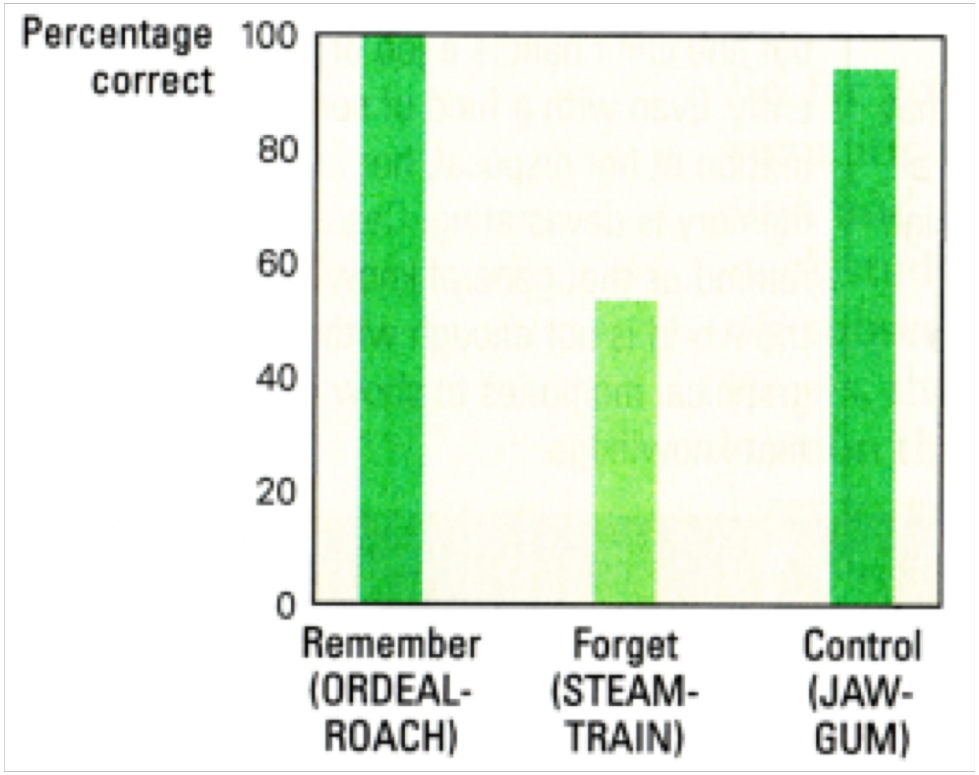


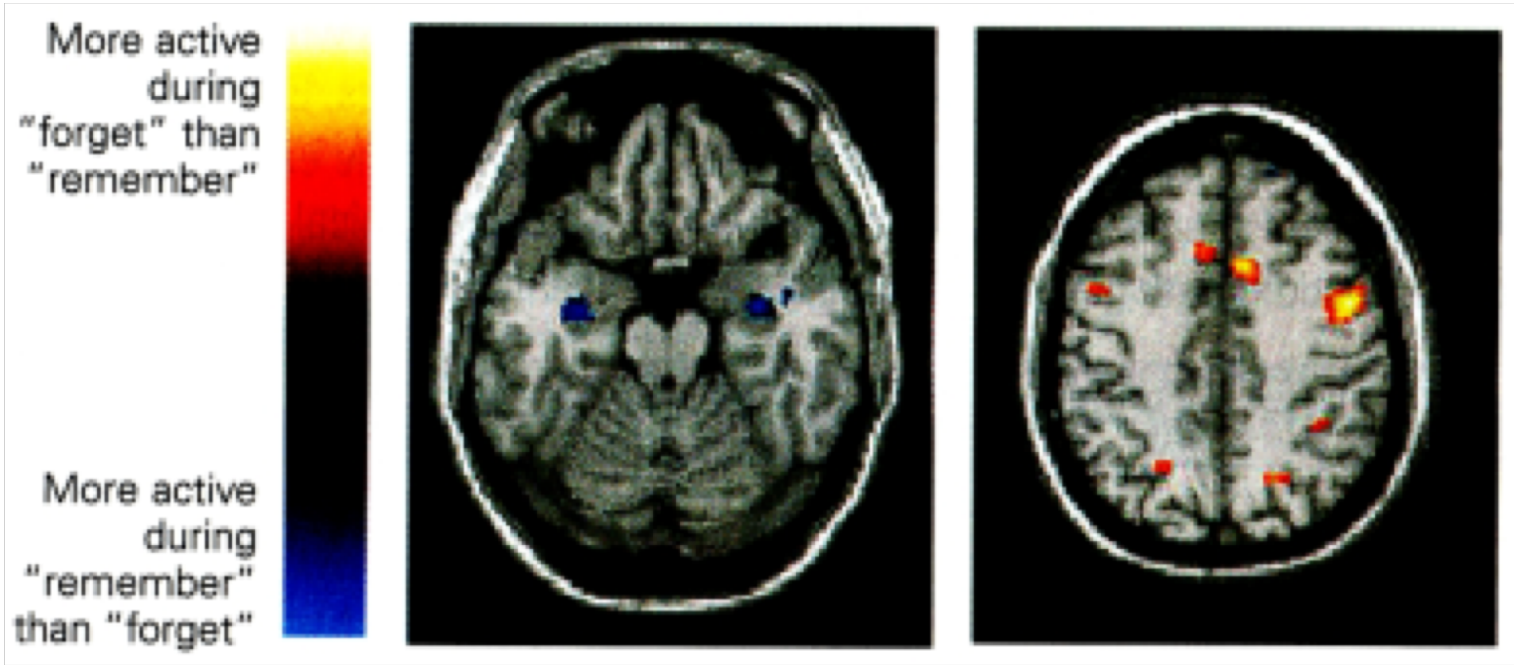
Depth of processing facilitates encoding

Interference during consolidation disrupts memory encoding


(a) Forgetting in healthy adults
Percentage correct
80
70
60
50
40
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Time since program aired (in years)
(b) Forgetting in depressed patients, before and after ECT
Percentage correct
70
60
50
40
30
Before ECT
After ECT
2–3
4–5
5–6
6–7
8–15
Time since program aired (in years)

Memory Loss and Deficits


Percentage correct
100
80
60
40
20
0
Remember (ORDEAL-ROACH)
Forget (STEAM-TRAIN)
Control (JAW-GUM)


More active during "forget" than "remember"
More active during "remember" than "forget"

Interference

Proactive

Previously acquired information interferes with new learning

Retroactive

Acquisition of new information disrupts old memories

Amnesia

Anterograde

Inability to form new memories

Retrograde

Loss of old memories

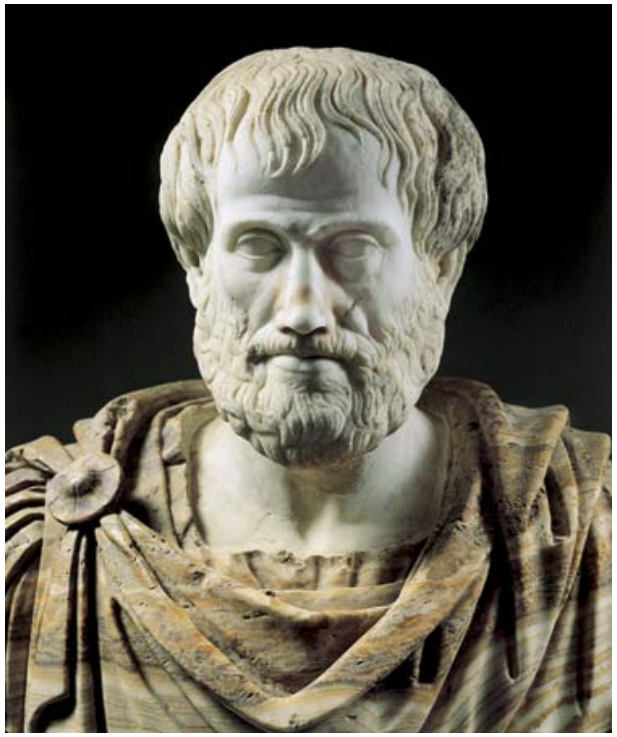
Source Amnesia

- Remembering the photograph, not the event

Cryptomnesia – the plagiarists excuse

- thinking your current thoughts and ideas are original

Models for episodic and semantic memory



Aristotle

Associationism

- Linkages between events or ideas

Three Principles

- Contiguity
- Frequency
- Similarity

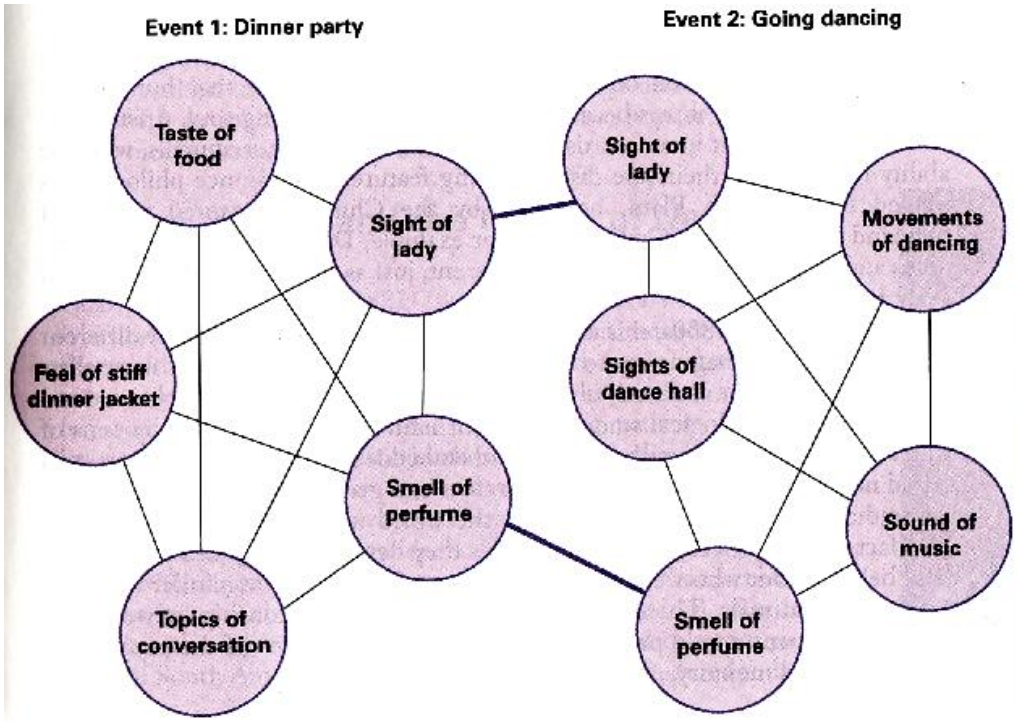


Figure 1.2 William James's memory model Memory of an event, such as a dinner party, has multiple components, such as the taste of the food, the topics of conversation, and the smell of perfume, all linked together. Another event, such as going dancing with a lady from the dinner party, also has component parts linked together. An association between the two events in turn consists of multiple connections between the underlying components.

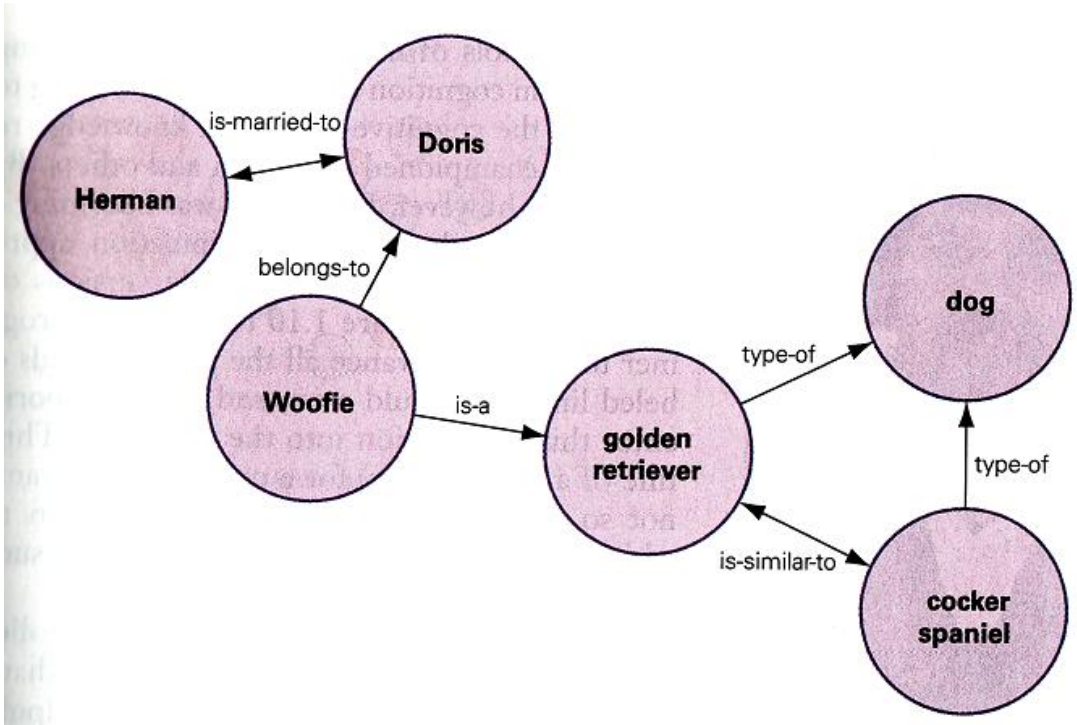
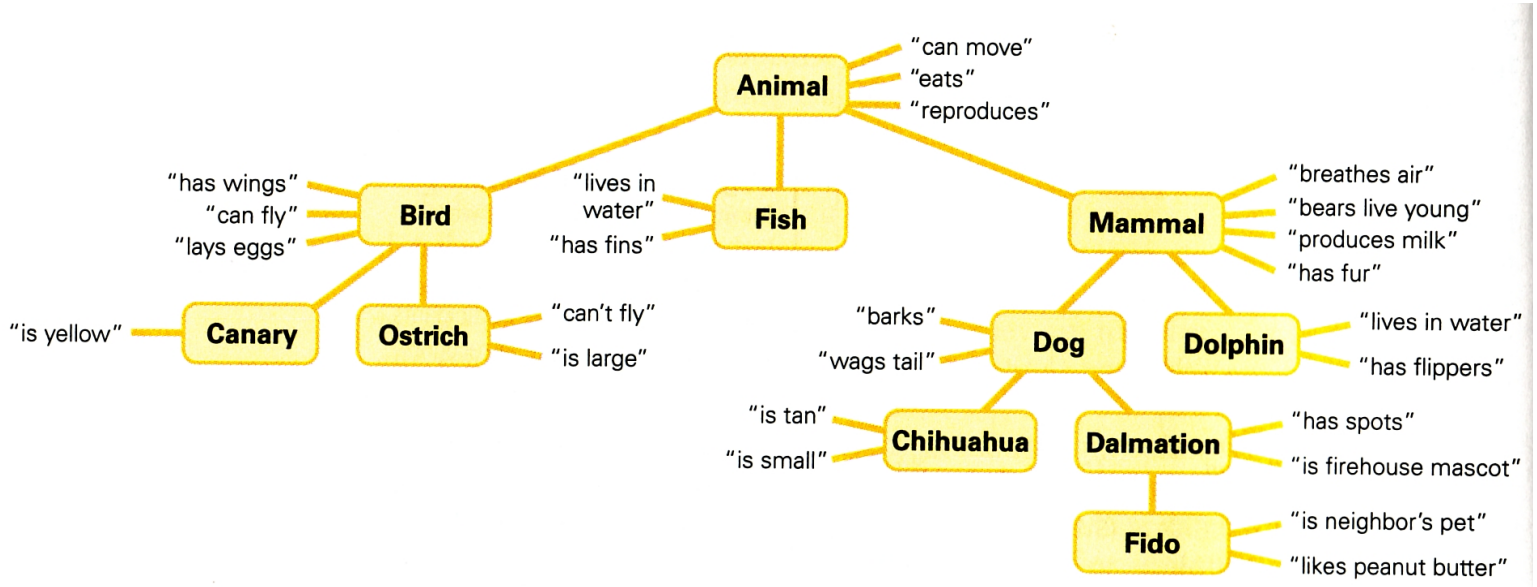


Figure 1.10 A symbol-manipulation model of memory Symbols, shown here as circles, represent different animals, objects, and people. Associations between symbols are encoded as labeled lines that specify certain relationships, such as "is-a," "is-similar-to," and "belongs-to."


Animal
"can move"
"eats"
"reproduces"
Bird
"has wings"
"can fly"
"lays eggs"
Fish
"lives in water"
"has fins"
Mammal
"breathes air"
"bears live young"
"produces milk"
"has fur"
Canary
"is yellow"
Ostrich
"can't fly"
"is large"
Dog
"barks"
"wags tail"
Dolphin
"lives in water"
"has flippers"
Chihuahua
"is tan"
"is small"
Dalmation
"has spots"
"is firehouse mascot"
Fido
"is neighbor's pet"
"likes peanut butter"

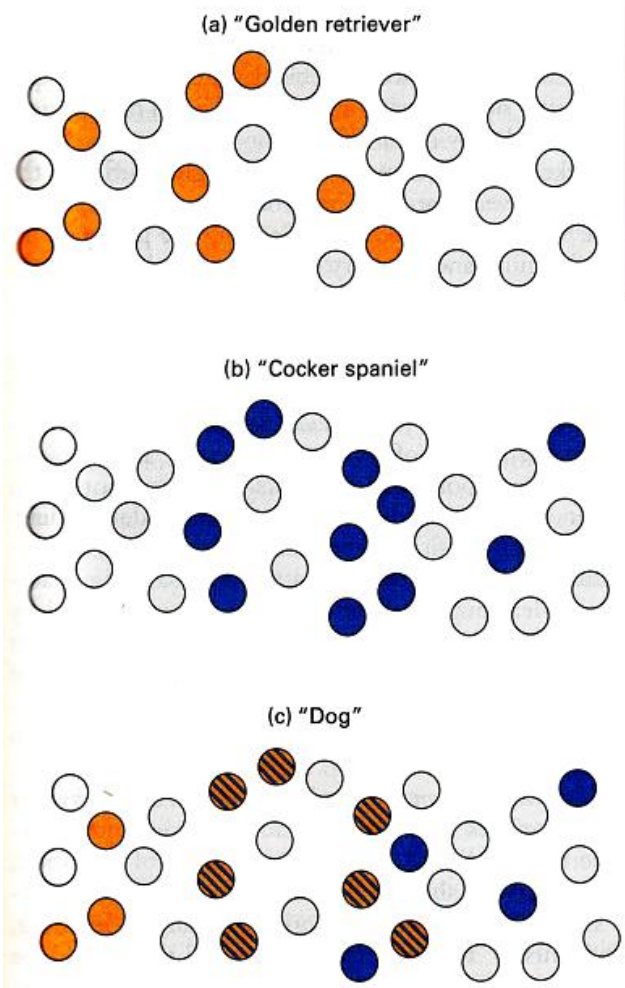
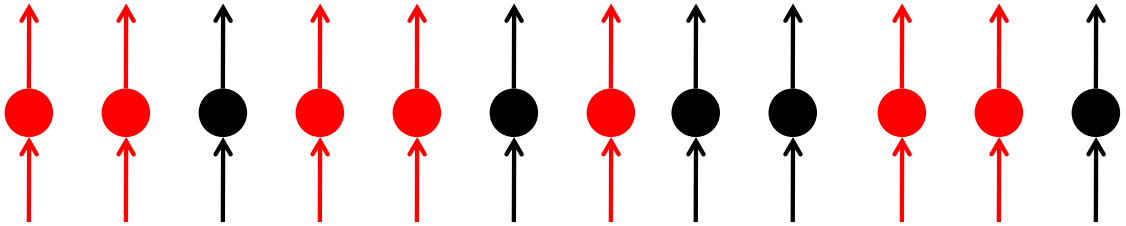
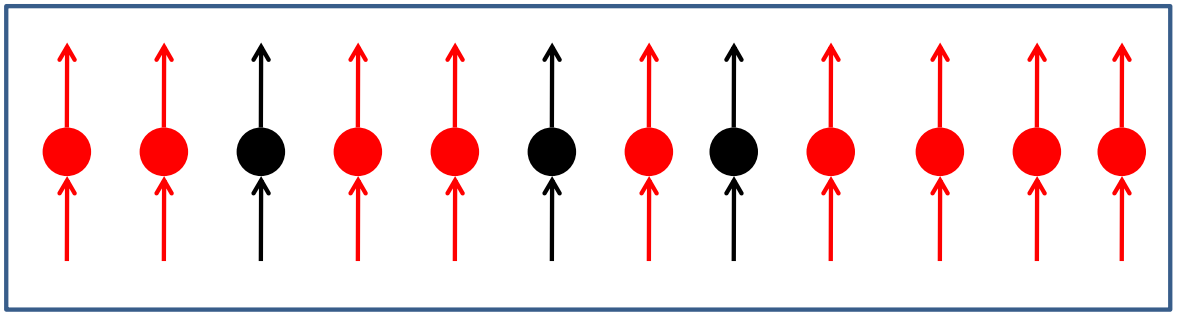


Figure 1.11 Distributed representations (a) The representation of "golden retriever" activates one subset of nodes, shown in yellow. (b) "Cocker spaniel" activates a different subset, shown in blue. (c) The similarity between them—both are dogs—emerges naturally as a function of the overlap between representations, shown by the yellow-and-blue nodes.





Dog

Run

Seawall

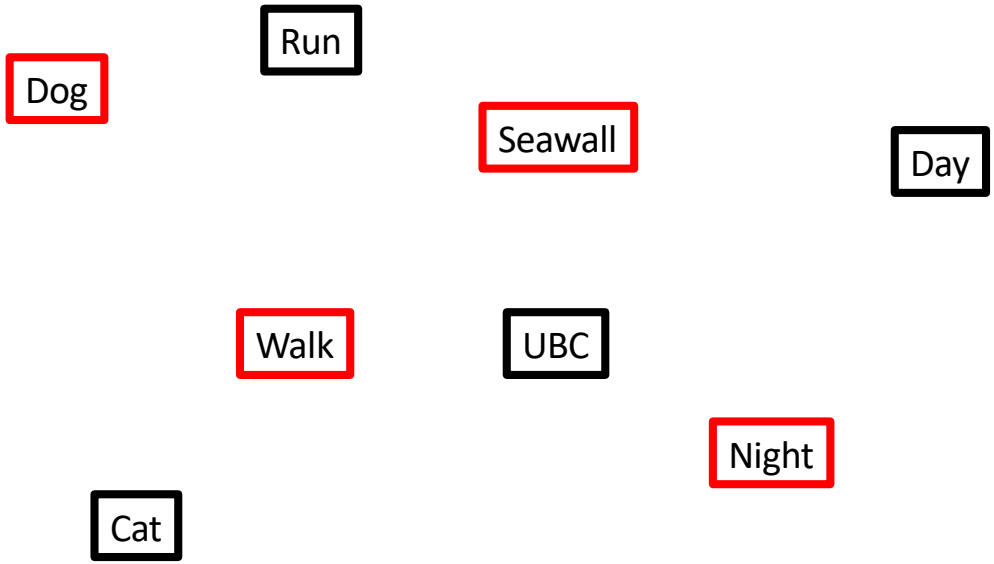
Day

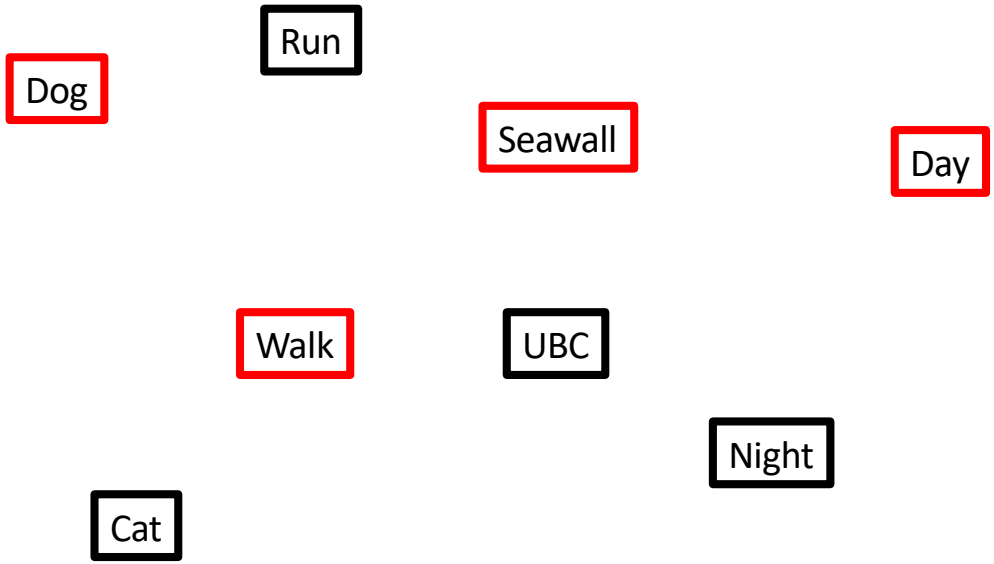
Walk

UBC

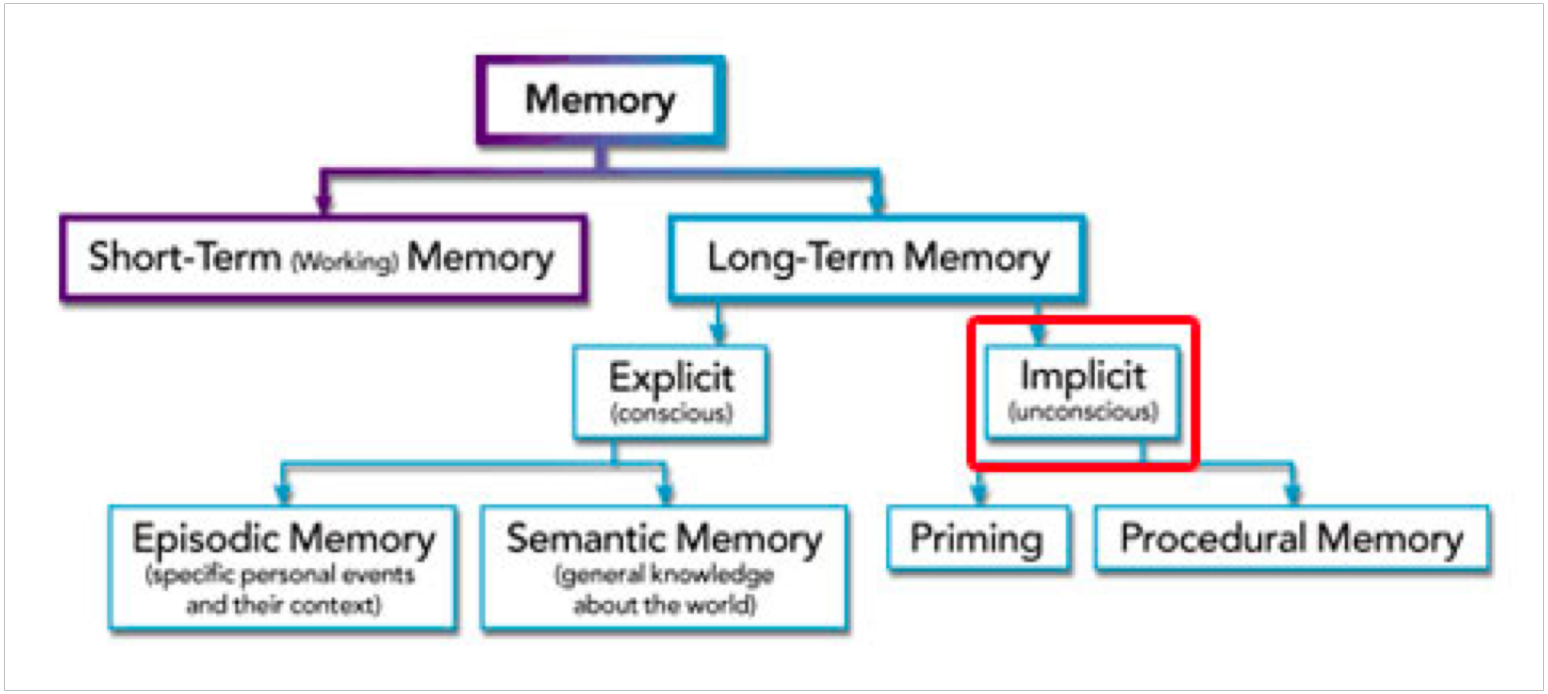
Night

Cat


Run
Dog
Seawall
Day
Walk
UBC
Night
Cat


Run
Dog
Seawall
Day
Walk
UBC
Night
Cat

Implicit Memory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Long-Term Memory
Explicit
(conscious)
Implicit
(unconscious)
Episodic Memory
(specific personal events
and their context)
Semantic Memory
(general knowledge
about the world)
Priming
Procedural Memory

Priming

PRIMING

- **Priming** is a non conscious form of human **memory** concerned with perceptual identification of words and objects.
- For example, if a person reads a list of words including the word *table*, and is later asked to complete a word starting with *tab*, the probability that he or she will answer *table* is greater than if they are not primed.

Fill in the missing word

1. Red
2. Blue
3. Orange
4. Yellow
5. Gr _ _ _

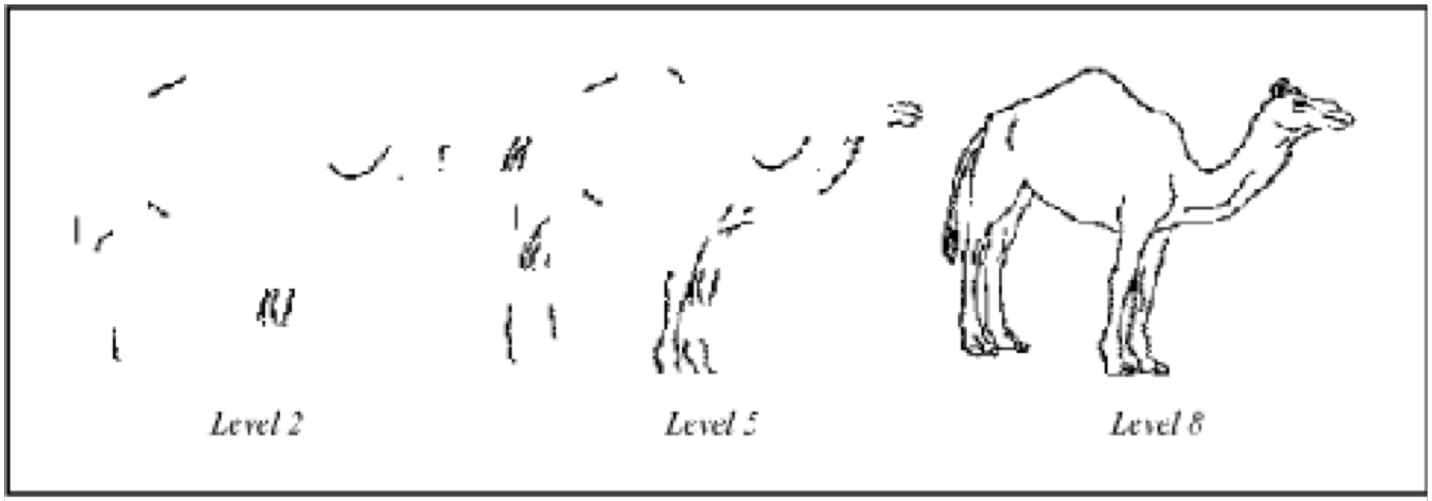


Fig 1: Example of a picture of the original set[13] (picture nr. 43-Camel) with levels 2, 5 and 8 of fragmentation[10]. (Printed by permission of Dr. J. G. Sandgrass).

Procedural Memories

2 + 2 = ?

Math Memory

- Your ability to remember specific facts would be an explicit memory
- Your ability to perform a mathematical operation is an explicit memory


CELTICS
33
VONS

MOTOR PLAN

"abstract representation, that, when initiated results in the production of a coordinated movement sequence"

- **1. issues commands to muscles (when, how much)**
- **2. organizes muscles and joints into a single unit**

Motor Plans have...

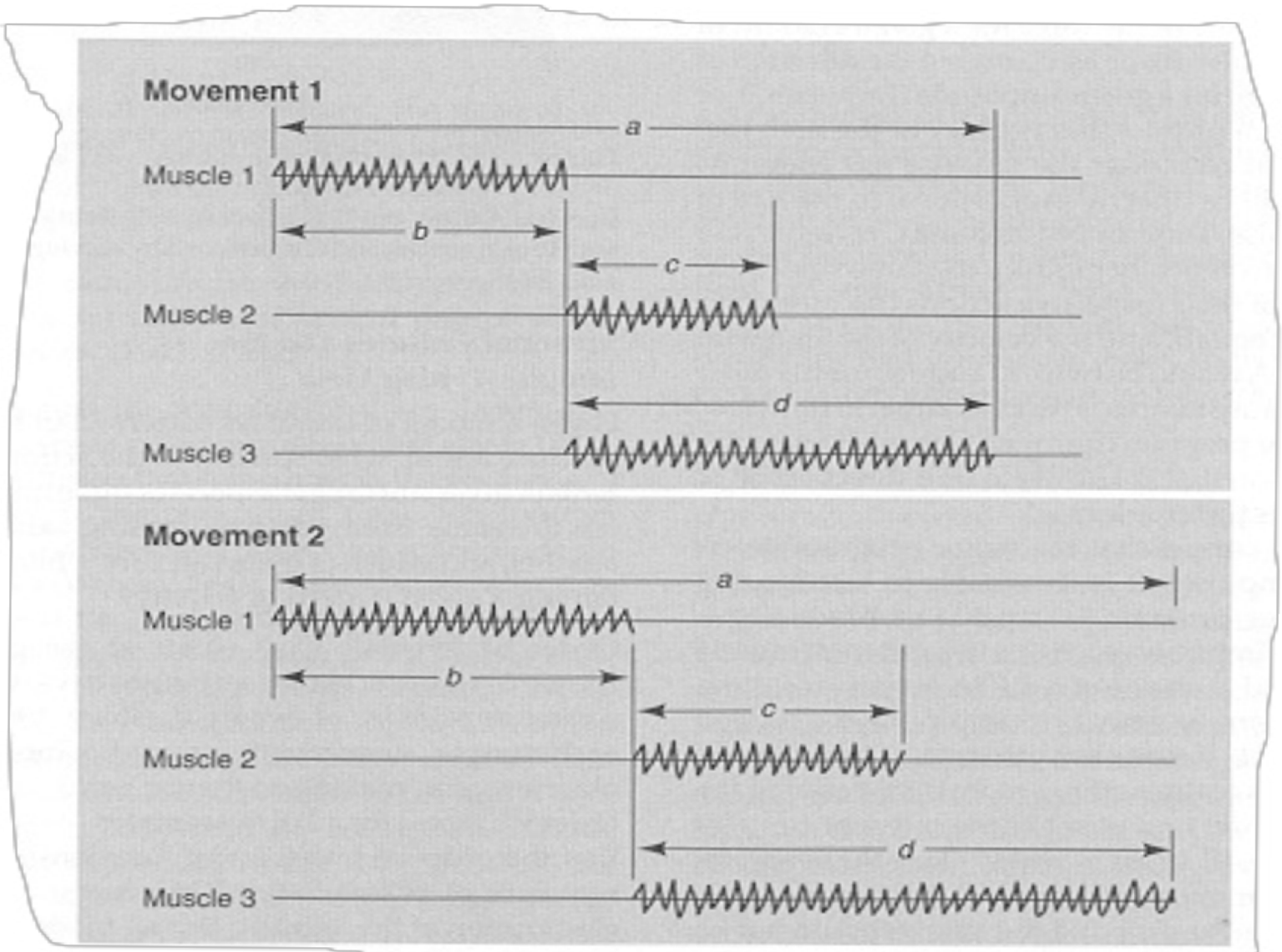
Invariant and Variant Parameters

Invariant Parameters

a. Order of Events

b. Phasing: Temporal Structure

c. Relative Force


Movement 1
a
Muscle 1
b
c
Muscle 2
d
Muscle 3
Movement 2
a
Muscle 1
b
c
Muscle 2
d
Muscle 3

Variant Parameters

a. Movement Time

b. Movement Amplitude

You also learn **Motor Schemas**