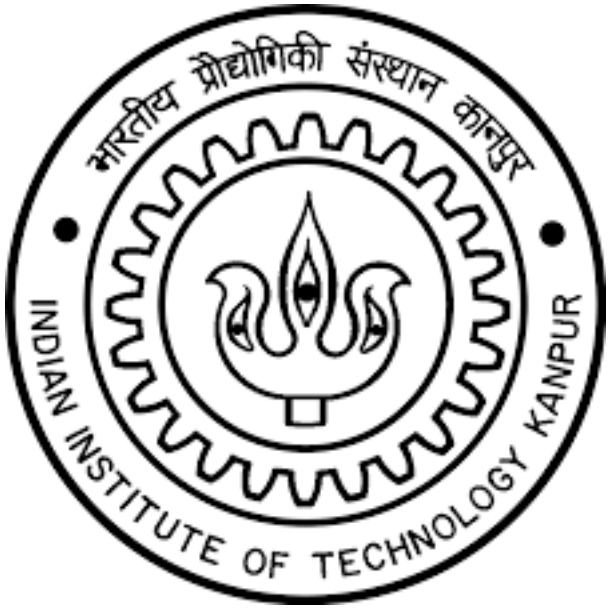

Indian Institute of Technology
Kanpur

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with

National Program on Technology Enhanced Learning (NPTEL)

Presents

Course Title:

Basic Cognitive Processes

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Lecture 35: Memory - VII

Retrieval

- Retrieval Cues are words or other stimuli that help us remember information stored in our memory. For e.g. location.

When I was 8 years old, both of my grandparents passed away. Their house was sold, and that chapter of my life was closed. Since then I can remember general things about being there as a child, but not the details. One day I decided to go for a drive. I went to my grandparents' old house and I pulled around to the alley and parked. As I sat there and stared at the house, the most amazing thing happened. I experienced a vivid recollection. All of a sudden, I was 8 years old again. I could see myself in the backyard, learning to ride a bike for the first time. I could see the inside of the house. I remembered exactly what every detail looked like. I could even remember the distinct smell. So many times I tried to remember these things, but never so vividly did I remember such detail. (Angela Paidousis)

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (p. 182)

- Recall Methods:
  - Free recall: a participant is simply asked to recall stimuli. This stimuli could be words previously presented or events experienced earlier in the participant's life.
  - Cued Recall: the participant is presented with retrieval cues to aid in recall of the previously experienced stimuli. This cues are typically words or phrases.
  - For example: Tulving & Pearlstone (1966) did an experiment in which they presented participants with a list of words to rmremember; which were drawn from specific categories. The memory test used was either a free or a cued recall one.

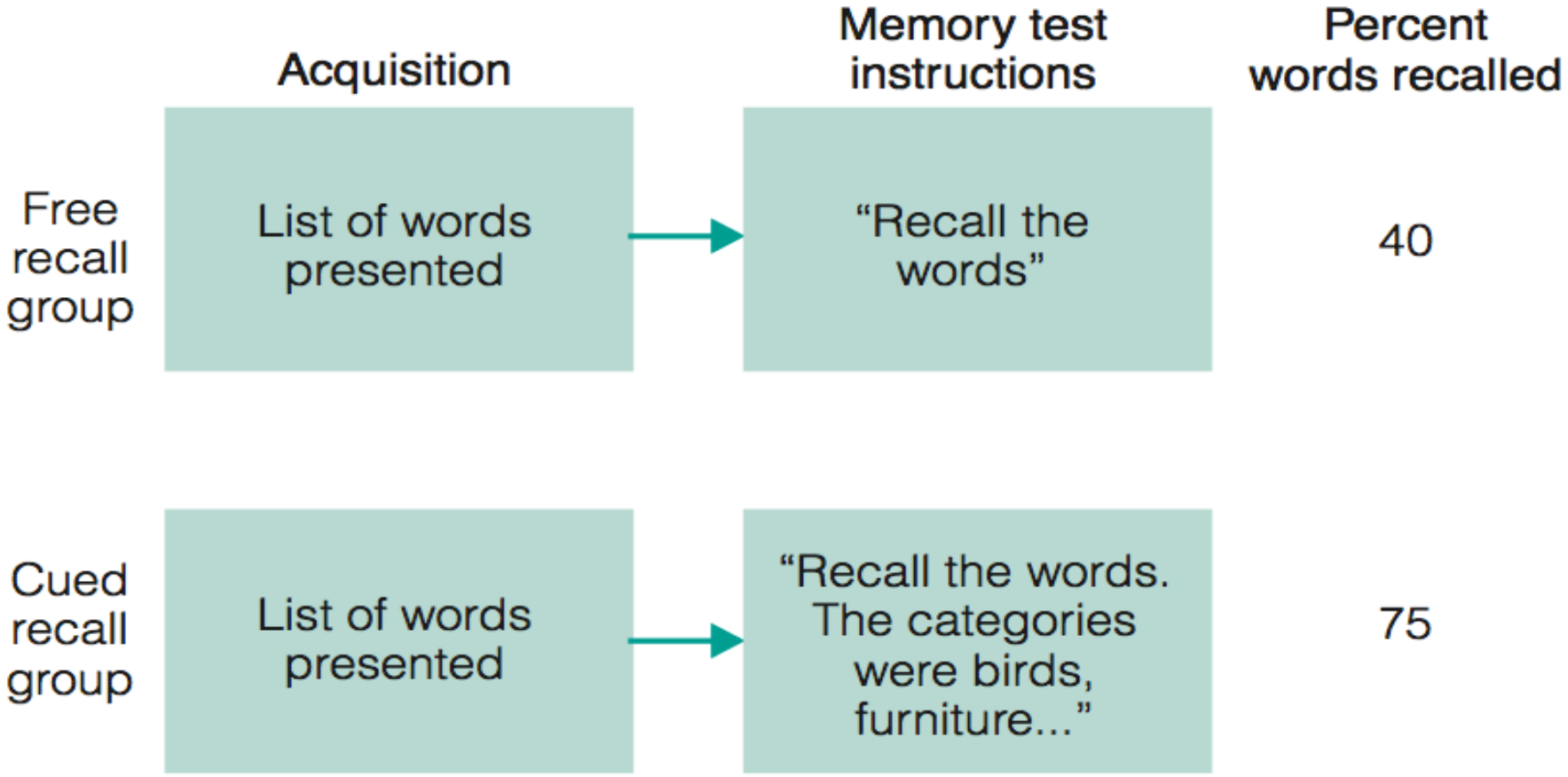


FIGURE 7.10 Design of the Tulving and Pearlstone (1966) experiment. The memory performance for each group is shown on the right.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.10, p. 183)

- The results of Tulving & Pearlstone's experiment demonstrated that retrieval cues aid memory. Participants in the free recall group recalled 40% of the words whereas those in the cued recall group could remember about 75% of the words.

- In another experiment, Mantyla (1986) presented ihis participats with a list of 600 nouns such as banana, freedom & tree.

- During learning, the participants were told to write down three words they associated with each noun. For example, for nbanan they could write yellow, punches & edible.

- When the participants took a surprise memory test, in which they were presented with the three words they had created & were asked to reproduce the original word, they were able to remember 90% of the 600 words.

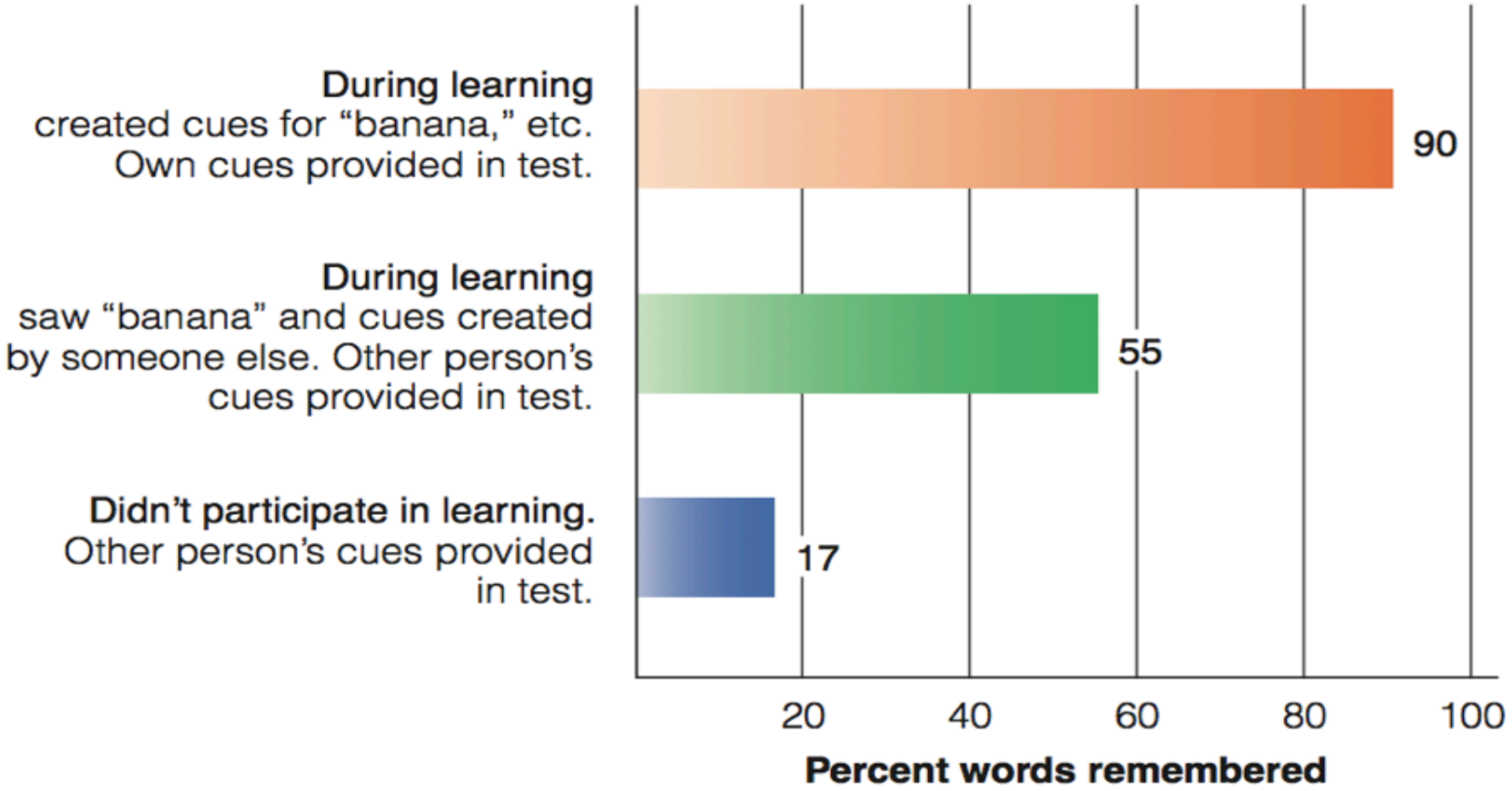


FIGURE 7.11 Mantyla's (1986) experiment. Memory was best when retrieval cues were created by the participant (top bar) and not as good when retrieval cues were created by someone else (middle bar). Participants guessed a small percentage of the words if they had not seen the words and saw only cues created by someone else (bottom bar).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.11, p. 183)

- **Matching Conditions of Encoding & Retrieval**

  - **Encoding Specifity**: The principle of ending specificity states that we encode information along with its context. For ex. Angela encoded many experiences within the context of her grandparent's house; which were reinstated by returning to the house after which she remembered many of those experiences.

  - Godden & Baddeley (1975) conducted a "diving experiment", where one group of participants put on diving equipment & studied a list of words underwater & another group studied them on land. They were later test for these, & the results showed that best recall occurred when encoding & retrieval occurred in the same condition.

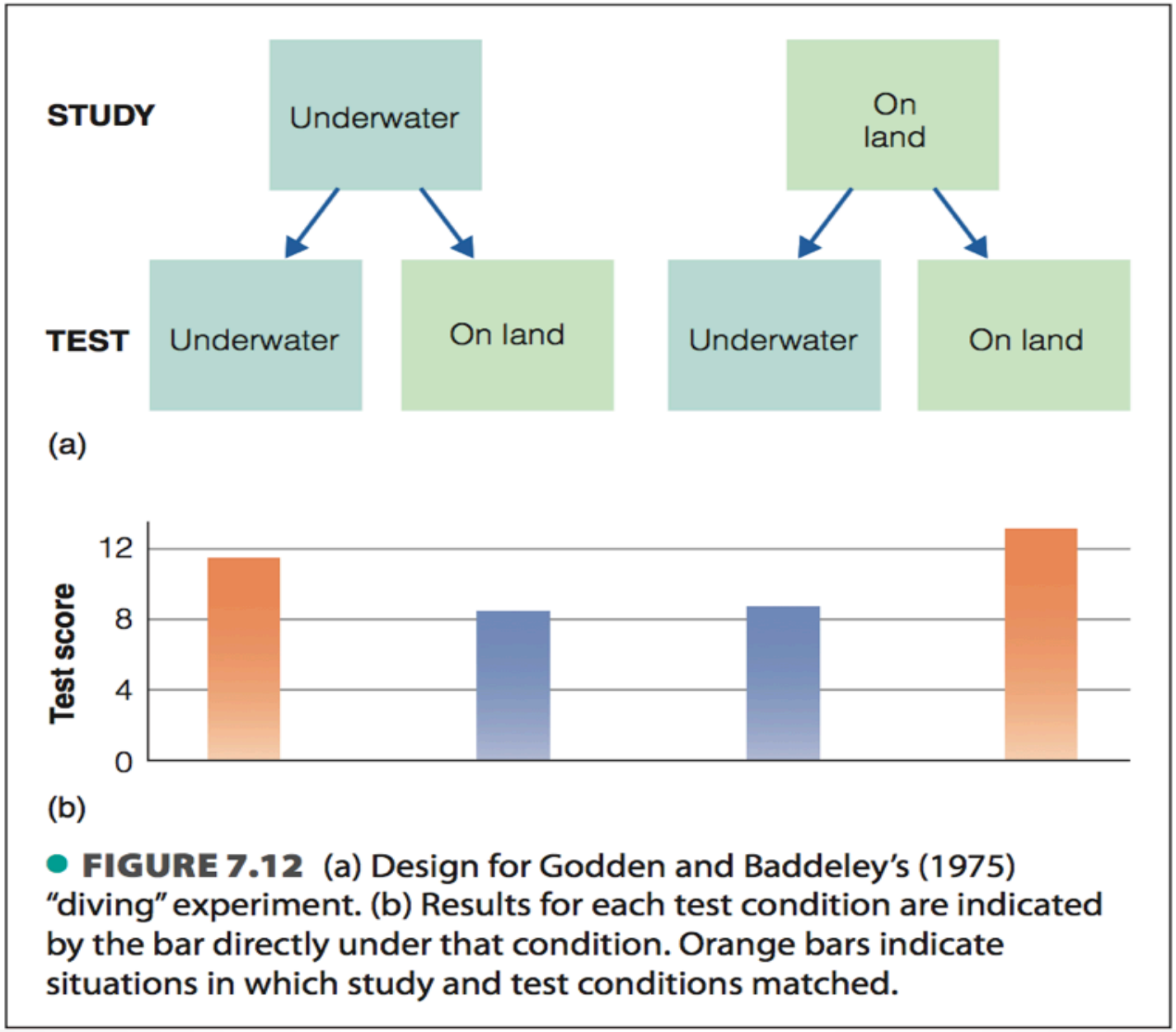


FIGURE 7.12 (a) Design for Godden and Baddeley's (1975) "diving" experiment. (b) Results for each test condition are indicated by the bar directly under that condition. Orange bars indicate situations in which study and test conditions matched.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.12, p. 184)

- **State - dependent learning:** learning that is associated with a particular internal state, such as mood or state of awareness.

- Acc. to this principle, memory will be better when a person's internal state during retrieval matches his or her internal state during encoding.

  - For example: Each & Metcalfe (1989) demonstrated that memory is better when a person's mood during retrieval matches his or her mood during encoding; by asking participants to think positive thoughts while listening to "merry"music or depressing thoughts while listening to "melancholic" music. Participants rated their mood as "very pleasant" or "very unpleasant".

- Once this occurred they were asked to study lists of words while in their positive or negative mood.

- After they study session ended, the participants were told to return in 2 days. Two days later, the participants returned & the same procedure was followed to induce the same mood.

- The results showed that they did better when their mood at recall matched their mood at encoding time.

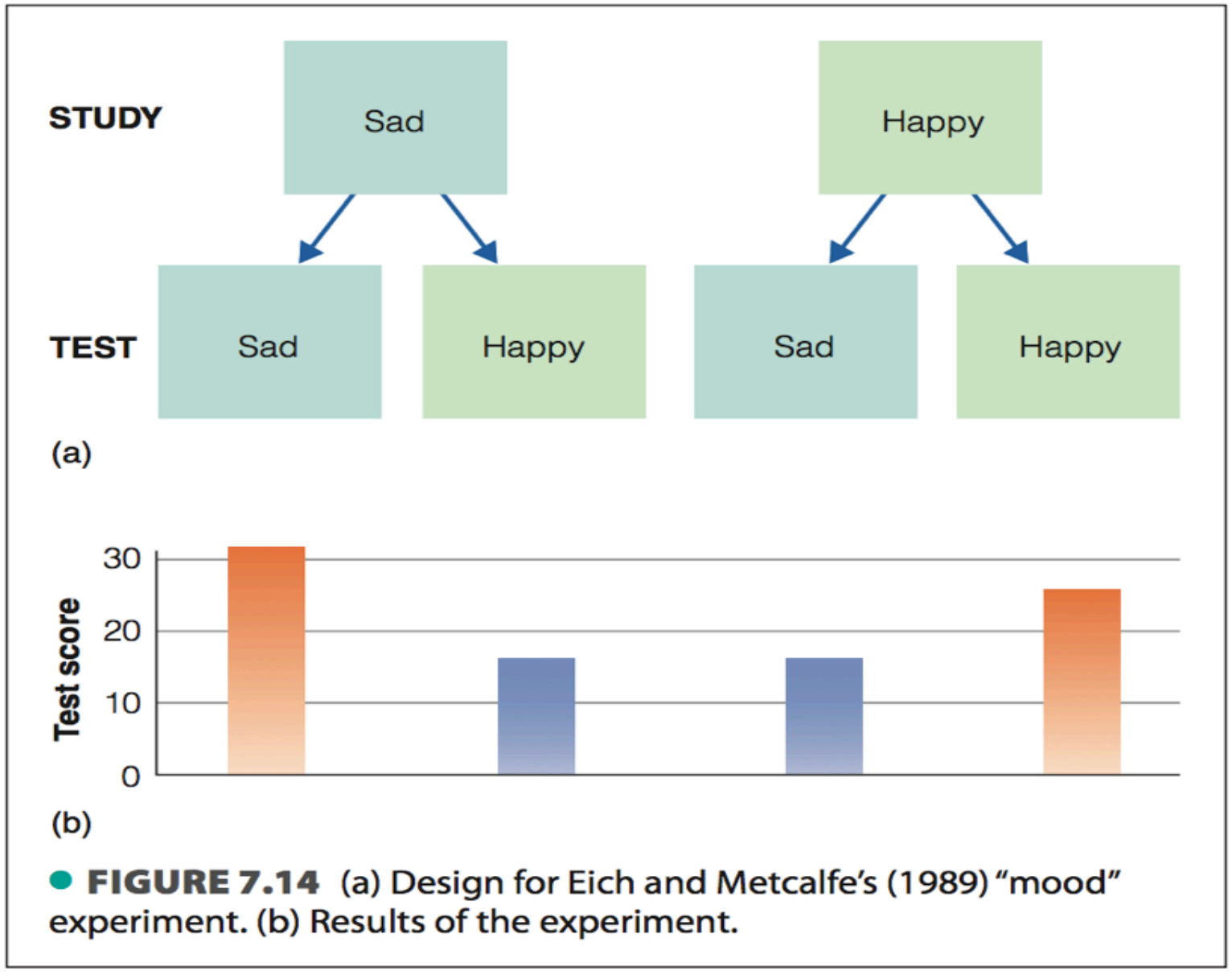


FIGURE 7.14 (a) Design for Eich and Metcalfe's (1989) "mood" experiment. (b) Results of the experiment.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.14, p. 185)

- **Transfer Appropriate Processing:** The phenomenon of transfer - appropriate processing shows that memory performance is enhanced if the type of task at encoding matches the type of task at retrieval.

- A transfer - appropriate processing experiment varies the type task used for encoding & the task used for retrieval.

- Morris & coworkers (1977) did an experiment with two parts: The encoding part of the experiment had two conditions: 1) the meaning condition, in which the task focused on the meaning f the word & 2) the rhyming condition, in which the task focused on the sound of the word.

- Participants in both conditions heard a sentence with one word replaced by the word “blank”; 2 seconds later, they heard a target word.

- The task for the memory group was to answer “yes” or “no” based on the meaning of the sentence creating by replacing the “blank” with the “target” word.

- The task for the rhyming word was to answer “yes” or no” based ont= the rhyme created by replacing “blank” with the target word.

Examples From the Meaning Condition

1. Sentence: The *blank* had a silver engine.

   Target word: *train*

   Correct answer: "yes"

2. Sentence: The *blank* walked down the street.

   Target word: *building*

   Correct answer: "no"

Examples From the Rhyming Condition

1. Sentence: *Blank* rhymes with pain.

   Target word: *train*

   Correct answer: "yes"

2. Sentence: *Blank* rhymes with car.

   Target word: *Building*

   Correct answer: "no"

Excerpt: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (p. 186)

- In the retrieval part of the experiment, participants from both the groups were given a rhyming recognition test. For the test, participants were presented with 32 words that rhymed with one f the target words presented during encoding & 32 words that dd not rhyme.

- The rhyming words presented in this test were always different rom the target word presented earlier.

- The participants task was to indicate whether each word presented during retrieval rhymed with one of the targets they had heard during learning.

- The results showed that participants who were in the rhyming group during encoding remembered more words than participants who are in the meaning group.

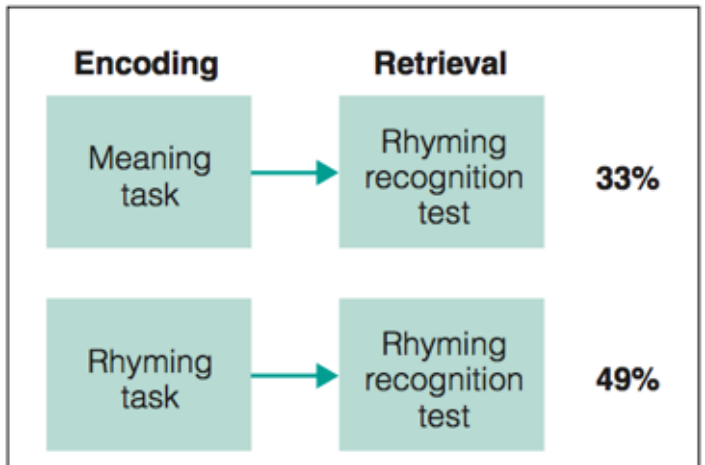


FIGURE 7.15 Design and results for the Morris et al. (1977) transfer-appropriate processing experiment. Participants who did a rhyming-based encoding task did better on the rhyming test than participants who did a meaning-based encoding task. This result would not be predicted by levels-of-processing theory, but is predicted by the principle that better retrieval occurs if the encoding and retrieval tasks are matched.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.15, p. 185)

Memory & The Brain

- Hebb (1948) introduced the idea that learning & memory are represented in the brain by physiological changes that take place at the synapse. Let's assume that a particular experience caused nerve impulses to travel down the axon of the neuron A onto neuron B.

- Hebb's idea was that this activity strengthens the synapse by causing structural changes, greater transmitter release & increased firing.

- Hebb also proposed that changes that occur in hundreds & thousands of synapses that are activated by a particular experience, provide a neural record of the experience.

- These proposals became the starting point for modern research. in memory & its physiology.

FIGURE 7.16 (a) What happens at a synapse as a stimulus is first presented. The record next to the electrode indicates the rate of firing recorded from the axon of neuron B. (b) As the stimulus is repeated, structural changes are beginning to occur. (c) After many repetitions, more complex connections have developed between the two neurons, which causes an increase in the firing rate, even though the stimulus is the same one that was presented in (a).

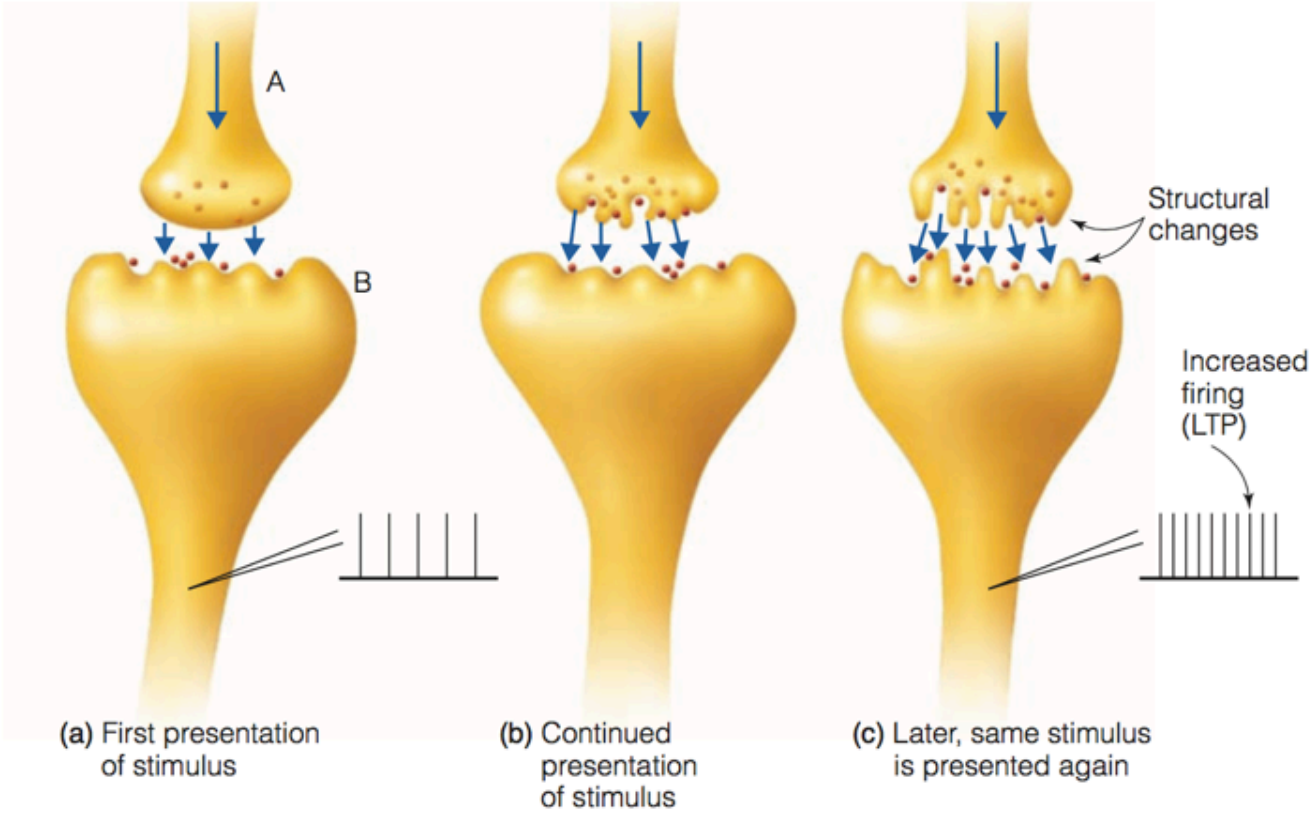
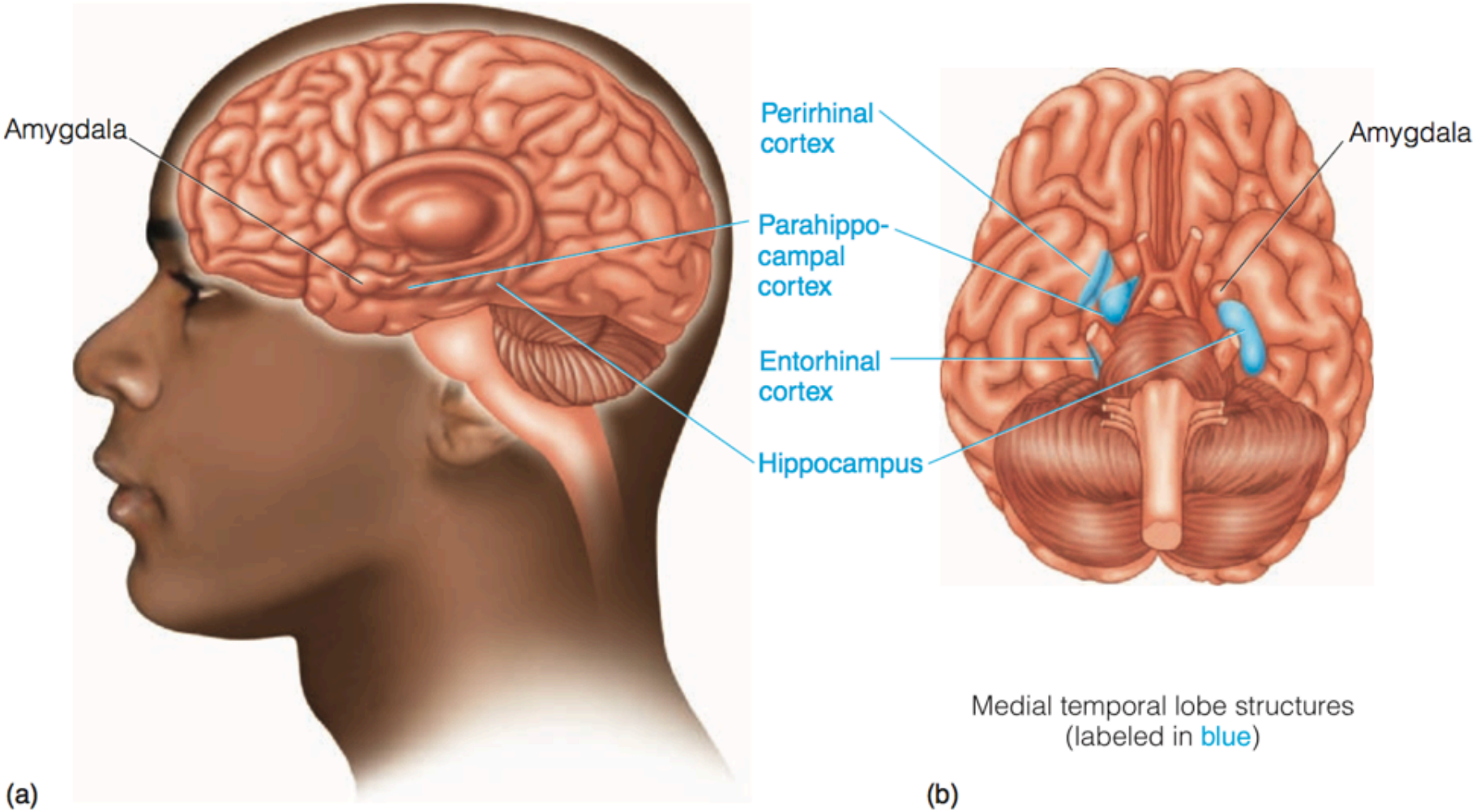


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.16, p. 190)

- One outcome of these changes at the synapse is called **long term potentiation** - enhanced firing of neurons after repeated stimulation.
- LTP is illustrated in the firing records in the figure shown earlier.
- However after repeated presentation, the neuron responds more rapidly to the same stimulus.
- LTP shows that repeated stimulation not only causes structural changes but also enhanced responding.

- Where does memory occur in the brain?
  - Memory does not occur in a specific place in the brain; it is distributed across a range of different areas.
  - the frontal cortex is important for memory while other areas for e.g. the medial temporal lobe can be said to be important for the LTM.



● **FIGURE 7.17** (a) Side view of the brain and (b) underside of the brain, showing the amygdala and structures in the medial temporal lobe (perirhinal cortex, parahippocampal cortex, entorhinal cortex, and hippocampus).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.17, p. 191)

- The medial temporal lobe houses the hippocampus. It also houses the perirhinal cortex.

- Davachi & coworkers (2003) designed a study to determine how these ares responded to the names of objects presented as a part of the memory experiment.

- Participants viewed a series of 200 words in a fMRI scanner & were instructed to create an image of a specific place that went with each words. for e.g. for *dirty* they could create a garbage dump.

- 20 hours later, the participants were presented with a recognition test in which they saw the same 200 words they had seen earlier, along with a new set of 200 words.

- During this part of the experiment, they were not in the scanner; their task was to indicate which of the words they had seen before, so a correct answer would be “old” when an old words was presented , and “new” when a new word was presented.

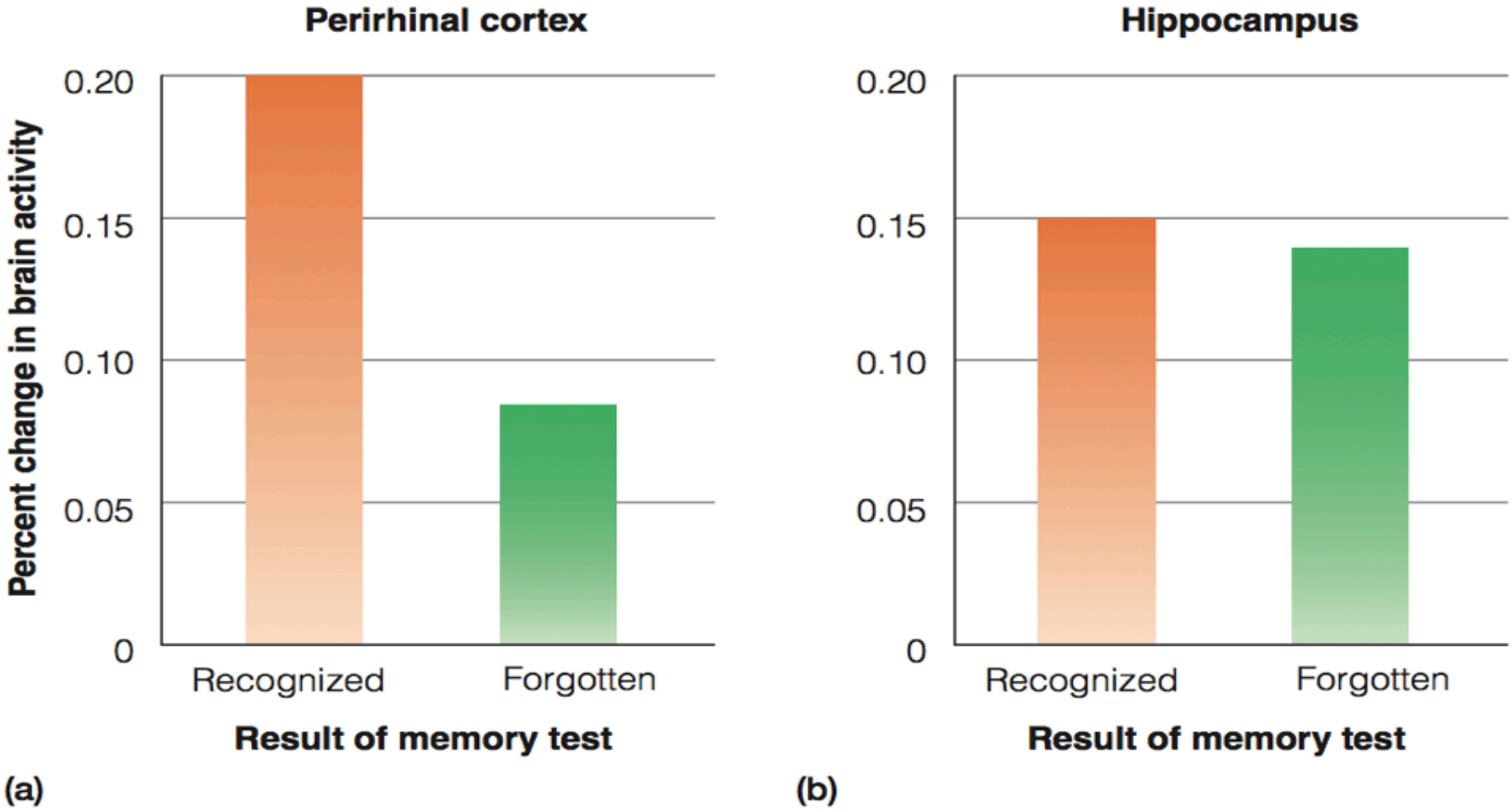
- Davachi found that participants remembered 54% of he old words & forgot the rest 46% words.

- The results indicate that activity in the perirhinal cortex was great for remembered words than for the forgotten words. This, in the perirhinal cortex, words that generated more activity during encoding were more likely to be familiar to the participants during the recognition test.

- This result confirms physiologically what we have seen behaviourally.

FIGURE 7.18 Design of Davachi's experiment. During encoding, participants in a scanner created images in their mind in response to words. During retrieval 20 hours later, the participants' task was to recognize the words they had seen.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.18, p. 192)



● **FIGURE 7.19** Results of Davachi's experiment. (a) Response in perirhinal cortex measured during encoding for items that were recognized and forgotten in the retrieval test. (b) Response of the hippocampus for recognized and forgotten items.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.19, p. 193)

- Other structures in the MTL are also involved in memory for e.g. the parahippocampal area is important for remembering spatial information; & the entorhinal cortex is involved in recognition memory.

Memory Consolidation

- ***consolidation*** refers to the process that transforms the newly formed fragile memories to more stable & permanent state where they are more resistant to disruption or change (Frankland & Bontempi, 2005).

- This process involves a reorganisation in the nervous system, which occurs at two levels:

- *synaptic consolidation* which occurs at the synapse and happens rapidly over a period of minutes. e.g. the structural changes in the neurons.

- *systems consolidation* involves the gradual reorganisation of circuits within brain regions and takes place over a much longer time scale.

- Early research , inspired by Hebb's pioneering work on the role of the synapse in the memory focused on synaptic consolidation. More recent research has focused on the phenomenon of systems consolidation & the role of different brain areas. for e.g. the hippocampuss plays a central role in the *standard model of consolidation*.

- Two Theories:
    - **Standard Model of Consolidation:** The graded property of retrograde amnesia, in which amnesia is worse for experiences that occurred just before the brain injury, plus other evidence, led to the proposal of this model.
    - The model proposes that memory retrieval depends on the hippocampus during consolidation, but that one consolidation is complete, retrieval no longer depends on the hippocampus.

- Incoming information activates a number of areas in the cortex; activation is distributed across the cortex because memories typically involve many sensory & cognitive areas. This is because the memory for events & things may involve activity in a variety of areas (for e.g. those involved in processing different sights, sounds & smells).

- The hippocampus coordinates the activity of the different cortical areas, which at this point are not connected in the cortex.

- The major mechanism of consolidation is reactivation, a process during which the hippocampus replays the neural activity associated with a memory.

- During reactivation, activity occurs in the network connecting the hippocampus & the cortex.

- This activity results in the formation of connections between the cortical areas. This reactivation process occurs during sleep or during periods of relaxed wakefulness & can also be enhanced by conscious rehearsing of a memory.

- Eventually, the cortical connections become strong enough so that the different sites in the cortex become directly linked, and the hippocampus is no longer necessary.

- Thus, acc. to the standard model of consolidation, the hippocampus is strongly active when memories are first formed but become less active as memories are consolidated, until eventually only cortical activity is necessary to retrieve remote memories.

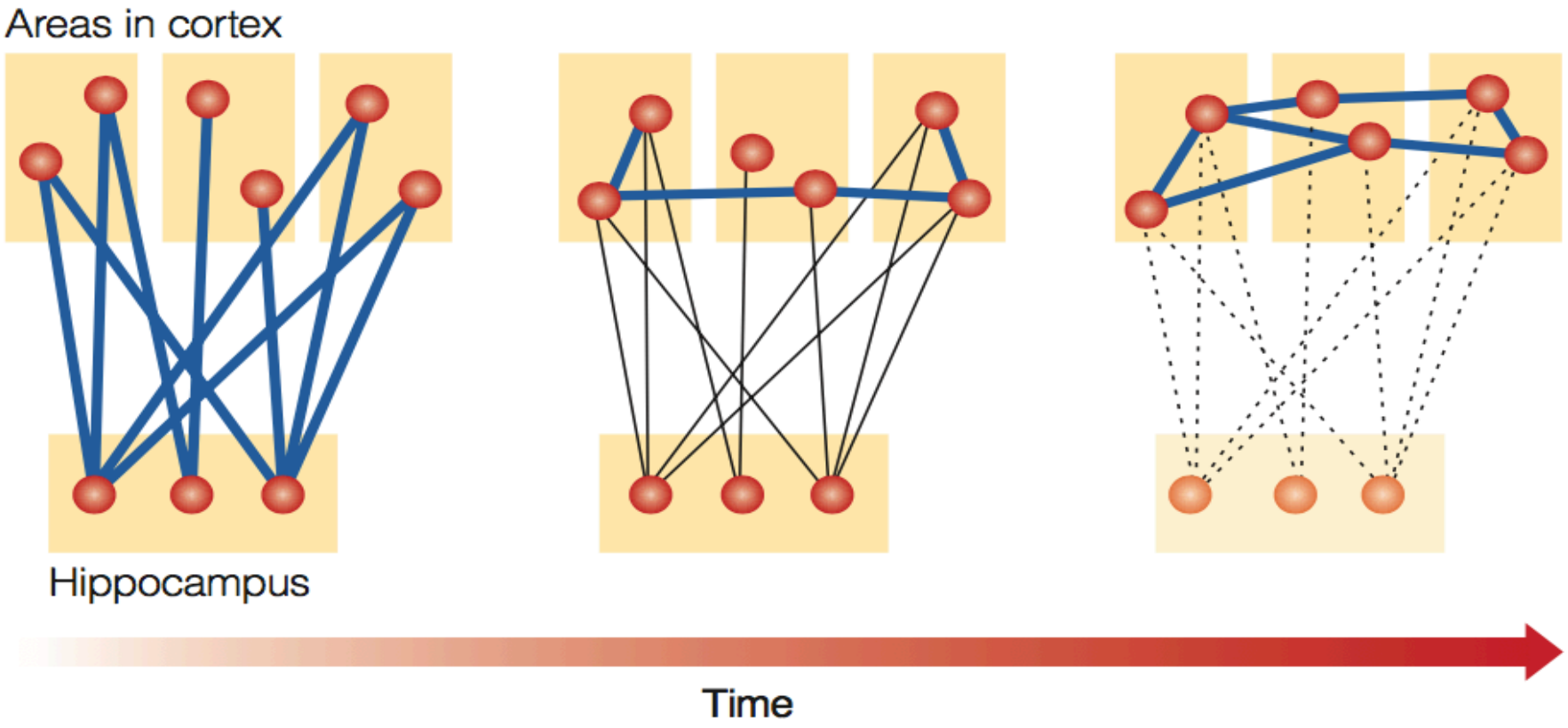


FIGURE 7.21 Sequence of events that occur in consolidation. Connections between the cortex and the hippocampus are initially strong but weaken as connections within the cortex are established. (Adapted from Frankland & Bontempi, 2005.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.20, p. 194)

- **The multiple trace hypothesis:** Acc. to the multiple trace hypothesis, the hippocampus is involved in retrieval of remote memories, especially episodic memories (Nadel & Moskovitch, 1997).

- Evidence for this idea comes from experiments like one by Giboa & coworkers (2004) who elicited recent & remote episodic memories by showing participants photographs of themselves engaging in variouss activities that were taken at times ranging from recently to when they were 5 yrs old.

- The result of the experiment showed that the hippocampus was active during retrieval of both, recent & remote memories.

- The fact that there is evidence supporting both the standard & multiple trace hypothesis has led to a great deal of discussion among memory researchers regarding whether or not the hippcocampus is involved in remote memories (Jadhav & Frank, 2009).

- Reconsolidation: Nader & other researchers propose that after a memory is reactivated, it must undergo reconsolidation, which is similar to the consolidation that occurred after the initial learning but apparently occurs more rapidly (Dudai, 2006).

- One can say that memory becomes susceptible to being changed or disrupted everytime it is retrieved.

- Reconsolidation might provide an opportunity for reinforcing or updating memories.

- For example: an animal that returns to the location of a food source & finds that food has been moved to a new location nearby.

- Now returning to the original location has reactivated the original memory, new information updates the original memory about the change in location & the updated memory is now reconsolidated.

- In another experiment, Nader & colleagues (2000) used classical conditioning on a rat to create a fear response of "freezing" to a presentation of a tone, by pairing the tone with a shock.

- In each condition, the rat received a tone-shock pairing & is injected with *anisomycin*, an anti-biotic that inhibits its protein synthesis & so prevents changes at the synapse that are responsible for formation of new memories.

- An important aspect of the experiment was the timing of injection of anisomycin.

- In condition 1, the rat recieves the pairing of the tone and shock on day 1; it recievs anisomycin on day 2 & then freezes to the tone when rested on day 3.
    - This is along the expected lines because the conditioning occurs on day 1 & the drug isn't injected till day 2.
- In condition 2, thhe rat recieves the pairing of the tone & shock on day1, but the drug is injected immediately, before the consolidation has occurred.
    - As the drug has blocked consolidation , the rat does not freeze to the tone on day 3.

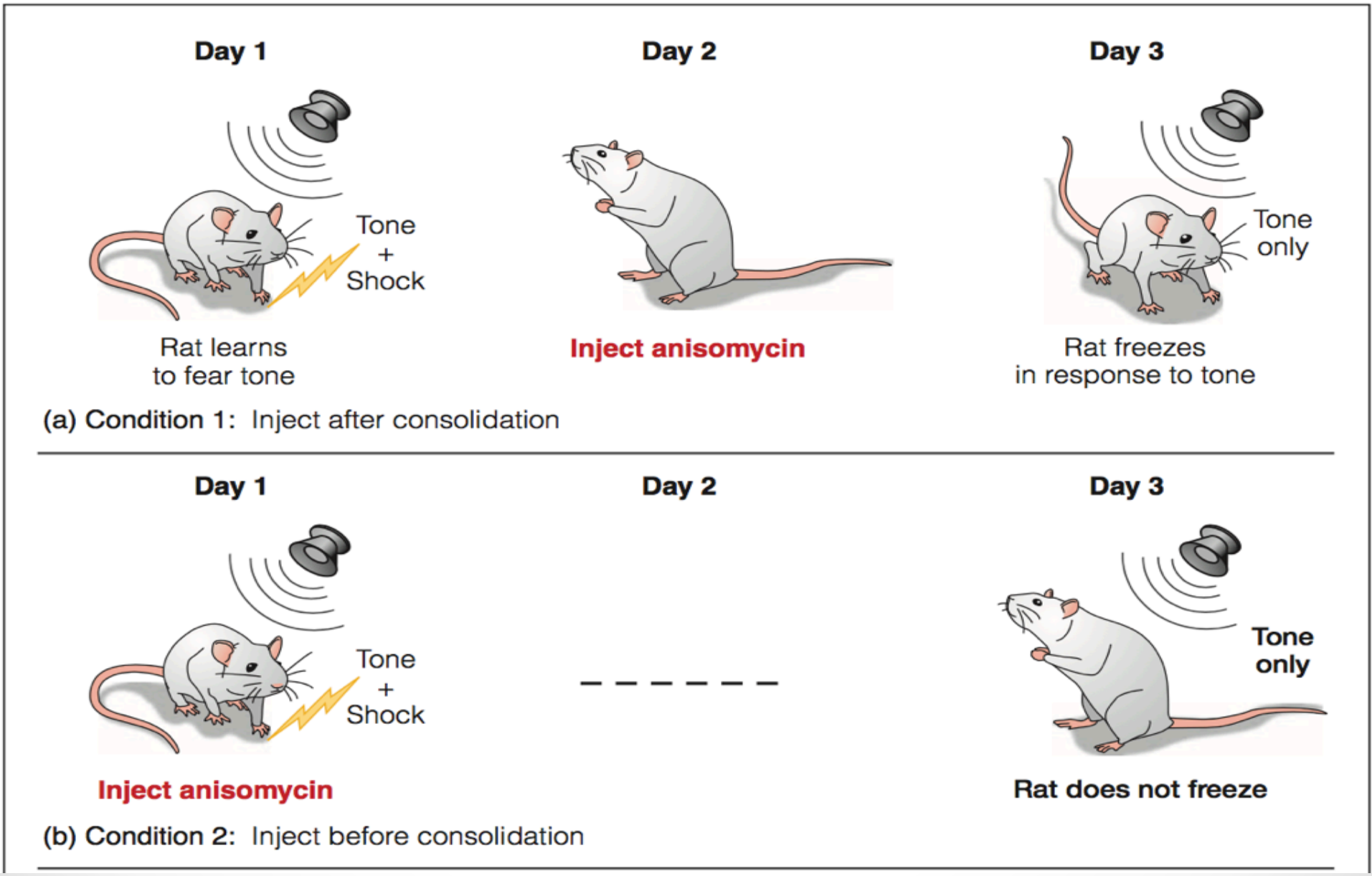
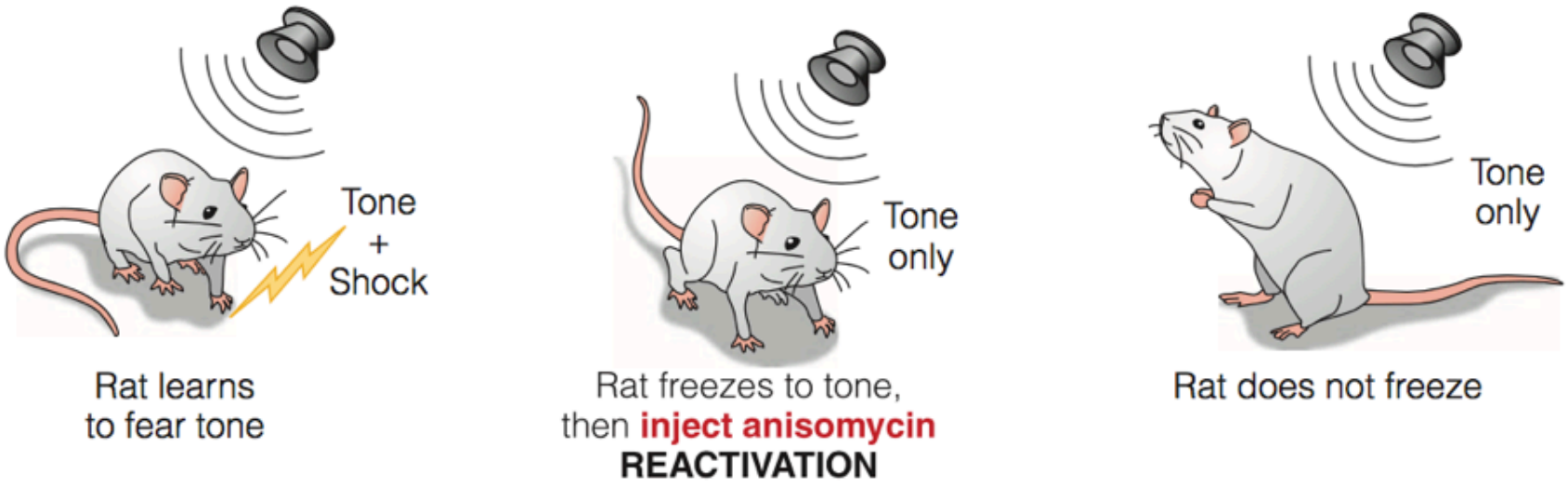


Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.22, p. 194)

- In condition 3, the memory becomes reacticated 7 becomes fragile, just as it was immediately after it was formed.



(c) Condition 3: Inject during reactivation

FIGURE 7.23 The Nader et al. (2000a) experiment on the effect on fear conditioning of injecting anisomycin.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.22, p. 194)

- **Does it occur in humans?**

  - Some evidence that it does (Nader, 2003). In an experiment by Hupbach & colleagues (2007), participants learned a list of words (List 1) on Day 1.

  - On Day 2, one group (the non – reminder group) learned a new list of words (List 2). Another group, (the reminder group) also learned the new list on Day 2, but just before learning the list, they were asked to remember their Day 1 training sesion (without actually recalling the List 1 words), thus reminding them of their learning.

- When on Day 3, these two groups were asked to remember List 1, the no – reminder group recalled 45% of the words from List 1 but mistakenly 5% of the words from List 2.
- The reminder group recalled 36% of the words from List 1, but in adition mistakenly recalled 24% of the words from List 2.
- Ac.. to Hupbach & colleagues, what happened was that the reminder on day 2 reactivated the memory for List 1, making it vulnerable to being changed.
- As participants immediately learned List 2, some of the words from List 2 became integrated into the participants memory for List 1.

- A practical implication outcome of research on reconsolidation is a possible treatment for post – traumatic stress disorder.

  - Clinical psychologist Alain Brunet (2008) tested the idea that reactivation of a memory followed by reconsolidation can provide a way to alleviate the symptoms of PTSD, such as having the flashback of the truma.

  - The idea is to reactivated the person's memory for the traumatic event & then administer the drug ***probanolol***, which blocks production of a stress hormone in the amygdala.

- Brunet ran two groups; one group of PTSD patients listened to a 30 second recording describing the circumstances of their traumatic experience and received *probanolol* & the other group listened to the recording describing their experience but received a placebo.

- One week later, both groups were told to imagine their traumatic experience, while again listening to the 30 - second recording.

- To determine their reaction to imagining their experience, skin conductance response & blood pressure were being monitored.

- Brunet found that the *probanolol* group experienced much smaller increases in their heart rate & skin conductance than the placebo group. He has used this procedure to treat patients with PTSD, and many of the patients report significant decrease in their symptoms even months after treatment (Singer, 2009).

References

- Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed.