Behavioral Neuroscience: Fear thou not

Thoughts

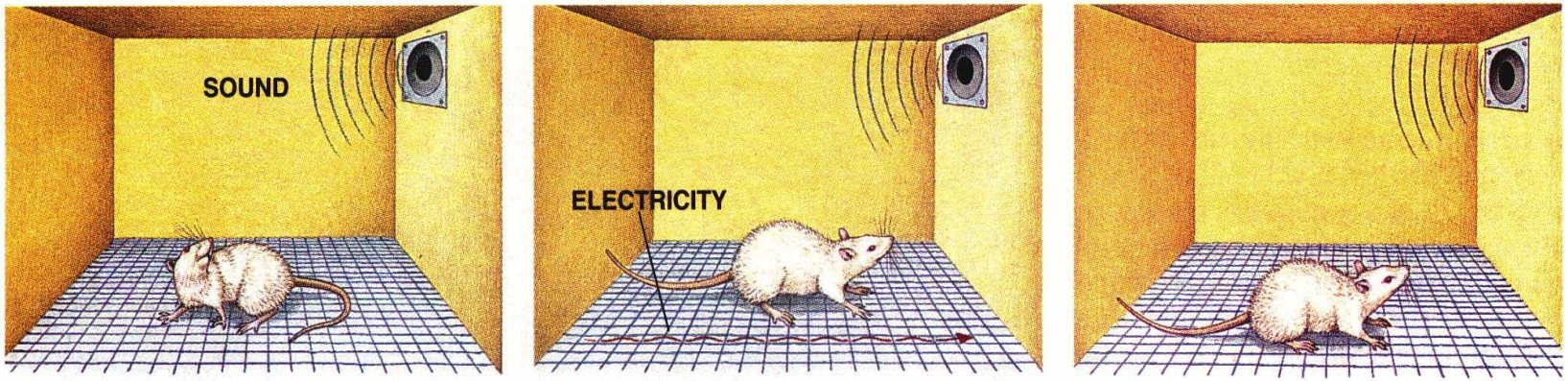
- What is a “reward”?
- Learning is best motivated by threats to survival?
- Threats are much better reinforcers?
- Fear is a prime motivator

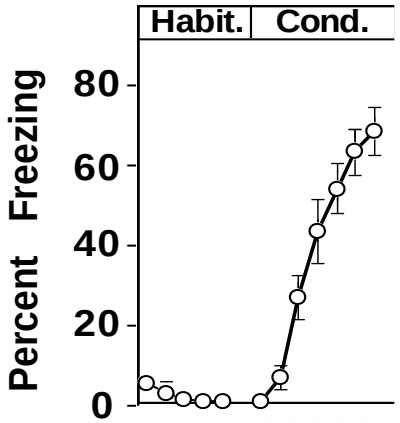
	Decreases behavior	Increases behavior
Presented	Positive punishment	Positive reinforcer
Taken away	Negative punishment	Negative reinforcer

Taking drugs?

More fun,
less withdrawal

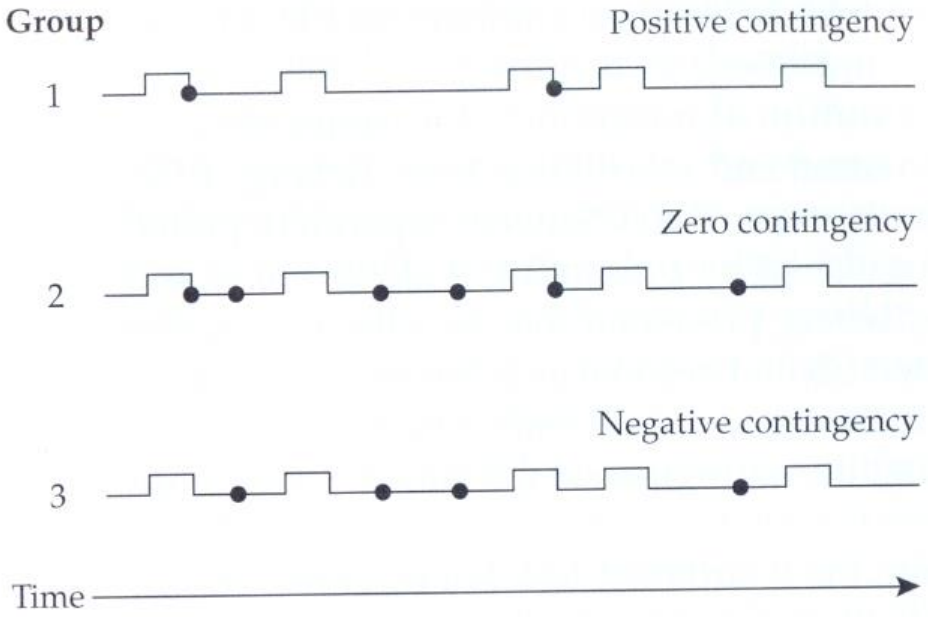
Classical fear conditioning

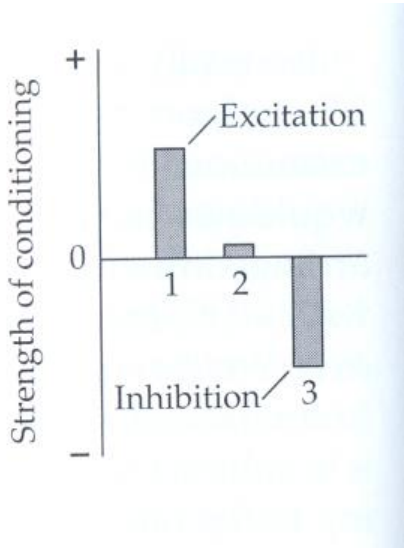




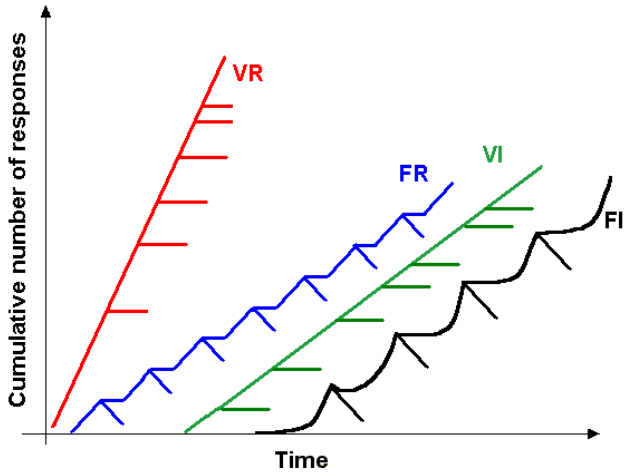
CS-US pairing
Tone = conditioned stimulus (CS)
Foot-shock = unconditioned stimulus (US)
Freezing = conditioned response (CR-UR)

Contingency: co-occurence

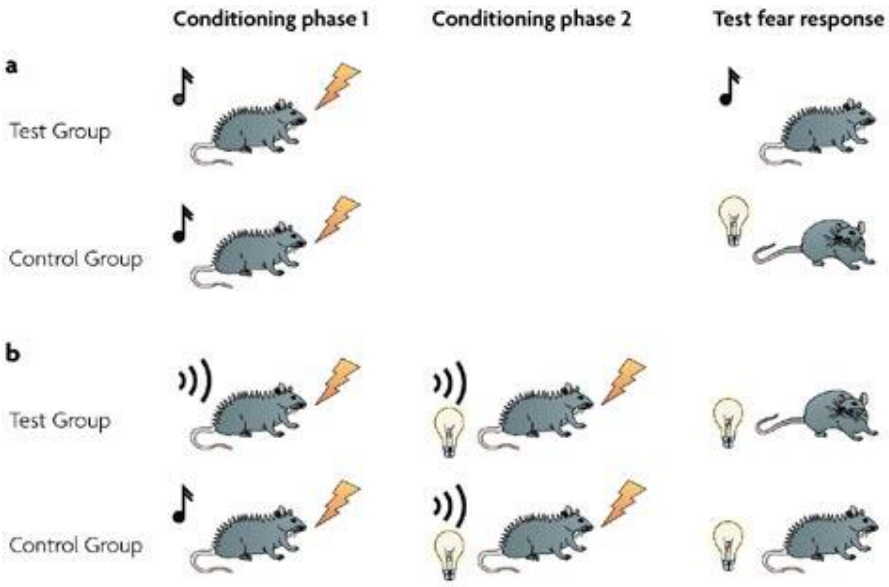




Schedules of reinforcement:
Variable/fixed interval/ratio



More than contingency: Surprise / added information



Aversive conditioning

Blocking

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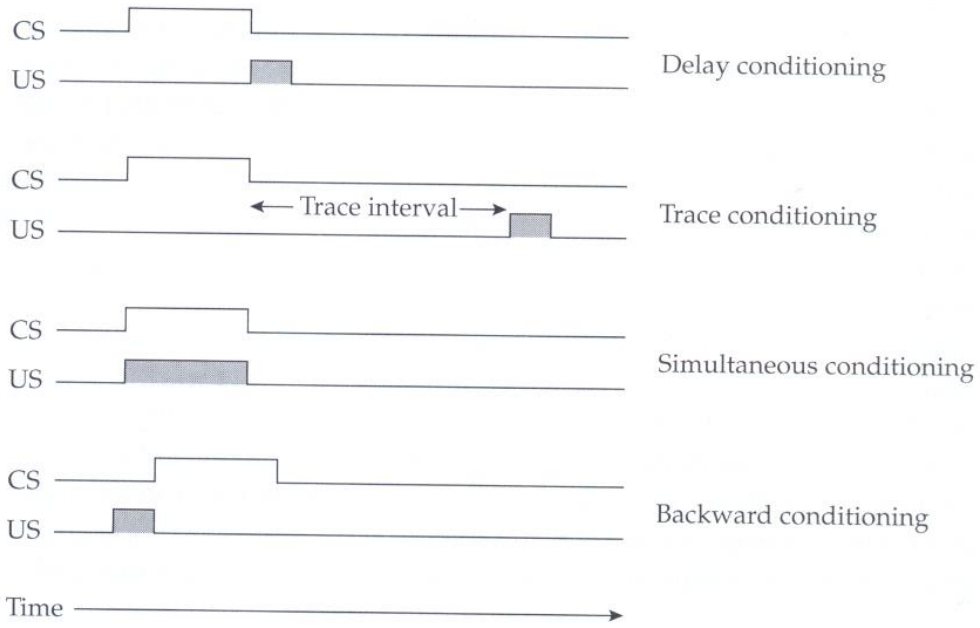
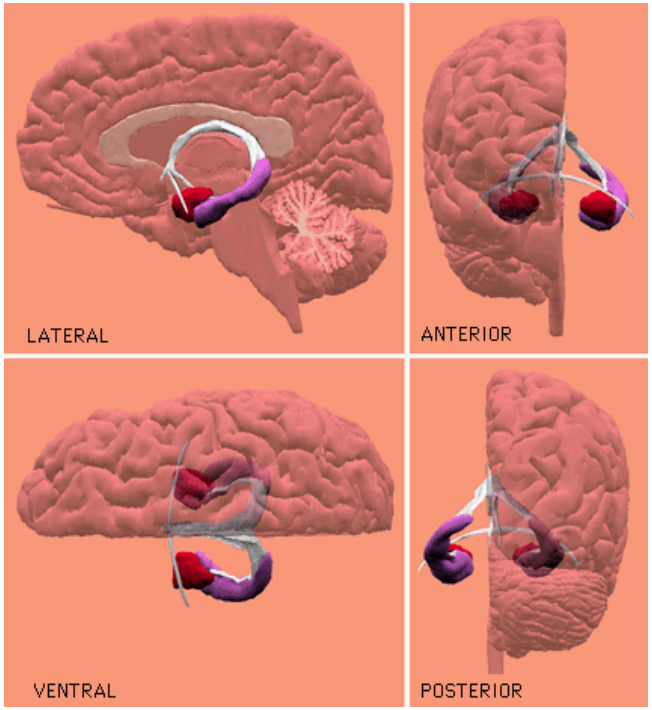
Rules of thumb for conditioning strength

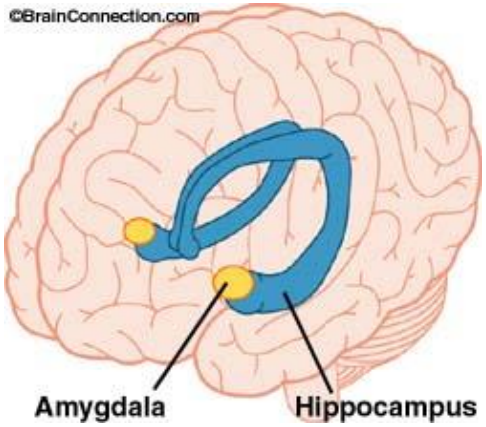


- Backward < simultaneous < trace < delay
- In trace: short interval > long interval
- In delay: short CS > long CS
- Salience of the CS
- Strength of the US
- Spaced trials is better than massed trials (the ratio between inter-trial-interval and the CS)

But notice it is hard to estimate backwards learning

Amygdala


LATERAL
ANTERIOR
VENTRAL
POSTERIOR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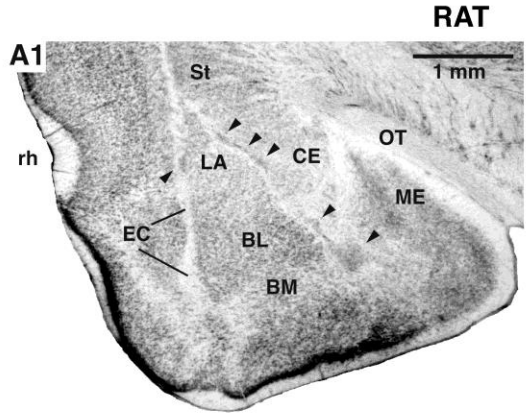
Amygdala
Hippocampus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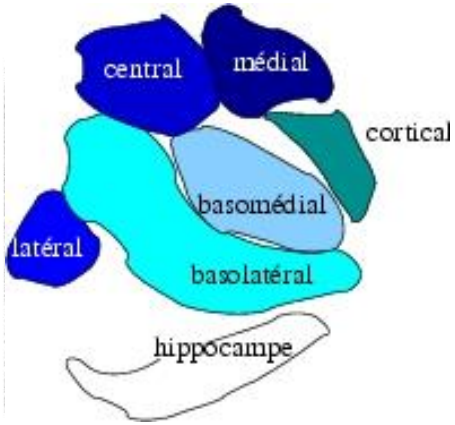
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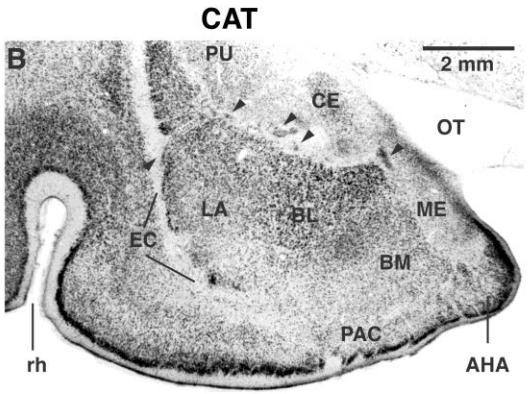
cortical
basomédial
latéral
basolatéral
hippocampe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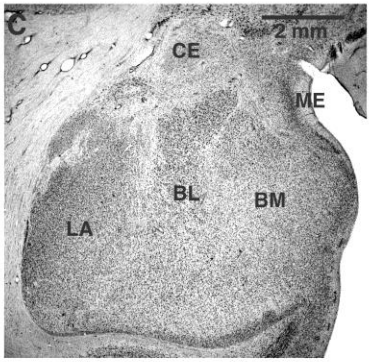
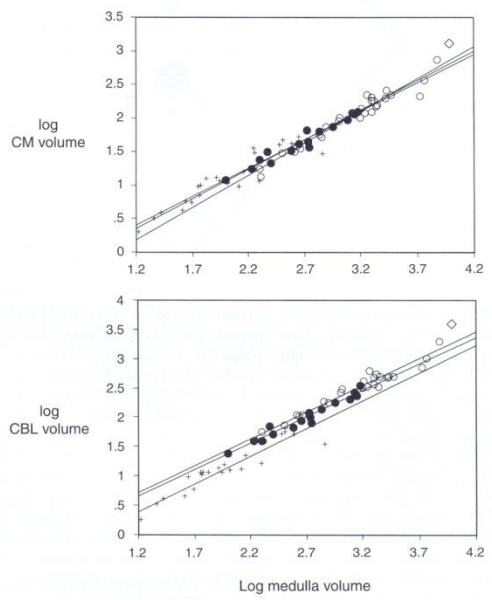
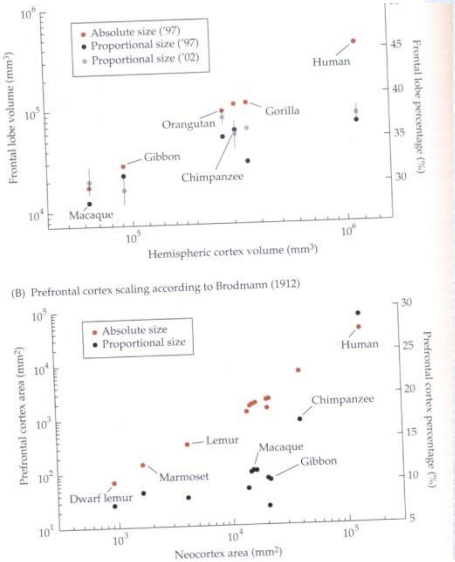
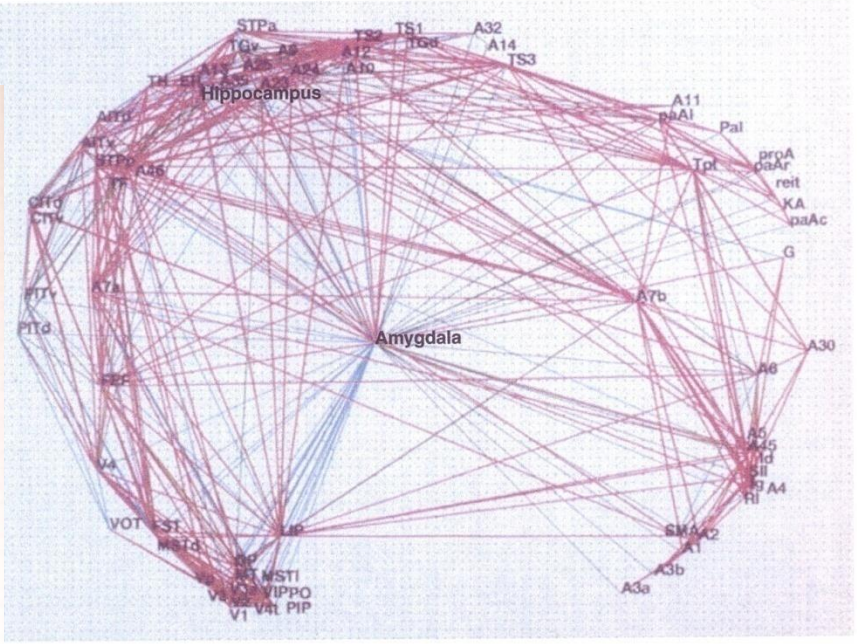

MONKEY
C
2 mm
CE
ME
BL
BM
LA

Amygdala and its basolateral complex (BLA)

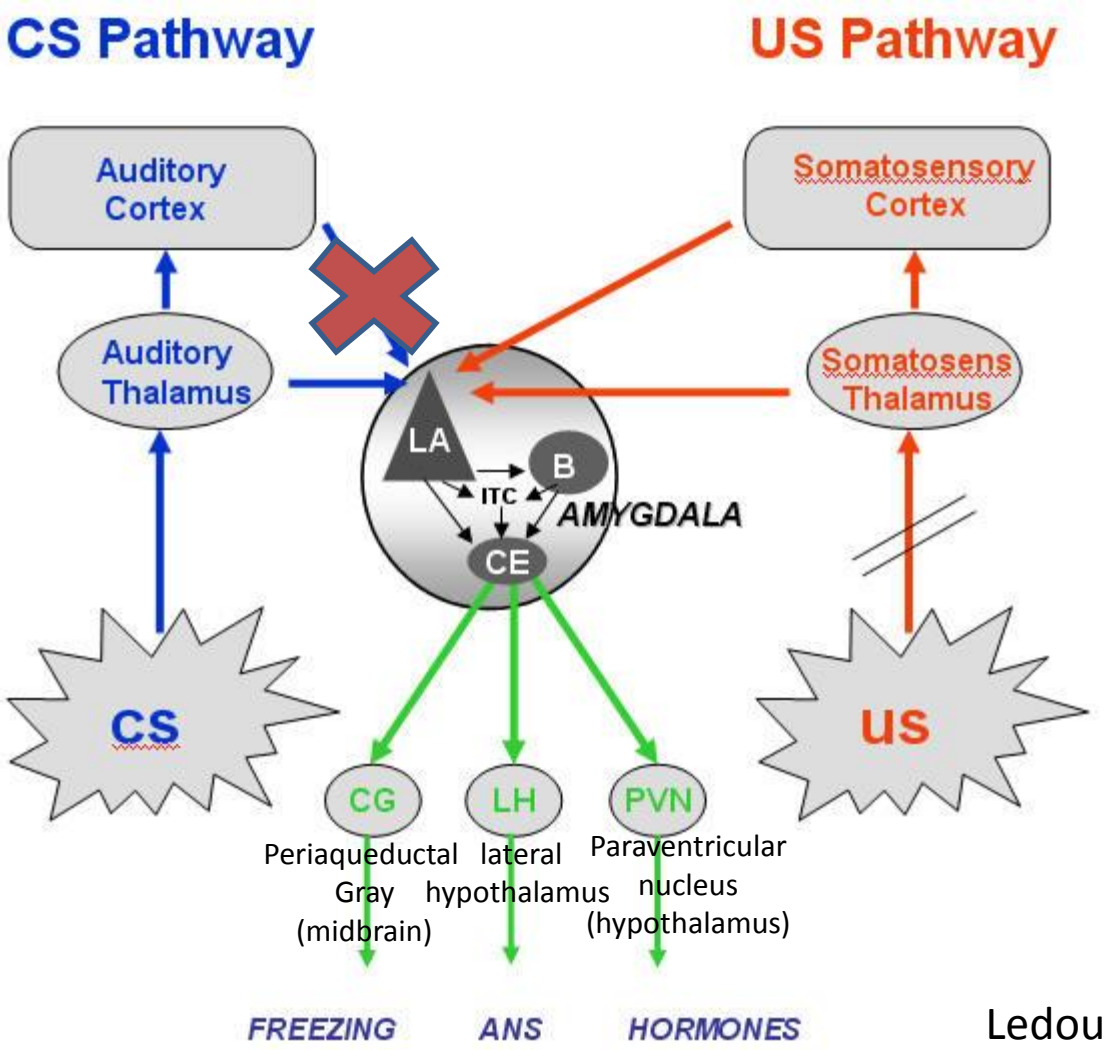
- BLA evolution parallels that of the prefrontal cortex
- BLA cell types reminiscent of cortex
- Cortical projections are much more extensive in primates
- Most cortical projections of the amygdala originate from BLA (none from CEA)





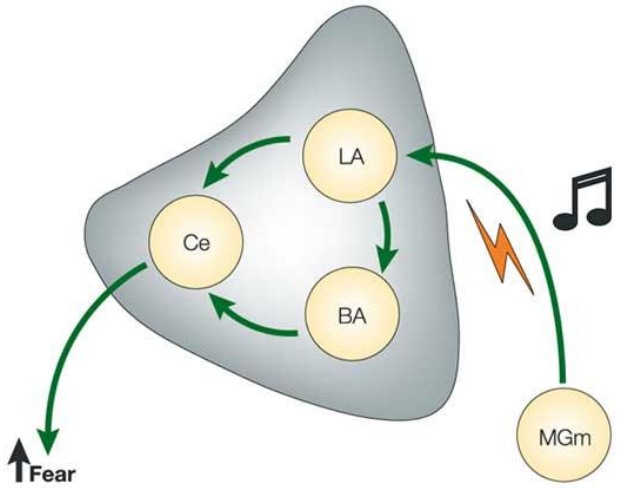


Fear circuit



Ledoux, Mcgaugh, Davis

Neurons acquire tone responses after conditioning



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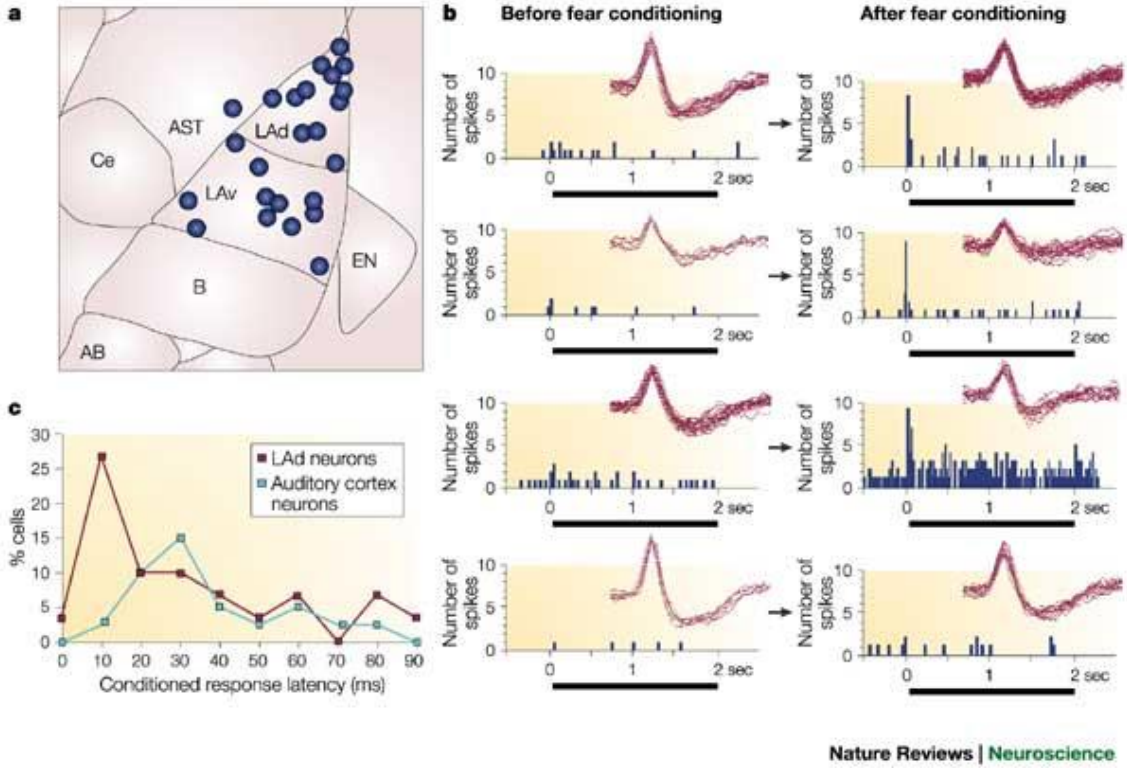

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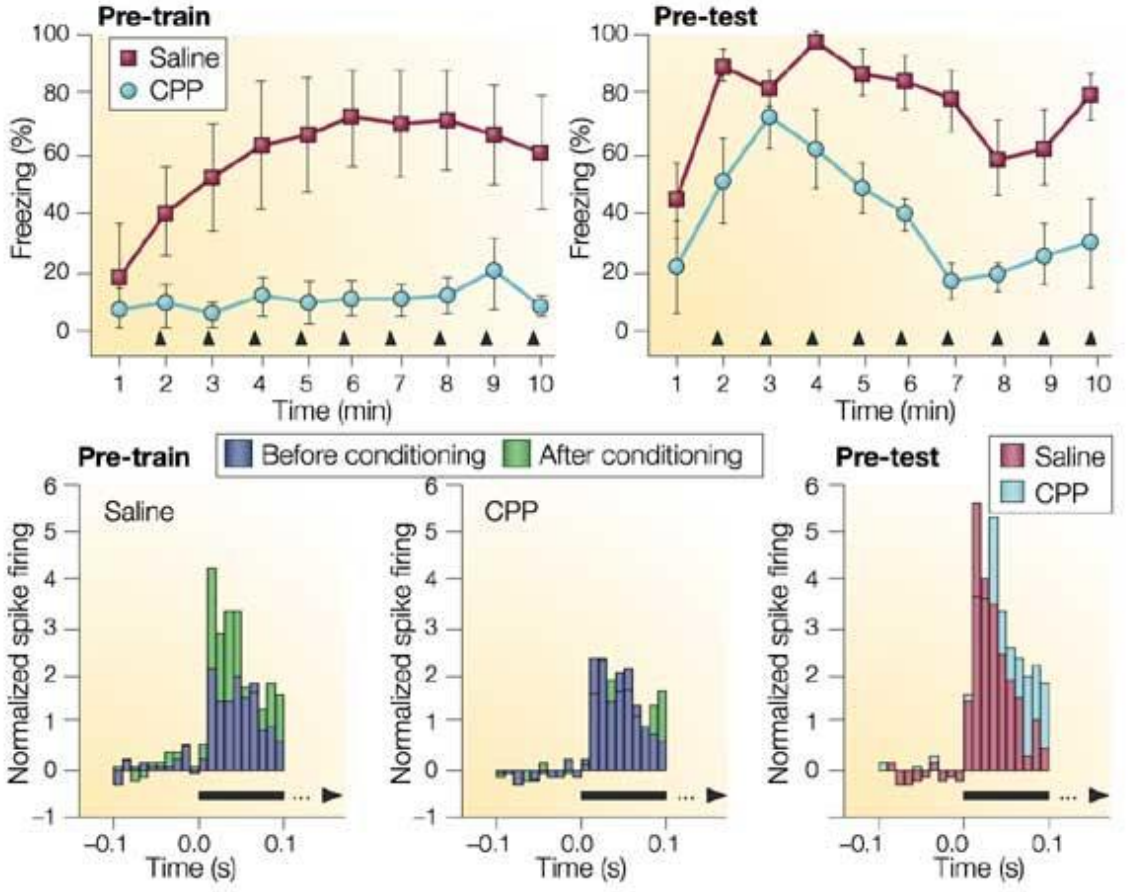
LTP in the LA is required

NMDA (***N***-methyl-**D**-aspartate, glutamate receptor) is involved in both the acquisition of fear memory and the induction of long-term potentiation (LTP) in the amygdala.



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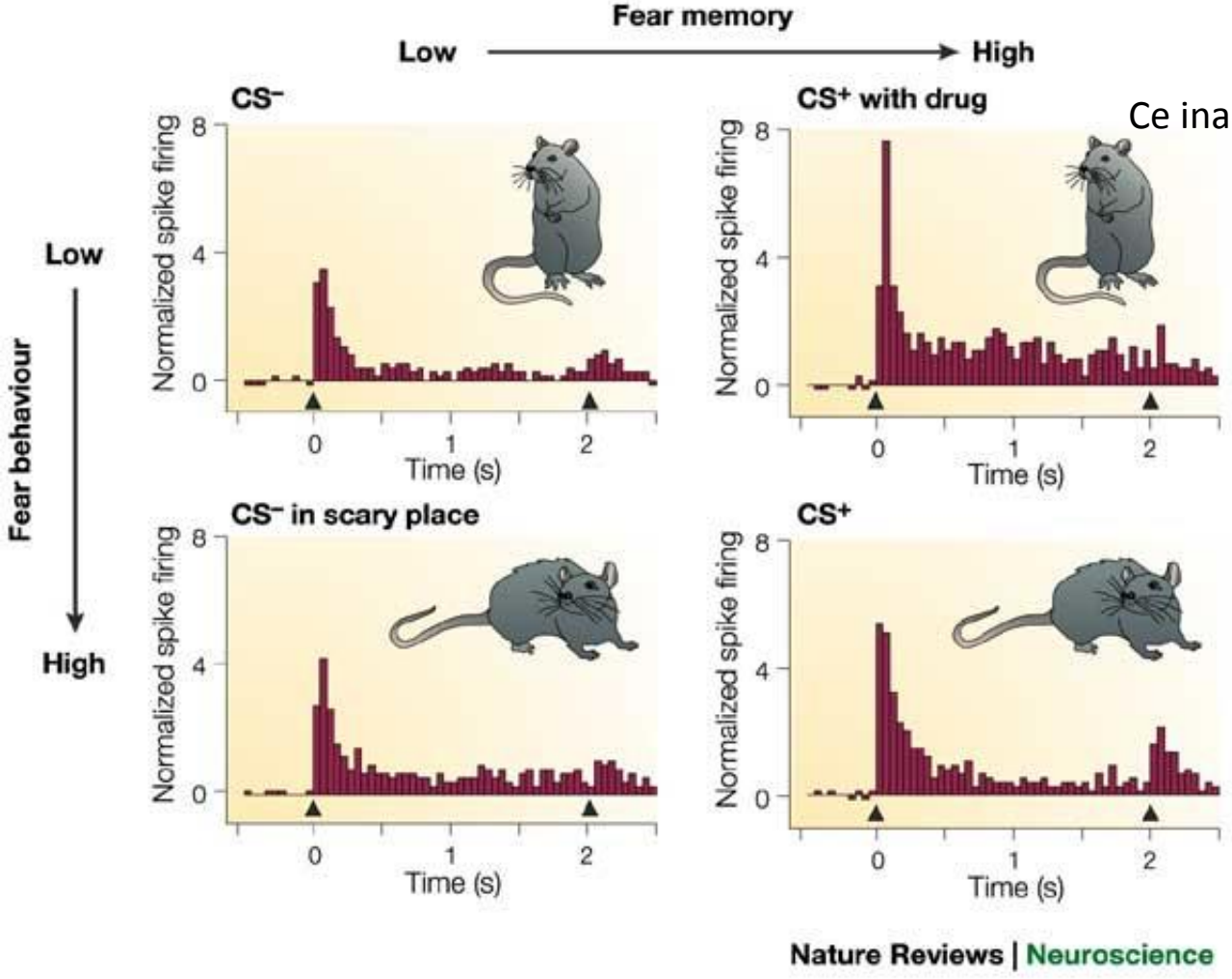
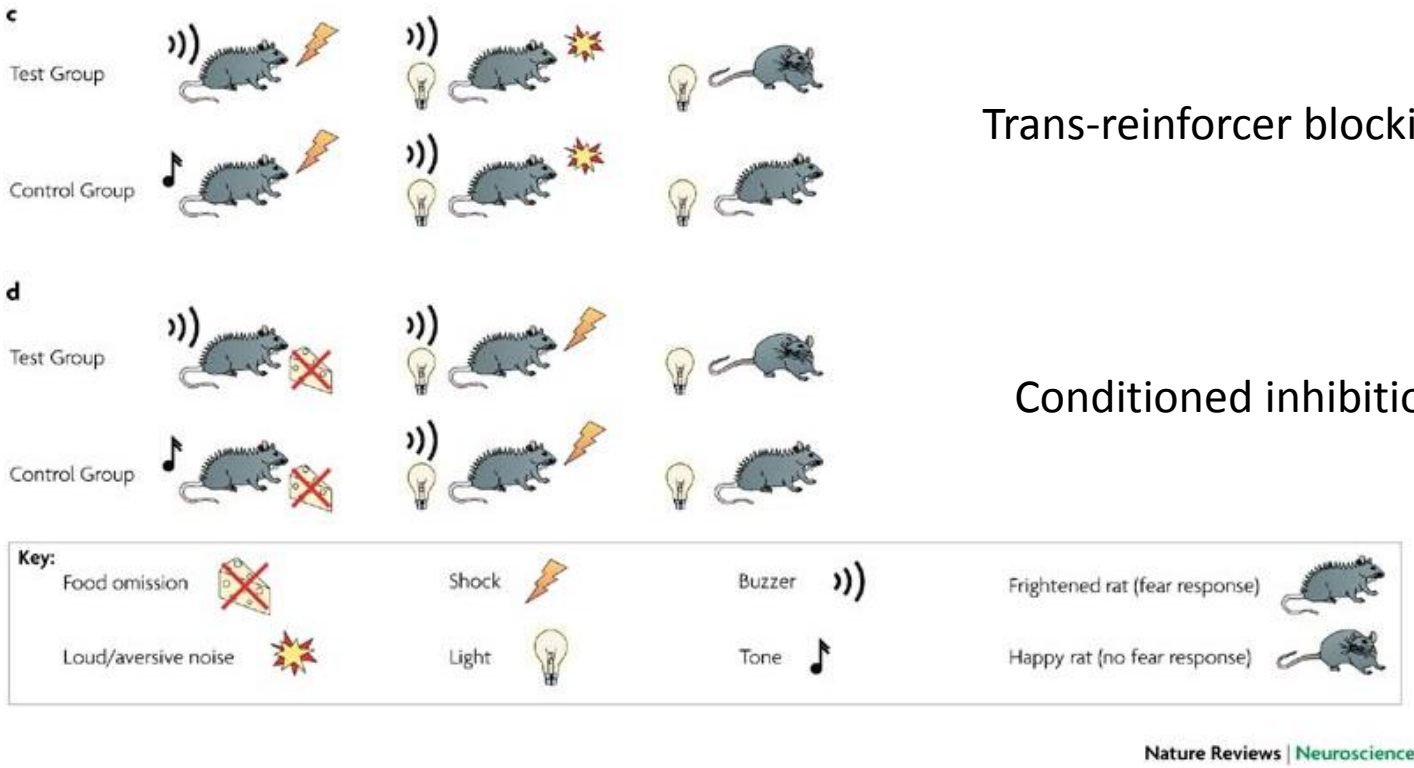
CPP (3-(2-carboxypiperazin-4-yl) propyl-1-phosphonic acid), a competitive NMDA-receptor antagonist

LA encodes memory independent of fear behavior



Ce inactivation

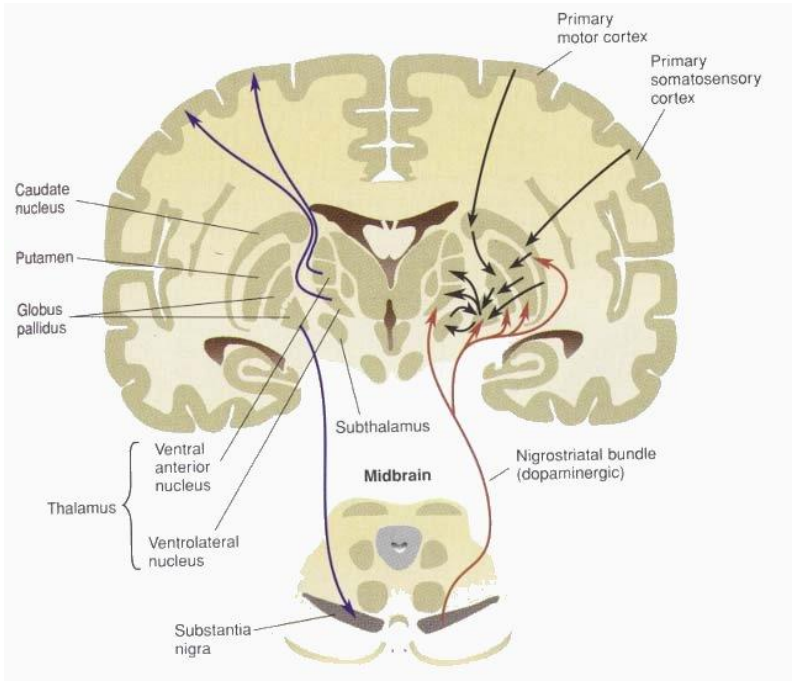


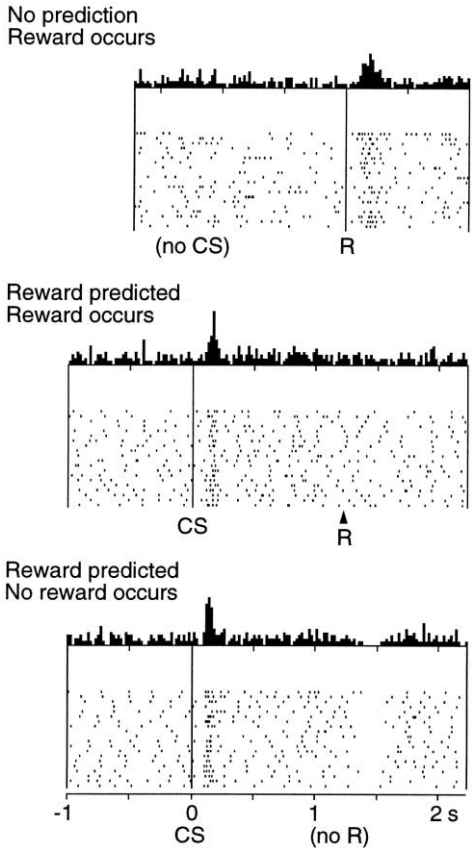
Trans-reinforcer blocking

Conditioned inhibition

Suggests common brain mechanisms

The dopamine system





Schultz et al, JNS 13: 900-913 ,1993

Pearce-hall and rescorla-wagner

the change (Δ) in the associative strength (symbolized V) of a CS

$\Delta V = S.\alpha.\lambda$

S is intensity of the CS and λ of the US. α represents the associability of the CS

$\alpha_n = |\lambda - \Sigma V|_{n-1}$

prediction V of the reward:

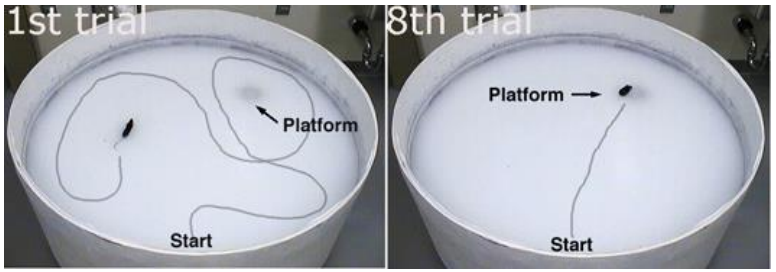
$V = \omega U$

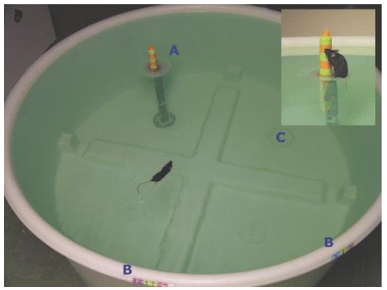
And learn to change ω :

$\Delta \omega = \varepsilon(R-V)U$

Amygdala modulation of memory

- Hippocampal dependent learning: spatial
- Striatum dependent-learning: cue-related





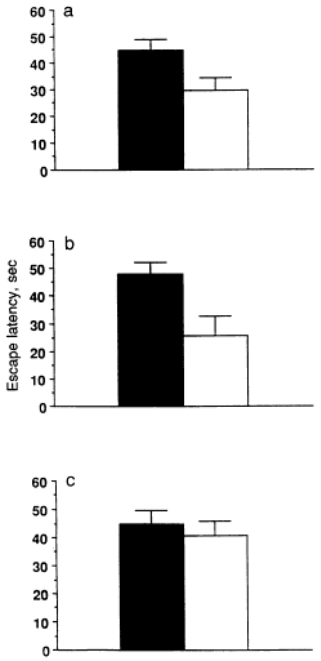


FIG. 1. Mean (±SE) escape latencies of *d*-amphetamine (10 μg) (□) and saline-treated (■) rats on the retention test trial in the spatial task. (*a*) Hippocampal injections. (*b*) Amygdala injections. (*c*) Caudate nucleus injections.

posttraining intracaudate and intrahippocampal injections of *d*-amphetamine on retention of cued and spatial learning in

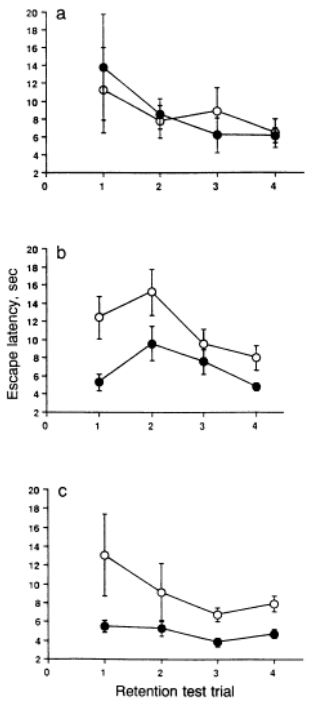


FIG. 2. Mean (±SE) escape latencies of *d*-amphetamine (10 μg) (●) and saline-treated (○) rats on the retention test trial in the cued task. (*a*) Hippocampal injections. (*b*) Amygdala injections. (*c*) Caudate nucleus injections.

Injection of d-amphetamine into the Amygdala affects both if right after training, but not if pre-testing

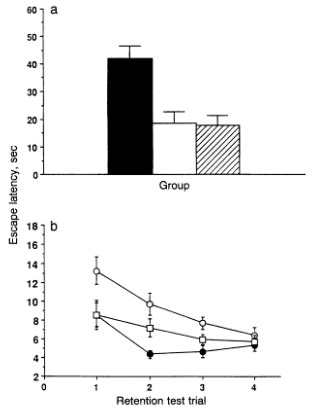


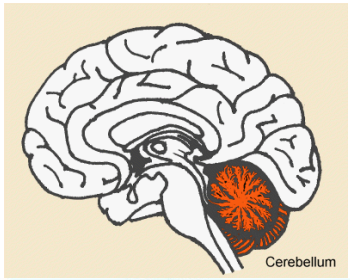
FIG. 3. Mean (±SE) escape latencies of rats receiving intraamygdala posttraining *d*-amphetamine or saline and rats receiving preretention test lidocaine or saline on the retention test trial(s) in the spatial task (*a*) and cued task (*b*). Posttraining/preretention: ■ (*a*) and ○ (*b*), saline/saline; □ (*a*) and ● (*b*), *d*-amphetamine/saline; ▨ (*a*) and □ (*b*), *d*-amphetamine/lidocaine.

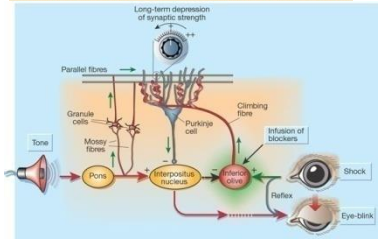
Packard, Mcgaugh

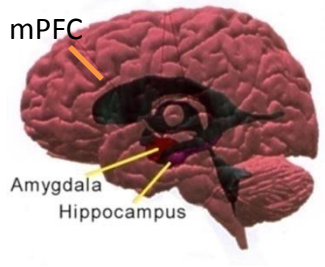
So, does it encode the memory or just modulates it?

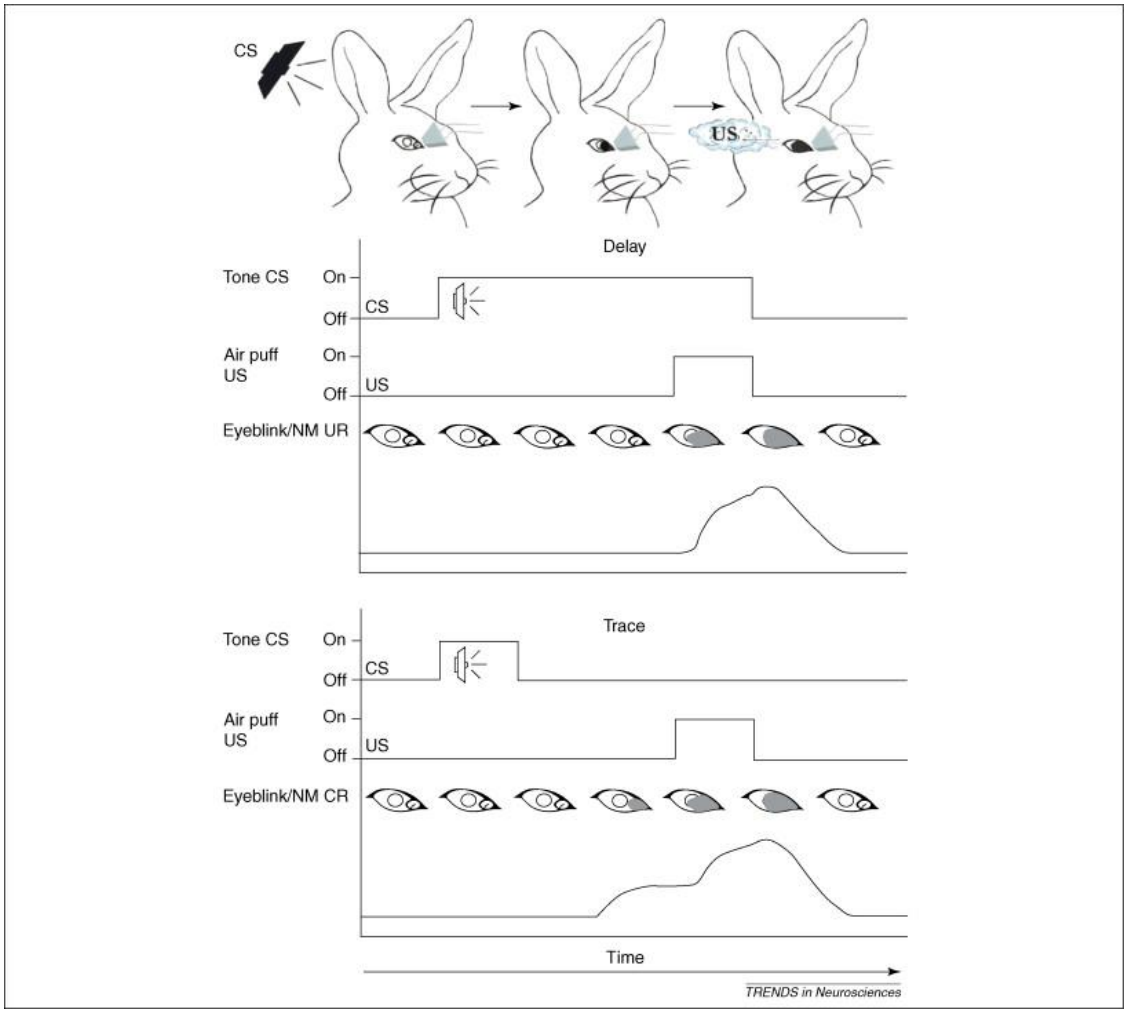
- **It depends.**

Eyelid (blink) reflex conditioning



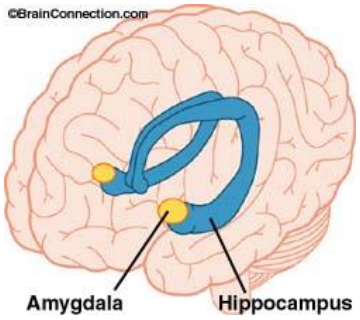


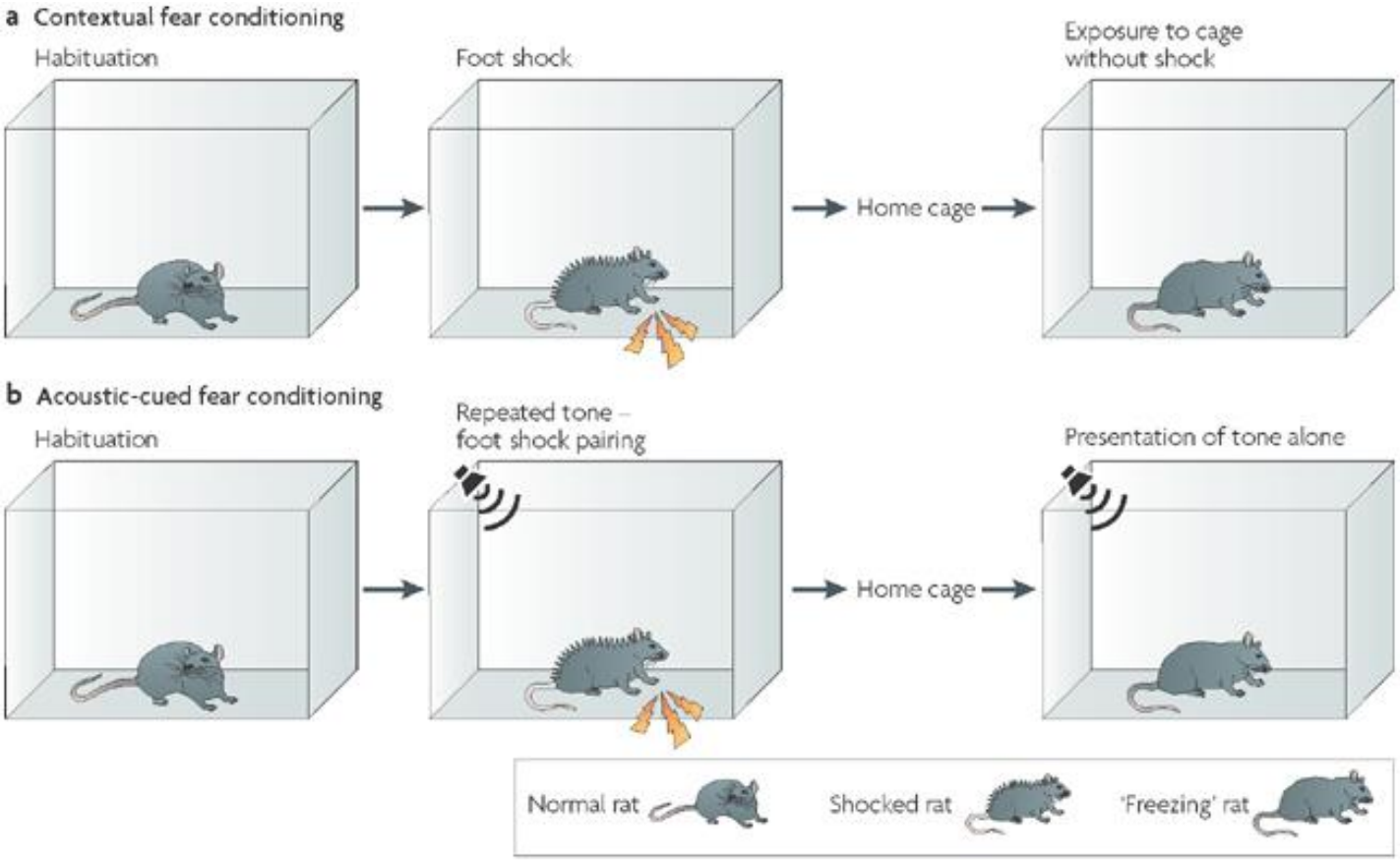




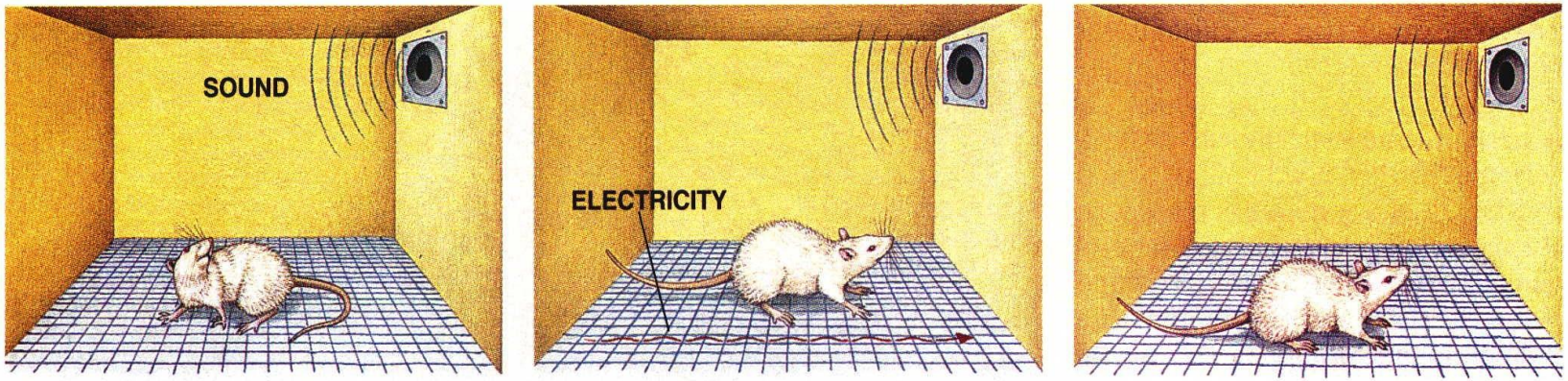
- Why is trace hippocampal-dependent?
- Maintaining the CS? Timing the trace? Harder?
- Eyelid requires ~0.3sec, and hippocampus is required when 0.5-1sec.
- In tone-shock, trace can be 3sec, and hippocampus is required for ~20sec
- This suggest context-conditioning

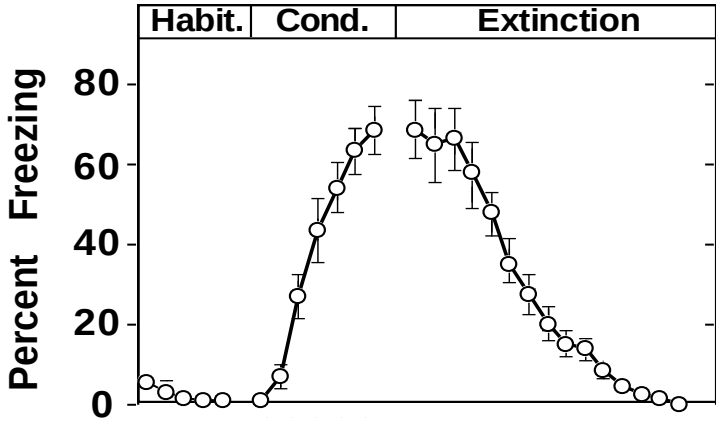
Contextual fear



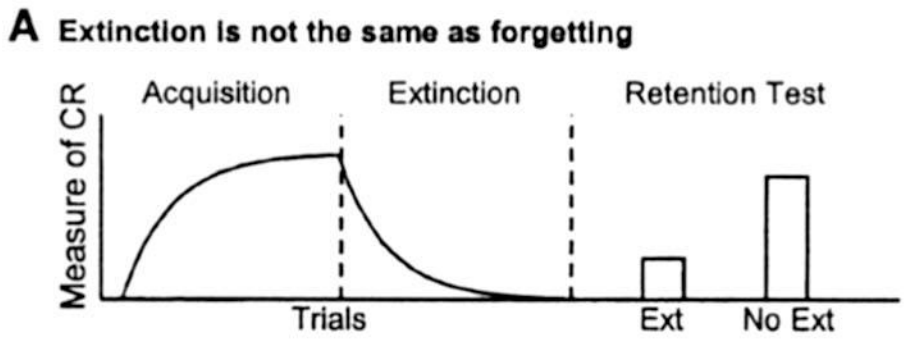


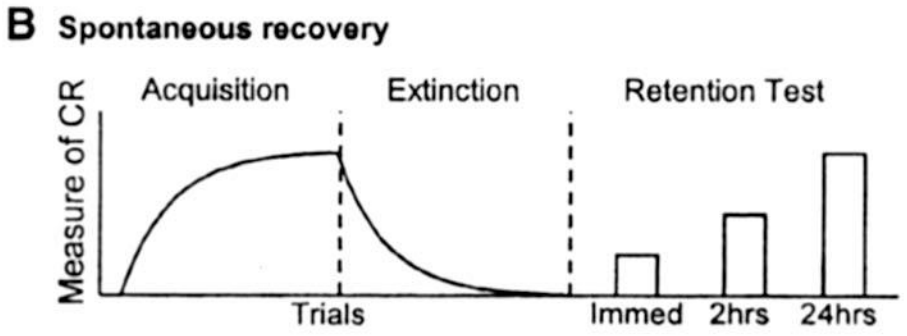
Extinction of fear-conditioning

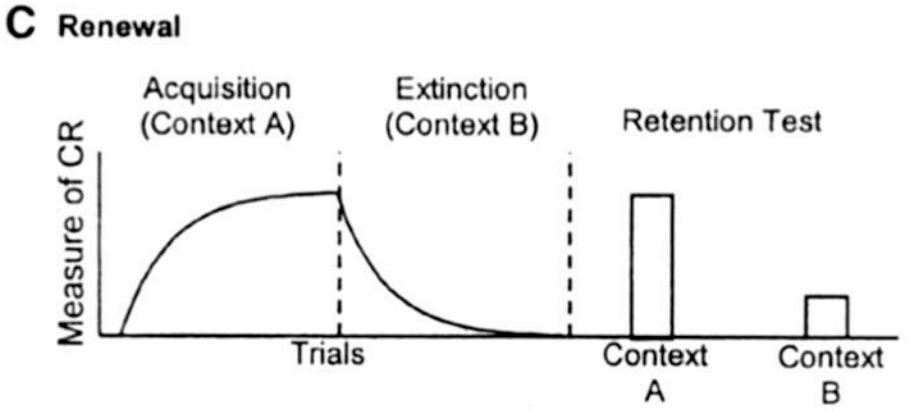


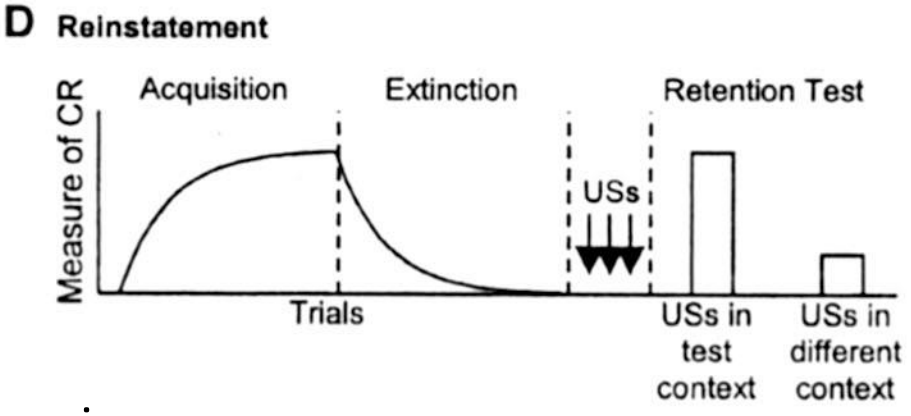


Extinction: a new learning



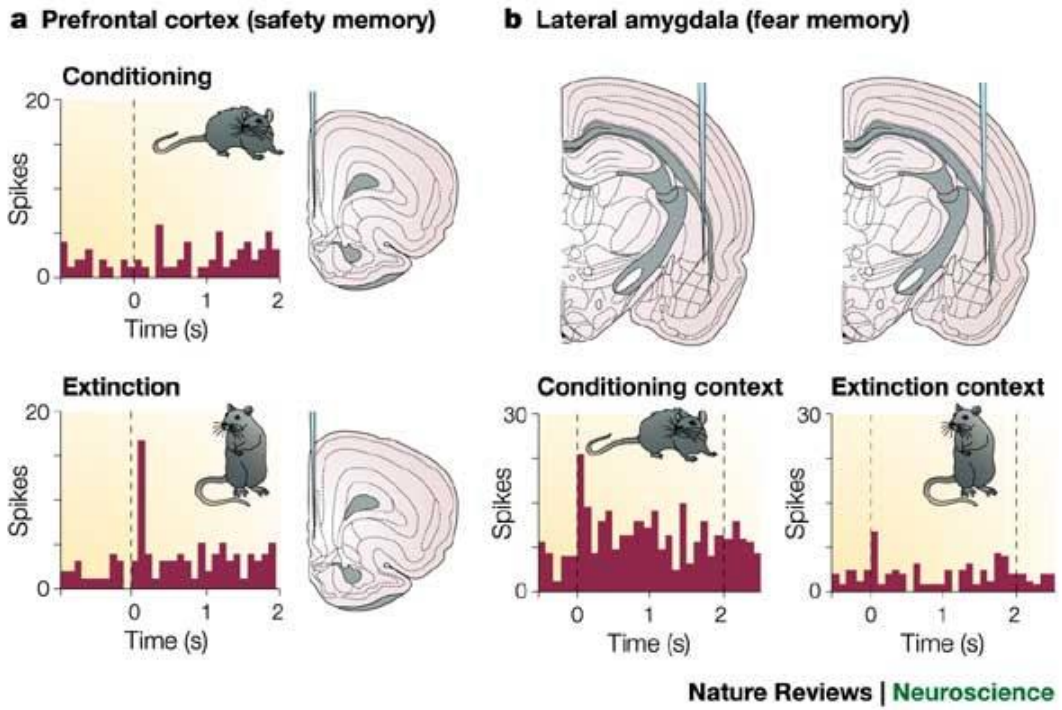


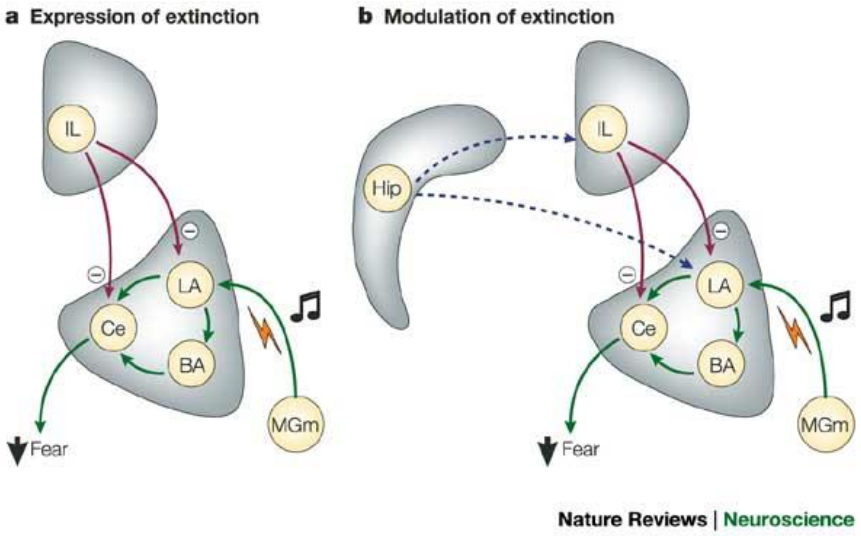


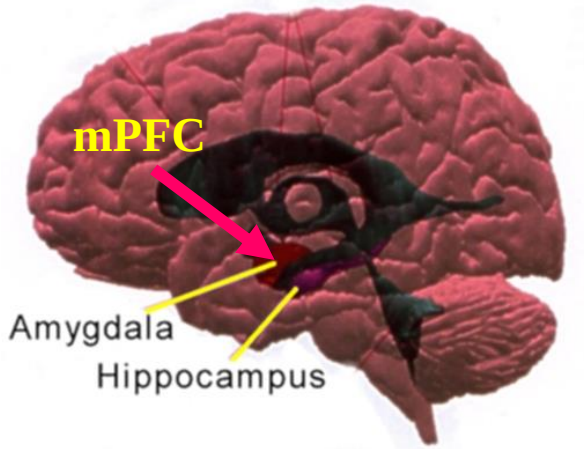


Faster re-learning

Extinction: brain mechanisms

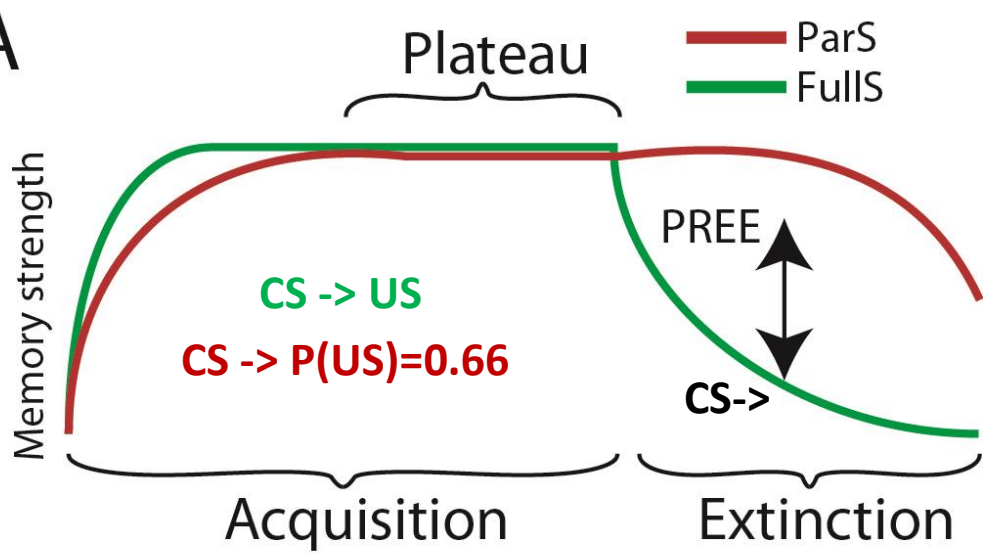






Partial reinforcement extinction effect

- Partial reinforcement
  - Fixed/variable ratio
  - Fixed/variable schedule
- Results in longer extinction

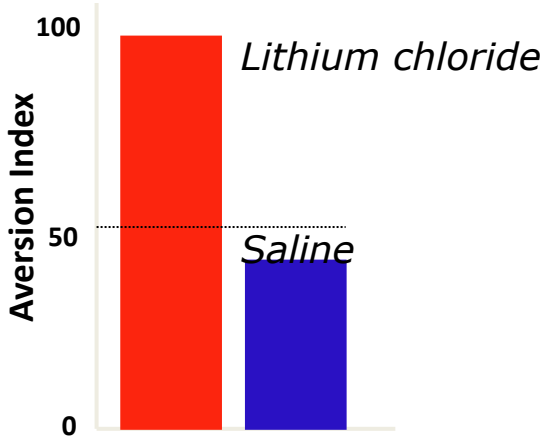


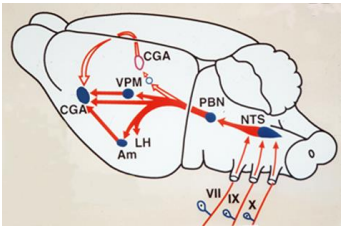
  - Frustration theory (Amsel): The omission of the US induces frustration. Therefore, during extinction, the frustration predicts the US.
  - Sequential theory (Capaldi): conditioning to strings of NNNRNNNR

Garcia J

Conditioned Taste Aversion

- One-trial learning
- Long-delay learning (few hours)
  - A [lack of] interference effect?
  - Still a problem for neuroscientists
- Hedonic shift: changes the CS, not its predictions

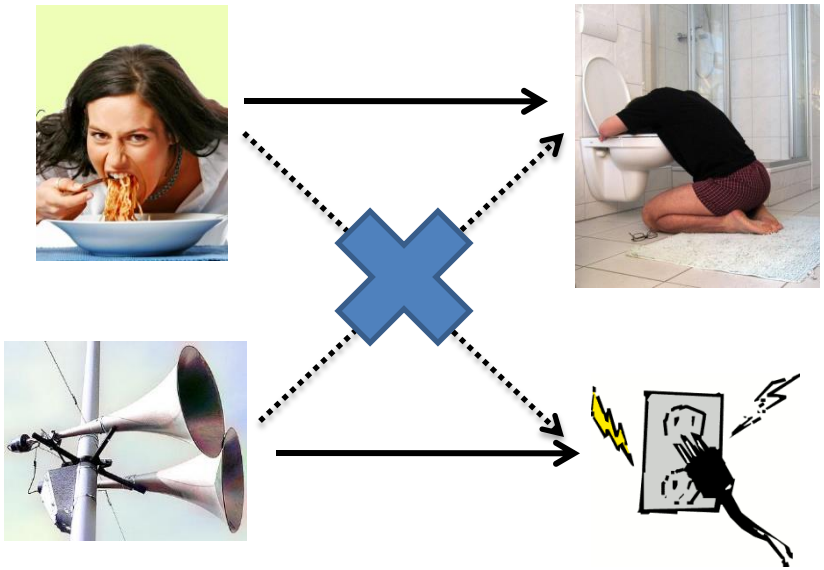




CTA

- Compound potentiation: odor + taste increase response to odor

- Preparedness:



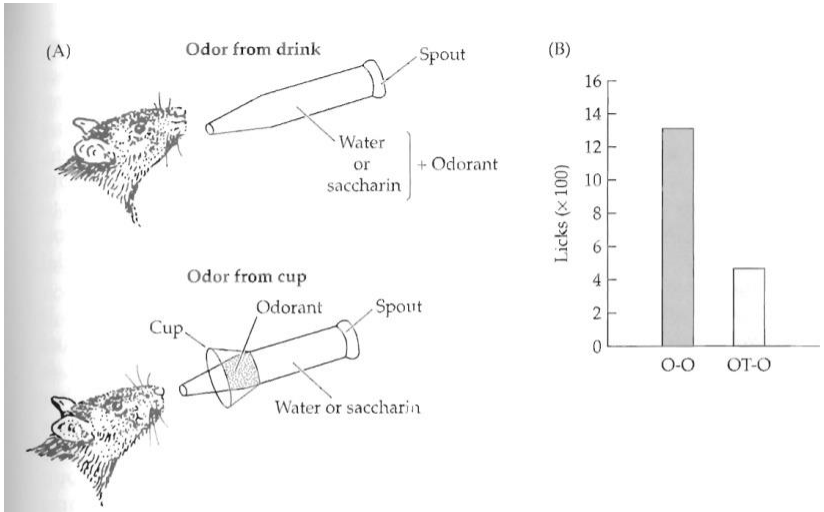
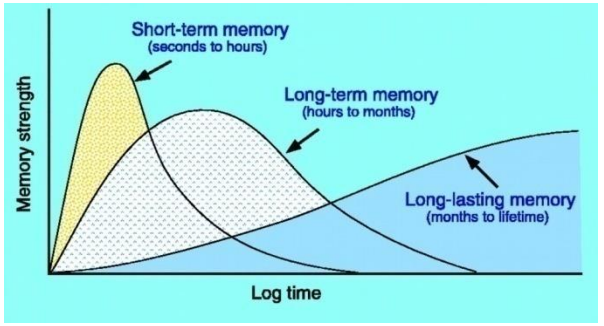
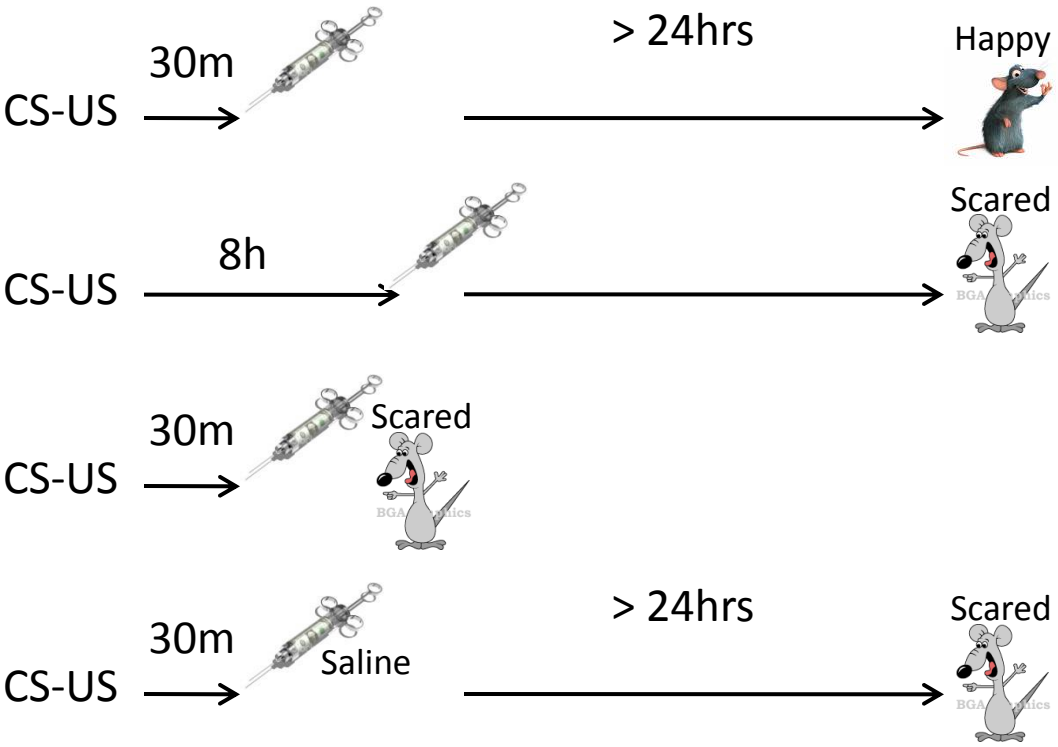


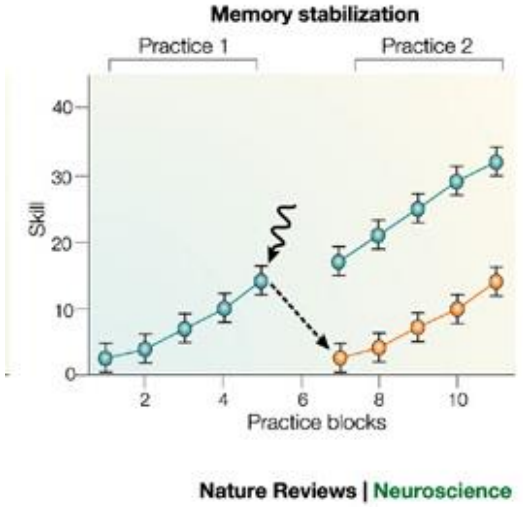
Figure 6.5 Potentiation of odor conditioning by taste. (A) A rat is given a taste in drinking water that also contains an odor. (In many experiments, the odor comes from a cup near the spout instead of being mixed in the drink.) (B) When odor is paired with illness on its own and then tested (O-O), it does not suppress consumption much. But if it has been combined with a taste on the conditioning trial (OT-O), strong odor conditioning is obtained. (A, after Inui, Shimura, & Yamamoto, 2006; B, after Palmerino et al., 1980.)

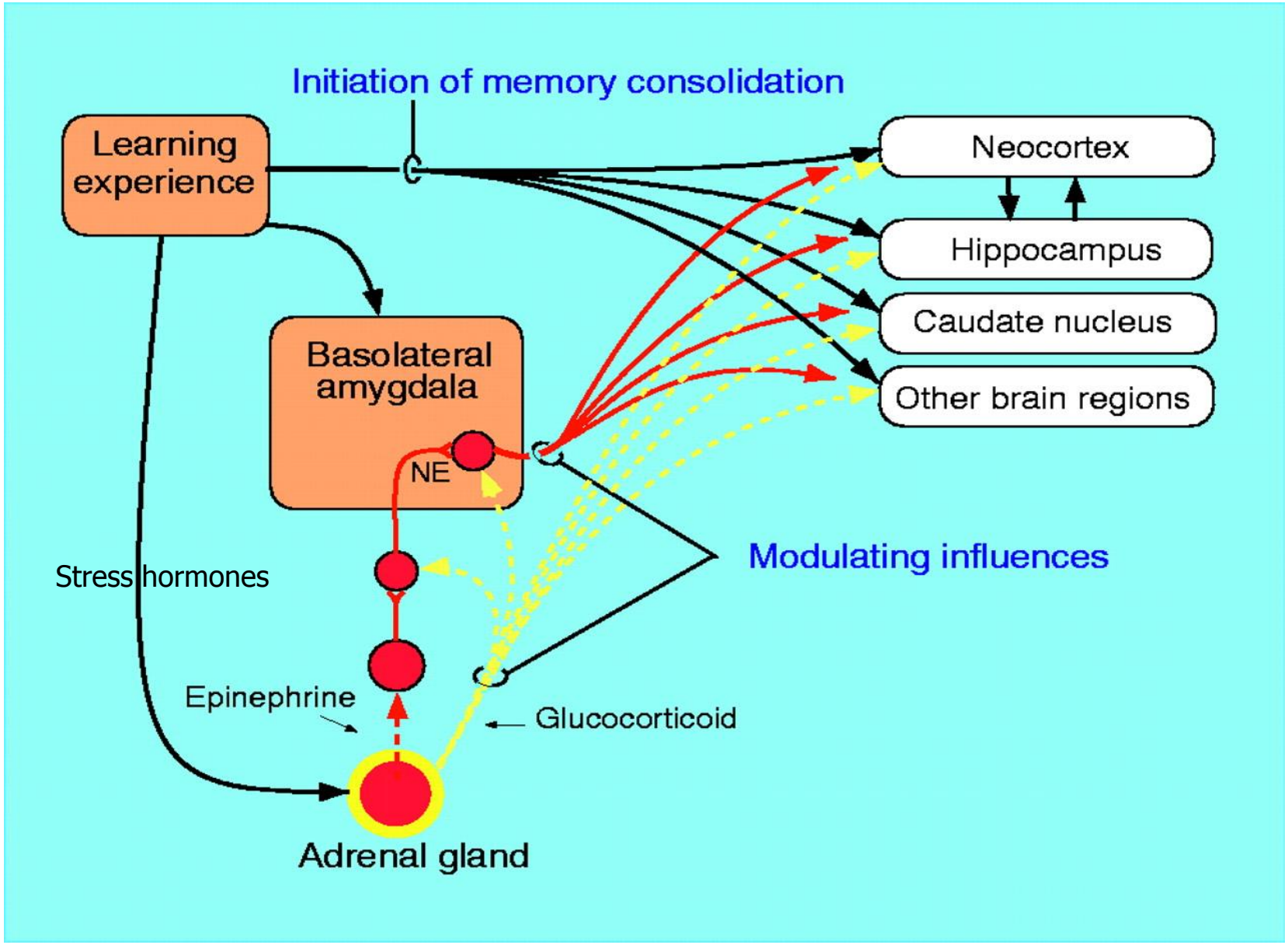
Consolidation

- Anisomycin, a protein synthesis inhibitor, into the Basolateral complex of the amygdala (BLA)
  - No effect on short-term-memory
  - No effect after XX time (rule of thumb is 6hrs)
  - But harms long-term memory below that.





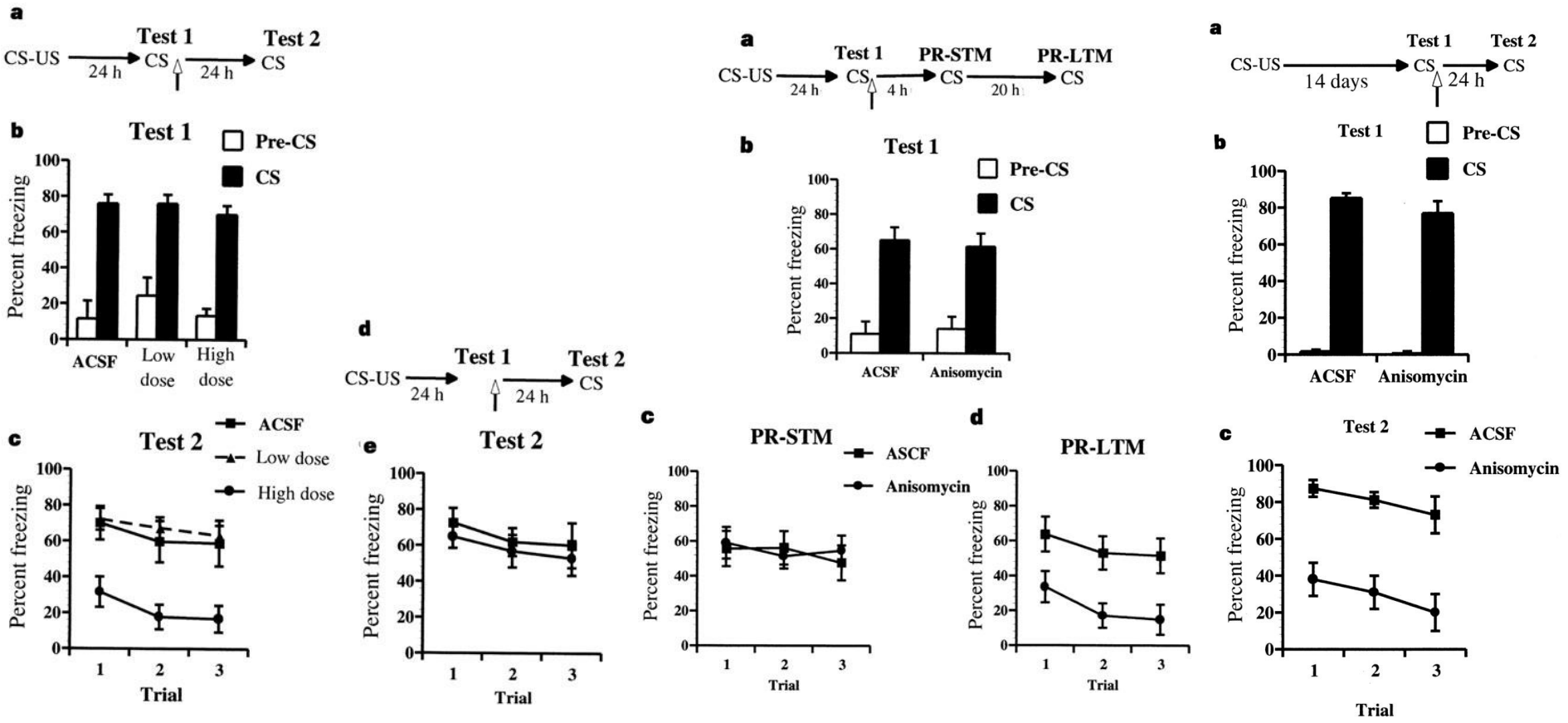




Mcgaugh JL, science, 2000

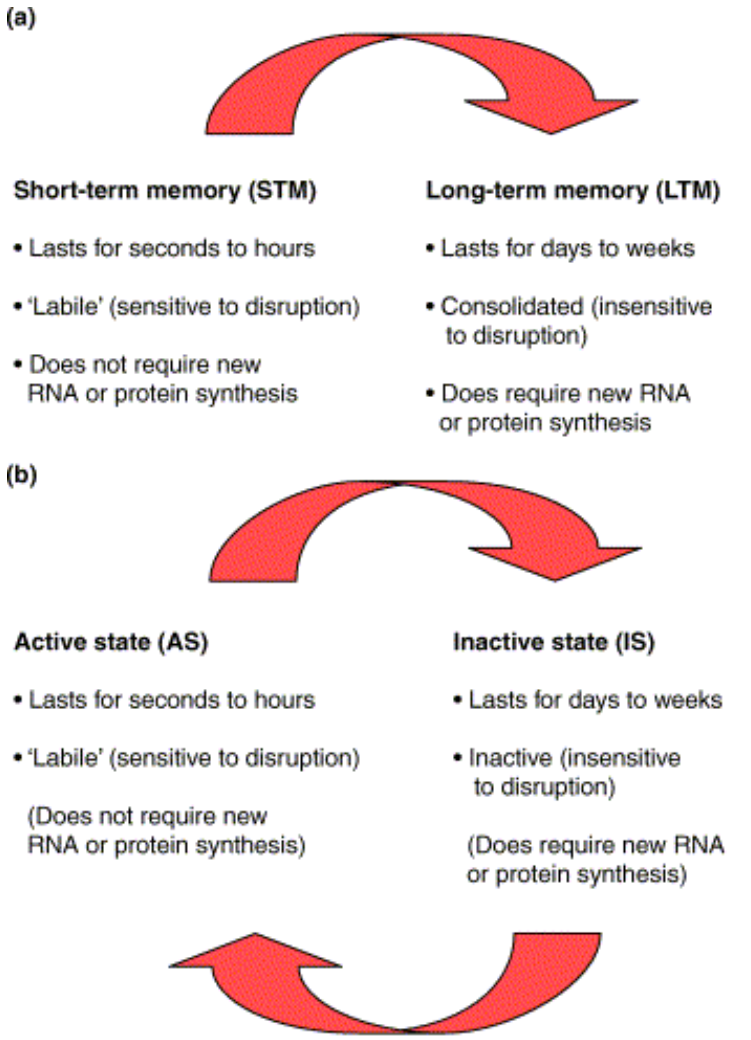
Reconsolidation

No effect on STM



Nader, Ledoux, Nature 2000

An updated view of memories



Stay safe, be fearless