Behavior Modification

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Part I

Basic (or theoretical) science

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I. Primitive adaptations to local environments

A. Kinesis is a non-directional movement or activity of a cell or an organism in response to a stimulus.

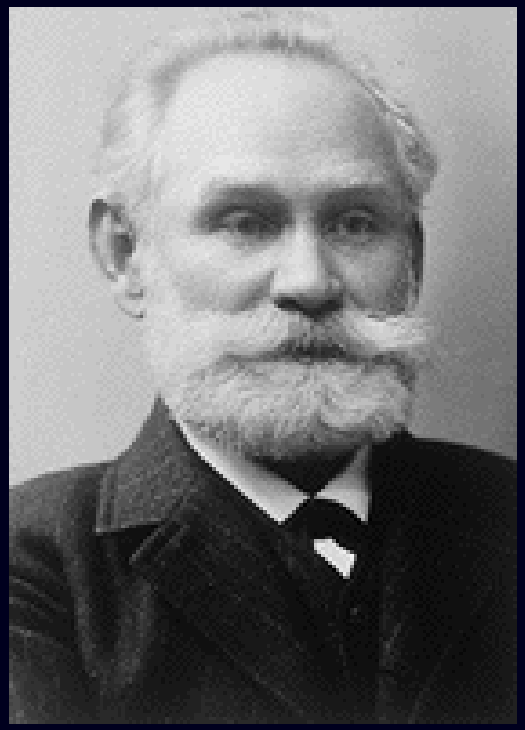
B. Taxes is an innate behavioral response by an organism to a directional stimulus (organism responding to light by moving towards it)

II. Coordinated adaptations to local environments: fixed action patterns (FAP)

A. Sign or releasing stimulus

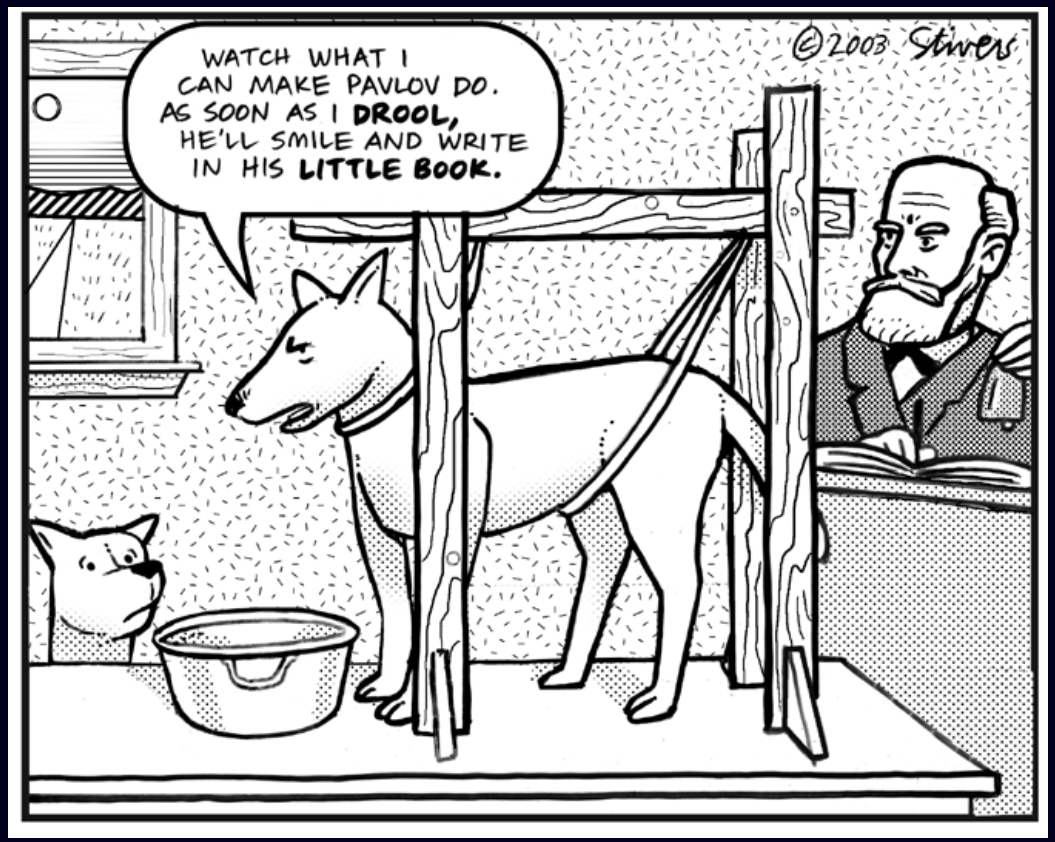
B. Stereotypy (FAP)
   A. Not affected by external events once begun
   B. Innate

Ivan Petrovich Pavlov

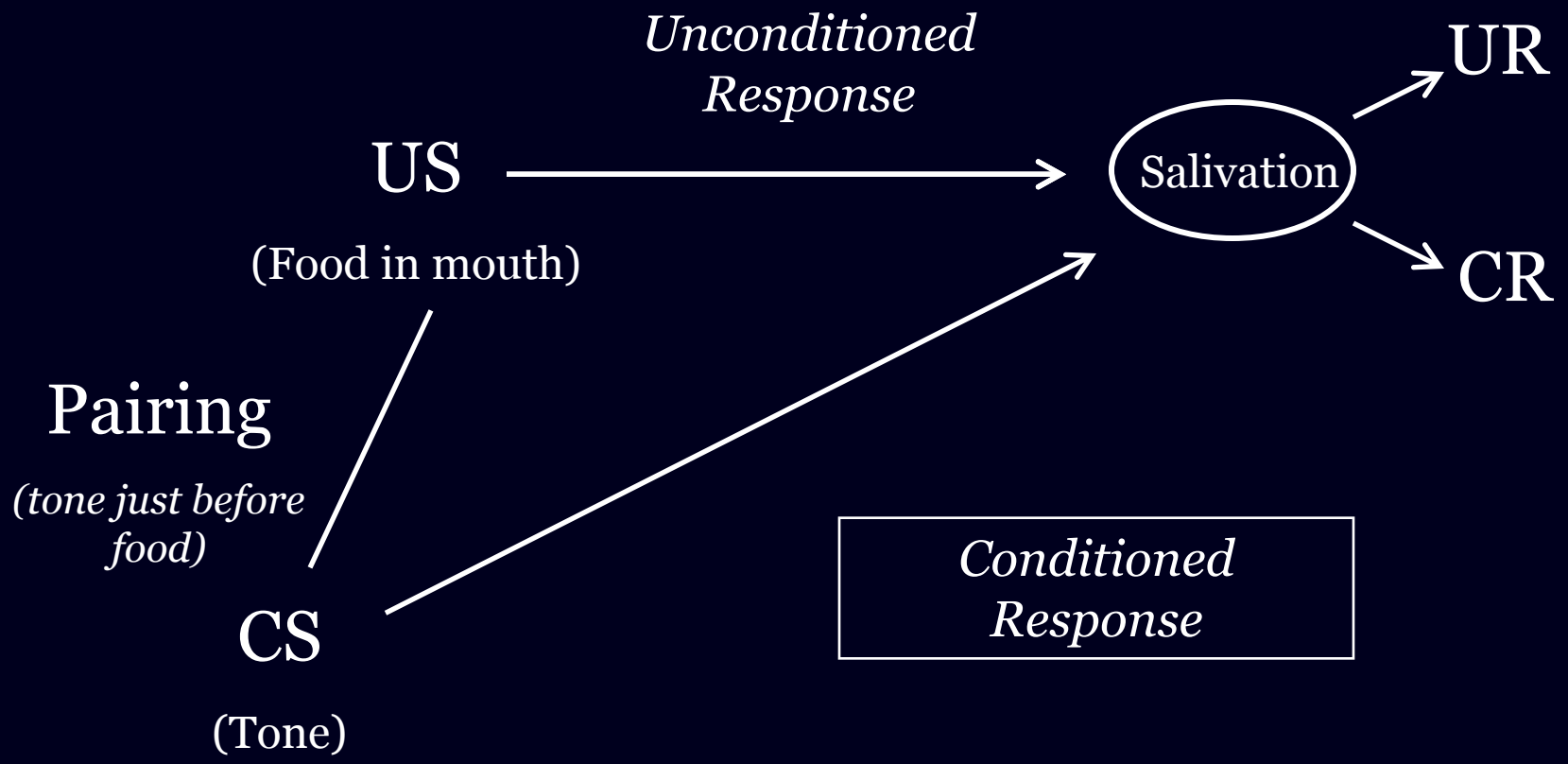


Widely known for his work on conditioned reflexes.

Nobel Prize in Physiology or Medicine in 1904 for research pertaining to the digestive system.



III. Pavlovian (or responded) conditioning



III. Pavlovian conditioning

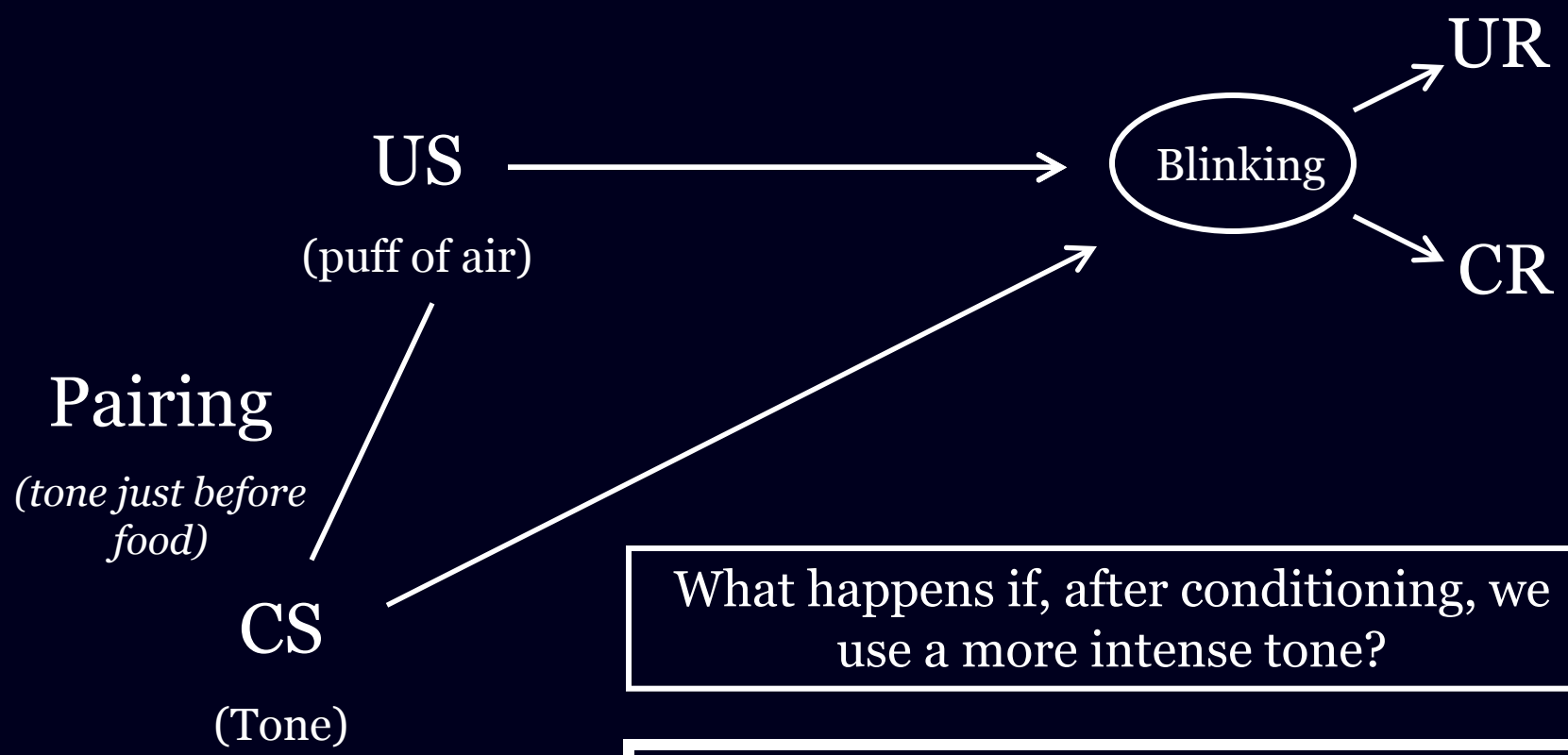
a. The law of intensity magnitude: as the intensity of the US increases, the intensity of UR increases as well. (there are upper limits)
   - A strong tap below the kneecap → strong kick.

b. The law of the latency (time between the onset of US and appearance of evoked response): as the intensity of US increases, the latency decreases. (the stronger the US, the faster the UR)
   - A strong tap below the kneecap → rapid onset of the kick.

A gentle tap = ?

Gentle kick with delayed onset

III. Pavlovian conditioning



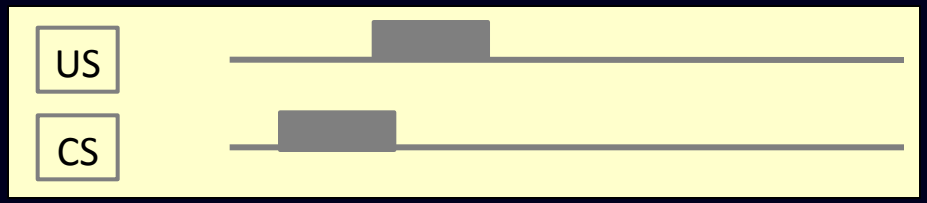
What happens if, after conditioning, we use a more intense tone?

The CS - CR relation is specific to the original conditioning. It does NOT follow the laws of the reflex.

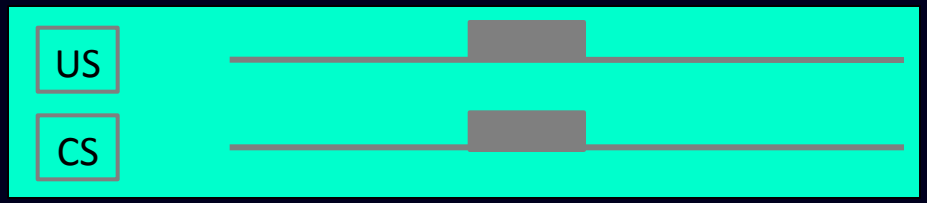
III. Pavlovian conditioning

Types of conditioning:

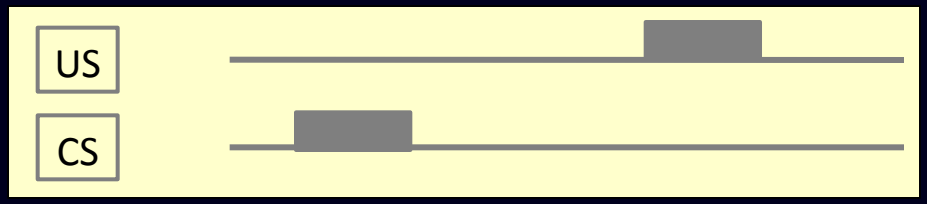
a. Delay
b. Long delay
c. Trace
d. Temporal
e. Backward



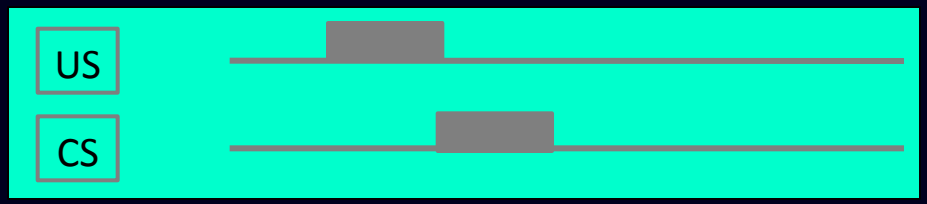
Delayed cond.: best for autonomic reflexes (5 – 30 seconds delay)



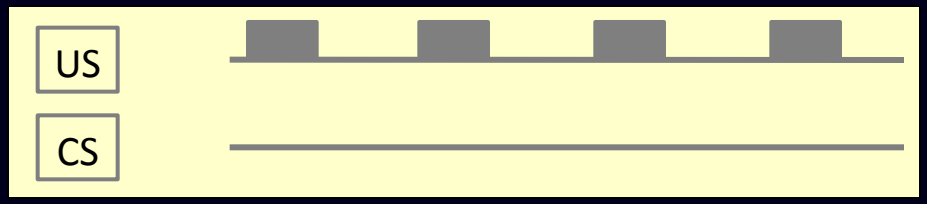
Simultaneous cond.: weaker CR (CS does not *predict* US)



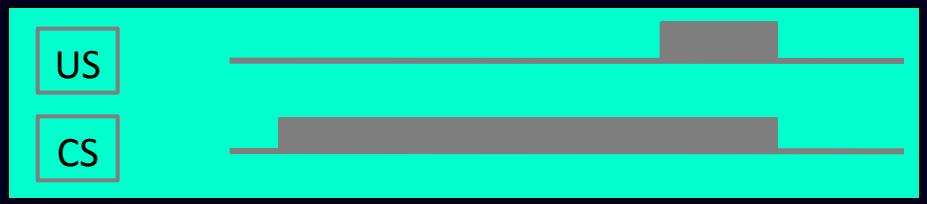
Trace cond.: weaker CR, not very effective, especially with longer intervals



Backward cond.: questionable results, some researchers say it doesn't exist.



Temporal cond.: the CS is the time interval between occurrences of US.



Long - Delayed cond.

III. Pavlovian conditioning

Basic phenomena:

a. Acquisition
b. Extinction
c. Spontaneous recovery
d. Generalization
e. Discrimination

f. Humphrey's paradox
g. High-order conditioning

III. Pavlovian conditioning

Acquisition

- Repeated CS-US pairing → magnitude of CR increases up to an asymptote; after that, no additional effect.

- Remember that CS – CR does NOT follow the same laws as US – UR (the laws of reflexes)

III. Pavlovian conditioning

Extinction

- The procedure: repeatedly presenting CS in the absence of US (tone without food)

- The behavioral process: CR's magnitude diminishes until eventually reaches the respondent level:
  - the strength of target response before any conditioning occurs

  - Note: as the time between test trials increases, the CR declines slower. Why?

III. Pavlovian conditioning

Spontaneous Recovery

- Increase in the CR after extinction occurred.
  - Extinction: target response reached respondent level. After some time the dog is again presented with the tone → CS will again evoke CR.

III. Pavlovian conditioning

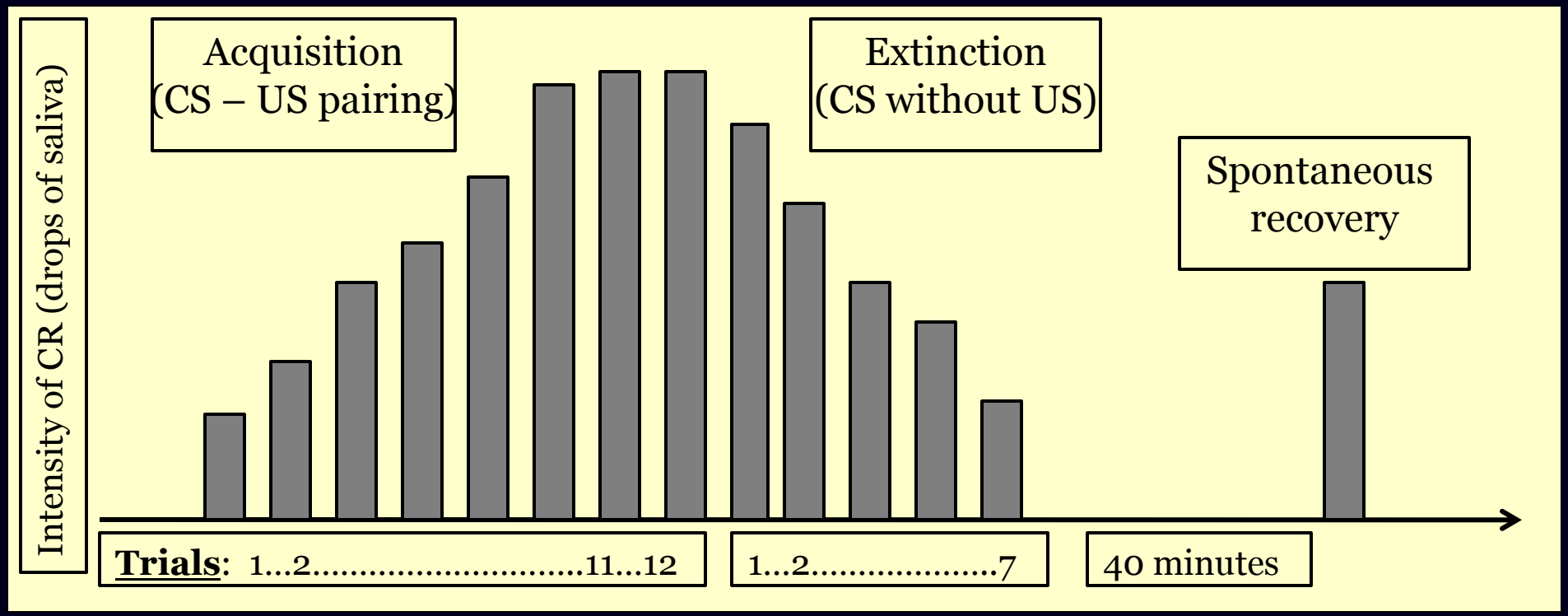
Generalization

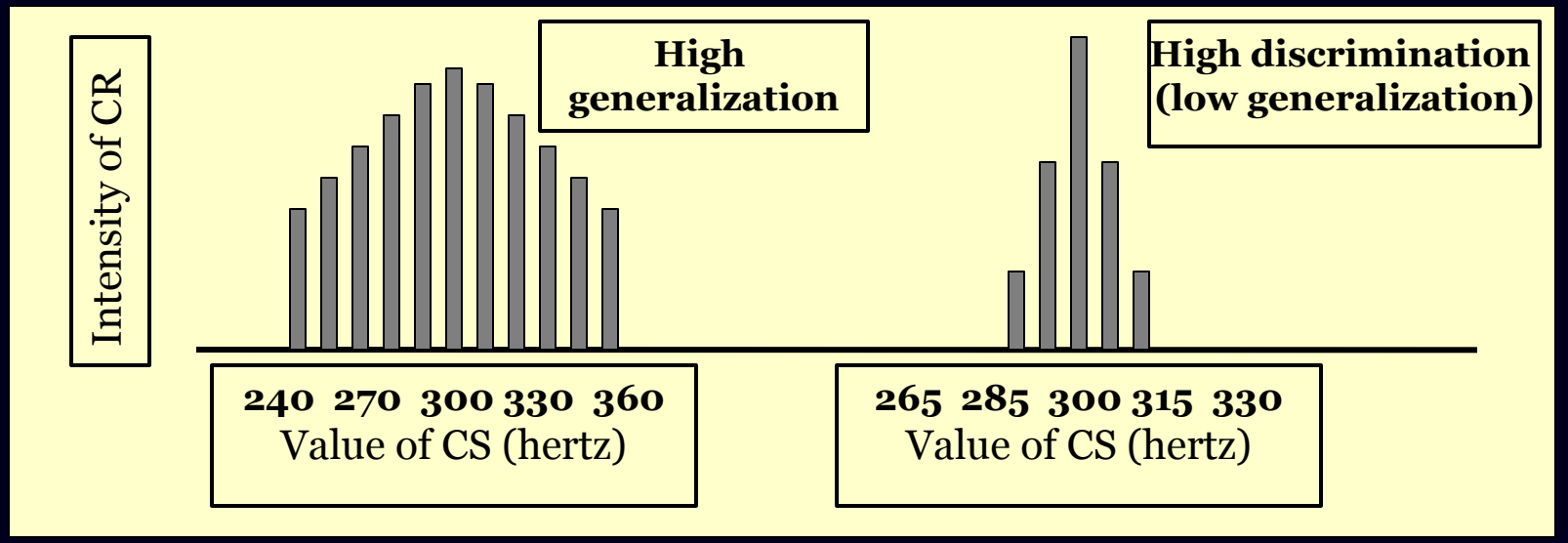
- Showing CR to values of CS that were not trained during acquisition
  - Trained for 50 Db → also salivates at 70 Db.
  - The more different the CS (from the initial, trained value) → the weaker the CR (e.g. trained for 50 Db → less salivation for 70 Db than for 60 Db)
  - Adaptive value

III. Pavlovian conditioning

Discrimination

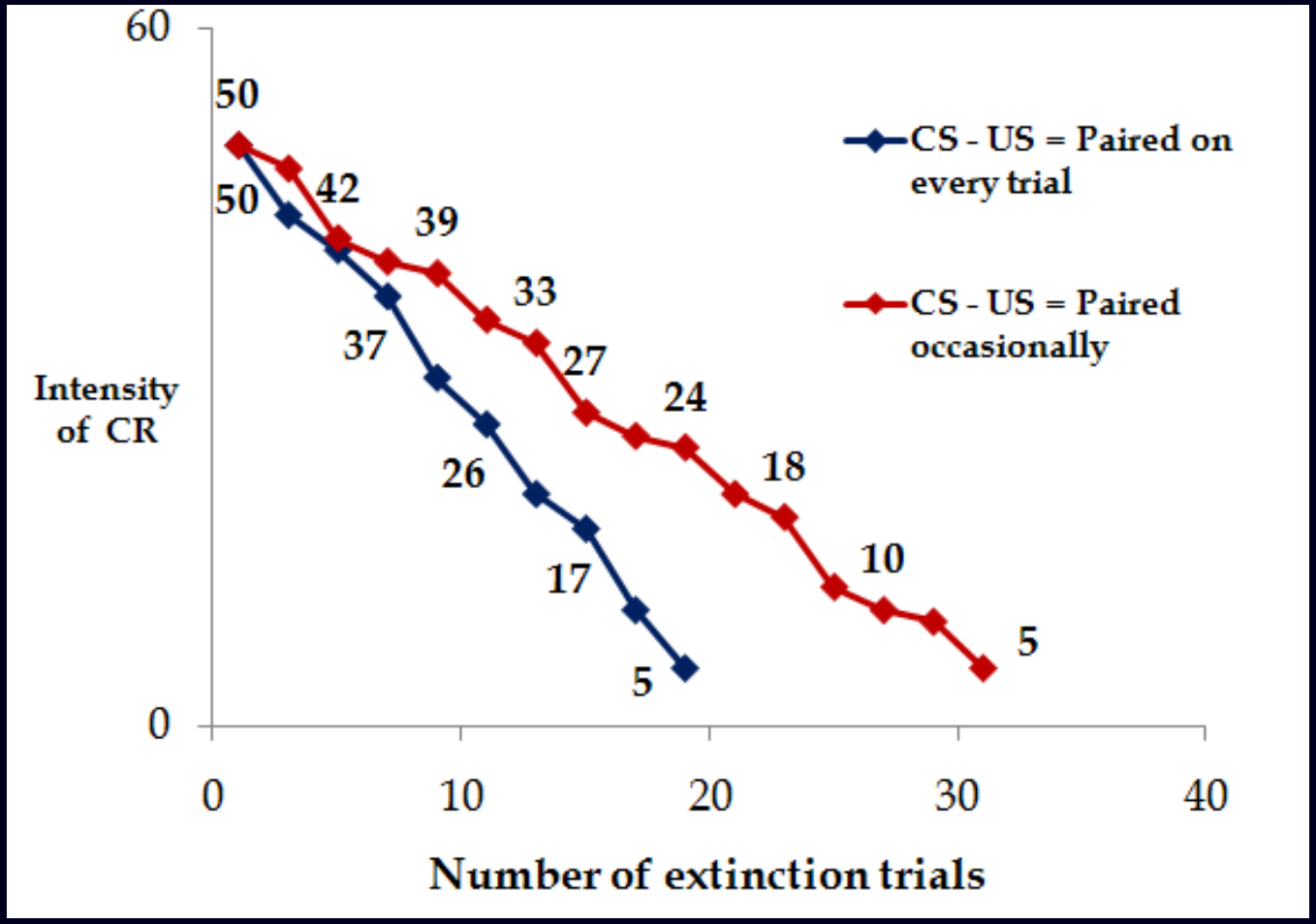
- Showing CR to values of CS, but not to values similar to CS; *differentiating* between CS values.
  - Trained for 50 Db → does NOT salivate when presented with 60 Db.
  - Adaptive value


Intensity of CR (drops of saliva)
Acquisition
(CS – US pairing)
Extinction
(CS without US)
Spontaneous
recovery
Trials: 1…2……11…12
1…2……7
40 minutes

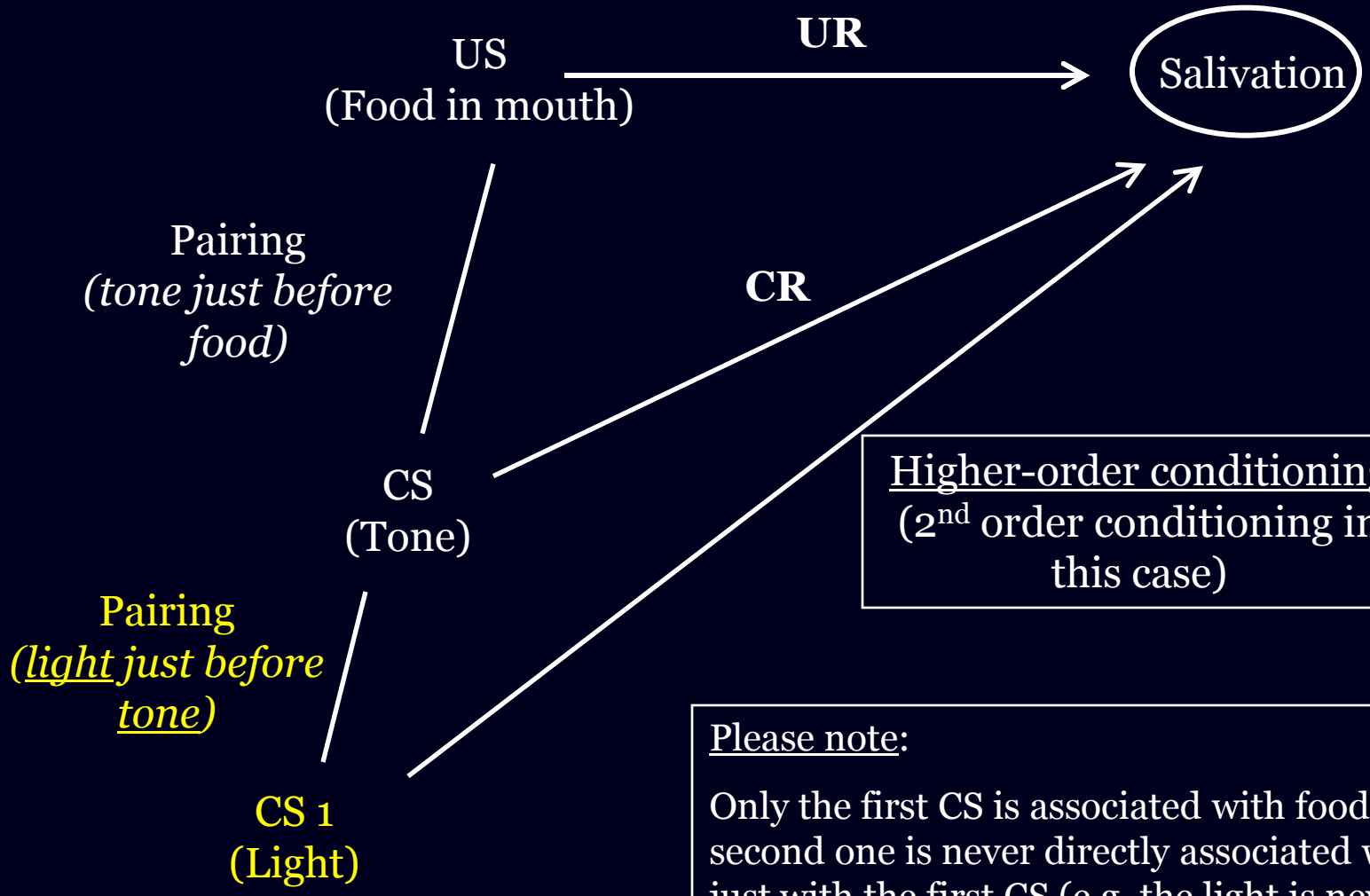

Intensity of CR
High
generalization
High discrimination
(low generalization)
240 270 300 330 360
Value of CS (hertz)
265 285 300 315 330
Value of CS (hertz)

III. Pavlovian conditioning

Humphrey's paradox = Extinction happens faster if the CS and US were paired on every trial, then if they were paired only occasionally.



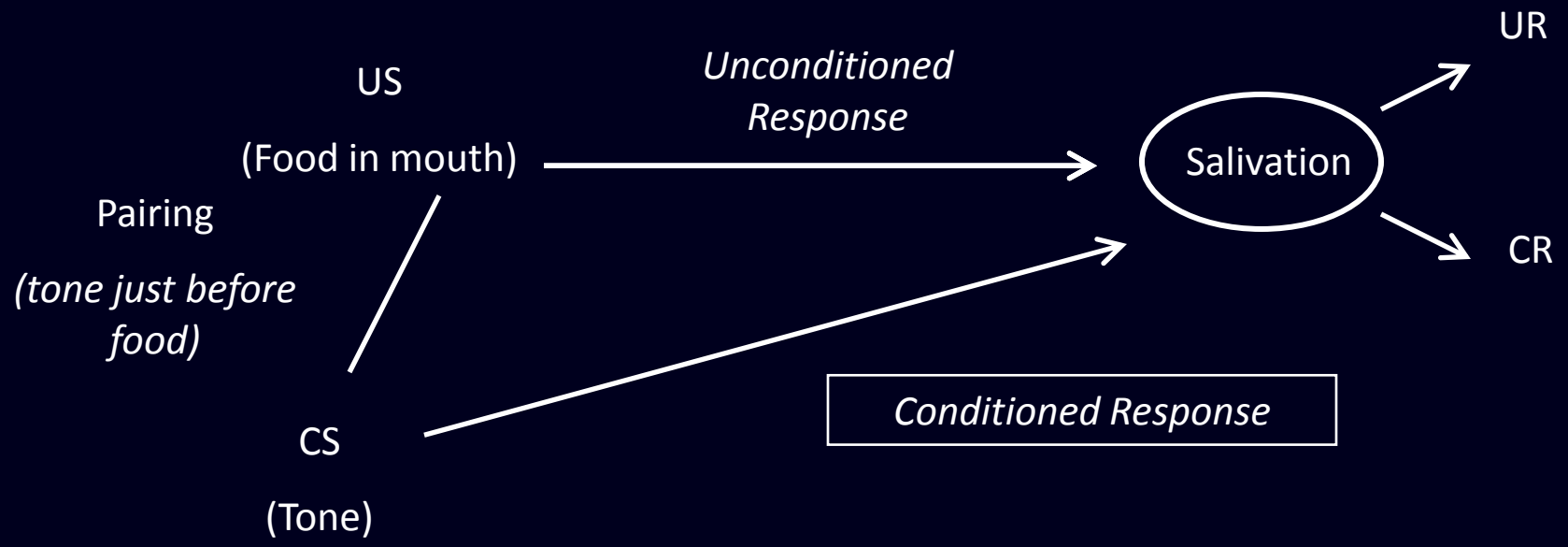
III. Pavlovian conditioning



Higher-order conditioning
(2nd order conditioning in this case)

Please note:

Only the first CS is associated with food. The second one is never directly associated with food, just with the first CS (e.g. the light is never associated with food, but just with the tone.



Imagine that you pair a puff of air (US) with a 60Db tone. After a certain number of trials you will obtain a conditioned response: the dog blinks when hears the 60Db tone.

The laws of reflexes say that if we present a stronger puff, the dog will blink more intensely (UR) and more rapidly (smaller latency).

Now, if you present the dog with a much stronger tone (CS, 100 Db), the dog **will not** blink more intensely. Now blinking is a CR. If we think about it, it may not blink at all, because it may **discriminate** between the tones. The 100Db tone was not actually paired with the puff of air at all.

It is easier if we think of lights and at what the stimuli do: a shade of **red (CS)** associated with a **tap** (**US**) on the knee starts to trigger a kick (**CR**). There is nothing in the dog's history that will tie **darker red** with stronger kicks and **shades of pink** with gentler kicks.

The strength of the CR is indeed measured by means of magnitude and latency. However, this has nothing to do with the lows of reflexes.

Example: pair food with tone, obtain salivation. The sequence is the following:

60 Db tone (**CS**)……2mg of food (**US**)…….10 drops of saliva (**US**).

After a few trials, as soon as the tone is turned on, the dog will salivate (**CR**). So:

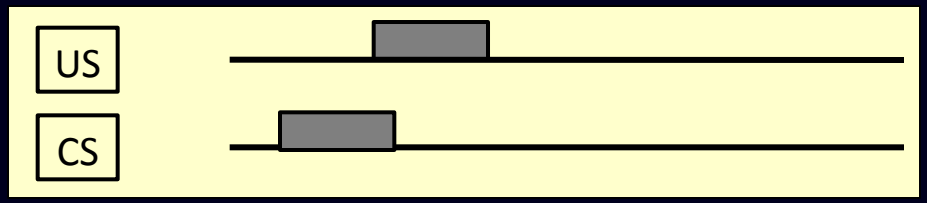
60 Db (**CS**)…….**X drops of saliva** (**CR**)……2mg of food (**US**)…..the dog keeps salivating (US-has food in its mouth)

Simply putted:

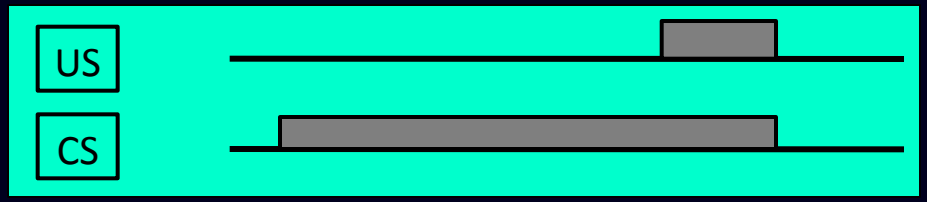
60 Db (**CS**)……..**x drops (CR)……**..2 mg (**US**)……..10 drops (**UR**)
A……B……..C……D

If in the above sequence we present the dog with more food at **step C** (5 mg), it will salivate more at **step D** (15 drops vs. the initial 10) it's natural. However, if we present it with 100 Db tone at **step A**, the dog may not salivate at all at **step B**, that tone was never associated with food. So, **C-D follow the laws** of the reflexes, **A-B do not**.

The **strength of the conditioning** (the CS-CR relation), lies between steps A-B. If x = 6, the conditioning between 60 Db and Salivation is pretty strong. If X = 1 drop of saliva at step B, the conditioning between 60 Db and Salivation is weak. If we present only A and B, without C (extinction), then X will start to decrease (e.g. from 6), the conditioning weakens, its strength decreases. The **explanation for latency** as a measure of strength of the conditioning is similar.



Delayed cond.: best for autonomic reflexes (5 – 30 seconds delay)



Long - Delayed cond.

There are a few differences:

1. Long delay: the CS is a turned for a longer period of time than in Delayed-Cond.
2. In Long delayed the CS and US end at the same time

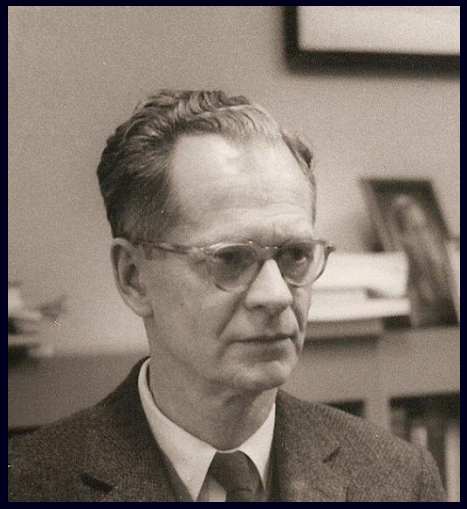
3. Example: tone (sound) lasts for 20 seconds. At second 18, we turn on a puff of air. The next 2 seconds they are both in effect. They both end at the same time.

4. In delayed-cond – the puff of air is turned on while the sound is on, but the sound ends before the puff air ends.

5. Long-delayed is basically a combination of delayed (the onset of CS precedes the onset of US) and Simultaneous Conditioning (they end at the same time)

6. Long-delayed is less effective than delayed.

Burrhus Frederic Skinner

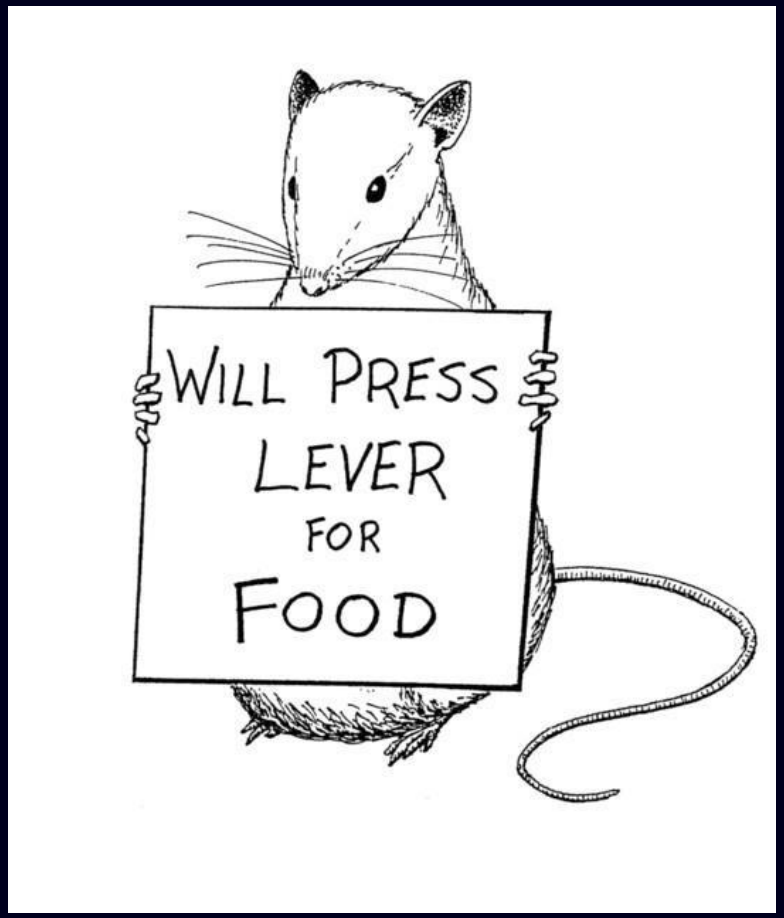


Founder of the *experimental analysis of behavior*.

Controversial ideas and terminology gave rise to a lot of myths regarding his views and beliefs, some true, some false.

IV. Operant conditioning

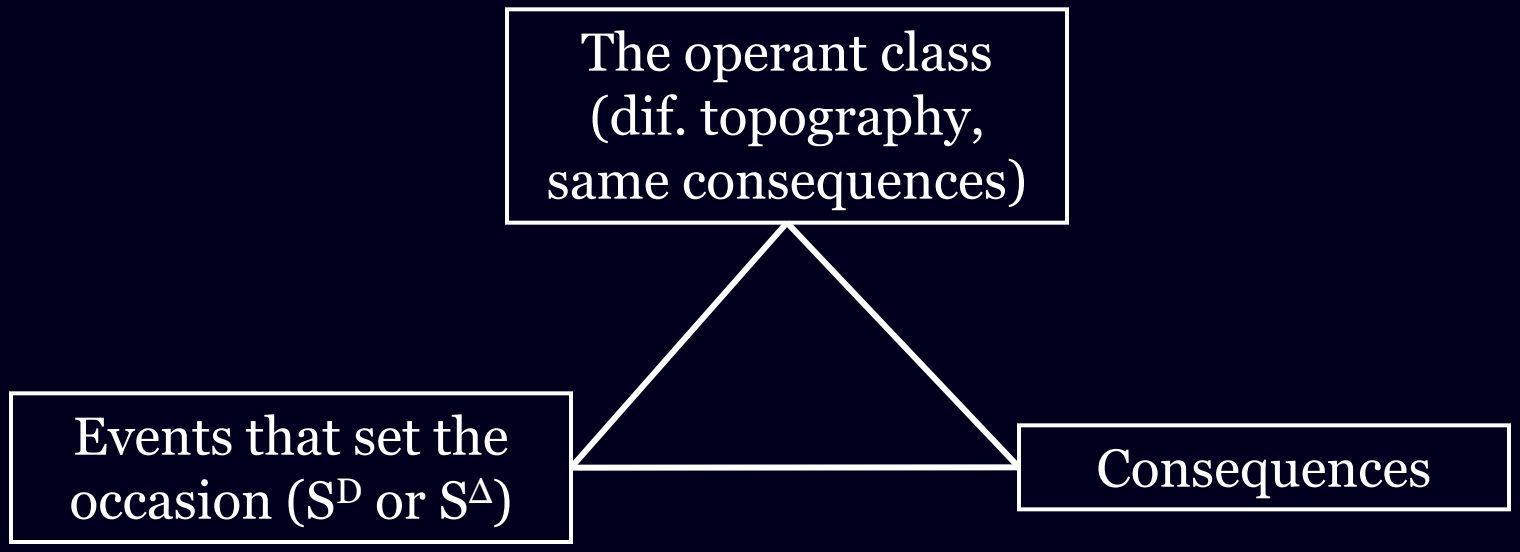
Operant (or instrumental) **behavior** = behavior which operates on the environment. It is driven by the consequences produced in the past.

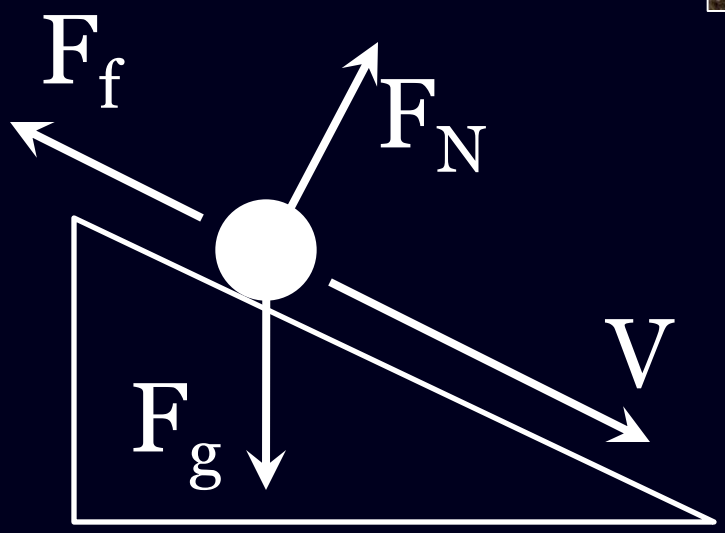


IV. Operant conditioning

Contingencies of reinforcement

- They define the **relations** between:





Laws of physics = context-independent, abstract relations (remove the "noise")

Merit: the discovery of general, fundamental relations between empirical entities.

Behavior

Consequences

The consequences of a behavior alter its probability to occur in the future.

Get good

AND/OR

void bad

The essen that govern

What matte *Y on such and*

Behavior < actions, not

such time? *e? Species? …*

their specific form.

Behavior ⇄ Consequences

The consequences of a behavior alter its probability to occur in the future.

Get good

AND/OR

Avoid bad

The essence = the general rules that govern Behavior ↔ Consequences interactions, not their specific form.

Social praise & GPA & Avoidance & "Get prof off my back" & "show Johnny who's better" & 10^{100} other combinations

IV. Operant conditioning

Four basic contingencies

Operation	Stimulus: Positive	Stimulus: Negative
Present	**Positive reinforcement** (present a positive situation – e.g. give the rat a pallet of food)	**Punishment** (present a negative situation – e.g. give the rat an electric shock)
Remove	**Response Cost** (remove a positive situation – e.g. block rat's access to food)	**Negative reinforcement** (remove a negative situation – e.g. interrupt an electric shock)

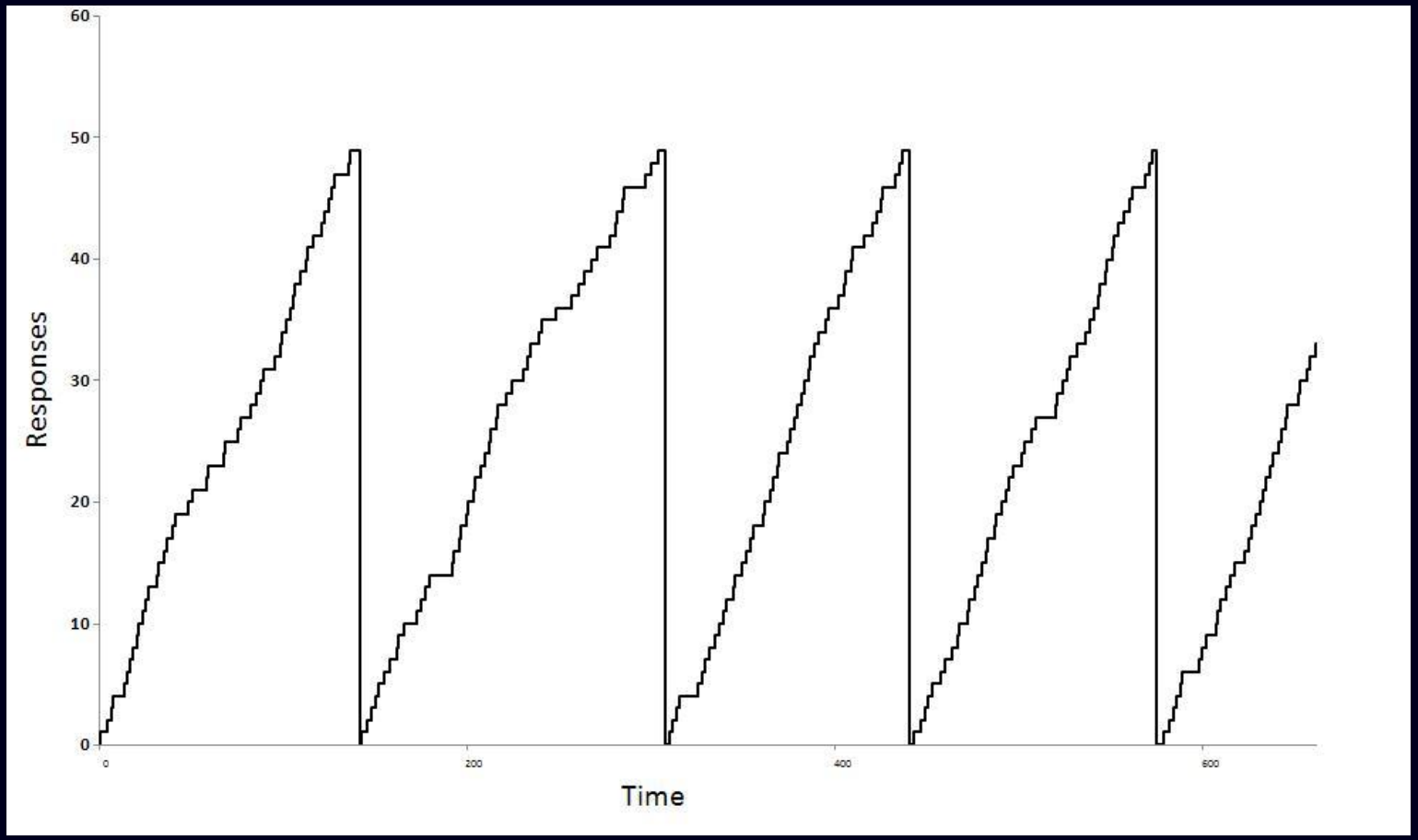
IV. Operant conditioning

Shaping by successive approximation

- Very successful for the acquisition of novel behavior
- Reinforcement of behavior that are more and similar to the target response.
- Earlier approximations are no longer reinforced (differential reinforcement)

IV. Operant conditioning

The cumulative record



IV. Operant conditioning

D. Reinforcement and Punishment

a. Positive reinforcement

b. Negative reinforcement
    a. Negatively reinforced behavior is called **escape**. Escape turns into **avoidance** if the environment permits it.

IV. Operant conditioning

D. Reinforcement and Punishment

a. Two types of punishment

- Contingent withdrawal of a reinforcer is sometimes called **omission training**.

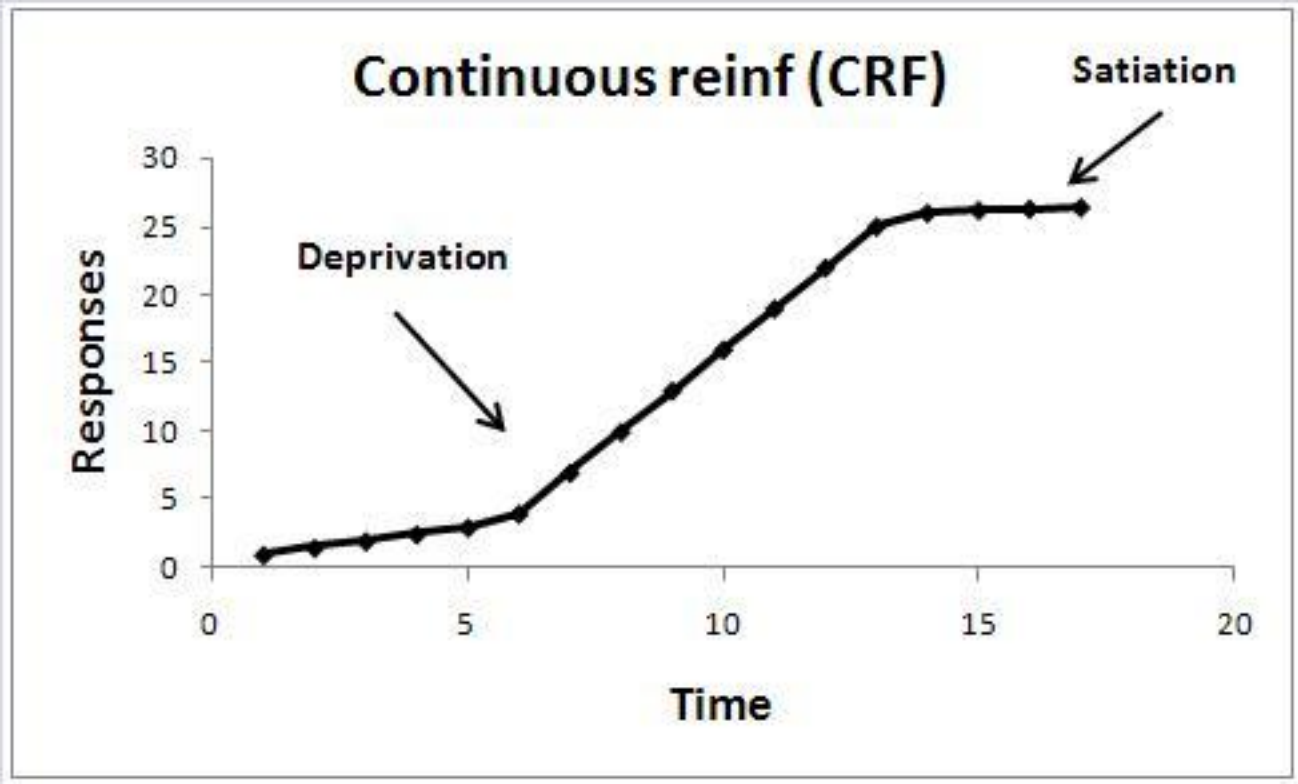
IV. Operant conditioning

E. Basic Phenomena

a. Acquisition
b. Extinction
c. Extinction bursts
d. Generalization
e. Discrimination
f. Humphrey's paradox

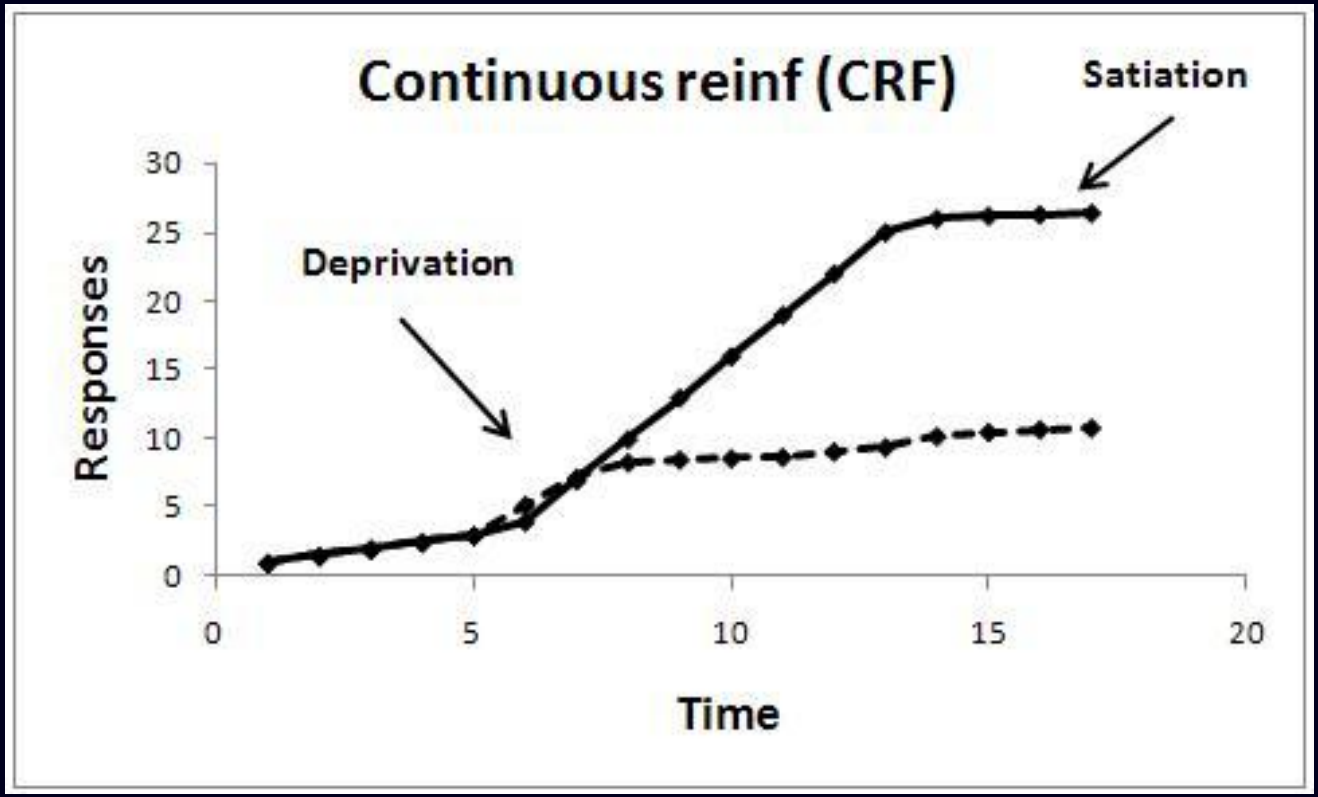
IV. Operant conditioning

Acquisition



IV. Operant conditioning

Extinction



IV. Operant conditioning

Extinction

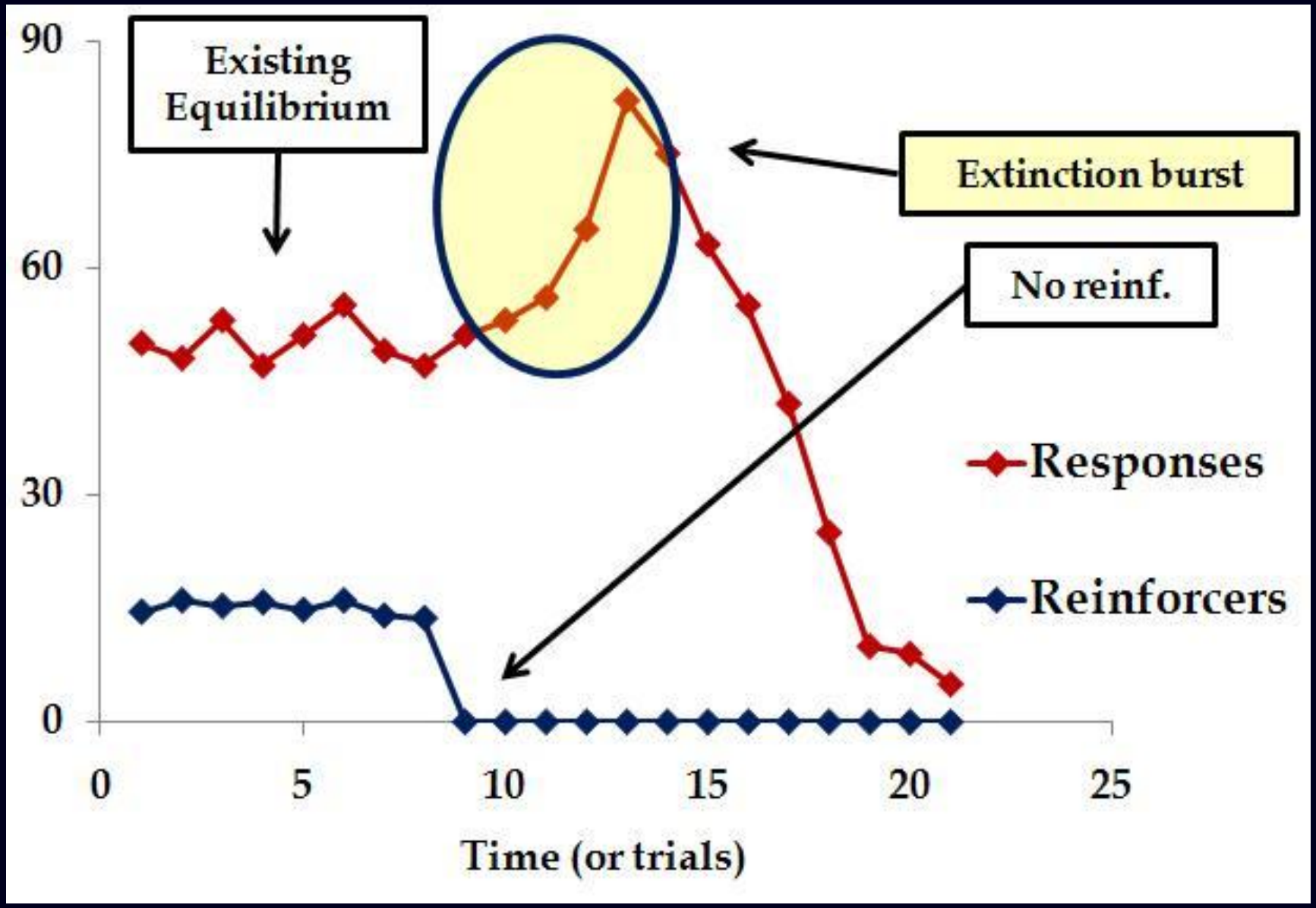
= withholding reinforcement for a previously reinforced response (or behavior).

Extinction burst – increase in frequency of target behavior

Increase in the variability of target behavior (topographically variable operants)

Increase in intensity of target behavior

Discriminated extinction = when a stimulus is present the organism learns that reinforcement is not available; extinction bursts do not appear, the animal simply does not respond.


90
60
30
0
0
5
10
15
20
25
Time (or trials)
Existing Equilibrium
Extinction burst
No reinf.
Responses
Reinforcers

IV. Operant conditioning

Resistance to Extinction

a. Hard to go back to operant level (many sessions are required)

b. Intermittent reinforcement – a lot more difficult to extinct.

c. Discriminative stimuli – most efficient extinction takes place when we precisely reproduce the conditions under which conditioning occurred (anything that is different can become a discriminative stimulus)

d. Spontaneous recovery – after extinction occurred and the target response is at operant level, if some time passes and the animal is placed back in the cage, the target behavior is displayed with rates above the operant level.

IV. Operant conditioning

Discrimination and Generalization

Generalization – a behavior that has been reinforced in the presence of a specific S^D is emitted in the presence of new stimuli.

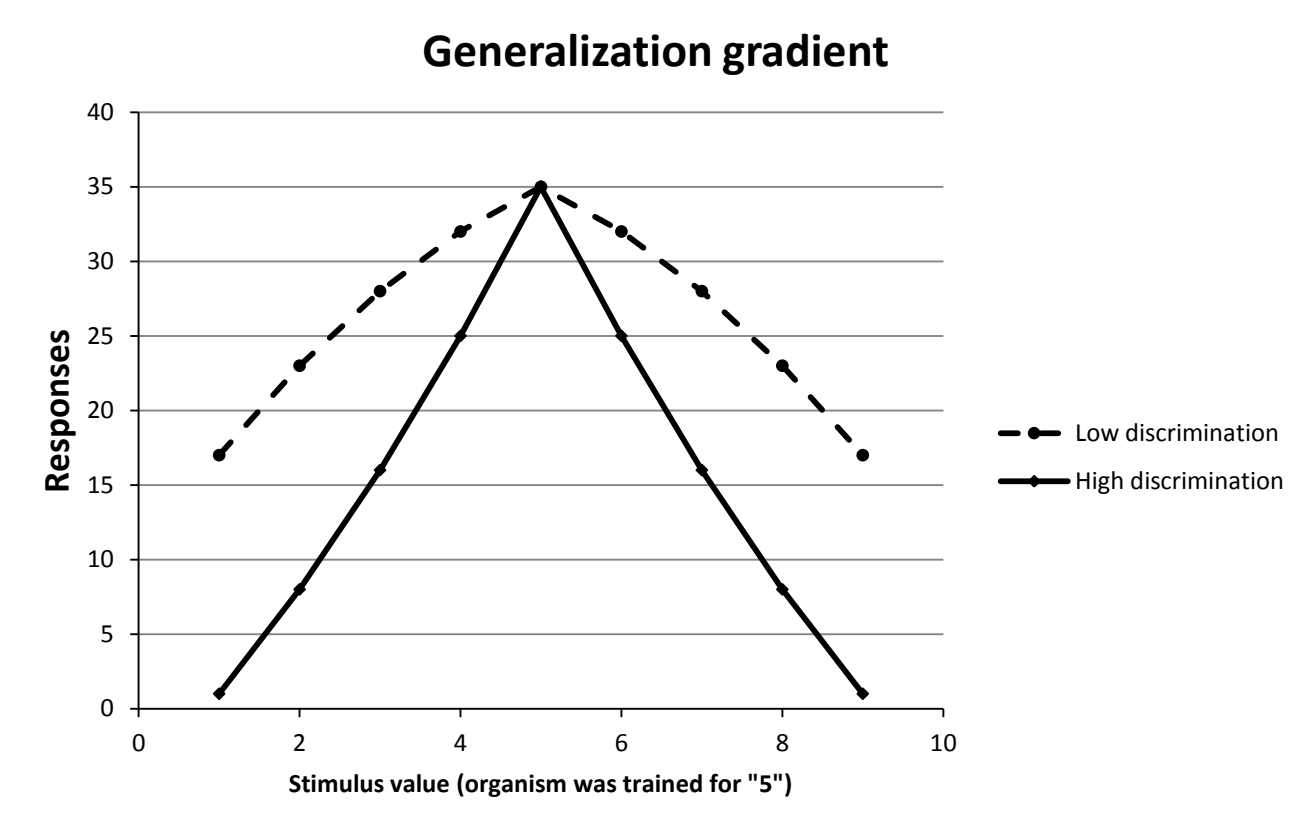
They refer to difference in the precision of stimulus control (high discrimination = very precise stimulus control)

Generalization gradient = probability of response and stimulus value.

e.g. fear for water phobia: increases with water depth, until reaches a plateau (there is no difference between

IV. Operant conditioning

Discrimination Vs. Generalization



IV. Operant conditioning

Stimulus control

Controlling stimulus = alters the probability of an operant (e.g. S^D – sets the occasion for reinforcement; S^Δ (S-Delta)= extinction stimulus)

To make a response under red light but not under green = discrimination (or differential response)

Easy to achieve by reinforcing under green light and withholding reinforcement under red light.

When the organism changes behavior in diferent situations = the behavior is under stimulus control.

IV. Operant conditioning

Behavioral Contrast

Positive contrast = we put the green key on extinction, R_1 declines, R_2 increases.

Negative contrast = we increase the reinforcement rate on the green key, R_1 increases, R_2 declines.

"Positive" and "negative" refer to the effect on the rate of responses on the unaltered alternative.

IV. Operant conditioning

Behavioral Contrast

We increase the reinforcement rate for "**running**". What happens with "**smoking**"?

Negative contrast = goes down.

We put "**Smoking**" on extinction. What happens?

Positive contrast: behaviors need to go somewhere. And they do!

IV. Operant conditioning

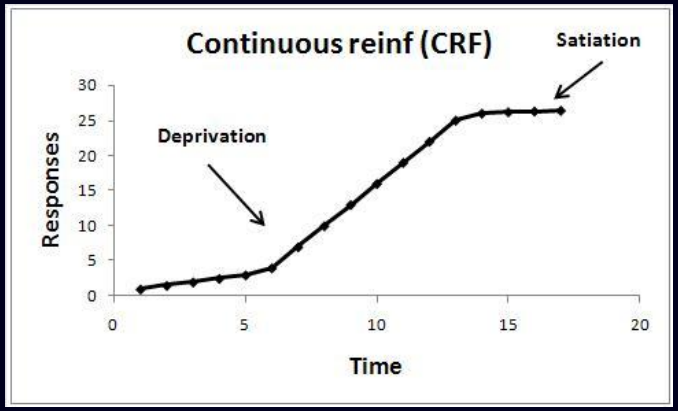
Schedules of reinforcements

= “prescription that states how and when discriminative stimuli and behavioral consequences will be presented” (Morse, 1966)

Different schedules show different response patterns of steady-state behavior.

CRF – the simplest schedules

- Every response acquires reinforcement
- Little resistance to extinction
- Produces stereotyped response topography.



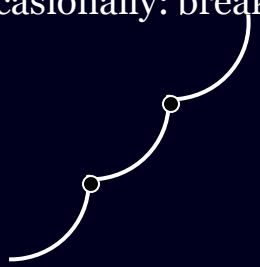
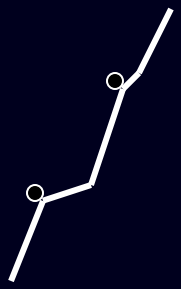
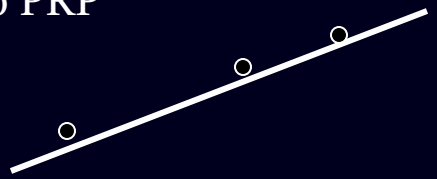
IV. Operant conditioning

Schedules of reinforcements

A. Simple schedules: VI, VR, FI, FR
B. Paced schedules:
    - DRL
    - DRH
    - combinations
C. DRO schedules
D. Compound schedules
    - Tandem
    - Chained
    - Mixed
E. Multiple schedules
F. Concurrent schedules

IV. Operant conditioning

Simple schedules

	Responses	Time
Fixed	**FR** Run of responses → Reinf. → Post-Reinf. Pause (PRP) 	**FI** - Scalloping pattern - Occasionally: break-and-run  e.g. the paycheck at the end of week
Variable	**VR** - high rate of response  e.g. gambling	**VI** - moderate and steady rate - frequently used as baseline - no PRP 

IV. Operant conditioning

Paced schedules of reinforcements

Differential **R**einforcement of **L**ow rate of response (DRL)

- is used to decrease rates of responding.
- like an interval schedule, except that premature responses reset the time required between behavior.

Differential **R**einforcement of **O**ther behavior (DRO)

Differential **R**einforcement of **H**igh rate (DRH)

- is used to increase rates of responding.
- like an interval schedule, except that a minimum number of responses are required in the interval in order to receive reinforcement.

IV. Operant conditioning

DRO Schedules

Differential **R**einforcement of **O**ther behavior (DRO)

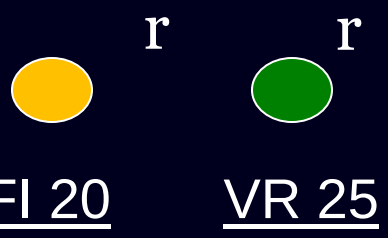
- Is used to decrease the rate of responding
- Successful in reducing/eliminating problem behavior (Why?)

- Behavior contrast

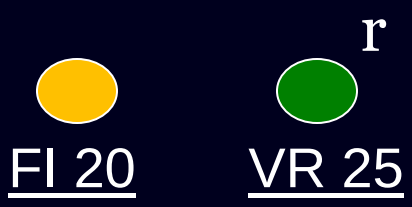
- See McDowell, 1988 for an example (a summary is provided by Pierce & Epling)

IV. Operant conditioning

1. Multiple schedule
   - multiple components
   - Each component is signaled
   - Each component delivers reinf.



2. Chained Schedules
   - multiple schedules, but only the terminal link results in primary reinf.



3. Tandem schedule = un-signaled chain

4. Mixed Schedule = un-signaled multiple schedule

IV. Operant conditioning

Concurrent schedules

- 2 or more schedules are simultaneously available;
- the alternatives are independent of each other;
- each delivers reinf.

- The distribution of time and responses among alternatives is the measure of choice and preference.
  - Concurrent ratio schedules: exclusive preference for the richer alternative
  - Concurrent interval schedules

IV. Operant conditioning

Issue: the organism is sometimes accidently reinforced for switching, not for responding on the alternatives (the changeover response gets accidently reinforced)

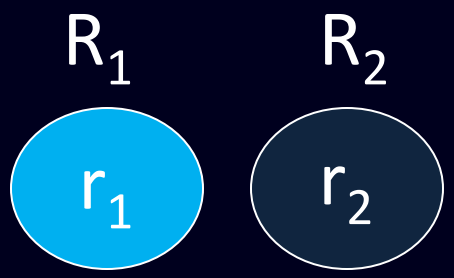
Solution: the changeover delay (COD)

- Implemented on each key, separately.
- Implemented by adding a COD key and placing the concurrent schedule on the same physical key.

Richard J. Herrnstein

The formulation of The Matching Law – the first operant definition in psychology (1961, Age 31)

The Matching Law
(Herrnstein, 1961)



$$\frac{R_1}{R_1 + R_2} = \frac{r_1}{r_1 + r_2}$$

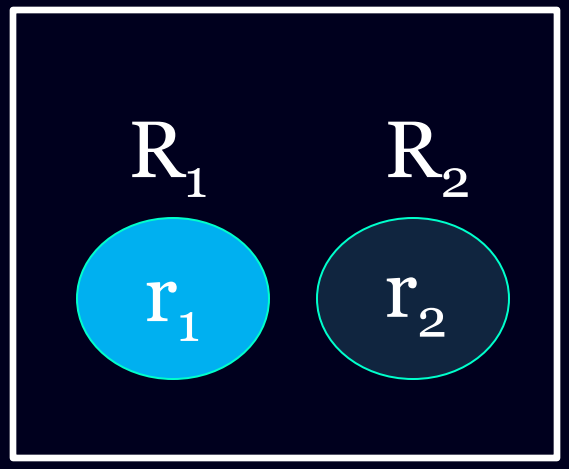
equivalent

$$\frac{R_1}{R_2} = \frac{r_1}{r_2}$$

$$R_1 r_1 + R_1 r_2 = R_1 r_1 + R_2 r_1$$

$$R_1 r_2 = R_2 r_1$$

The Matching Law
(Herrnstein, 1961)



$$\frac{R_1}{R_2} = \frac{r_1}{r_2}$$

Developed into

$$\frac{R_1}{R_2} = b\left(\frac{r_1}{r_2}\right)^a$$

The Power Function Matching Equation
(Baum, 1974)

IV. Operant conditioning

The Matching Law

The bias parameter (≈ 1)

The exponent 0.8 = "good matching"

$$\frac{R_1}{R_2} = \frac{r_1}{r_2}$$

R_s = Rates of adaptive behavior

r_s = Rates of resource acq.

The power function matching equation

The power function matching equation

a. Violations of symmetry – bias (b)
   a. A preference for one alternative or the other, preference which **is not due** to differences in the rates of reinforcement.
   b. $b = 1 \longrightarrow$ no violation of symmetry

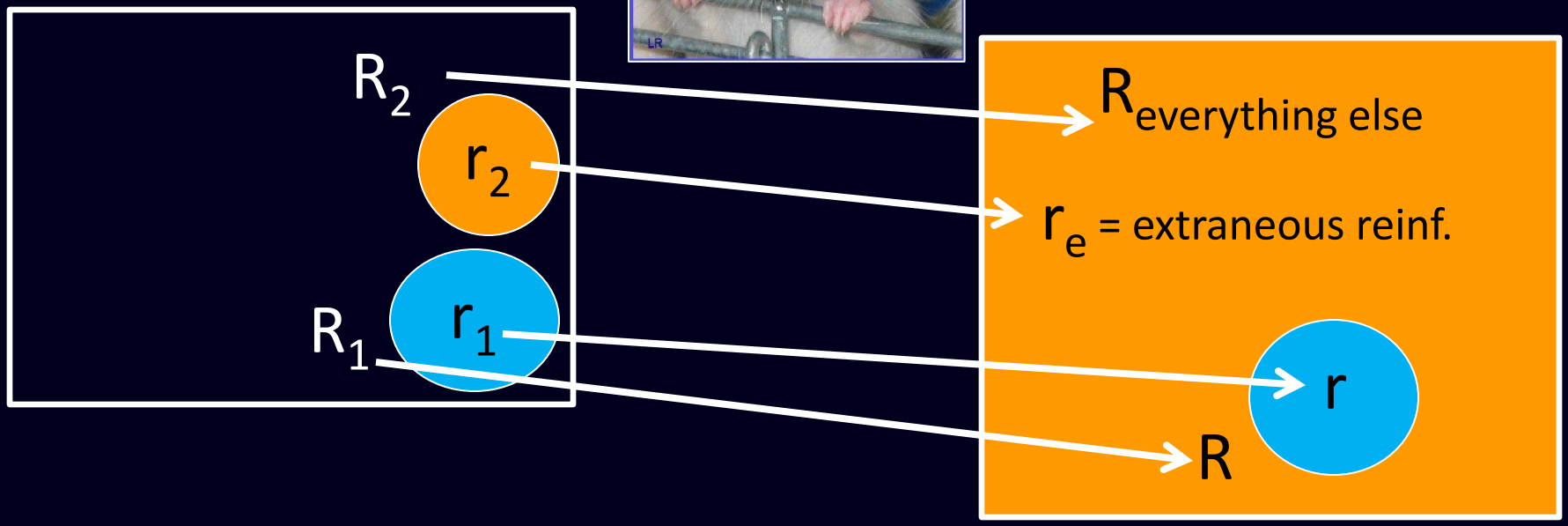
b. Sensitivity to reinforcement (a):
   a. Total indifference (a = 0)
   b. Undermatching (a < 1)
   c. Perfect matching (a = 1)
   d. Overmatching (a > 1)

Herrnstein's Quantitative Law of Effect

- Formulated in 1970
- Deduced from the Matching Law (1961)

Concurrent-schedules
(2 levers available simultaneously)

Single-alternative
(1 lever)



Assuming $R_1 + R_2 = k$ (constant, the total number of responses)

$$\frac{R_1}{R_1 + R_2} = \frac{r_1}{r_1 + r_2} \rightarrow \frac{R}{k} = \frac{r}{r + r_e} \searrow$$

$$R = \frac{kr}{r + r_e}$$

Herrnstein's Quantitative Law of Effect

- Formulated in 1970
- Deduced from the Matching Law (1961)
- K = the total number of responses
- r_e = extraneous reinforcement, *everything else* the organism *obtains* from the environment

The Matching Theory

The Quantitative Law of Effect (Herrnstein's hyperbola) describes steady-state behavior in single-alternative environments (1 lever)

The Power Function Matching equation describes steady-state behavior in **concurrent-schedules** environments (2 levers, available simultaneously)

N.B. Herrnstein's Matching Law (1961), the initial equation, expressed as ratios, without parameters, developed into the Power Function Matching equation (Baum, 1974)