Neuro 80 Lecture 17 Nov 4, 2019

MCB/Neuro 80 - Neurobiology of Behavior

Today's Topic:

MEMORY

Lecture 16

Optional reading: Purves et al., Neuroscience 6th pages _____

Lecture notes, review questions, office hour times available at:

https://canvas.harvard.edu/courses/59120


CLIMBING MT. POTENTIAL
(IN PRACTICE)
Response
Sensory/motor diseases
Upper Motor
Spinal Circuits
Neuronal processing
Cognition
Structural changes and aging
Long term synaptic plasticity
Memory systems
Stimulus (sensing information)
Information Coding
Other Senses
Visual system:
• Sensory transduction
• Visual circuits
• Cortical visual processing

Learning and Memory

Learning: the process by which we acquire knowledge about the world

Memory: the encoded knowledge that is stored and sometimes later retrieved

Compare **memory** with **instincts**. Instincts are phylogenetic memories based on the experience of a species over eons rather than over a lifespan, and they can be remarkably specific

Instinct: memory without experience

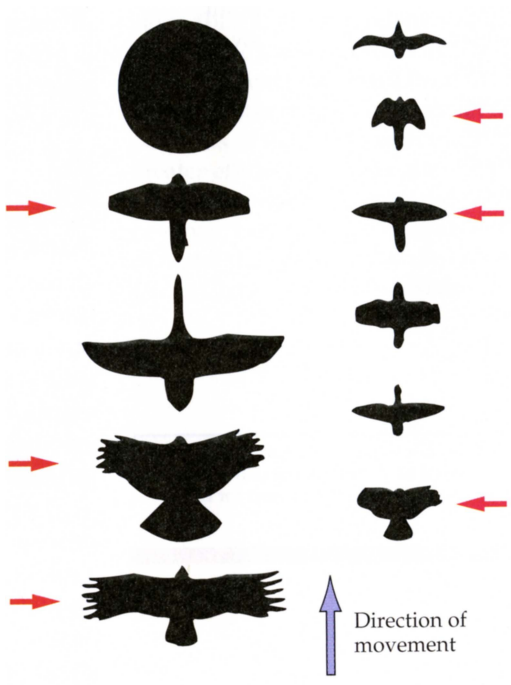
Naïve herring gull chicks crouched and sought cover when the silhouette of a bird of prey passed over them.

Silhouette associated with danger but not based on personal experience

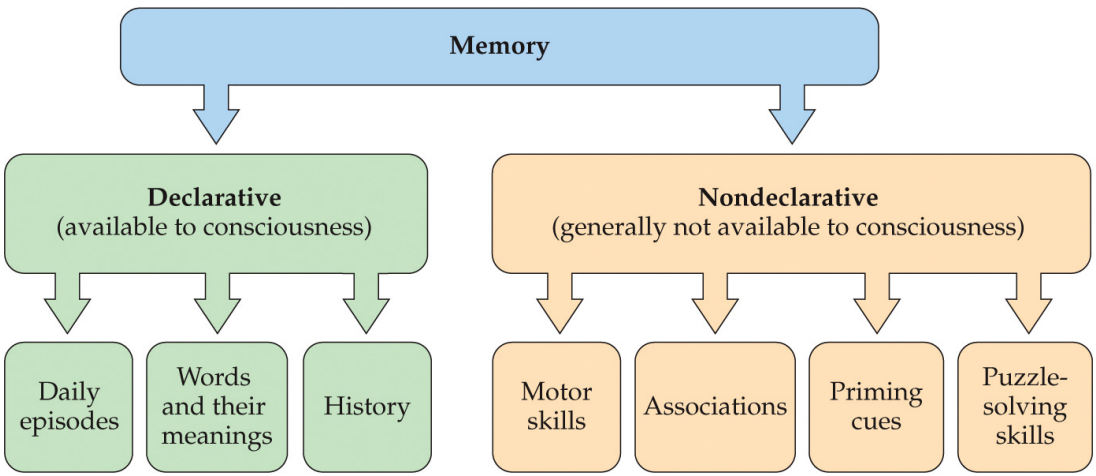
Instinct: memory without experience

Silhouette shape matters – those that resemble birds of prey elicited these defensive responses.

Brain mechanisms not clear, but related studies in other animals suggest a role for superior colliculus (optic tectum).

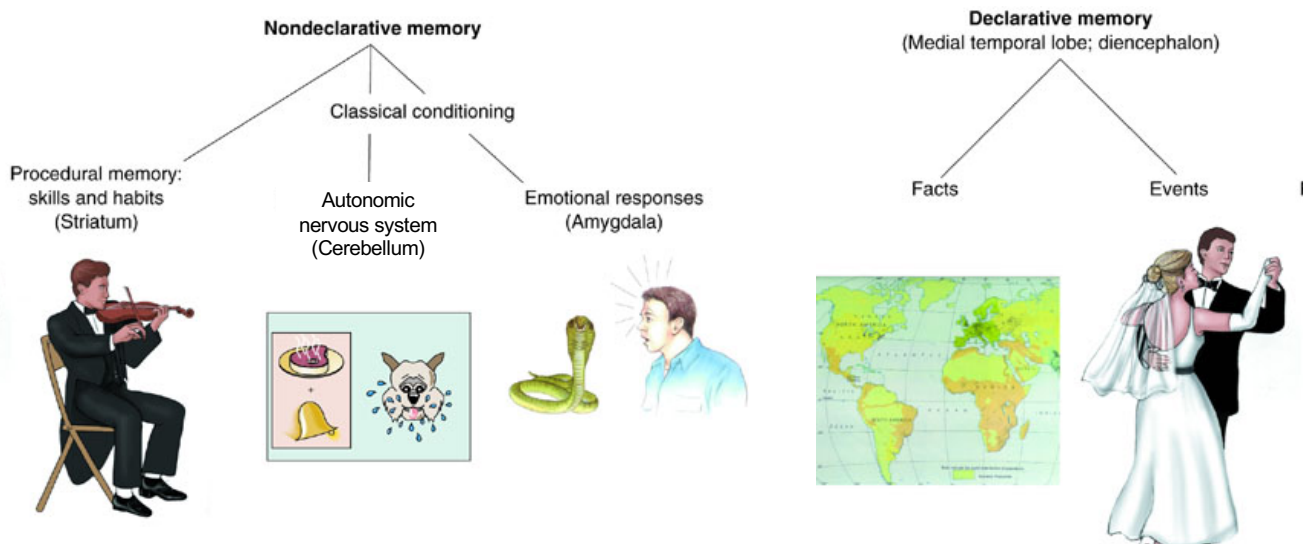


Declarative and non-declarative memory



NEUROSCIENCE 6e, Figure 30.1

Declarative and non-declarative memory



Memory across time-scales

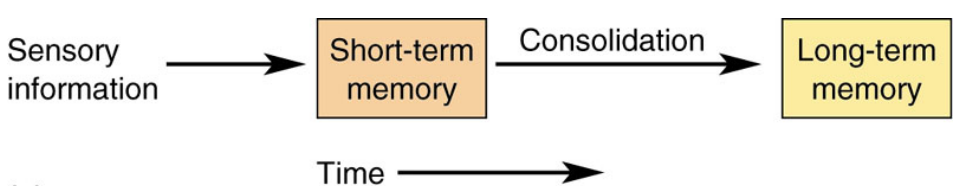
Memory categorized into 3 general classes based on time-scales:

1) Immediate memory: our sense of the present

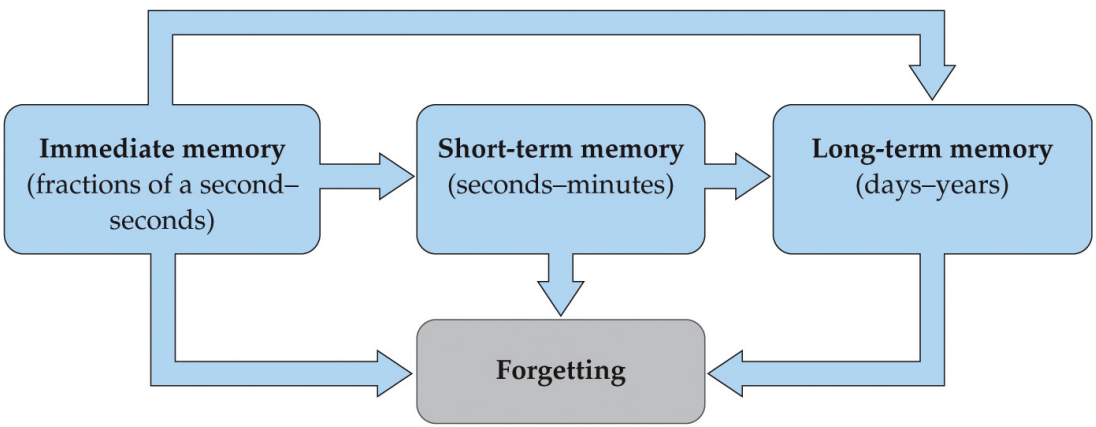
2) Short-term memory: seconds to minutes; related to “working memory”

3) Long-term memory: days to decades

General belief that memory passes from the short to long-term category by a process of “consolidation”



Memory across time-scales

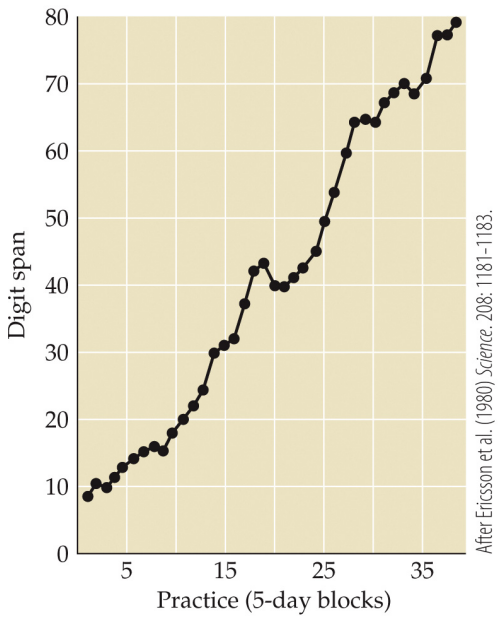


NEUROSCIENCE 6e, Figure 30.2

Short-term memory

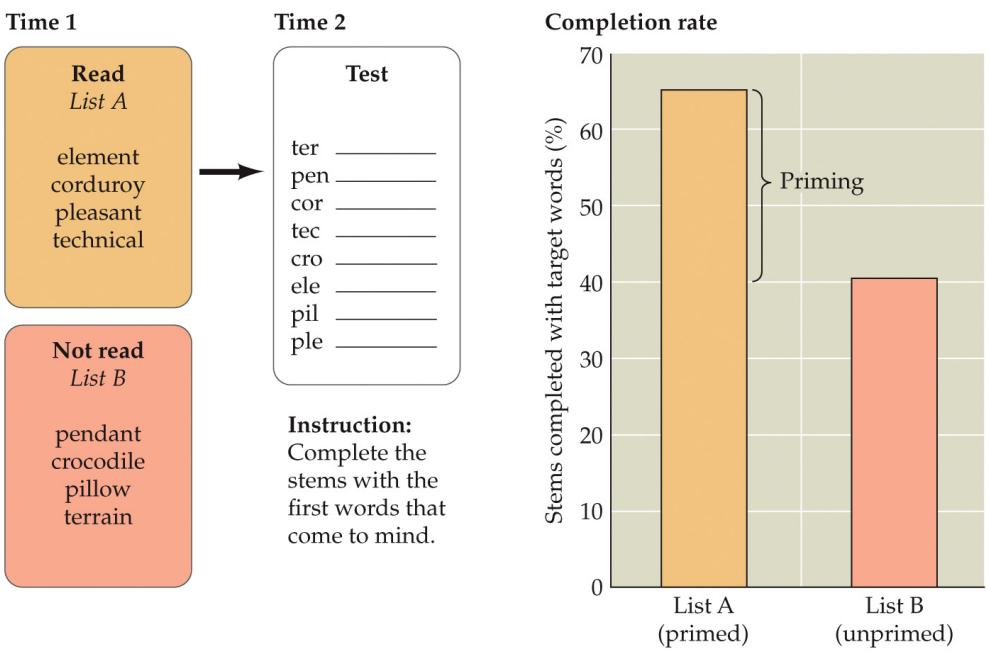
"Digit span" is typically 7-9

Without consolidation, not very useful



NEUROSCIENCE 6e, Figure 30.4

Priming



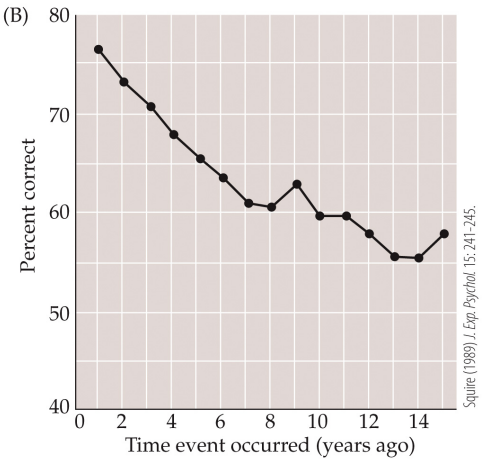
NEUROSCIENCE 6e, Figure 30.3

Forgetting

After Rubin and Kontis (1983) *Mem. Cog.* 11: 335–341.

NEUROSCIENCE 6e, Figure 30.8 (Part 1)

Which penny is authentic?



Squire (1989) *J. Exp. Psychol.* 15: 241–245.

NEUROSCIENCE 6e, Figure 30.8 (Part 2)

Rate of forgetting (chance = 25%)

H.M. – an important patient

Henry Molaison (H.M.) was a very important neurological patient - has taught memory researchers a huge amount about human memory

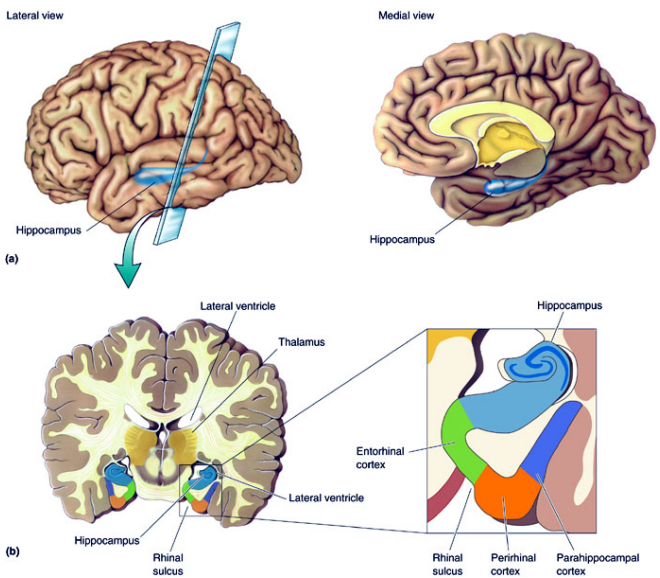
Obituary:

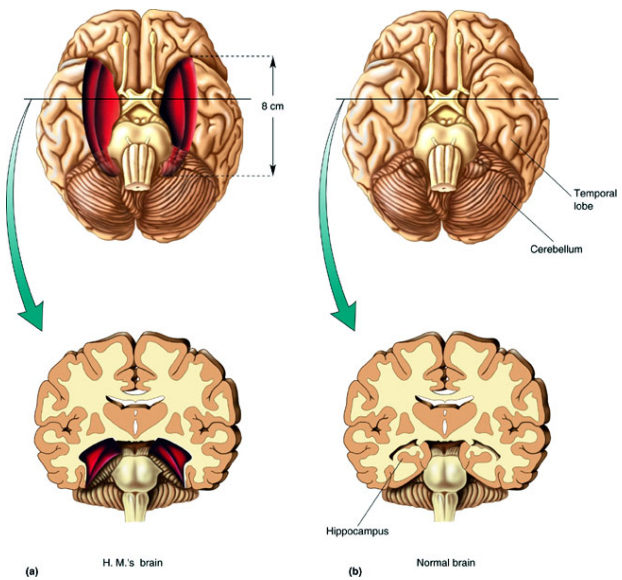
H. M., an Unforgettable Amnesiac, Dies at 82

By BENEDICT CAREY

New York Times December 4, 2008

Hippocampal and related areas removed in H.M.





Amnesia for recent events (cannot consolidate)

J. Neurol. Neurosurg. Psychiat., 1957, **20,** 11.

LOSS OF RECENT MEMORY AFTER BILATERAL HIPPOCAMPAL LESIONS

BY

WILLIAM BEECHER SCOVILLE and BRENDA MILNER

From the Department of Neurosurgery, Hartford Hospital, and the Department of Neurology and Neurosurgery, McGill University, and the Montreal Neurological Institute, Canada

In 1954 Scoville described a grave loss of recent memory which he had observed as a sequel to bilateral medial temporal-lobe resection in one psychotic patient and one patient with intractable seizures.

Summary

Bilateral medial temporal-lobe resection in man results in a persistent impairment of recent memory whenever the removal is carried far enough posteriorly to damage portions of the anterior hippocampus and hippocampal gyrus. This conclusion is based on formal psychological testing of nine cases (eight psychotic and one epileptic) carried out from one and one-half to four years after operation.

H.M. after his surgery

Seizures were much improved

Devastating memory deficit: normal immediate and short-term memory, but no consolidation of short-term declarative memory into long-term

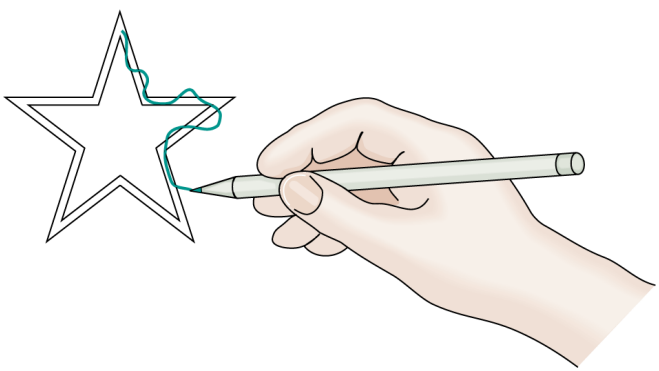
Spatial orientation severely affected

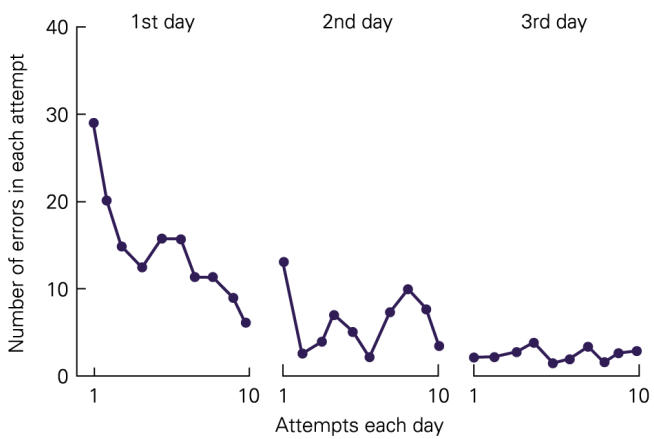
Procedural memory was not affected at all

Procedural memory not altered

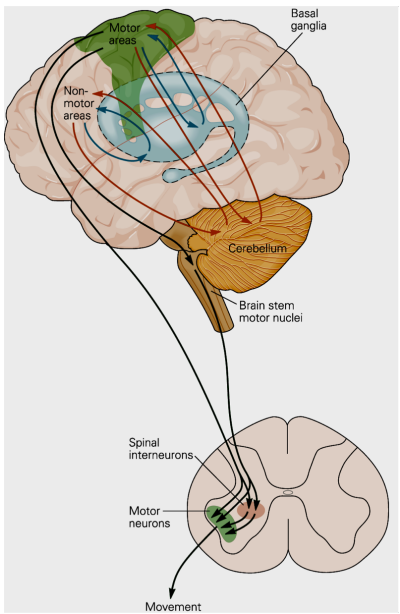
Learned how to mirror draw at normal rate

Had no idea how he learned it (episodic memory gone) - each time he practiced he thought it was the first time he had tried- nonetheless he steadily improved





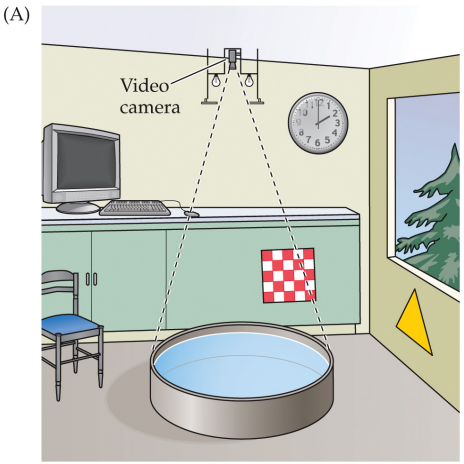
Procedural memory



Likely involves basal ganglia, cerebellum and cortex

Has to do with motor system (movement control)

Hippocampus and spatial memory in rodents



NEUROSCIENCE 6e, Figure 30.10 (Part 1)
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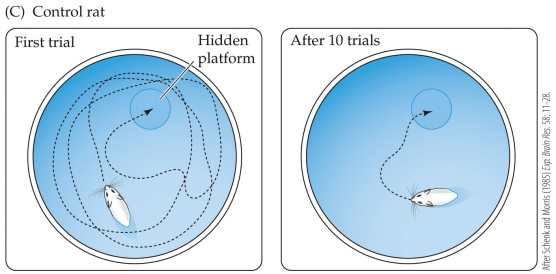

NEUROSCIENCE 6e, Figure 30.10 (Part 3)
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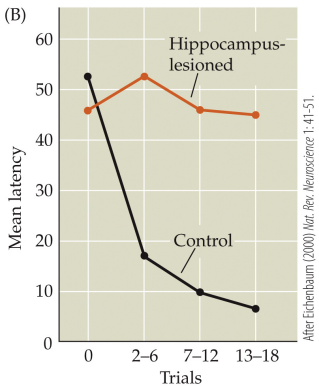

NEUROSCIENCE 6e, Figure 30.10 (Part 2)
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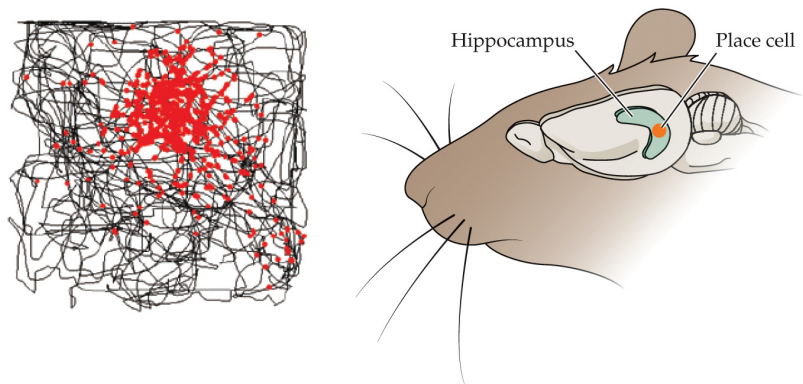
Spatial memory and hippocampal place fields

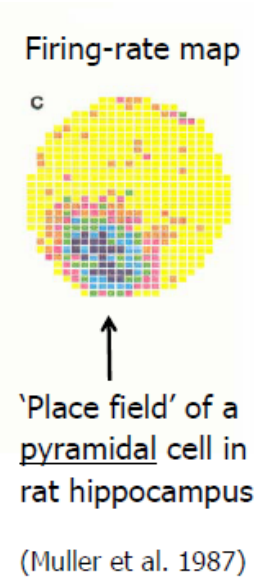
Neurons in the hippocampus fire when the animal is in a specific spatial locations

(A)



From Moser et al. (2008) *Ann. Rev. Neuroscience.* 31: 69–89.

NEUROSCIENCE 6e, Box 30D (Part 1)

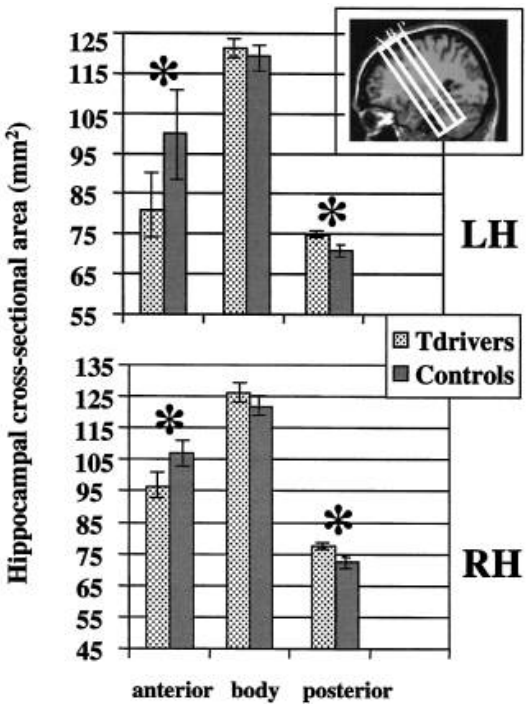


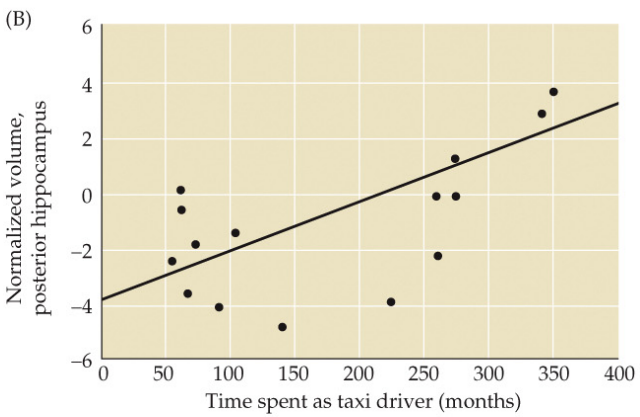
(Recall this figure from Lecture 16)

why hippocampus larger?

- more glial cells?
- more neuronal connections?

London taxi drivers have larger hippocampus



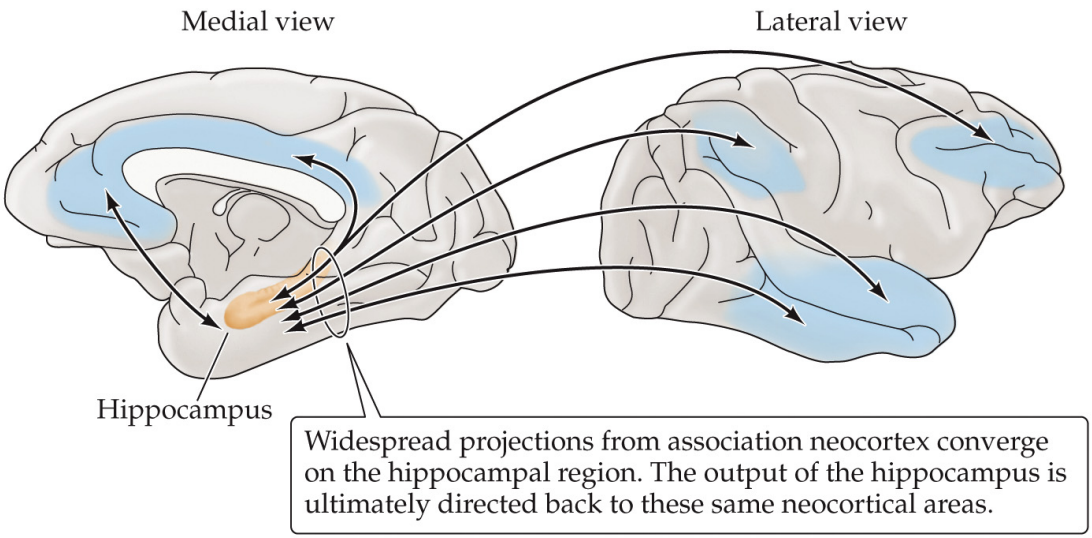


Magnetic Resonance Imaging (MRI) can be used to look at brains of living humans. Specific brain regions can be identified

Size of hippocampus (anterior, body, posterior bits) was estimated in London taxi drivers and control people.

Posterior hippocampus was slightly larger in taxi drivers (LH/RH – left/right hemisphere). How much larger was correlated with how many months they were taxi drivers.

Hippocampus is reciprocally connected to many cortical areas



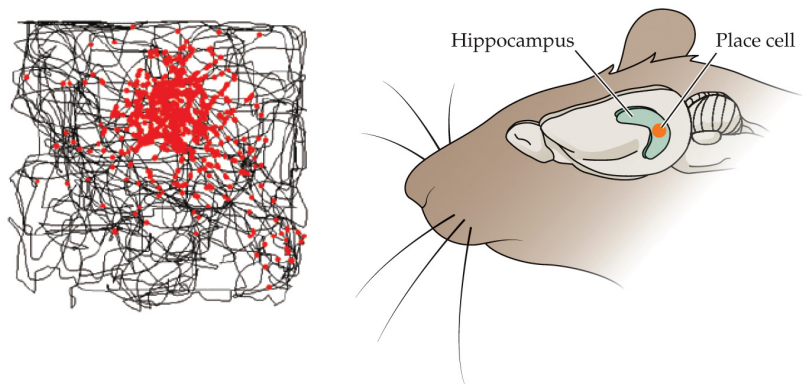
Van Hoesen (1982) *Trends Neurosci.* 5: 345–350.

***NEUROSCIENCE 6e*, Figure 30.14**

Spatial memory and hippocampal place fields

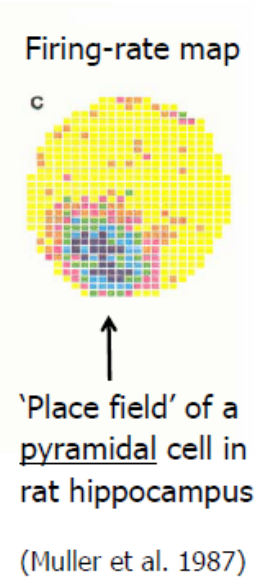
Neurons in the hippocampus fire when the animal is in a specific spatial locations

(A)



From Moser et al. (2008) *Ann. Rev. Neuroscience.* 31: 69–89.

NEUROSCIENCE 6e, Box 30D (Part 1)



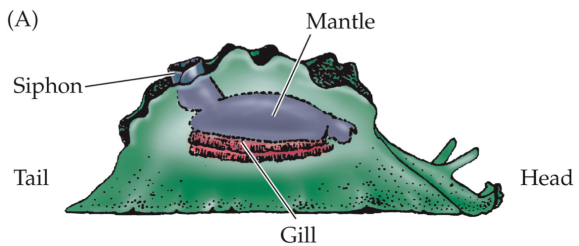
(Recall this figure from Lecture 16)

Memories are formed through learning

What is learning?

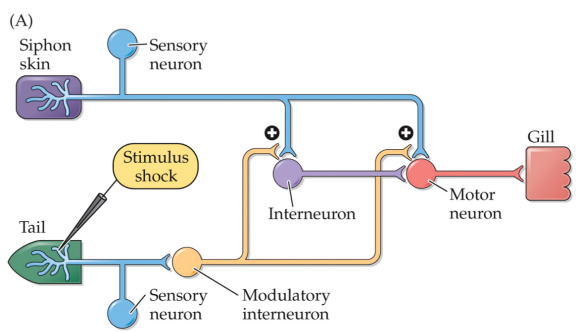
Different forms of learning

- Habituation and Sensitization (from Lecture 11)
- Associative learning
- Conditioning



After Squire and Kandel (1999) New York: Scientific American Library, 40.

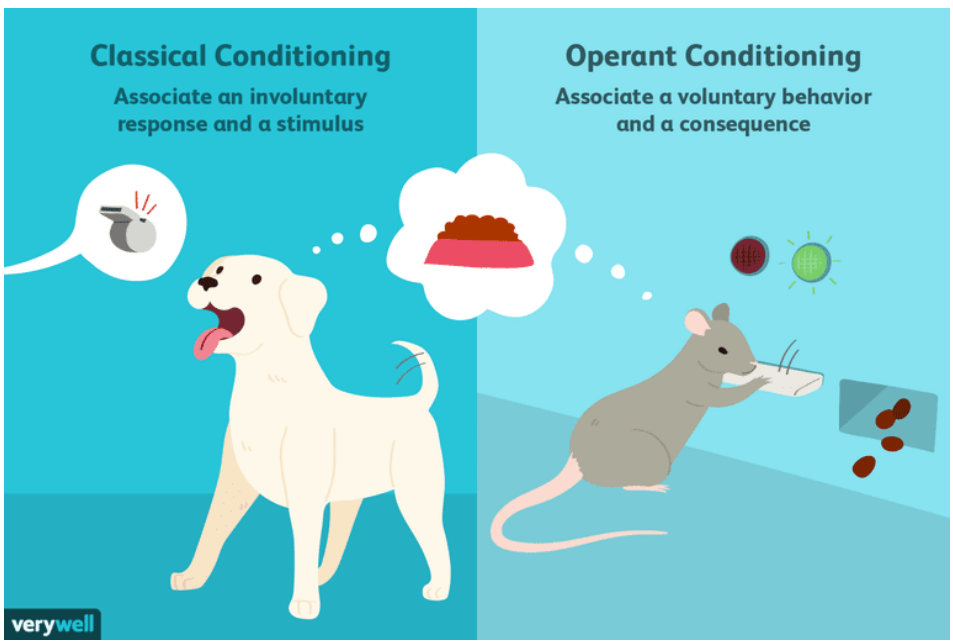
NEUROSCIENCE 6e, Figure 8.3 (Part 1)



After Squire and Kandel (1999) New York: Scientific American Library, 54.

NEUROSCIENCE 6e, Figure 8.4 (Part 1)

Conditioned learning



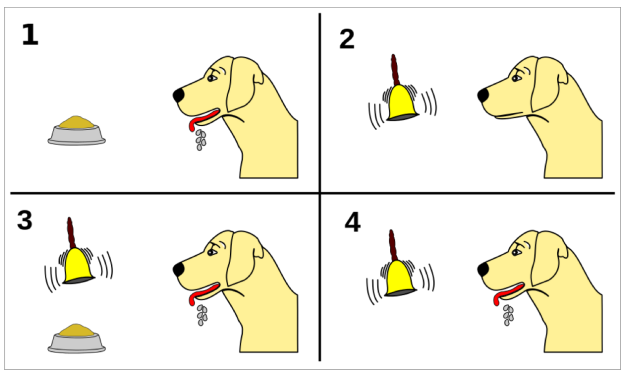
https://www.verywellmind.com/classical-vs-operant-conditioning-2794861

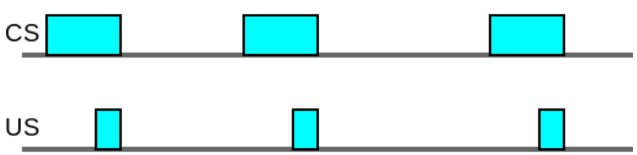
Classical conditioning

Famous example of Pavlov's dog

Sight (or smell) of food leads to salivation – this is an innate response that is referred to as the unconditioned response (food is the unconditioned stimulus, US). Ringing a bell on its own does NOT lead to salivation.

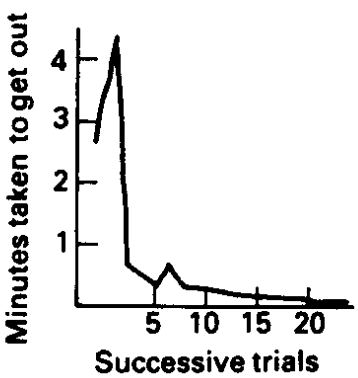
If a bell is rung at the same time as food (or at time close to it) repeatedly, the dog will salivate (and expect food) when just the bell is rung (conditioned stimulus, CS). The timing between the CS and UsS during learning is important.

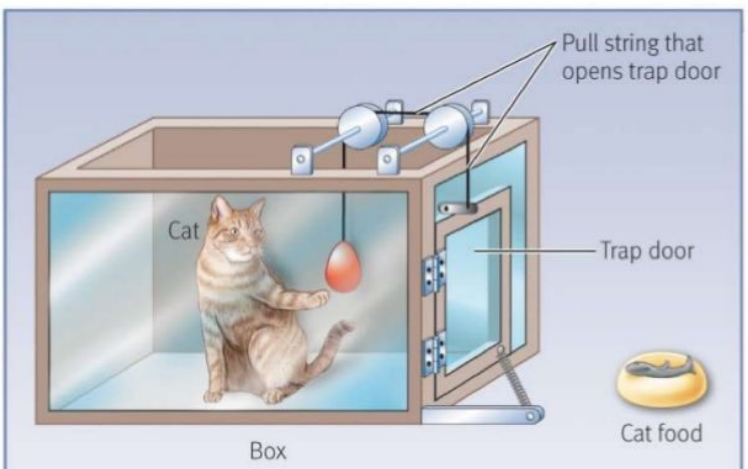




Operant conditioning

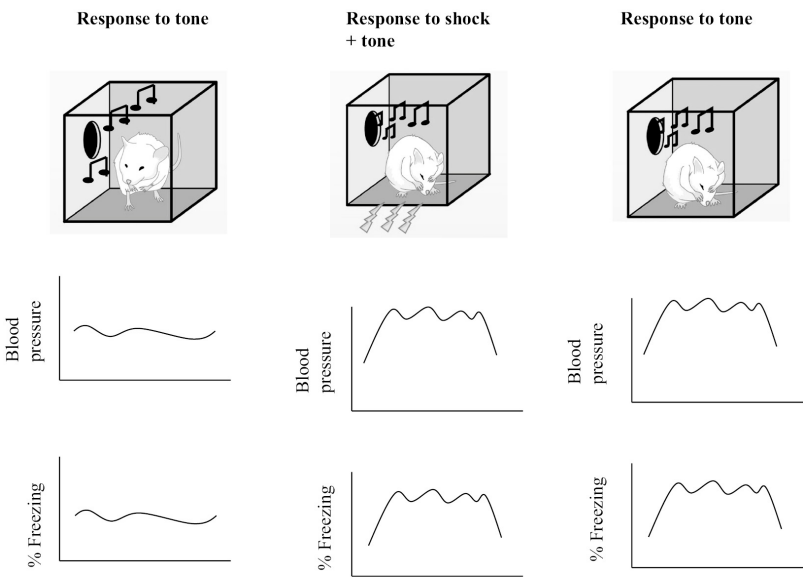
Thorndike's experiments





Operant conditioning is when a behavior is followed by a reward, that behavior is more likely to be repeated. Thorndike did experiments where he put cats inside a puzzle box, with a lever that will open a trap door. The cat will experiment with various motions and eventually figures out the lever. The time it takes across repeated trials to open the door decreases. This is trial and error learning, reinforced by the food (or perhaps the escaping itself!).

Fear conditioning

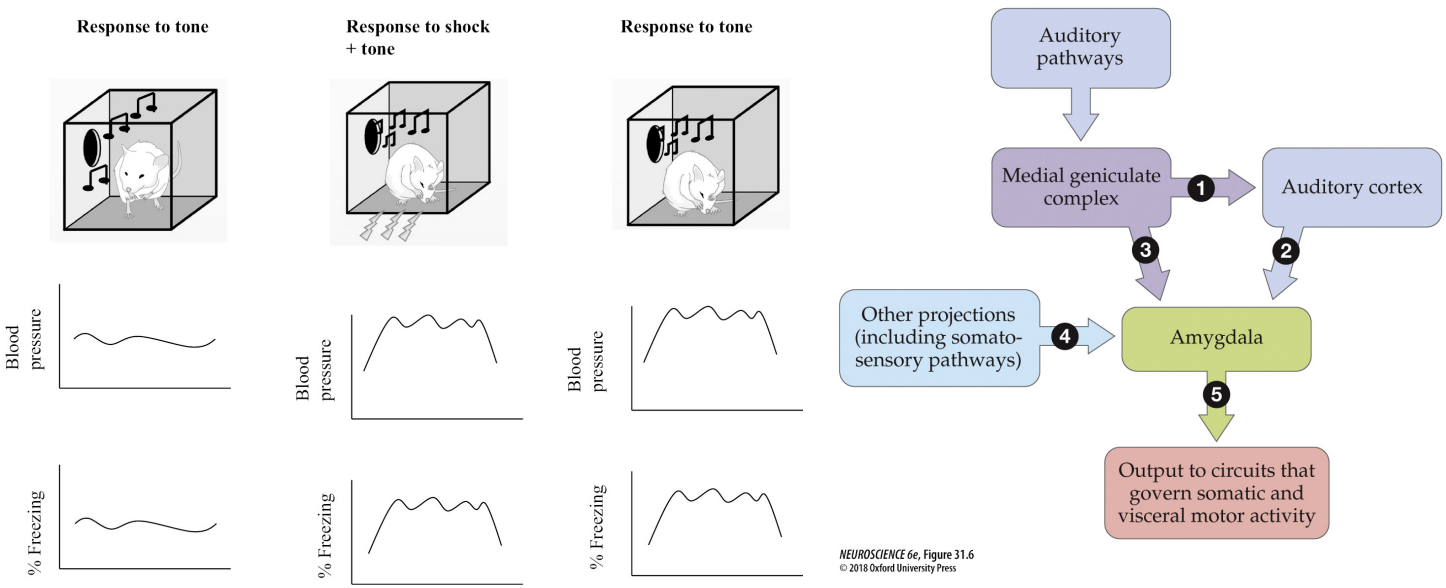


In mice, fear is manifest in “freezing” behavior (crouching, with no movement).

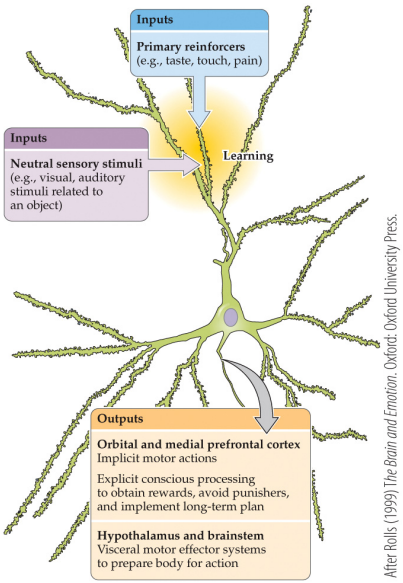
Fear conditioning: pairing an (otherwise innocuous) sound with an electric shock will cause the animal to freeze (expression of fear) with just the sound alone.

This is a form of associative learning that likely involves the amygdala.

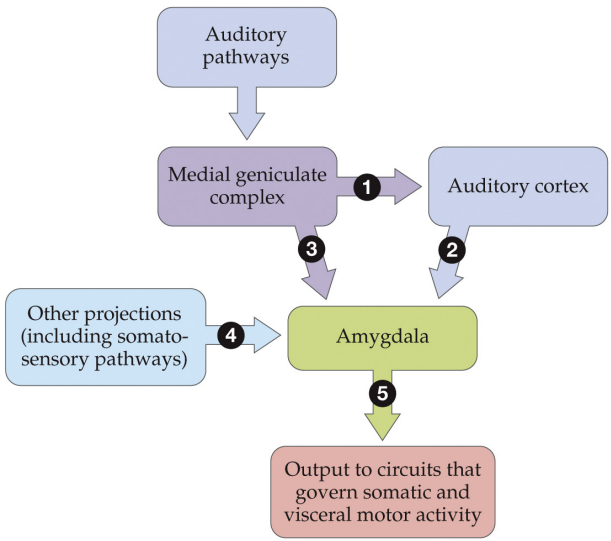
Key role of amygdala in fear conditioning



Key role of amygdala in fear conditioning



NEUROSCIENCE 6e, Figure 31.7



NEUROSCIENCE 6e, Figure 31.6

We will examine how these changes can occur at a molecular & cellular level in the next lecture

Learning Objectives

Know the different classes of human memory: declarative and non-declarative memory

Understand the role of hippocampus and temporal lobe in declarative memory

Know the role of hippocampus and spatial memory

Know about classical conditioning and operant conditioning

Fear conditioning and amygdala

Lecture 17 - Memory and learning

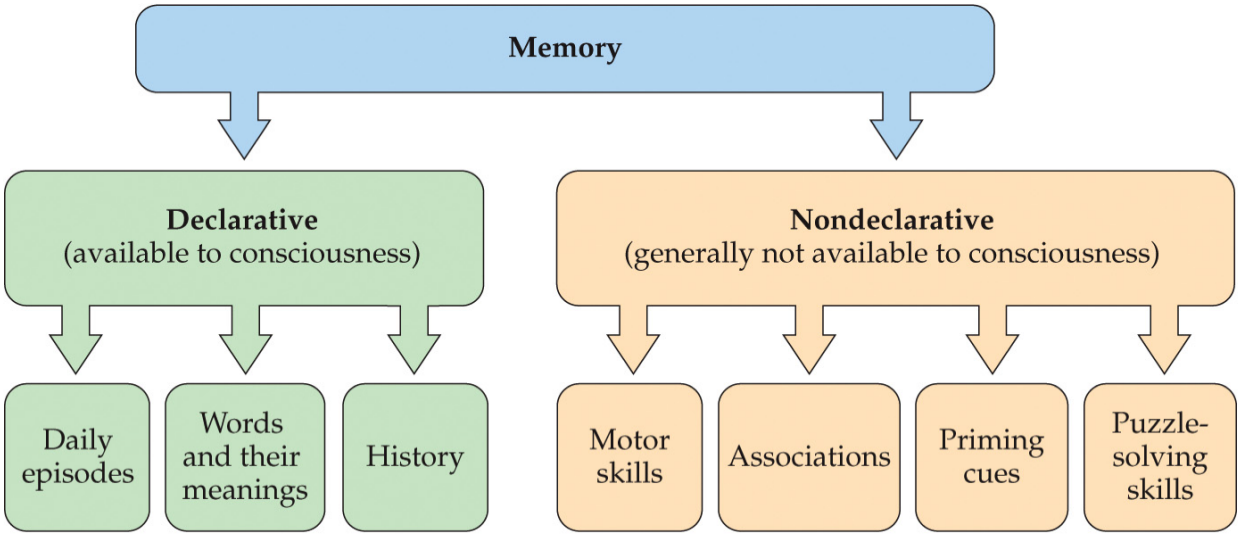
Pre-class notes for November 4, 2019
Reading: *Neuroscience ed. 6* by Purves et al., pages _____

Learning - the process by which our brain adapts and/or we acquire knowledge about the world.

Memory - the encoded knowledge that is stored and sometimes later retrieved.

Instinct - an innate, fixed pattern of behavior in response to certain stimuli. Can be complex and remarkably specific, but does not need to be learned. Also known as *phylogenetic memories*, as they are based on the experience of a species over eons.

Declarative memory - also known as *explicit memory*, is a memory that is available to the consciousness that can be expressed by language. Includes *episodic memories* (memories of experiences and specific events in time) and *semantic memories* (general world knowledge or facts).



NEUROSCIENCE 6e, Figure 30.1

Non-declarative memory - also known as *procedural memory* or *implicit memory*, is an unconscious memory such a motor skills and associations.

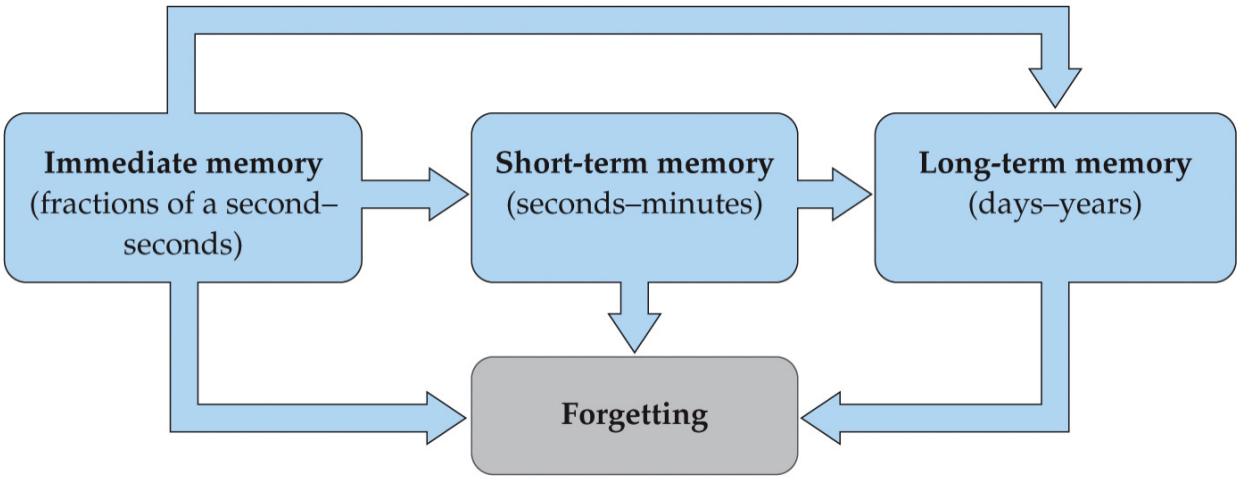
Immediate memory - also known as *sensory memory*, is the term for the shortest element of memory. It is the ability to retain impressions of sensory information for a couple of seconds after the original stimuli have ended and gives us a sense of the present.

Short-term memory - memories held briefly in the mind that enable a particular task to be accomplished (e.g. efficiently searching a room for a lost object). Also called *working memory.*

Long-term memory - memories that last days, weeks, months, years, or a lifetime.

Consolidation - the process by which short-term memory is encoded into long-term memory.

Digit span - an evaluation of short-term memory that tests the number of items (numbers) that a person can repeat back in the correct order immediately after presentation. It is frequently used to quickly evaluate cognitive abilities.



NEUROSCIENCE 6e, Figure 30.2

Hippocampus - area of the mammalian brain, located in the temporal lobe, that is particularly important in memory formation and/or retrieval.

Place cell - type of neuron within the hippocampus that fires when the animal in in a specific spatial location.

Amnesia - loss of memory due to brain injury, disease or psychological trauma. Loss of memory for events that happened before the onset is retrograde. The inability to create new memories after the event is anterograde.

Conditioning - a behavioral process whereby a response becomes more frequent or more predictable in a given environment as a result of reinforcement, with reinforcement typically being a stimulus or reward for a desired response.

Classical conditioning - learning of a novel response to a stimulus

Operant conditioning - learning to increase the probability of a particular behavior

Fear conditioning - a simple form of classical conditioning in which an animal learns to associate a neutral stimulus such as a light or a tone with the presence of an innately aversive stimulus such as a mild foot shock. After several pairings the animal will demonstrate fear (freezing behavior in rodents) in response to the neutral stimulus alone. This is a form of associative learning that likely involves a brain structure called amygdala.

Unconditioned stimulus - a stimulus that naturally triggers a response. (e.g. feeling hungry when you smell food)

Conditioned stimulus - a previously neutral stimulus that initially caused no behavioral response that, after becoming associated with the unconditioned stimulus eventually will trigger the response produced by the unconditioned stimulus itself.

Fear extinction - a decline in the conditioned fear responses caused by repeatedly presenting the conditioned stimulus without the fear-eliciting unconditioned stimulus

Learning Objectives: (By the end of Lecture 17 you should be able answer questions about the following)

1. List the two main kinds of human memory and briefly describe how they differ.
2. Understand the role of hippocampus and temporal lobe in declarative memory
3. Know the role of hippocampus and spatial memory
4. Know about classical conditioning and operant conditioning
5. Fear conditioning and amygdala