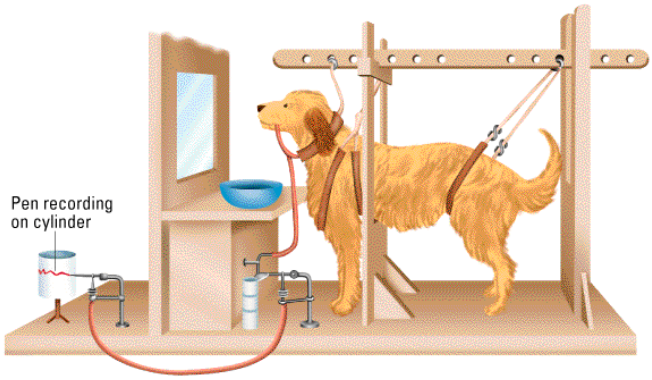
CLASSICAL CONDITIONING

US (unconditioned stimulus - e.g., food in mouth): input to a reflex

UR (unconditioned response - e.g., salivation to food): output of reflex

CS (conditioned stimulus - e.g., bell): initially results in investigatory response, then **habituation**; after conditioning, results in CR

CR (conditioned response): response to CS; measure amplitude, probability, latency



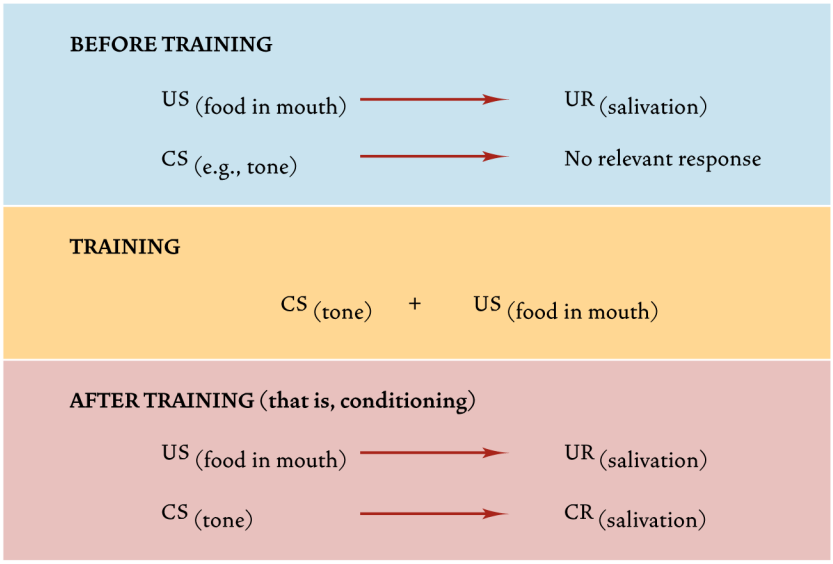


Figure 4.2: Relationships between CS, US, CR, and UR in classical conditioning

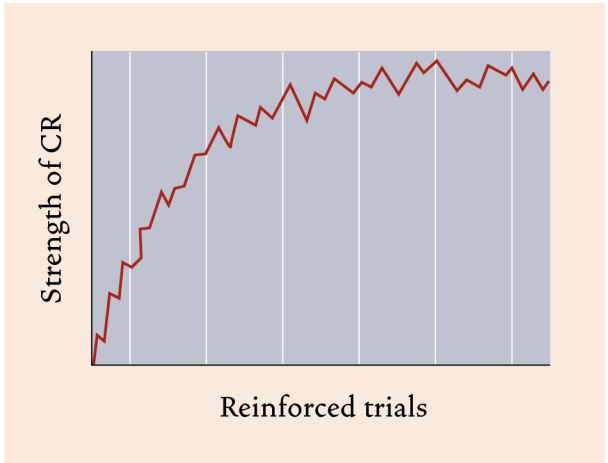


Figure 4.3: An idealized learning curve

extinction and spontaneous recovery:

extinction:
CR declines and disappears over trials without US

- due to buildup of inhibition

spontaneous recovery:
after rest interval, extinguished CR reappears at almost previous strength, and extinguishes faster next time

- due to dissipation of inhibition

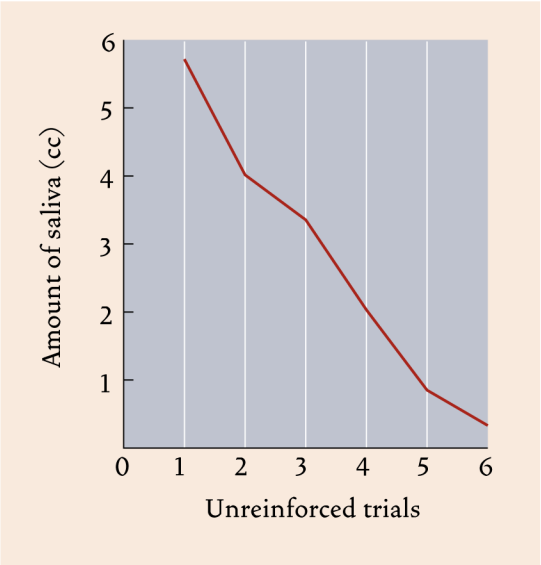
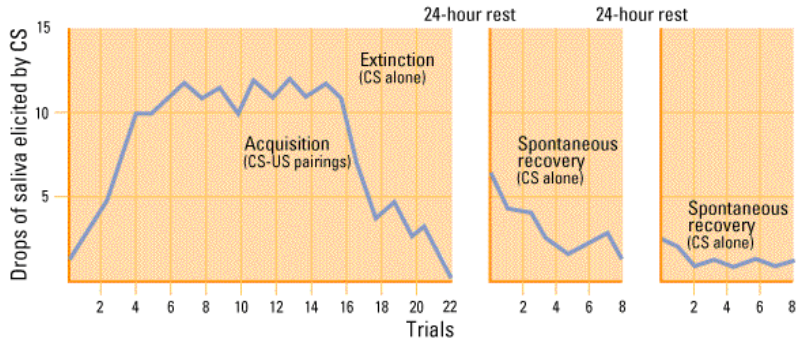


Figure 4.4: Extinction of classically conditioned response



observations on conditioning:

involuntary responses involved

contiguity: closeness in time is basis of acquisition of conditioned reflex (...?)

optimal time interval between CS and US differs depending on particular reponse being conditioned (e.g., 5-30 sec for dog's salivation response, .5 sec for human eyeblink response); no. of trials required for conditioning varies too!

more intense CS produces greater CR (e.g., louder tone, brighter light -> more salivation)

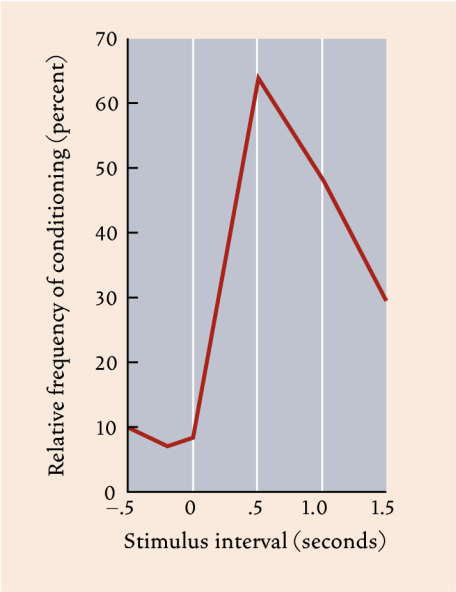


Figure 4.16: The CS-US interval in classical conditioning

higher order conditioning:

1) establish CS (e.g., bell->salivation)

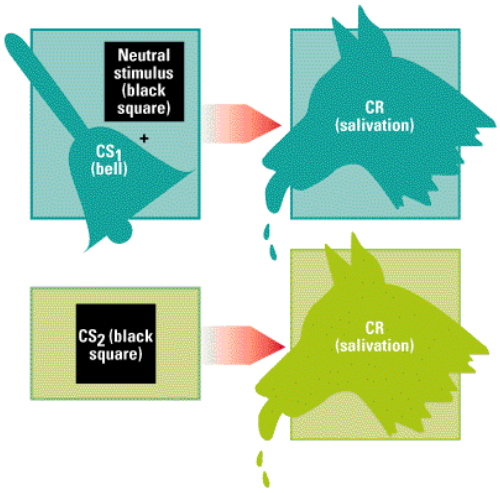
2) **new CS** is paired with old CS **without US** (e.g., **tone**->bell->salivation)

3) eventually, new CS is established **without US** (e.g., **tone**->salivation)

call this "second-order conditioning"

US acts as **reinforcer** for conditioned reflex

in higher order conditioning a CS **acts like** a US ("secondary reinforcer")



generalization: similar stimuli produce similar responses (pet both dogs and cats)

new stimulus similar to CS also produces CR (e.g., different pitch tone still produces salivation)

discrimination: different stimuli produce different responses (say "dog" and "cat" appropriately)

train "CS+" (high tone with US) and "CS-" (low tone w/o US): result is CR to CS+ but not to CS-

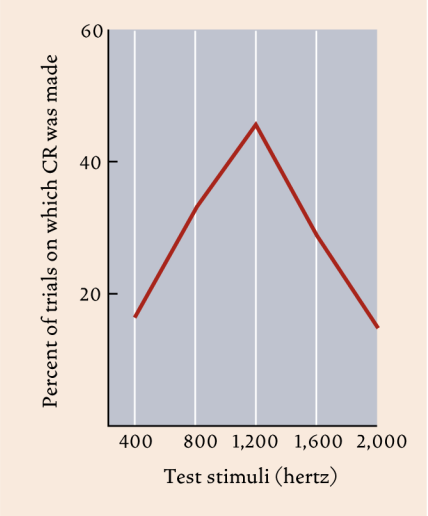


Figure 4.5: Generalization gradient of a classically conditioned response

CR≠UR: CR may be **preparatory response** for US

- CS tone->US shock->UR fast heartbeat, breathing
  but then: CS tone->CR slower heartbeat, breathing

- CS injection->US morphine->UR less pain
  but then: CS injection->CR more pain sensitivity

What gets learned?

- Pavlov's view: CS-CR conditioned reflex

- modern view: CS-US association, such that
  CS provides info about US

- note: backward conditioning (US before CS!) fails

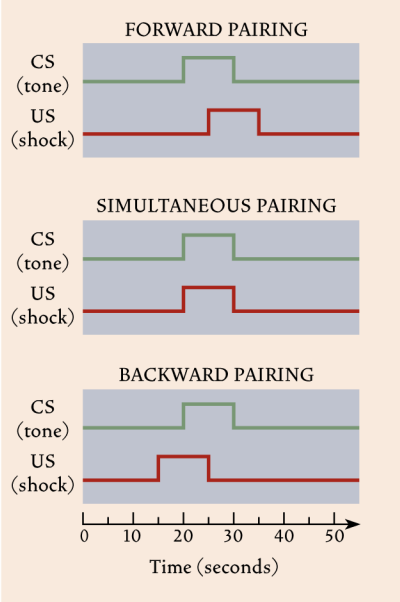


Figure 4.17: Some temporal relationships in classical conditioning

INSTRUMENTAL or **OPERANT** CONDITIONING

cats in puzzle box (Thorndike, 1898)

- trial and error; incremental learning

Law of Effect - response is automatically strengthened when followed by reinforcement ("satisfying state of affairs"); automatically weakened when followed by punishment ("annoying state of affairs")

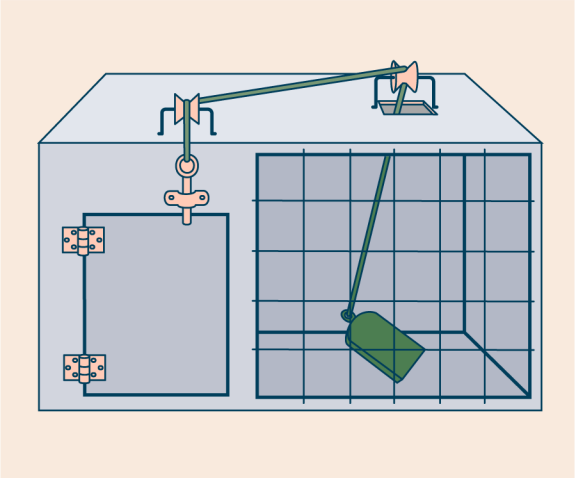


Figure 4.7: Puzzle box

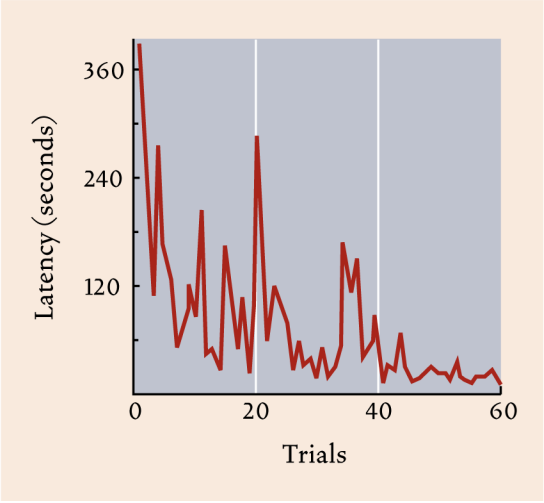


Figure 4.8: Learning curve of one of Thorndike's cats

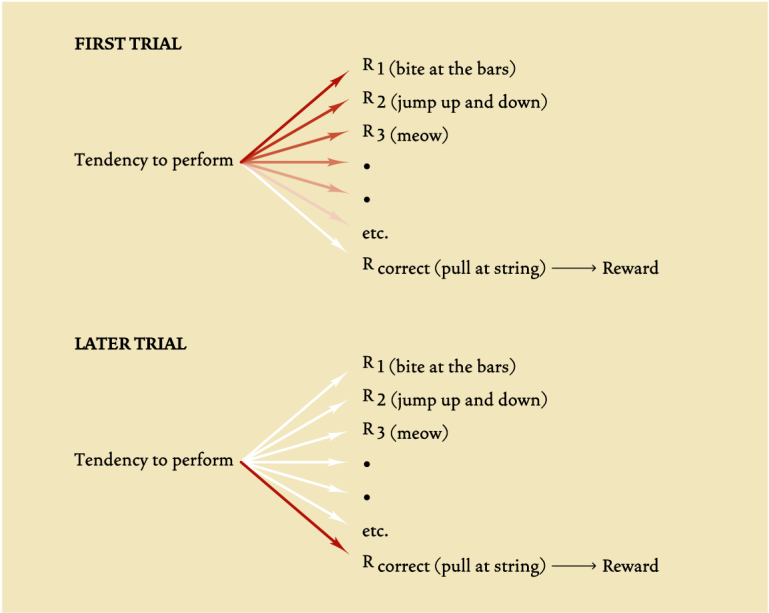


Figure 4.9: The law of effect

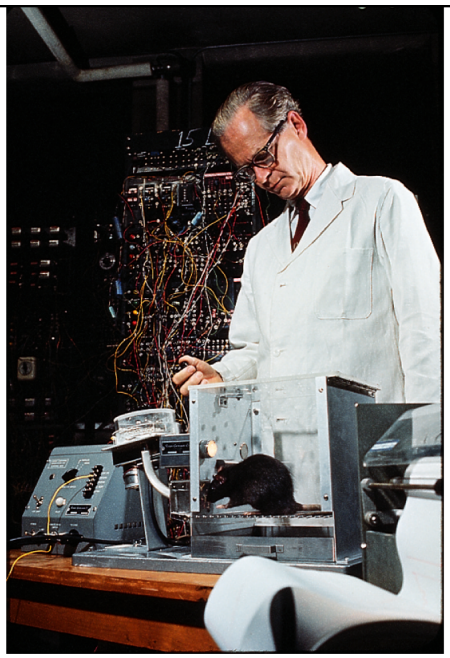
Operant conditioning vs. classical conditioning:

- operant cond. - reinforcement depends on response;
  class. cond. - reinforcement (US) comes regardless
- operant response is emitted and voluntary;
  classical cond. response is elicited and involuntary
- What is learned?
  in operant cond. - a BEHAVIOR
  in classical cond. - a SIGNAL (CS-->US)
- Through what mechanism?
  operant: Law of Effect: CONSEQUENCES
  (but delay of reinforcement weakens response!)
  classical: CONTIGUITY... so far!
- "conditioning", because changing the conditions changes response frequency; not under conscious control even though voluntary!

B.F. SKINNER - "Skinner box":

- many responses
- little time and effort
- easily recorded

- RESPONSE RATE is the Dependent Variable



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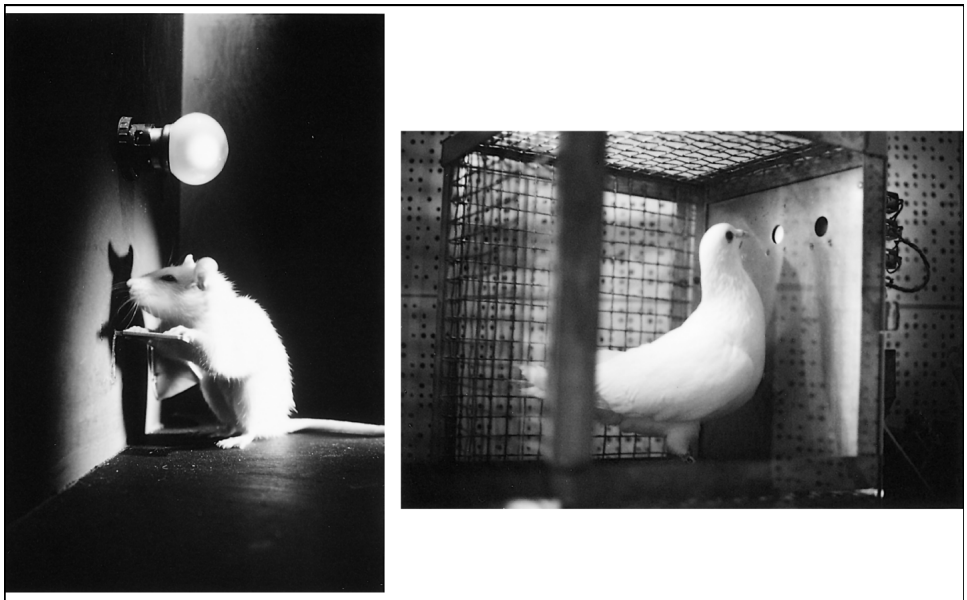


Figure 4.10: Animals in operant chambers

REINFORCEMENT AND PUNISHMENT

REINFORCEMENT (both pos. and neg.) always increases rate of responding

- **positive** reinforcement delivers appetitive stimulus (food, approval);

- **negative** reinforcement removes aversive stimulus (shock, alarm clock noise)

PUNISHMENT decreases rate of responding

w/ NO reinforcement: extinction and spontaneous recovery happen just as in classical conditioning

	Increases Behavior	Decreases Behavior
Present Stimulus	**Positive Reinforcement**	**Positive Punishment**
Remove Stimulus	**Negative Reinforcement**	**Negative Punishment**

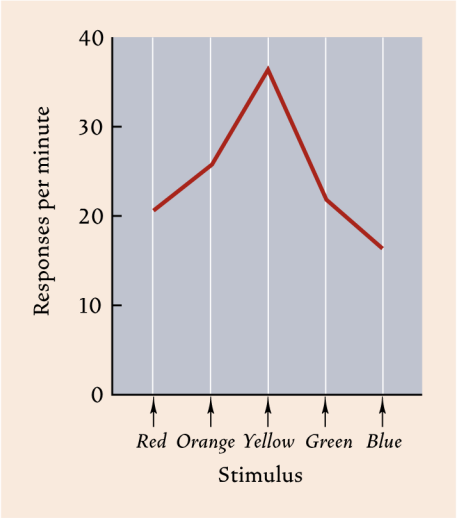


Figure 4.11: Stimulus generalization of an instrumental response

DISCRIMINATIVE STIMULUS: indicates under what circumstances response will be reinforced

ex: rat presses bar, but only gets food when light in box is on; eventually doesn't press unless light is on

stimulus does NOT CAUSE response, or SIGNAL reinforcement; it SETS OCCASION for response

parallel to classical:

instead of CR there's operant response
instead of US, reinforcement
instead of CS, discriminative stimulus

but order changes:

- CLASSICAL: stim (CS) reinf (US) resp (CR)
- OPERANT: stim **resp**! **reinf**!

conditioned (secondary) reinforcer:

stimulus paired with reinforcer acquires reinforcing properties

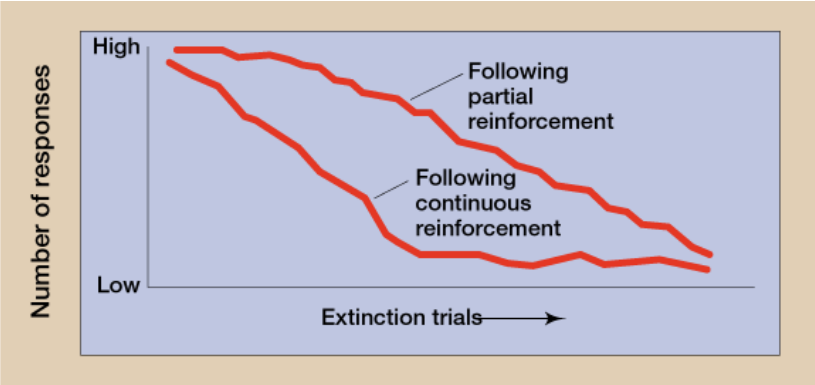
- how does something get to be a conditioned reinf? through classical conditioning!

- ex.: in higher order classical conditioning - once bell is connected with food, it's used like a US

partial reinforcement effect:
reinforcing ONLY SOME TRIALS produces even STRONGER response than reinforcing ALL TRIALS;
but what does some mean?..

SCHEDULES OF REINFORCEMENT:

- describe as interval, ratio, fixed, variable
- continuous reinforcement (CR) = all responses get reinforced



interval schedule - reinforce next response after some **time interval**

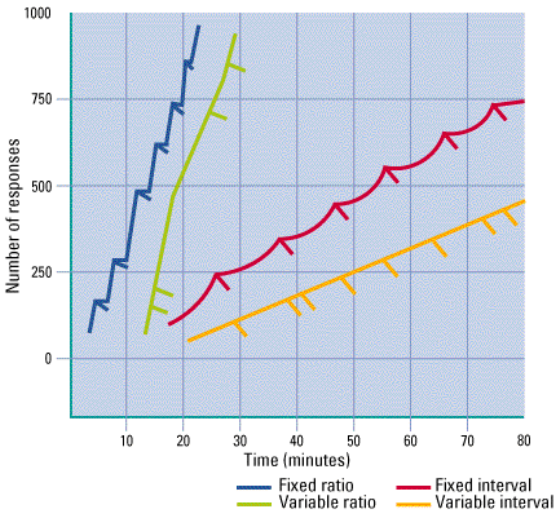
-"fixed interval" (FI) - time is fixed; rat gets food pellet for next bar press, say, 30 seconds after last pellet (ex: checking mail, delivered daily)

-"variable interval" (VI) - time is average; rat gets food pellet for next bar press 20, 40, 25, 35 seconds after last pellet, etc. - 30 seconds on average (ex: checking e-mail, delivered whenever)

ratio schedule - reinforcement after some **number of responses** (ratio of responses to reinforcements)

-"fixed ratio" (FR) - ratio is fixed; rat gets food pellet for every 10th bar press (ex: factory piecework)

-"variable ratio" (VR) - ratio is average; rat gets food pellet after 8, 12, 5, 15 responses - 10th response on average (ex: gambling)



shaping - differential reinforcement of successive approximations to desired response

- can produce a response the animal would never have made spontaneously on its own

chaining - linking responses into long sequence allows training of very complex behaviors

CONTINGENCY, **NOT CONTIGUITY** is what matters in classical conditioning

Robert Rescorla (1968): exp't on what it takes to make a **signal** work (-- more than just contiguity!)

3 groups of rats all hear tone lasting for 2 minutes; when tone is **ON**, probability of shock = 40%

- all 3 groups have same degree of contiguity of tone and shock: shock is on for 48 sec out of 120 sec

- but vary p(shock) for 3 groups when tone is **OFF**:
  grp 1: **without** tone playing, p(shock) = 40%
  grp 2: **without** tone playing, p(shock) = 20%
  grp 3: **without** tone playing, p(shock) = 10%

results:

grp 1 shows NO fear conditioning to tone
grp 2 shows some fear, but less than grp 3
grp 3 shows strong conditioned fear of tone

what does tone say to grp 3?

"your 10% now goes up to 40%, so BE SCARED!"

what does tone say to grp 1?

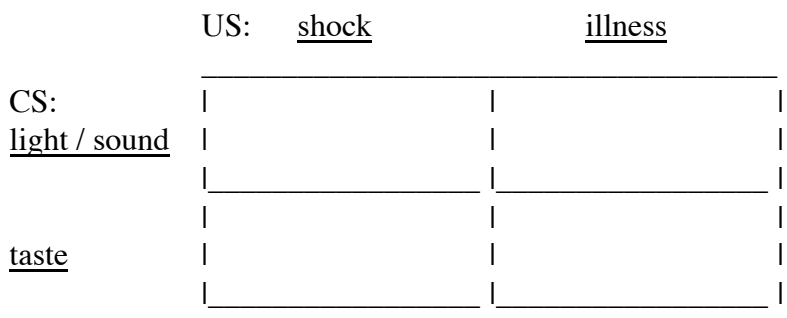
"your 40% stays the same; sure, life sucks, but it's BUSINESS AS USUAL!"

CONTINGENCY: how the US depends on the CS -- "probability of US in presence of CS" relative to "probability of US in absence of CS"

Pavlov: contingency confounded with contiguity

BELONGINGNESS - biological preparedness to make certain associations

- Pavlov assumed:
  ALL ASSOCIATIONS ARE ARBITRARY
  CONTIGUITY CAUSES CONDITIONING
- Garcia and Koelling (1966) exp't used 4 groups:
  US = shock OR illness (produced by X-ray or LiCl)
  CS = light and sound OR saccharin taste in test:



light/sound->shock group avoided bright noisy water
light/sound->illness group did not avoid bright noisy water
taste->shock group did not avoid saccharin water
taste->illness group avoided saccharin water

CS and US had to be both inside (taste-illness) or both outside (light and sound-shock) the animal's body

	US: shock	illness
CS: light / sound	AVOID	DON'T AVOID
taste	DON'T AVOID	AVOID

"Garcia Effect": special facility for learning taste aversion (taste-illness association) - difficult for classical conditioning because
1) association established in one trial;
2) up to 24 hrs between CS and US;
3) very resistant to extinction

ARBITRARINESS: NO - associations are selective
CONTIGUITY: NO - very long CS-US intervals

cognitive learning - Edward Tolman (1930's-1950's):

learning is NOT just automatic response-strengthening (in Thorndike's sense) but involves acquiring knowledge

ex.: "contingency" in classical conditioning

LEARNED HELPLESSNESS (Martin Seligman) - learning that actions have no effect on world

Phase I (classical):

Dog A and Dog B shocked at same time
Dog A can stop shock for both - ESCAPABLE
Dog B cannot stop shock at all - INESCAPABLE

Phase II (operant):

Each dog in own two-part box divided by barrier
Hear tone followed by shock after 10 sec
Dog A learns to jump barrier when tone plays
Dog B does not - howls, whines, whimpers, accepts

- In Phase I, animal learns:
  (1) relation between CS and US, and
  (2) what it does has no effect on US (shock)

- experienced as depression in humans

LATENT LEARNING: rats ran around maze at leisure for 10 days, then for food from 11th day on...

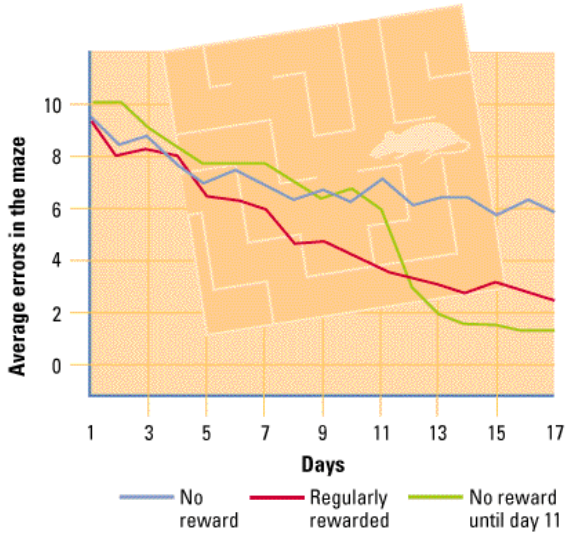
Thorndike / Skinner: learning begins when reinforcement begins - rats should run slow for 10 days, **then gradually get better** starting from that 11th day...but instead:

Tolman found running was slow for 11 days, **then was suddenly fast** from 12th day on

- they had learned it gradually over the 10 days, but didn't show it (it was latent) until motivated (i.e., until they got food at the end)

Conclusion:

learning is NOT caused by reinforcement
learning IS a building up of "cognitions"



BEHAVIORIST view would say response is learned automatically, due to reinforcement - we know response is learned when rat performs it

COGNITIVE view says "cognitive map" of maze is learned (even without reinforcement) - used later when animal has purpose or motivation