synthetic perceptive, emotive and cognitive systems

Cognitive Science & Psychology: Mind, Brain and Behavior

Philosophical and historical roots I (Week 5)

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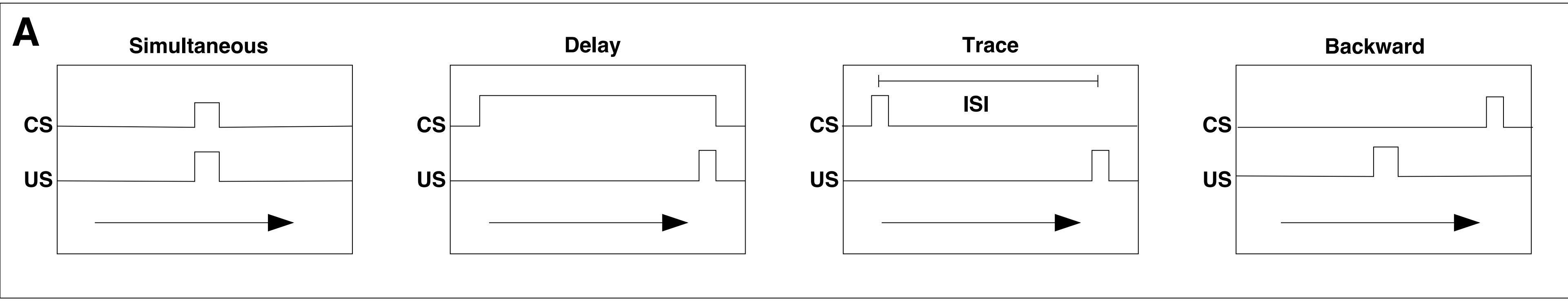
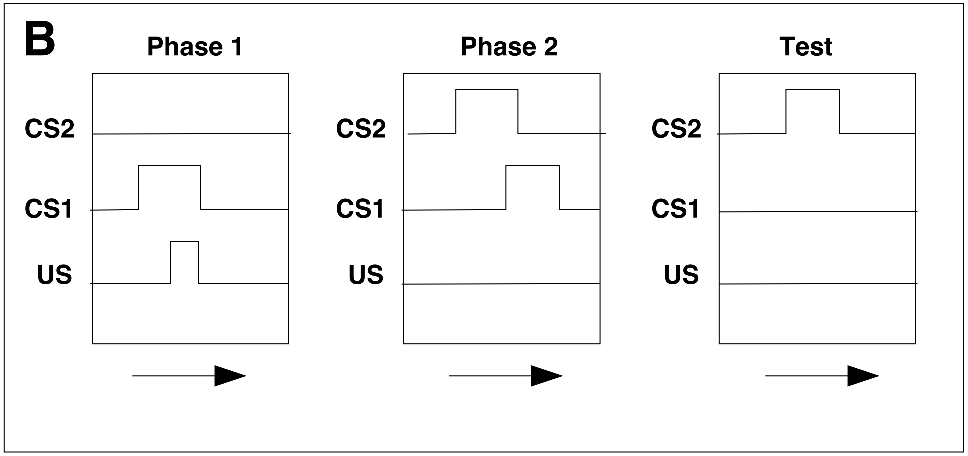
variations on classical conditioning



Higher-order conditioning



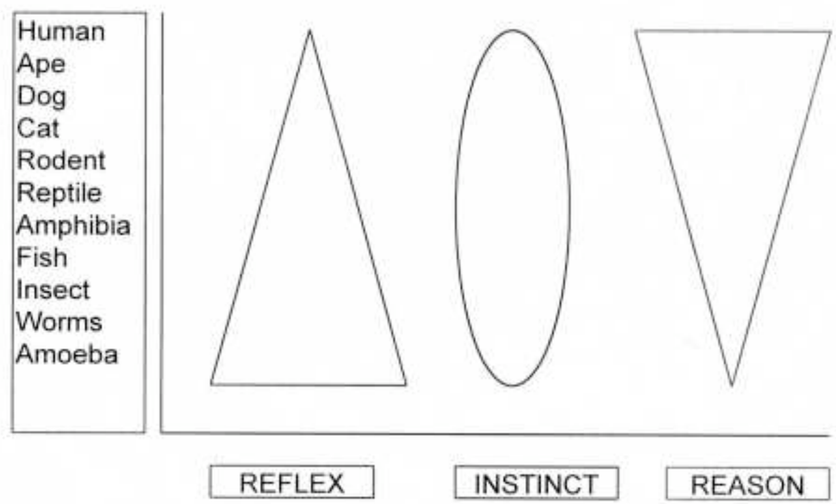
Pavlov reported the best conditioning results when the CS preceded the US with a relatively short time interval or Inter Stimulus Interval (ISI)

Pavlov‘s Classical Conditioning or Psychic Reflex

- Learning results from a clear well defined experience
  - Unconditioned stimulus (e.g. food)
  - Unconditioned response (e.g. salivation)
  - Conditioned stimulus (e.g. sound)
  - CS and US are in „close“ contiguity
- Affects autonomous nervous system (mistake)
- Results from CS-US substitution
- The interaction of cortical and subcortical systems
- Allows adaptation by maintaining the dynamic equilibrium between the organism and its environment
- .....

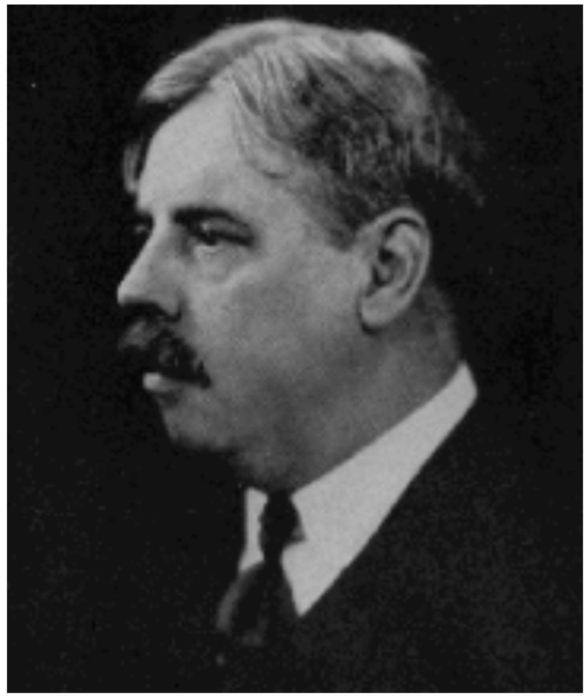
In the mean time in the west comparative psychology is taking of

"...Rengger describes a monkey employing a stick herewith to prise open the lid of a chest, which was too heavy for the animal to raise otherwise. This use of a lever as a mechanical instrument is an action to which no animal other than a monkey as ever been known to attain;...my own observation has fully corroborated that of Rengger in this respect" (Romanes 1967, pp. 52).



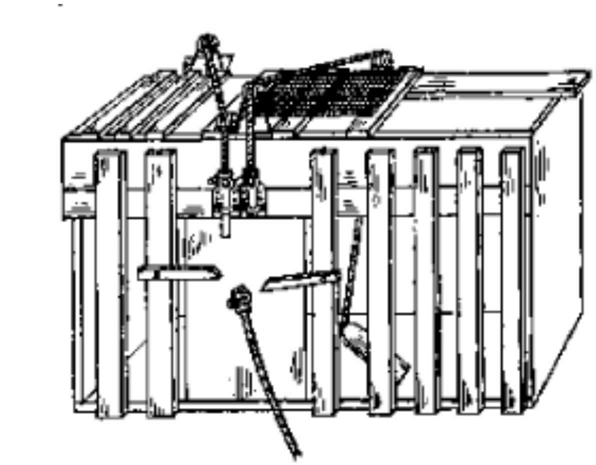
Romanes, G. (1888). Animal Intelligence, New York: Appleton

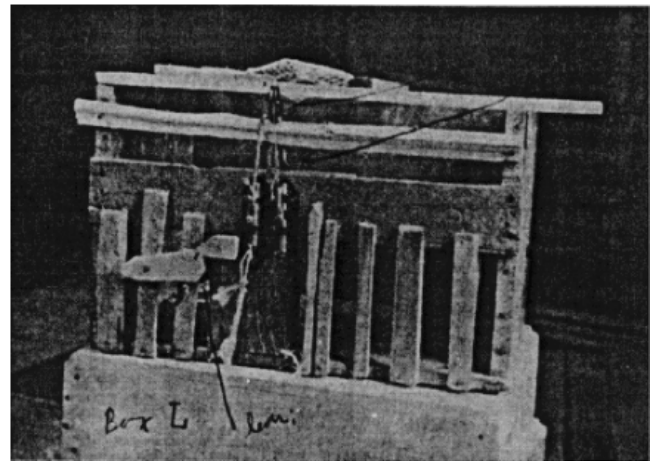
Thorndike and the laws of goal oriented learning

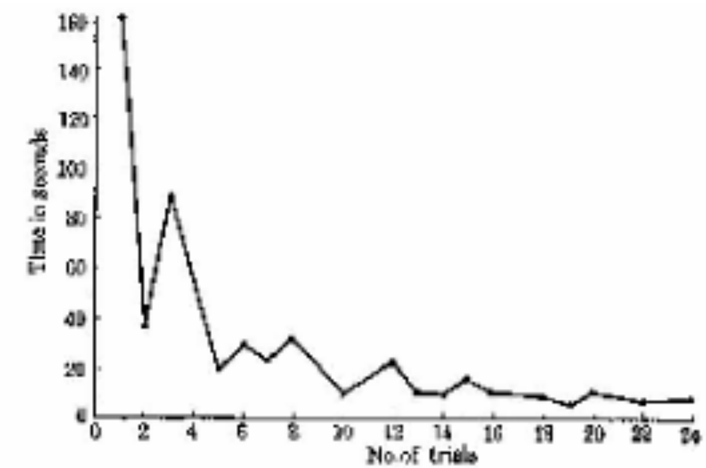


E.L.Thorndike (1874-1949)

The puzzle box & learning curve







Laws of conditioning

- Law of readiness: learning is motivated
- Law of exercise: law of use/law of disuse
  - Situation & response „bond“
  - bond is strengthened by exercise
- Law of effect: when an action is followed by a satisfying state of affairs it is stamped in, if it leads to an annoying state of affairs it is stamped out
- Learning is connecting, „the mind is man‘s connection system“

classical vs operant (animal operates on the environment)/instrumental (behavior is instrumental in obtaining something form the environment the organism wants) conditioning, all organism with nervous systems show CC, all vertebrates display OC, OC gives rise to habitual behaviors, acquired under conditions of incentives.

- cc reinforcement does not depend on the behavior, OC it does
- cc: US elicits the UR, OC: organism emits the behavior
- cc: involuntary innate response is being conditioned, OC: voluntary
- cc brings reflexes under environmental control, limited repertoire. OC can build more complex behavioral patterns
-

Outline

Lecture 1 Introduction - robot future
Lecture 2 The Mind, Brain, behaviour Cycle
Lecture 3 The Knowledge Problem in the Science of Mind and Brain
Lecture 4 The Five Revolutions defining Current Reality
Lecture 5 Conceptual Revolutions in Philosophy of Mind
Lecture 6 (1850-1915) Structuralism and Functionalism
Lecture 7 (1915-1950) Behaviorism, Cognitive Behaviorism
Lecture 8 (1950-1960) The Demise of Behaviorism
Lecture 9 (1945-1960) Cybernetics and the Cognitive Revolution
Lecture 10 (1960-Now) Mind as Computation
Lecture 11 (1985-Now) Biology as a Metaphor and Beyond
Lecture 12 (Now-Future) Flux and Synthesis

Behaviorism

- Phenomenon:
  - overt adaptive behavior
    - learning
      - adaptation sensory and response systems
        - » “Everything can be learned”
    - Ontogeny
    - Learning is instruction by the environment
- Goal to control and predict behavior
- Objective psychology
- Operationalism – borrowed from physics:
  - atomistic decomposition into S-R chains
  - universality
  - correspondence between process and mechanism
    - Structure function isomorphism

The universality of behaviorism

"I see no reason why the application of systematized knowledge to the control of human nature may not in the course of the present century accomplish results commensurate with the nineteenth century applications of physical science to the material world"

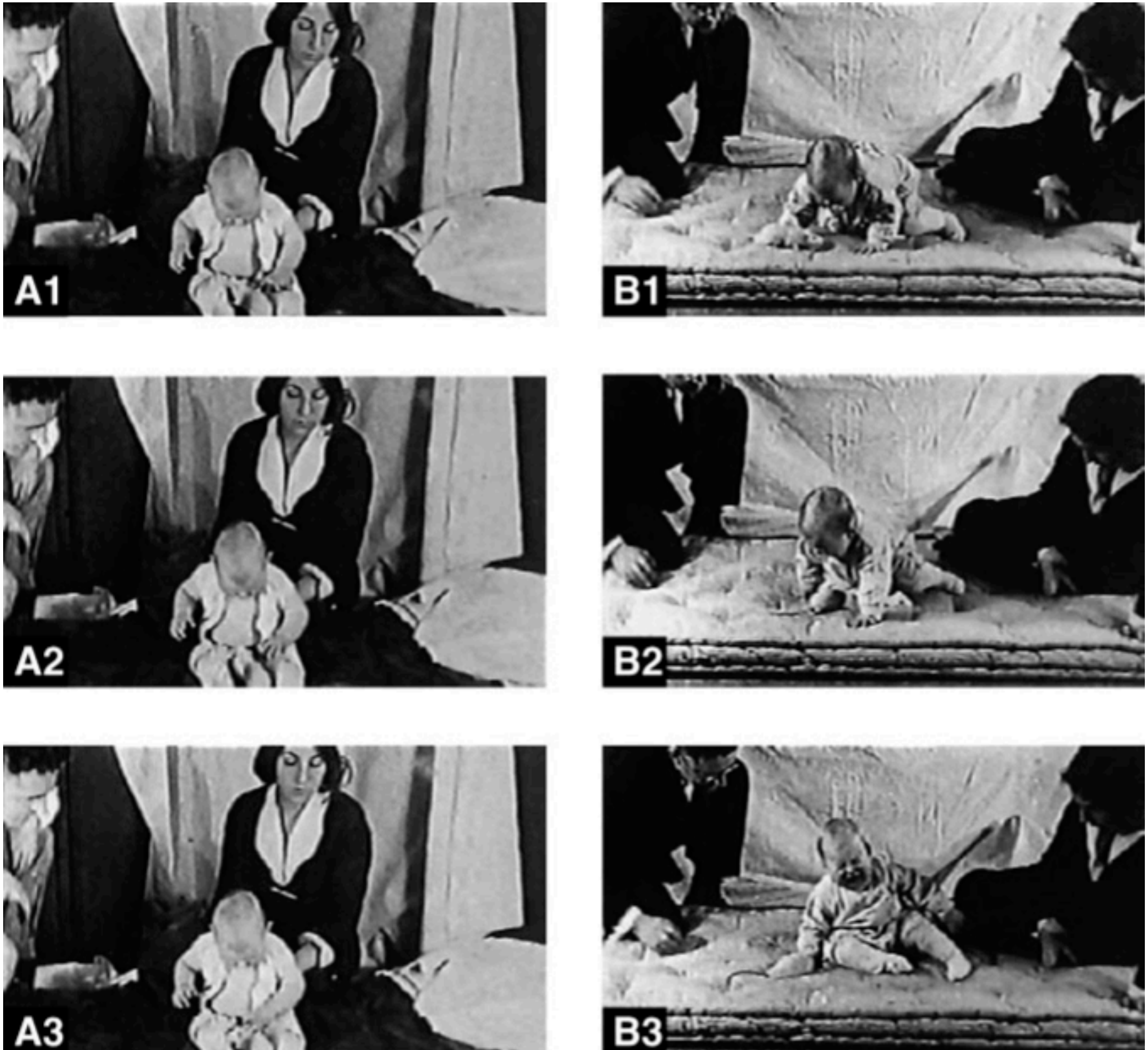
Cattell, J. M. (1904). The conceptions and methods of psychology, Popular Science Monthly 66: 176-186. (P186)

Cattell, J. M. (1860-1944)

”Psychology as the behaviorist views it is a purely objective experimental branch of natural science. Its theoretical goal is the prediction and control of behavior” (Watson 1913, p. 158)

Watson & Rayner's "Little Albert“ experiment (1920)

"Little Albert" again

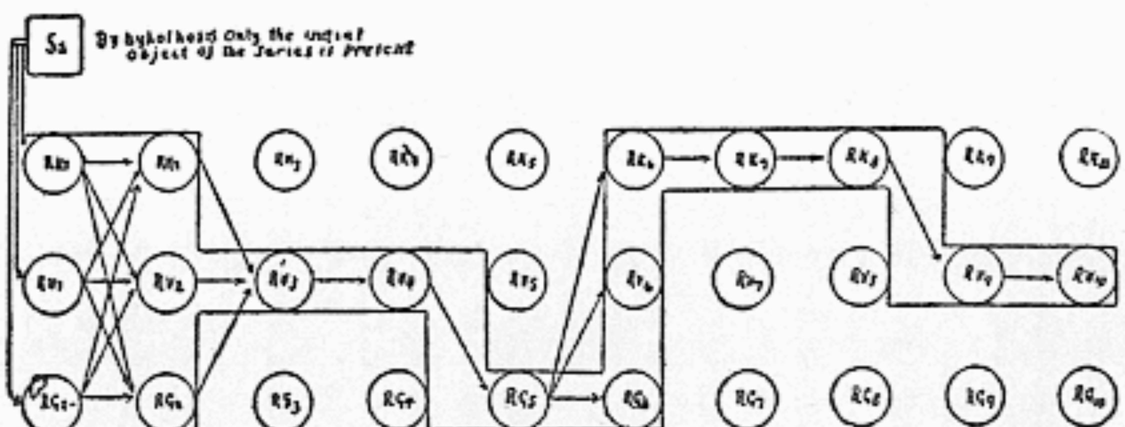


Watson & Rayner's interpretation of the "Little Albert" experiment

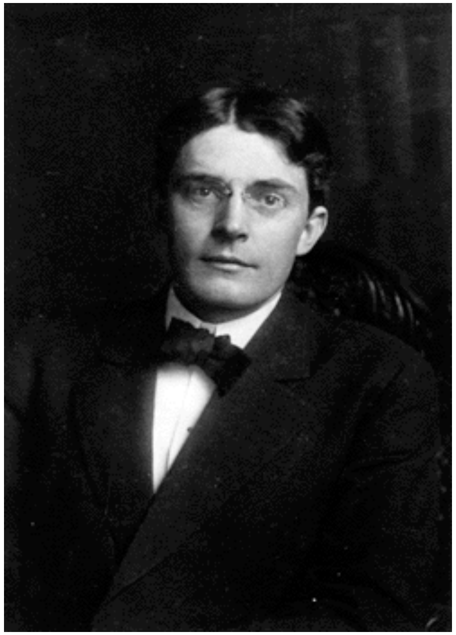
(U) S		(U) R
Loud sound Loss of support	}	"Start" crying, etc. (fear).

AFTER CONDITIONING

C		U (R)
Rabbit, dog, furry objects	—	Fear



This diagram shows the behaviorist's theory of thinking.



John Watson and Rosalie Rayner

Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select--doctor, lawyer, artist, merchant- chief, and yes, even beggarman and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors
- John Watson

Behaviorism does away with teleological explanation

Material cause describes the material out of which something is composed.

Formal cause is a concept used by Aristotle, and originates from the idea of the **form** by Plato and Socrates.

The efficient cause is the agent which brings something about.

Final cause or telos, the purpose, the good, or the end of something.

Watson discards the Aristotelian metaphysical concept of material, efficient, formal and final causes and replaces it with a pragmatic one where a causal law of behavior allows prediction and control. Watson rejects any explanation of behavior that relies on the notion of the purpose or goal of behavior, or teleological explanations that go back to Aristotle's notion of final cause, or other mentalistic constructs.

> *"This leads me to the point where I should like to make the argument constructive. I believe we can write a psychology... and never go back upon our definition: never use the terms consciousness, mental states, mind, content, introspectively verifiable, imagery, and the like. I believe we can do it in a few years without running into the absurd terminology of Beer, Bethe, Von Uexkull, Nuell and that of the so-called ob jective school generally. It can be done in terms of stimulus and response, in terms of habit formation, habit integrations and the like."(Watson 1913, p. 167)*

Watson, J. (1913). Psychology as the behaviorist views it, Psychological Review 20: 158{
177.

From dogma to methodology

B.F. Skinner
(1904-1990)

Skinner’s life
Predetermined, lawful, and orderly
A product of past reinforcements

1925: Hamilton College (NY): degree in English, no courses in psychology; Read about Pavlov’s and Watson’s experimental work
1931: Ph.D. from Harvard

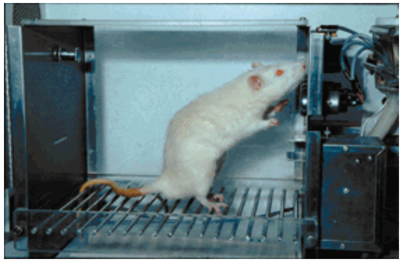
No presumptions about factors internal to the mind
The "empty organism" approach

Skinner's dictum:

- "All we need to know in order to describe and explain behavior is this: actions followed by good outcomes are likely to recur, and actions followed by bad outcomes are less likely to recur." (Skinner, 1953)

Environmental consequences of action shape behavior

Operant Conditioning and the Skinner box



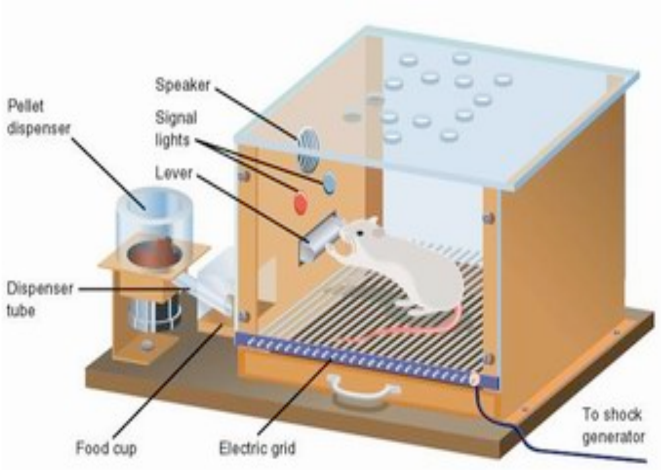
Operant behavior: occurs without an observable external stimulus

“class of responses”: all the responses that are capable of producing the consequence.

Organism **operates** on its environment

The behavior is **instrumental** in securing an outcome more representative of everyday learning

Type of learning in which the future probability of emitting a behavior is affected by its consequences



The law of effect

Laboratory Examples

Operant Conditioning

Pigeon

Exploring

Scratching

Key-pecking

Grooming

Defecating

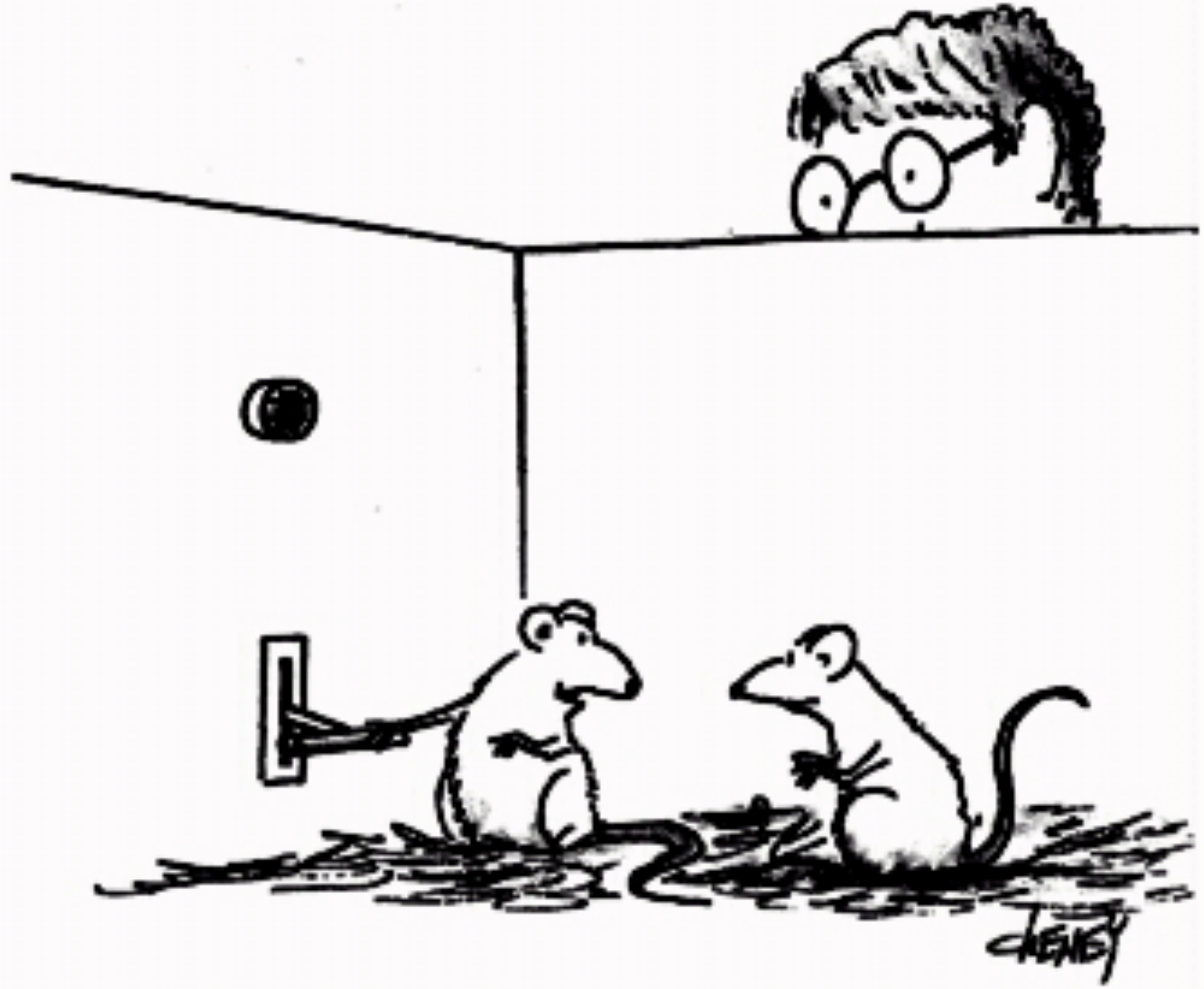
Urinating

......

Reinforcement

(food pellet)

The law of effect selects the behavior that leads to reward



It's a rather interesting phenomenon. Every time I press this lever, that post-graduate student breathes a sigh of relief.

Operant Consequences

- **Reinforcers**: events that follow behavior and *increase* the future probability of that behavior
- **Punishers**: events that follow behavior and *decrease* the future probability of behavior.
- **Behaviors are reinforced** or punished not organisms.

Operant Antecedents

- **Discriminative stimuli**: environmental stimuli in the presence of which responses are reinforced and in the absence of which they are not reinforced.
- Signals that indicate that a response will be reinforced.

Contingencies of Reinforcement

- Operant behavior is define by a 3 term **contingency**:
  - Events that set the occasion for behavior
  - The operant class
  - Consequences that follow the behavior

Classes of Reinforcing and Punishing Stimuli

	Increase Reinforcer	Decrease Punisher
Present Positive	Positive Reinforcer	Positive Punisher
Remove Negative	Negative Reinforcer	Negative Punisher

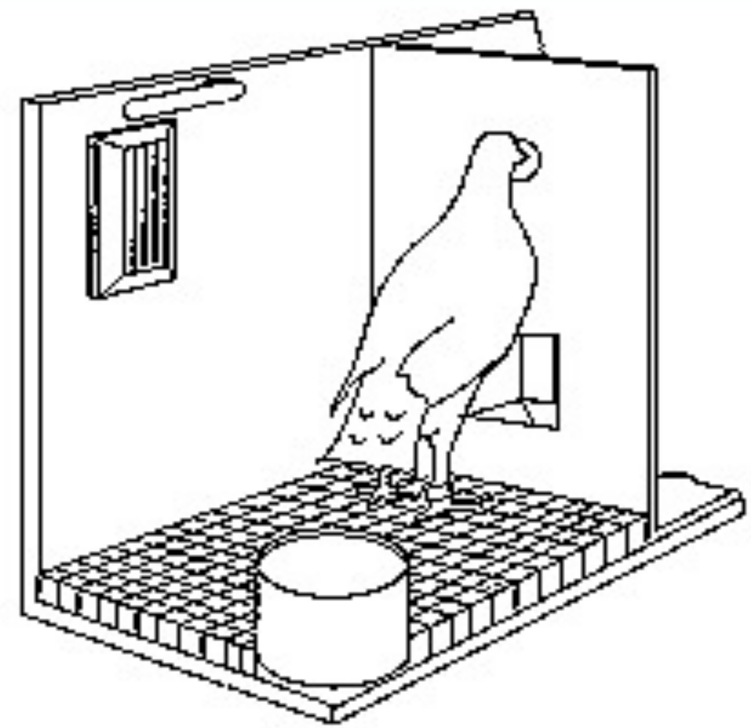
SCHEDULES OF REINFORCEMENT

- **Interval schedules**: reinforcement occurs after a certain amount of time has passed
- **Continuous Reinforcement**: Every time the rat does the appropriate behavior, it receives reward.
- **Fixed Interval** = reinforcement is presented after a fixed amount of time. If the rat presses the bar at least once during a particular period of time, say 20 seconds, he gets a pellet. But whether he presses the bar once or a hundred times within that 20 seconds, he only receives one reinforcer.
- **Variable Interval** = reinforcement is delivered on a random/variable time schedule. You keep changing the time period. First 10 seconds, then 35, then 5, then 40.
- Ratio schedules: reinforcement occurs after a certain number of responses
- **Fixed ratio schedule**: If the rat presses the pedal three times, he gets a pellet… or five times, or twenty times, or x times. There is a fixed ratio between behaviors and reinforcers. Reinforcement presented after a fixed # of responses
- **Variable ratio schedule**: Reinforcement delivery is variable but based on an overall average # of responses. e.g. First it takes 3 presses to get a pellet, then 10, then 4, etc.

Schedules of Intermittent Reinforcement

	Ratio (# responses)	Interval (time)
Fixed	Fixed Ratio	Fixed Interval
Variable	Variable Ratio	Variable Interval

The case of the superstitious pigeon



Skinner's Superstition Experiment

A landmark study in the debate about the role of contiguity versus contingency

Method

Food presented to pigeons every 15 s regardless of the behavior of the bird.

Result

Birds showed stereotyped behavior patterns as time for food delivery approached.

'SUPERSTITION' IN THE PIGEON
B. F. Skinner 1948 Journal of Experimental Psychology, 38, 168-172.

Superstition in the pigeon

'SUPERSTITION' IN THE PIGEON
B. F. Skinner
Indiana University
First published in Journal of Experimental Psychology, 38, 168-172.

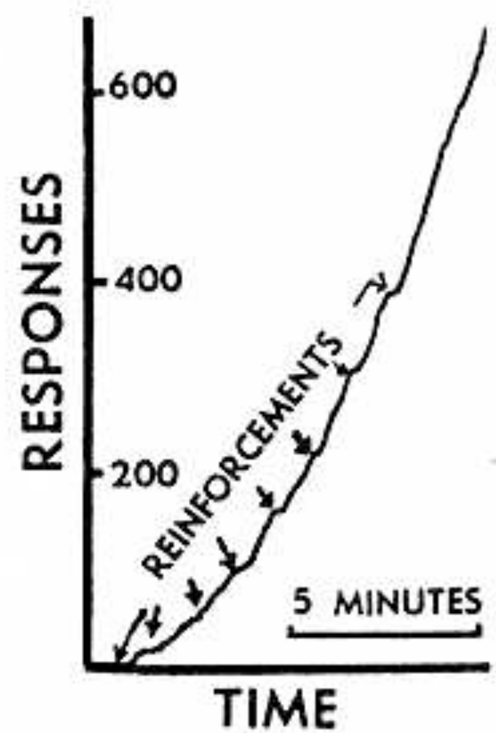


Fig. 1. 'Reconditioning' of a superstitious response after extinction. The response of hopping from right to left had been thoroughly extinguished just before the record was taken. The arrows indicate the automatic presentation of food at one-min. intervals without reference to the pigeon's behavior.

Skinner's operant conditioning explanation:

- Adventitious (accidental) reinforcement of the bird's behavior
- Stresses the importance of contiguity between R and the reinforcer

Logic of Skinner's explanation:

- Animal could pick out which response was being reinforced
- Animal was insensitive to contingency
- Extinction was much weaker than acquisition

Instrumental Conditioning involves three key elements:

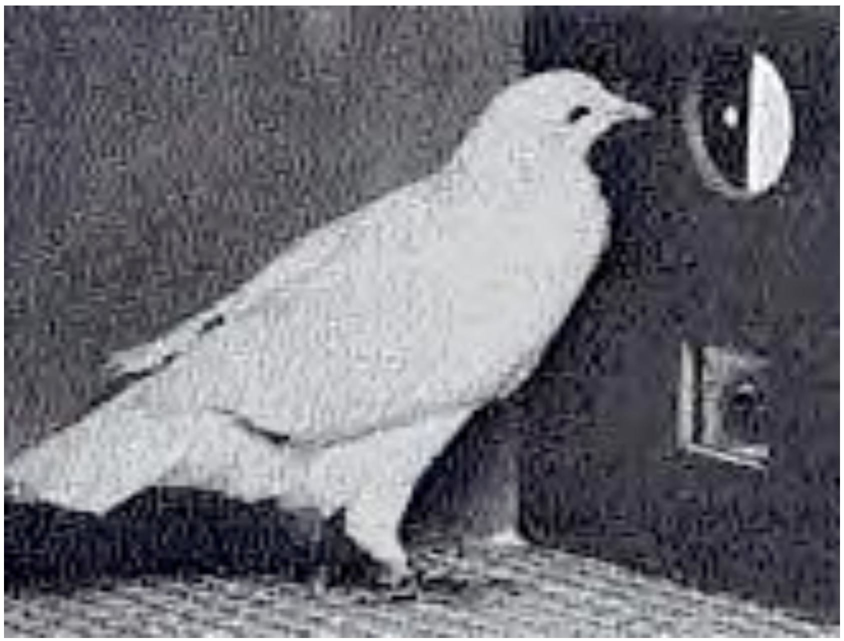
- a response
  - usually an arbitrary motor response
  - relevance or belongingness
- an outcome (the reinforcer)
  - bigger reward = better conditioning
  - contrast effects
- a relation between the response and outcome
  - contiguity
  - contingency

Contiguity

- delay of reinforcement
  - bridge the delay with a conditioned reinforcer
  - marking procedure

- studies of delay of reinforcement show that a perfect causal relation between the response and outcome is not sufficient to produce strong instrumental responding
  - even with a perfect causal relation, conditioning does not occur if reinforcement is delayed too long
  - led to the conclusion that response-reinforcer **contiguity**, rather than **contingency**, was the critical factor

Superstition



Animal Behavior Terminology

- **Appetitive Behavior – Occurs when reinforcement not available**
- **Consumatory Behavior – Occurs when reinforcement is about to appear**

Contingency

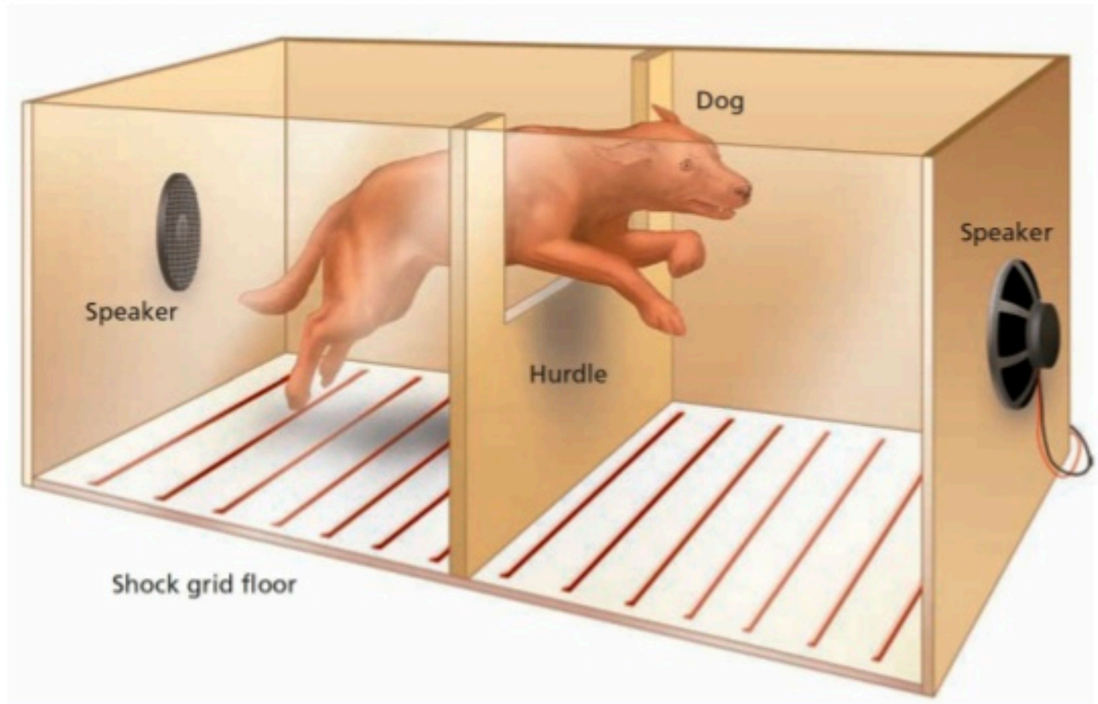
- effects of controllability of reinforcers
- a strong contingency between the response and a reinforcer means the response controls the reinforcer
- most of the research has focused on control over aversive stimulation
- contemporary research originated with studies by Seligman and colleagues
- they investigated the effects of uncontrollable shock on subsequent escape-avoidance learning in dogs
- the major finding was that exposure to uncontrollable shock disrupted subsequent learning
- this phenomenon called the <u>learned-helplessness effect</u>

Learned Helplessness

Group 1: control

Group 2: yoked

Figure 5.11 Seligman's Apparatus
In Seligman's studies of learned helplessness, dogs were placed in a two-sided box. Dogs that had no prior experience with being unable to escape a shock would quickly jump over the hurdle in the center of the box to land on the "safe" side. Dogs that had previously learned that escape was impossible would stay on the side of the box in which the shock occurred, not even trying to go over the hurdle.



PEARSON *Psychology*, Fourth Edition
Saundra K. Ciccarelli • J. Noland White

Overmier, J. B., & Seligman, M. E. P. Effects of inescapable shock upon subsequent escape and avoidance learning. Journal of Comparative and Physiological Psychology, 1967, 63, 28-33.

B. F. Skinner

Walden Two (1948): A behavioristic society

Program of behavioral control

A technology of behavior

Application of laboratory findings to society at large

B. F. Skinner

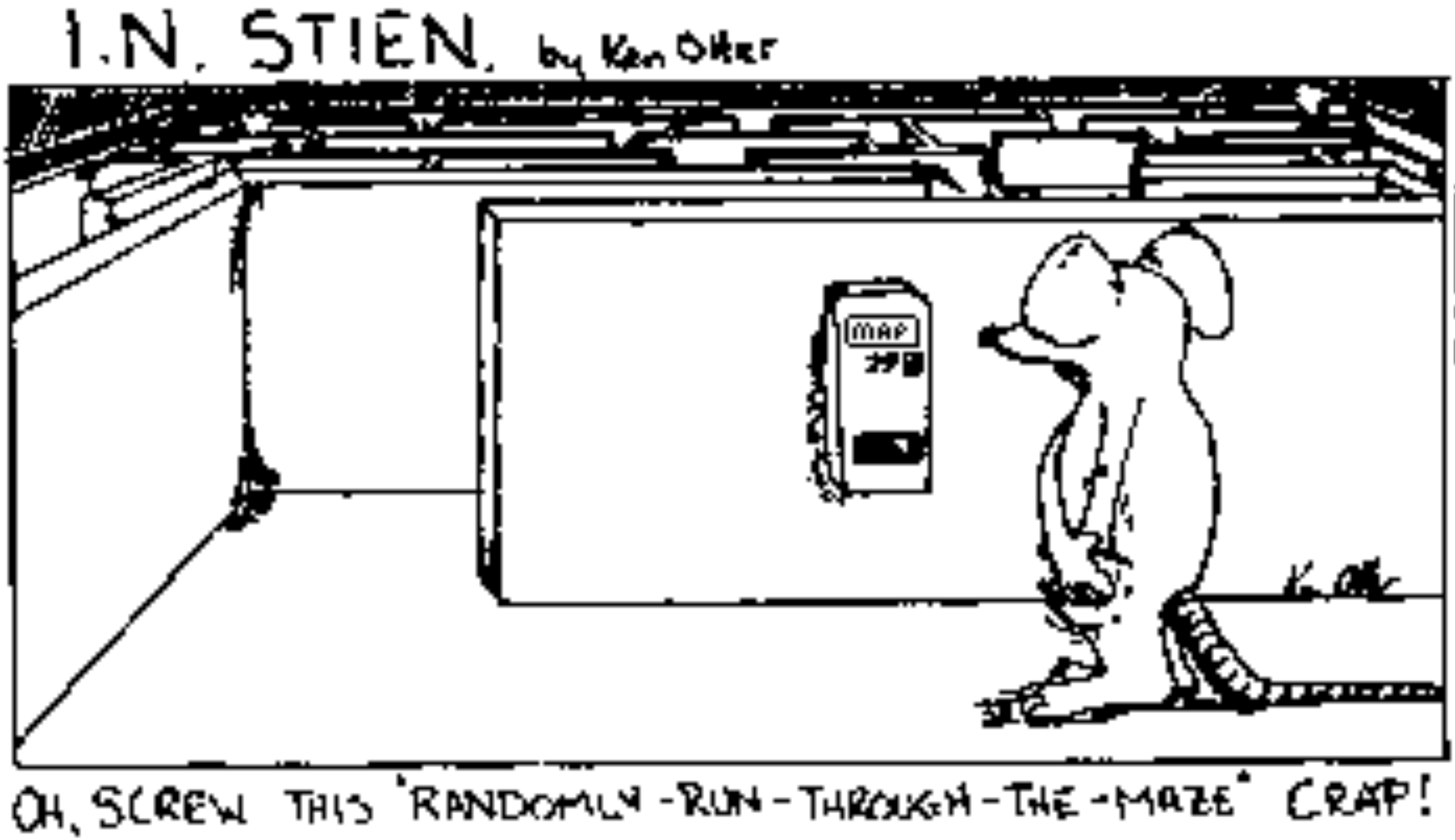
Criticisms of Skinner’s behaviorism

His extreme positivism
His opposition to theory
His willingness to extrapolate beyond the data
The narrow range of behavior studied
Problem of instinctive drift
His position on verbal behavior

B. F. Skinner

Contributions of Skinner’s behaviorism

Shaped American psychology for 30 years
His goal: the improvement of society
Strength and ramifications of his radical behaviorism

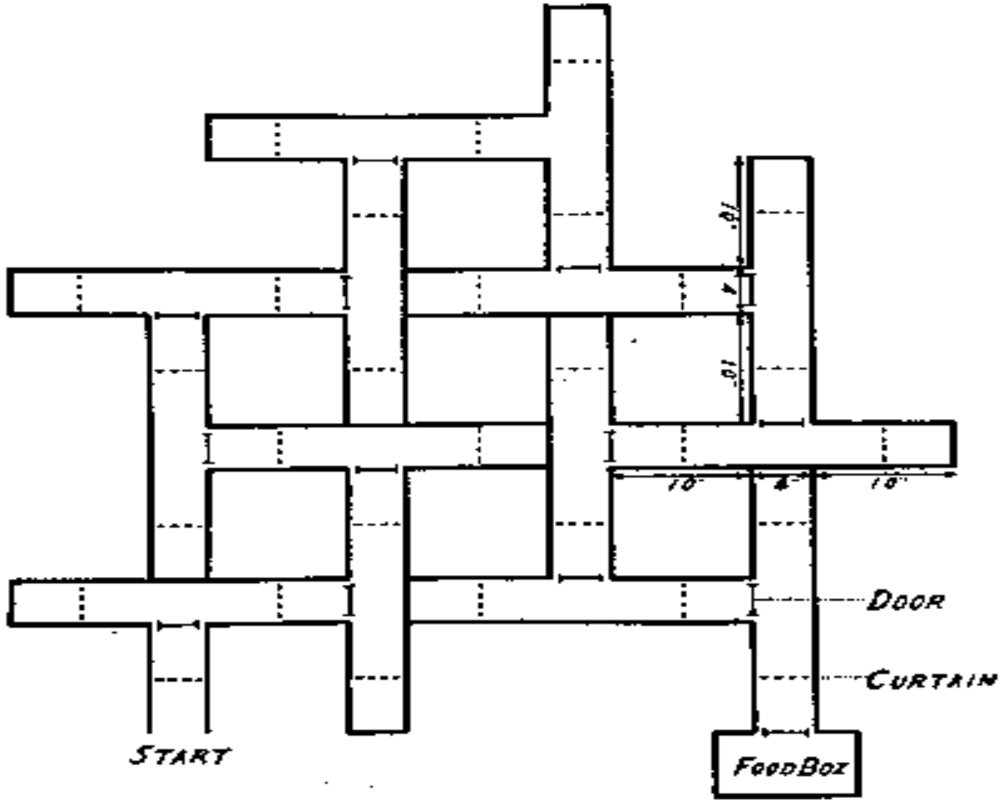

I.N. STIEN. by Ken Otter
MAP
K. Otter
OH, SCREW THIS 'RANDOMLY-RUN-THROUGH-THE-MAZE' CRAP!

An early challenge: Cognitive behaviorism

Edward Chase Tolman (1886-1959)

Testing the law of effect: the role of cognitive and motivational factors

Tolman 1928



Plan of maze
14-Unit T-Alley Maze

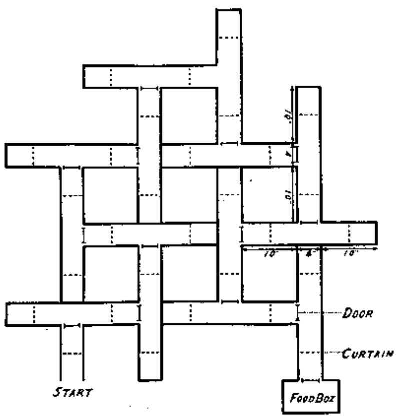
FIG. 1

(From M. H. Elliott, The effect of change of reward on the maze performance of rats. *Univ. Calif. Publ. Psychol.*, 1928, 4, p. 20.)

Elevated maze task

Dependent variable: number of errors in finding the food box

Testing the law of effect: the role of cognitive and motivational factors



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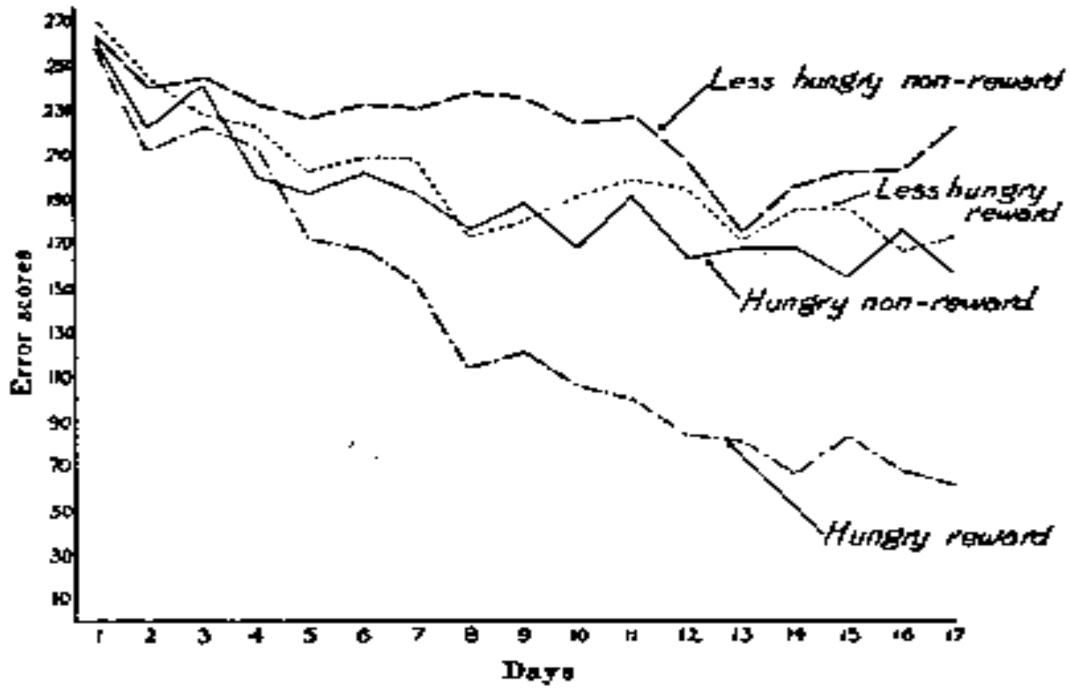


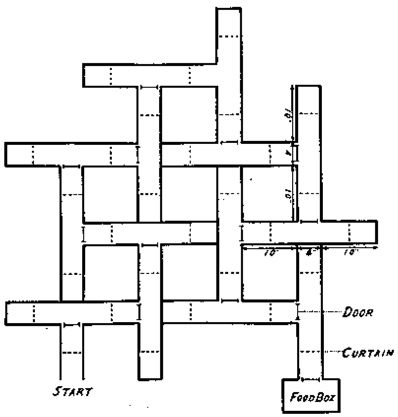
Error curves for four groups, 36 rats.

FIG. 3

(From E. C. Tolman and C. H. Honzik, Degrees of hunger, reward and non-reward, and maze learning in rats. *Univ. Calif. Publ. Psychol.*, 1930, 4, No. 16, p. 246. A maze identical with the alley maze shown in Fig. 1 was used.)

Learning performance is modulated by motivation (independent variable: hunger)

Testing the law of effect: the role of cognitive and motivational factors



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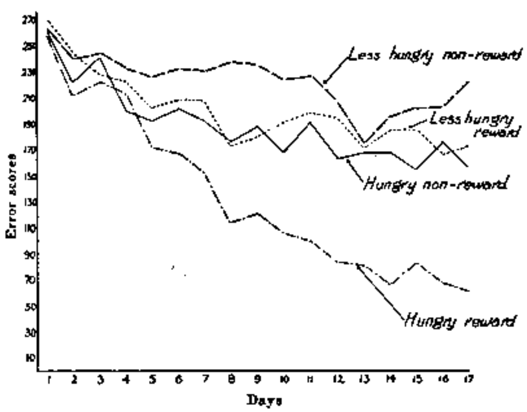

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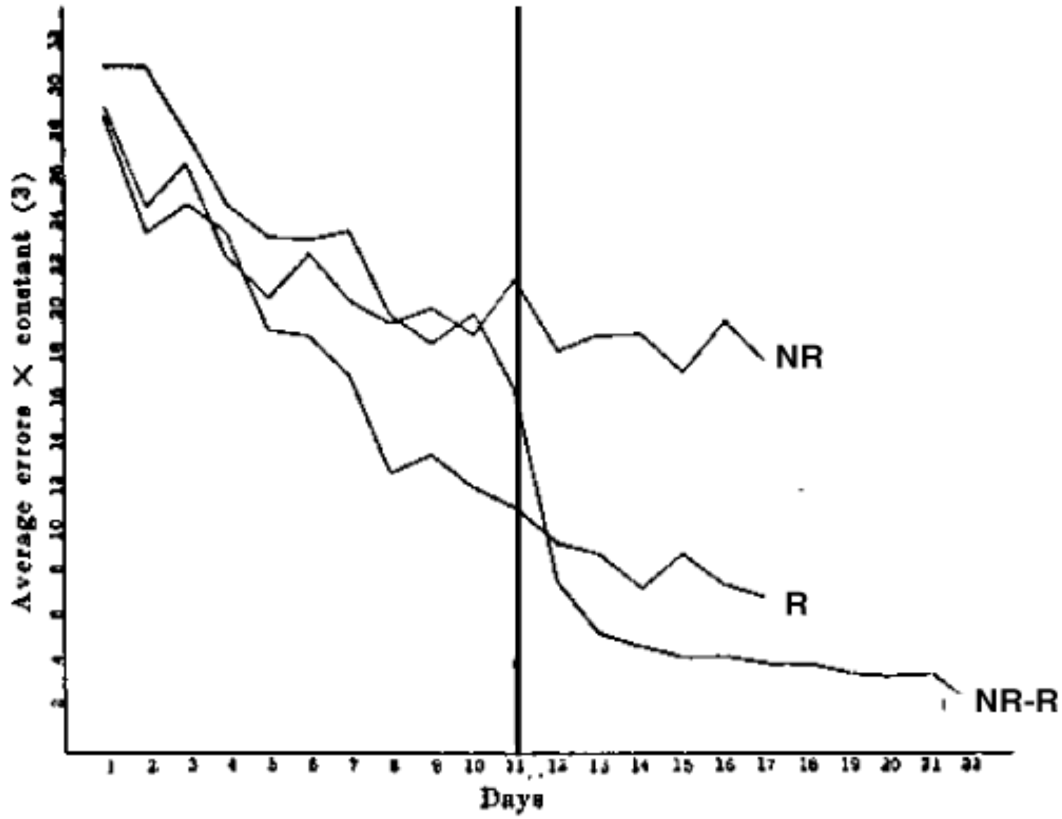
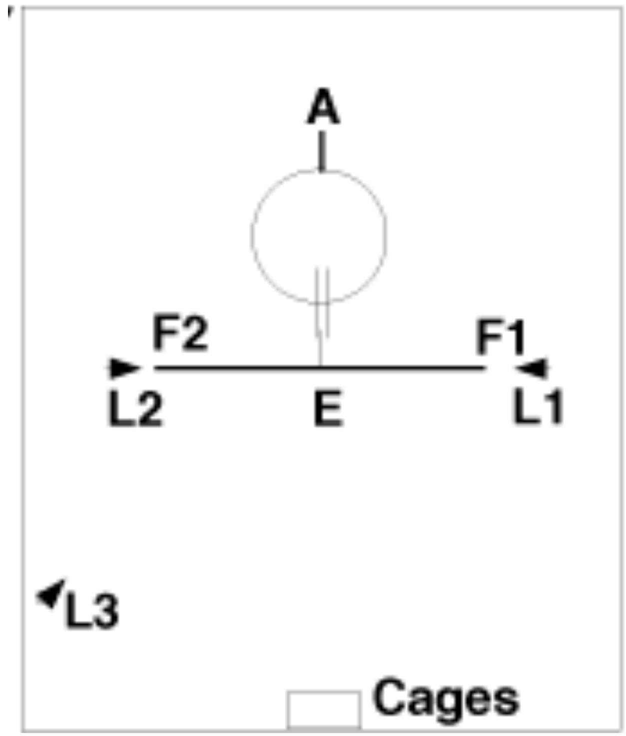


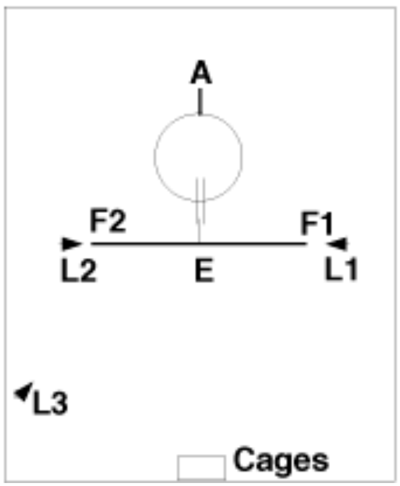
Learning does not fully depend on external reinforcement “cognitive maps” can be acquired through “latent learning”
>> law of effect is not universal

Cognitive maps are local or global?

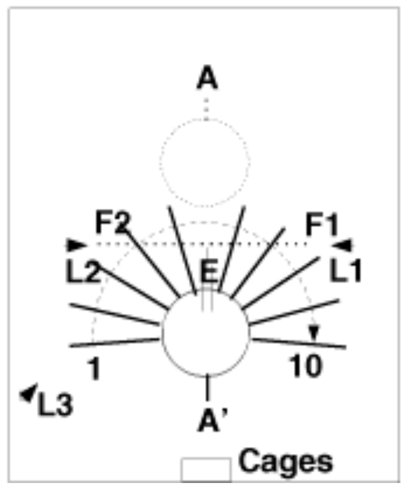


Training

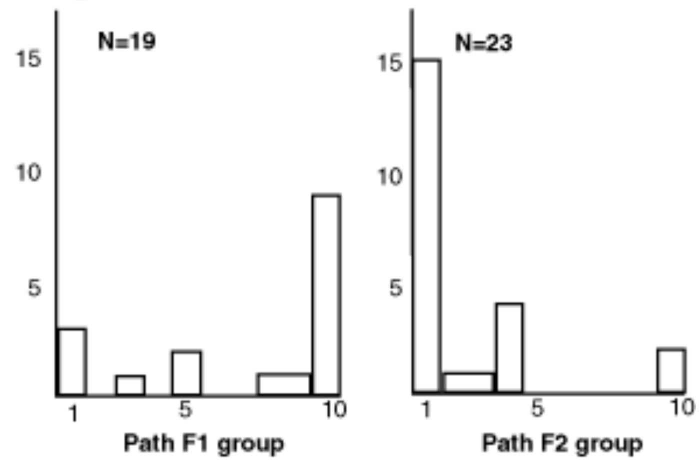
Cognitive maps and navigation



Training



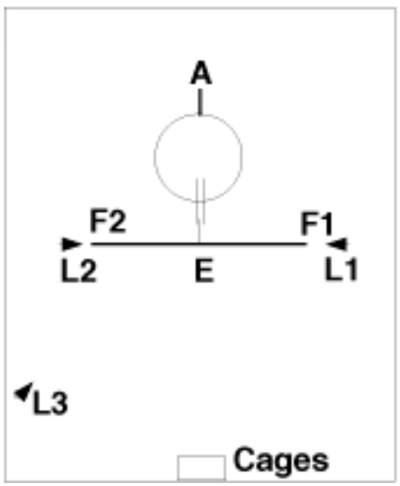
Test



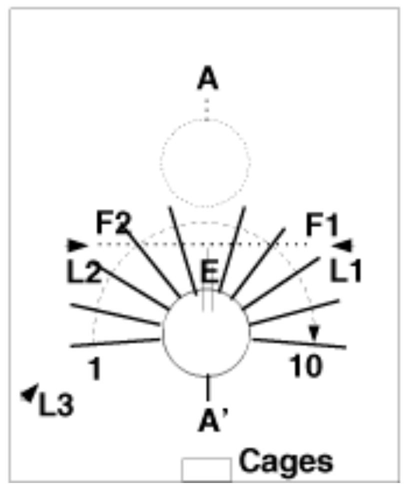
Performance

Acquired knowledge is organized in maps that include global information of the task

Cognitive maps and navigation



Training



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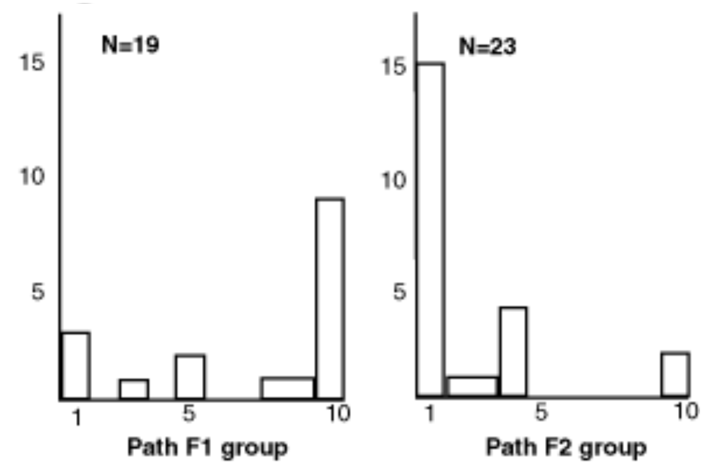


Performance

Acquired knowledge is organized in maps that include global information of the task

Clark Leonard Hull (1884-1952)

the logico-deductive method applied to behavior

behavior provides survival value

behavior is purposive: In this view animals strive for goals, or values, that reduce needs resulting from situations where the system's survival is threatened (Hull 1937)

Drive reduction provides a foundation for value theory and moral judgement

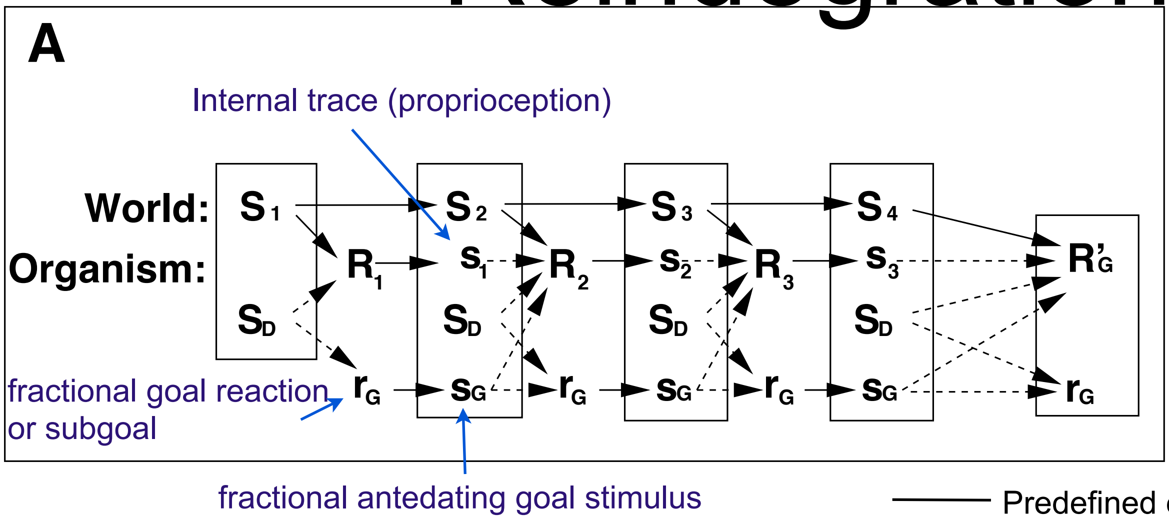
Value is In this view value can be brought back to the potentiality of action or the, so called, reaction potential S ER one of the key intervening variables in his framework.

The framework developed by Hull is one of the most elaborate psychological theories ever proposed, considered second to Freud in the period 1880-1959, that at the time had a strong impact on the field

Hull's theoretical program

Hull, 1934

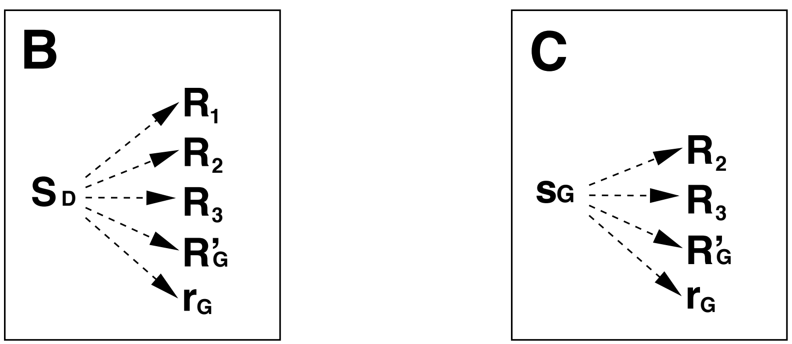
The behavior chain and Reindegration



S1...S3 gives rise to R1...R3

How can this sequence be learned?

Predefined excitatory relation
Acquired excitatory relation
Reindegrative stimulus complex/behavioral segment



Reindegration: a chain of causal events is transformed into a chain of excitatory tendencies

The excitatory tendencies of the drive stimulus s_D and the "antedating goal stimulus s_G

Reindegration and the stimulus complex

- Sequence can be replayed in the absence of external stimuli through internal substitute stimuli
- Optimizing sequences or “short circuiting” is achieved through assuming a goal gradient.
- Behavior sequences are organizaed in *habit families*
- Purposive behavior results from the assumption of the drive stimulus
  - 4Fs: Fight, Flight, Feed & Reproduce

8 major automatic adaptive behavior mechanisms

First, the inborn response tendencies, $_sU_R$, that allow the body to deal with “emergencies”.

Second, in order to deal with the “infinity of complex situations” in which an organism will find itself, evolution has developed basic mechanisms for learning such as the conditioned reflex; “to profit by past experience”.

Third, the previous mechanism combined with stimulus generalization provides the antedating defense reaction.

Fourth, reactive inhibition, I_R, due to work, W , allows the selection of appropriate actions out of the inborn $_sU_R$ hierarchy by reducing the habit strength of irrelevant ones, $_sH_R$, or negative response learning.

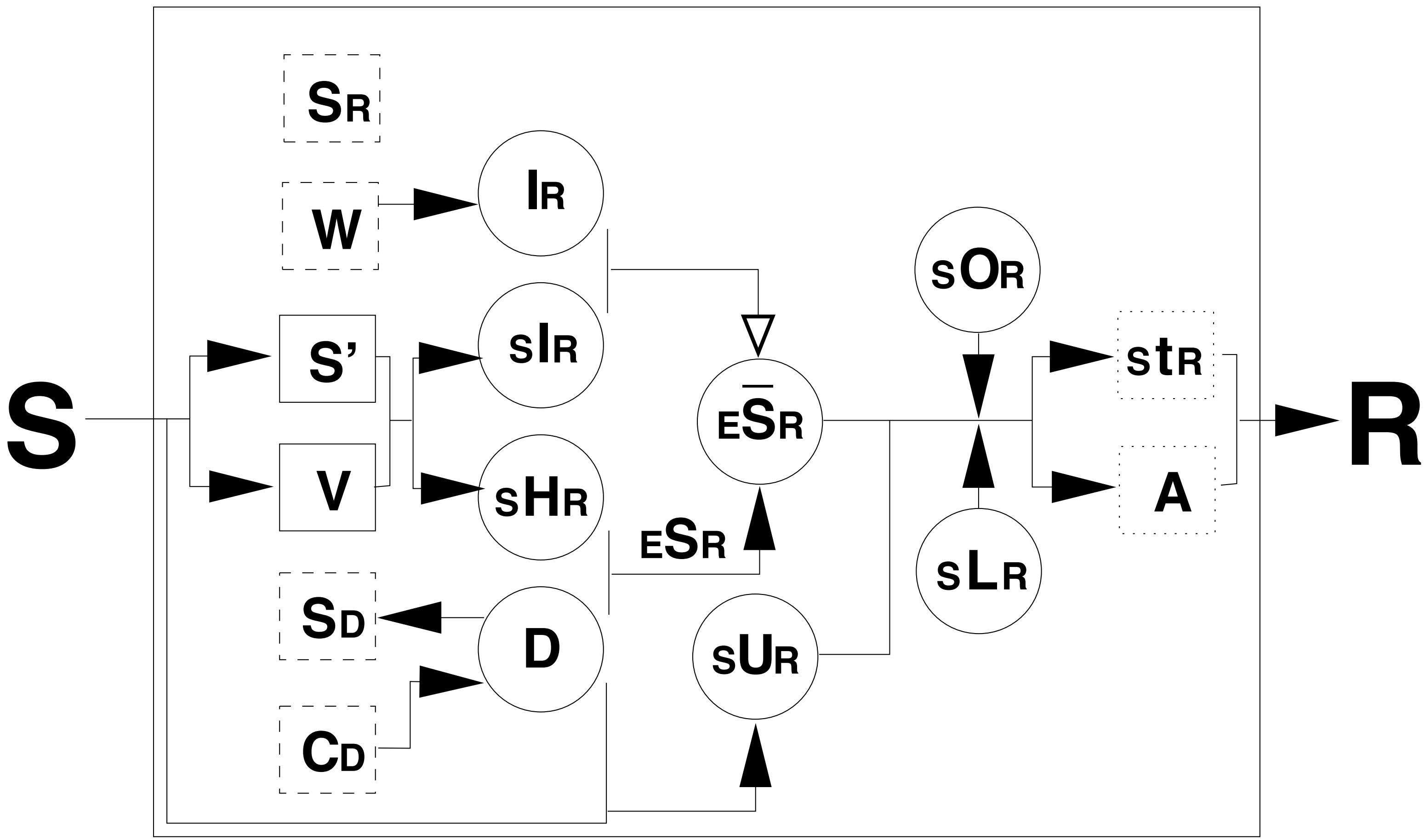
Fifth, response generation required for trial-and-error learning resulting from spontaneous behavioral oscillations $_sO_R$ that allows different responses from $_sU_R$ to be expressed resulting the selection of adaptive responses on the basis of trial learning.

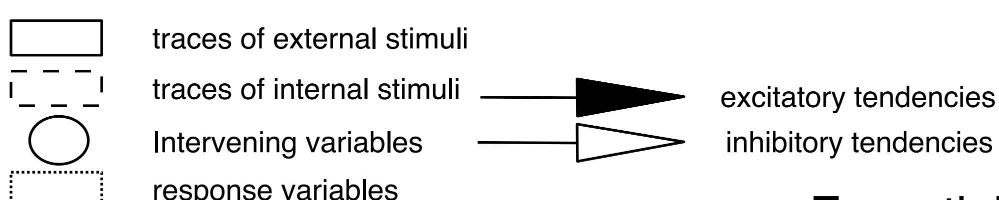
Sixth, positive-negative trial learning or discrimination learning allows the specific coupling of elements of a stimulus continuum to a response and the suppression of the coupling of other non-adaptive elements.

Seventh, due to property of the stimulus trace to gradually decrease with time, a stimulus continuum is defined that allows generalization in time, in particular from the low subsident part of the trace towards the higher antecedent part. The acquired response will antedate the stimulus conditions under which it was defined and result in an antedating reaction.

Eight, the fractional antedating goal reaction, r_G, provides for the pure stimulus act. Together with its proprioceptive stimulus trace, s_G, it antedates all goals of the organism. s_G provides the stimuli that will lead to the realization of particular goals. The r_g -> g coupling provides the mechanism underlying all “psychic” phenomena such as planning, interest, expectancy and purpose.

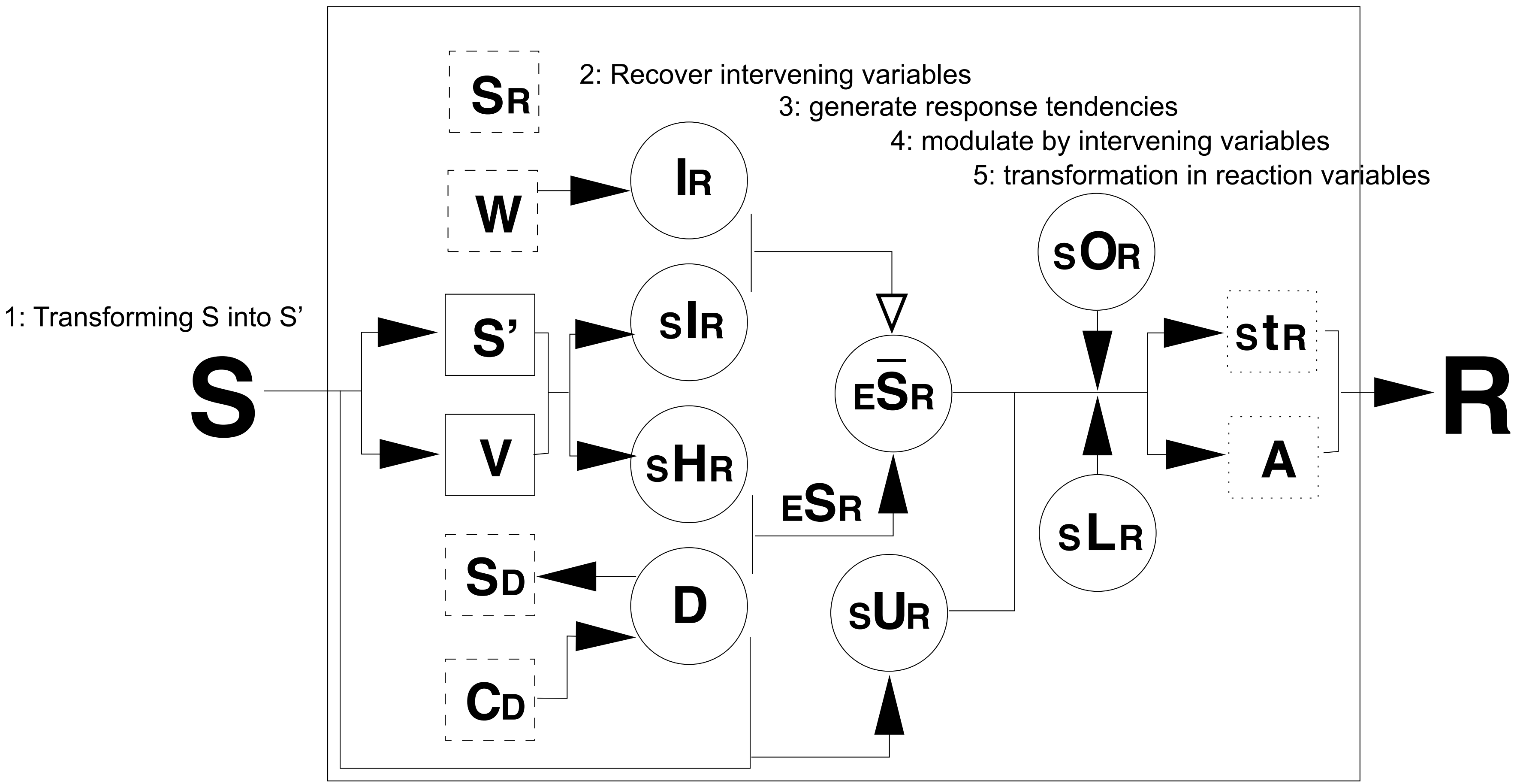
Transforming a stimulus into a response





Essentials of Behavior (Hull 1943)

Transforming a stimulus into a response



traces of external stimuli

traces of internal stimuli

Intervening variables

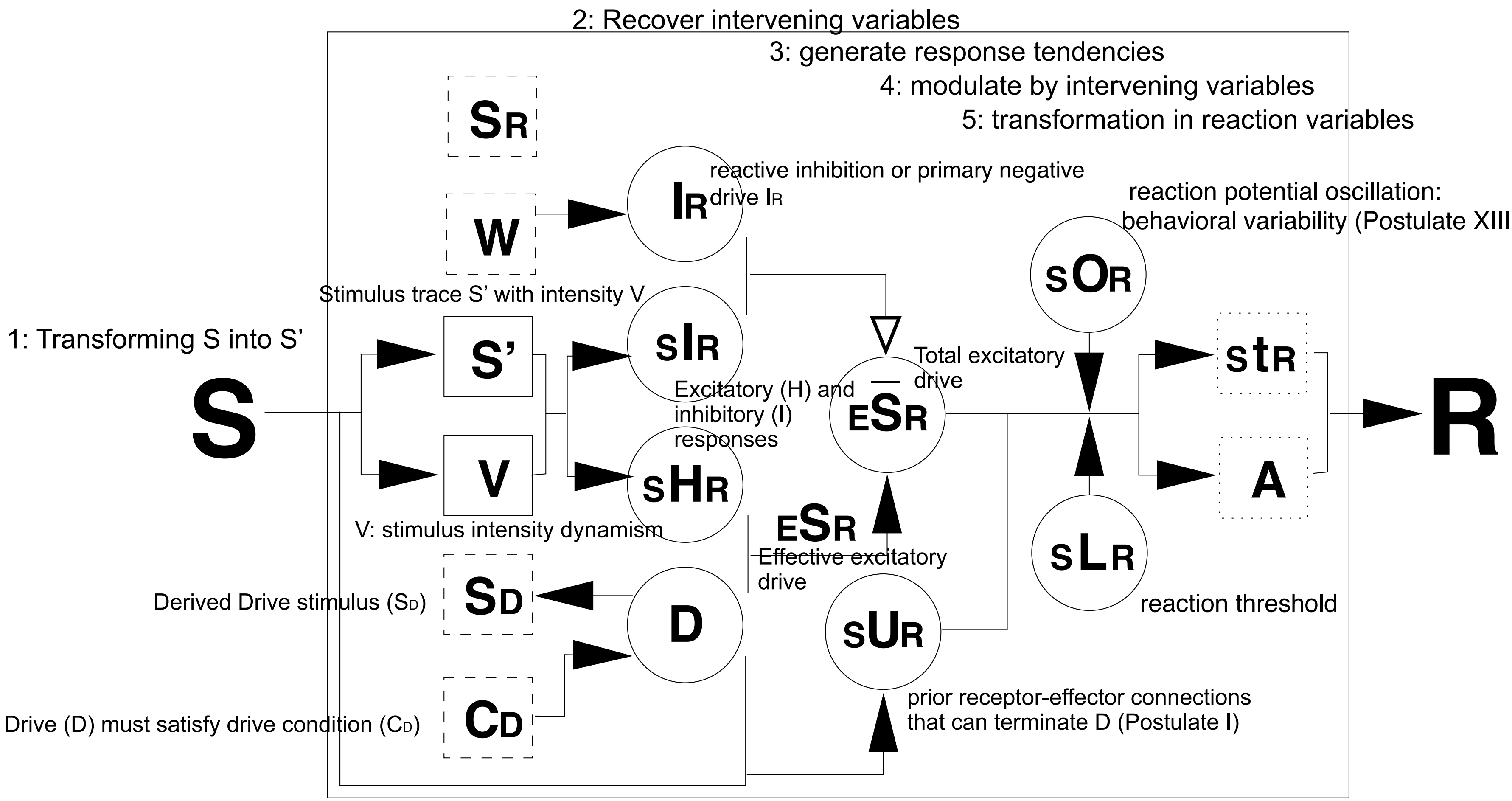
response variables

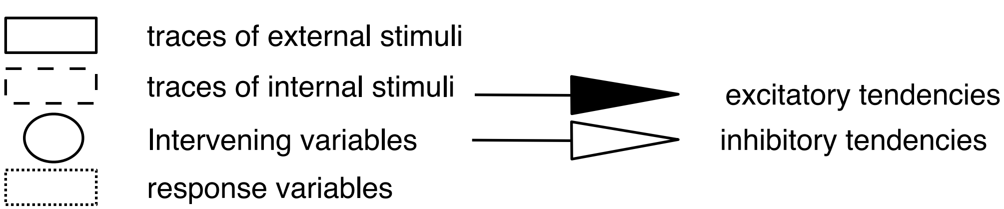
excitatory tendencies

inhibitory tendencies

Essentials of Behavior (Hull 1943)

Transforming a stimulus into a response





$_sE_R = ({_sH_R} \times D \times K \times V) - ({_sI_R} + I_R)$

$_sH_R = 1 - 10^{-.0305N}$ N = N trials

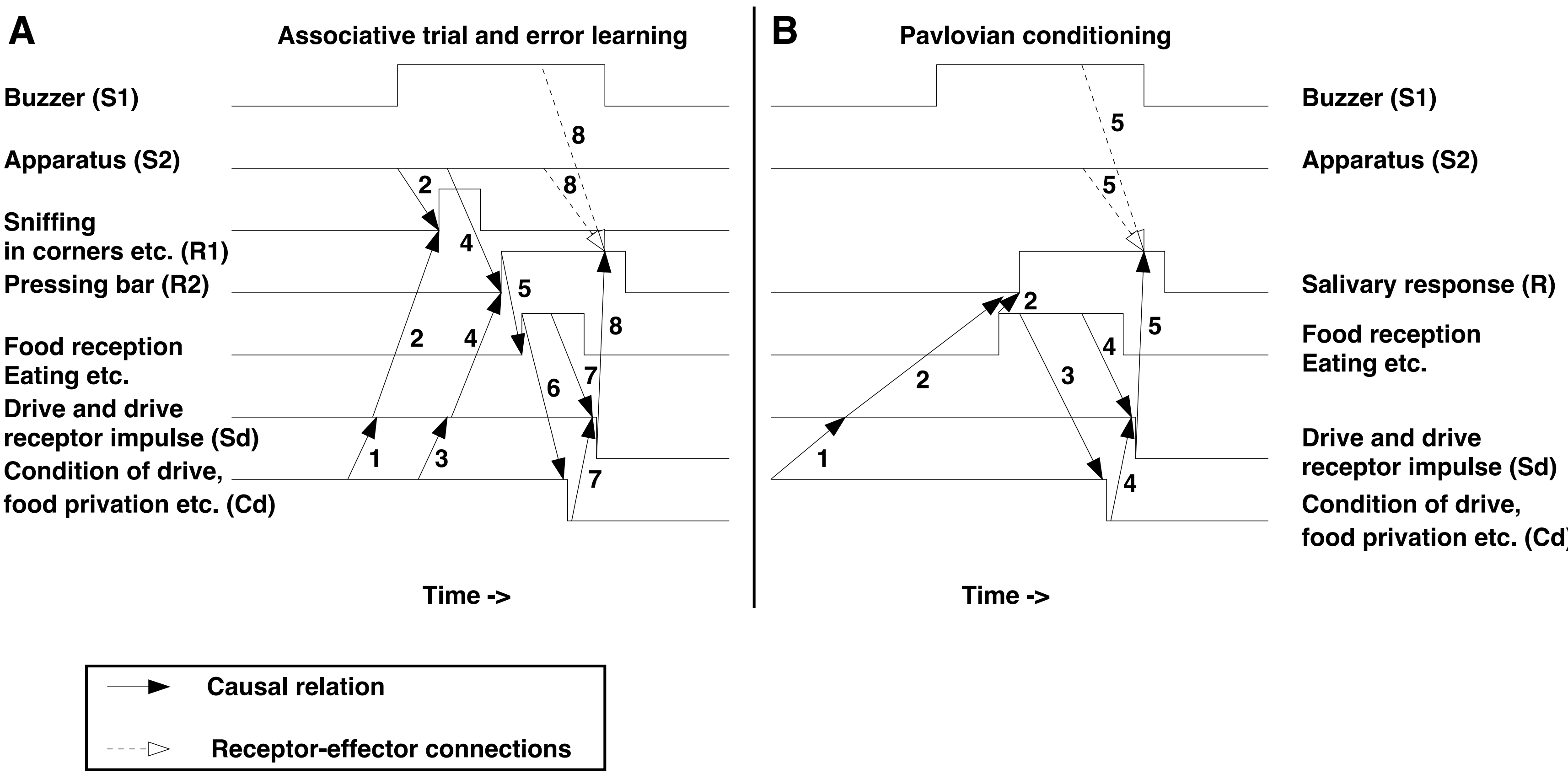
The law of habit formation

$\Delta {_sE_R} = M_E - {_sE_R} - (M_E - {_sE_R})10^{-i}$

M = Maximum reaction potential
i = animal dependent learning rate

Essentials of Behavior (Hull 1943)

A general framework



problems with Hull's proposal

- psychology as a natural science
- obscure framework
- it will need "50 years" to be fully defined
- exceptions for instance in eye blink conditioning

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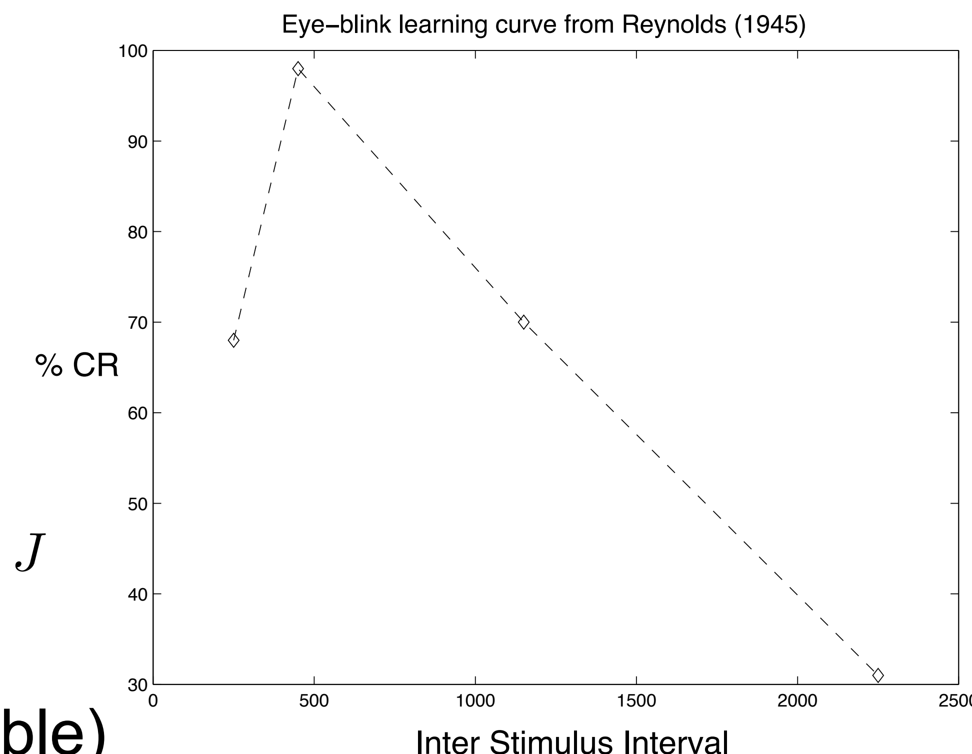
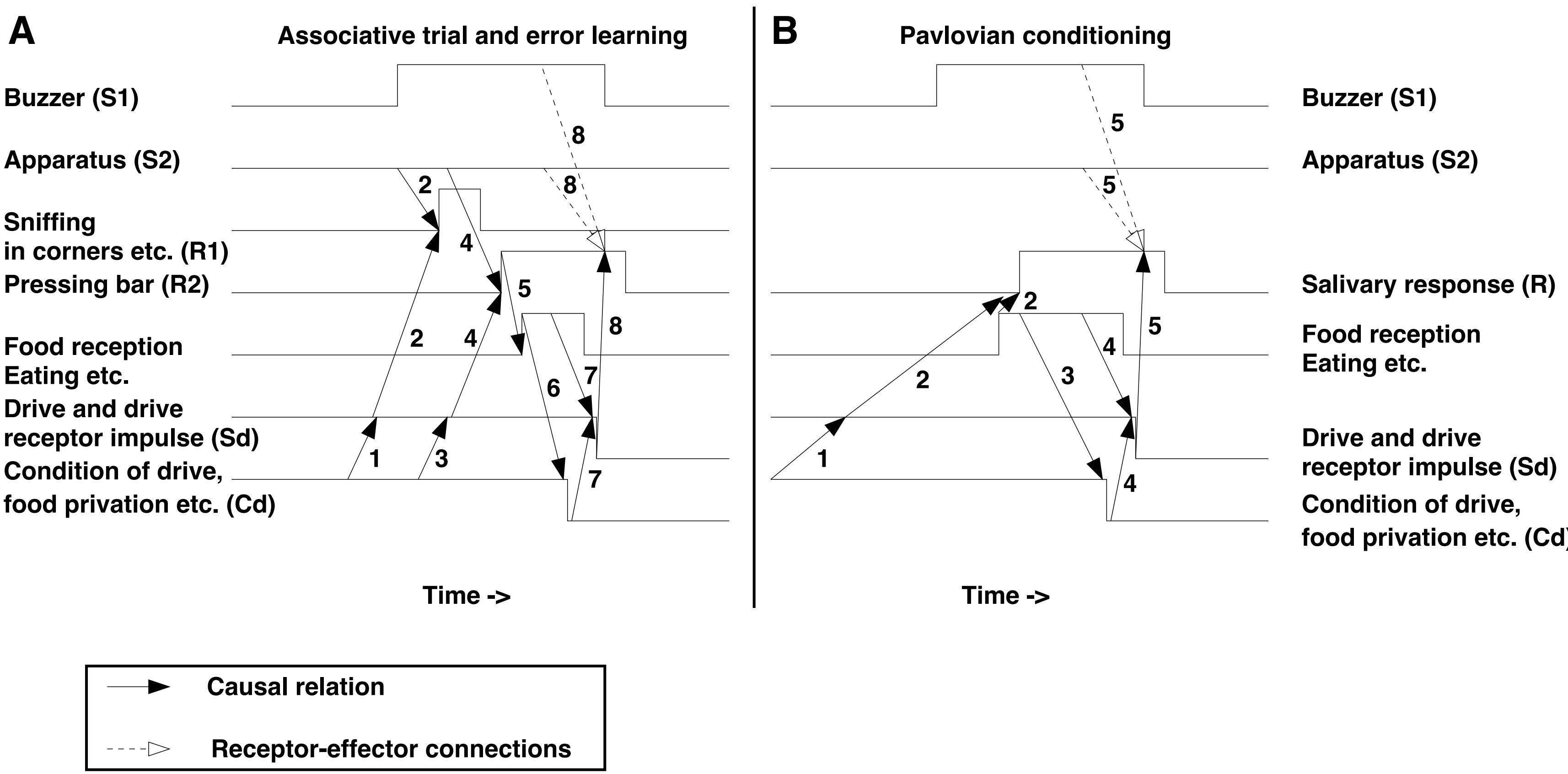


$$_SE_R =_S H_R \times D \times V \times K \times J$$

J is defined as 10^{-jt}

j = 0.163 (empirical variable)

A general framework



BUT

- the animal as active goal oriented learner synthetic perceptive, emotive and cognitive systems

Cognitive Science & Psychology: Mind, Brain and Behavior

Lecture 8 (1950-1960) The Demise of Behaviorism

Paul Verschure
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specs.upf.edu

Outline

Lecture 1 Introduction - robot future
Lecture 2 The Mind, Brain, behaviour Cycle
Lecture 3 The Knowledge Problem in the Science of Mind and Brain
Lecture 4 The Five Revolutions defining Current Reality
Lecture 5 Conceptual Revolutions in Philosophy of Mind
Lecture 6 (1850-1915) Structuralism and Functionalism
Lecture 7 (1915-1950) Behaviorism, Cognitive Behaviorism

Lecture 8 (1950-1960) The Demise of Behaviorism
Lecture 9 (1945-1960) Cybernetics and the Cognitive Revolution
Lecture 10 (1960-Now) Mind as Computation
Lecture 11 (1985-Now) Biology as a Metaphor and Beyond
Lecture 12 (Now-Future) Flux and Synthesis

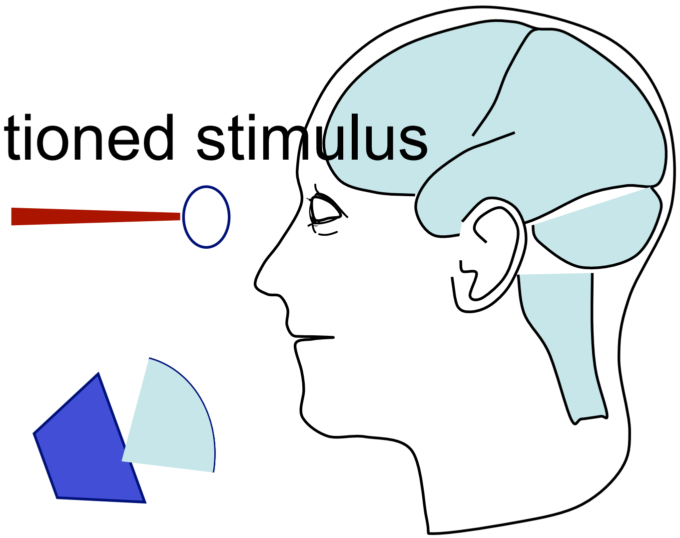
Classical conditioning: Motor response

Fig. 9-3 A subject wearing the headgear for recording eyelid movement.

Gormezano, I. (1966). Classical Conditioning. In J. B. Sidowski (Ed.), *Experimental methods and instrumentation in psychology* (pp. 385-420). New York, NY: McGraw-Hill.

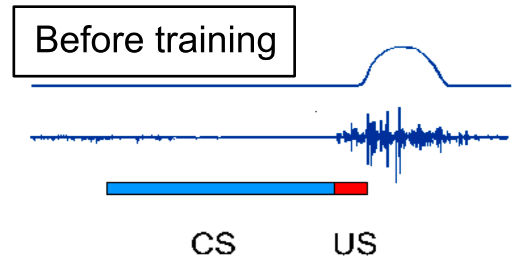
Classical conditioning: experimental paradigm

Unconditioned stimulus



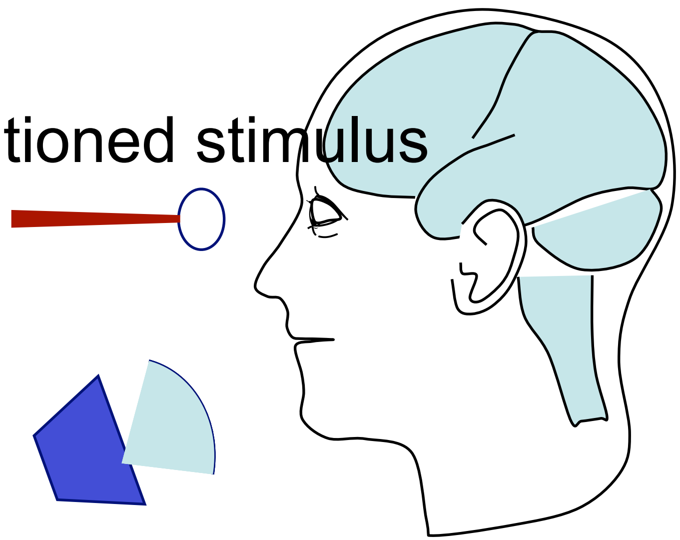
Conditioned stimulus

Unconditioned/
conditioned response



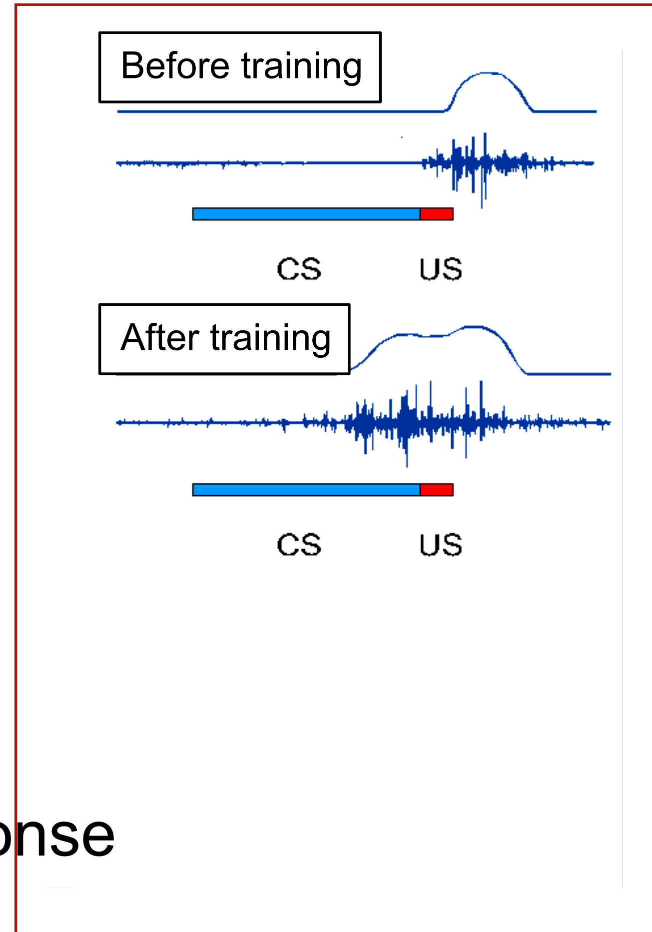
Classical conditioning: experimental paradigm

Unconditioned stimulus



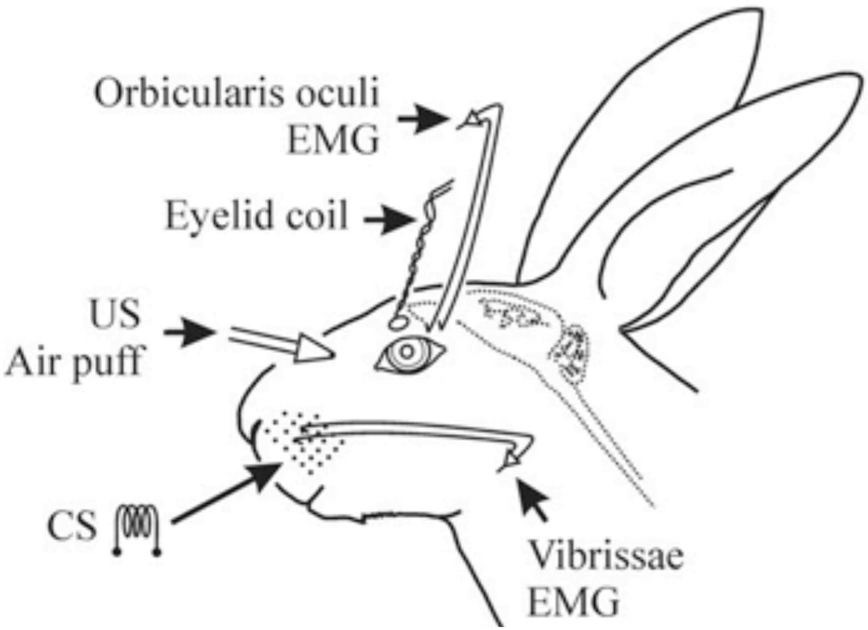
Conditioned stimulus

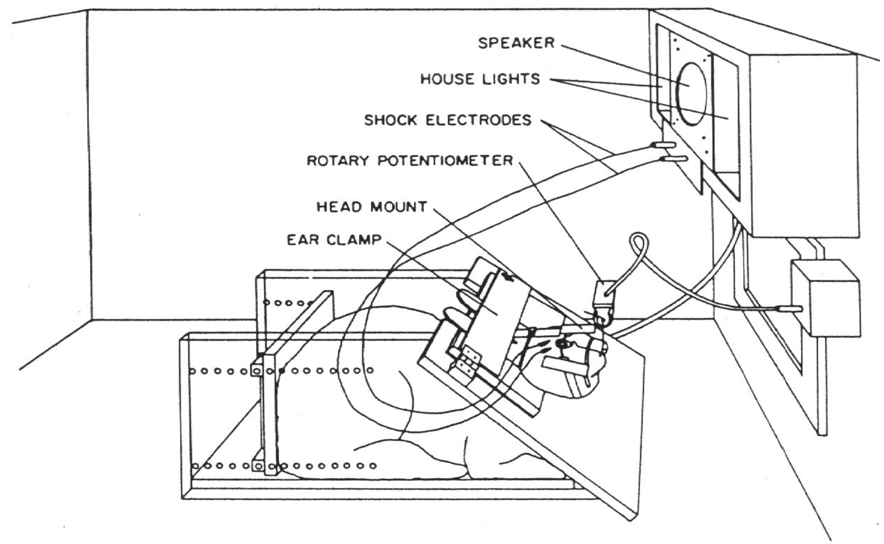
Unconditioned/
conditioned response



CS “substitutes” US

Eyeblink Conditioning

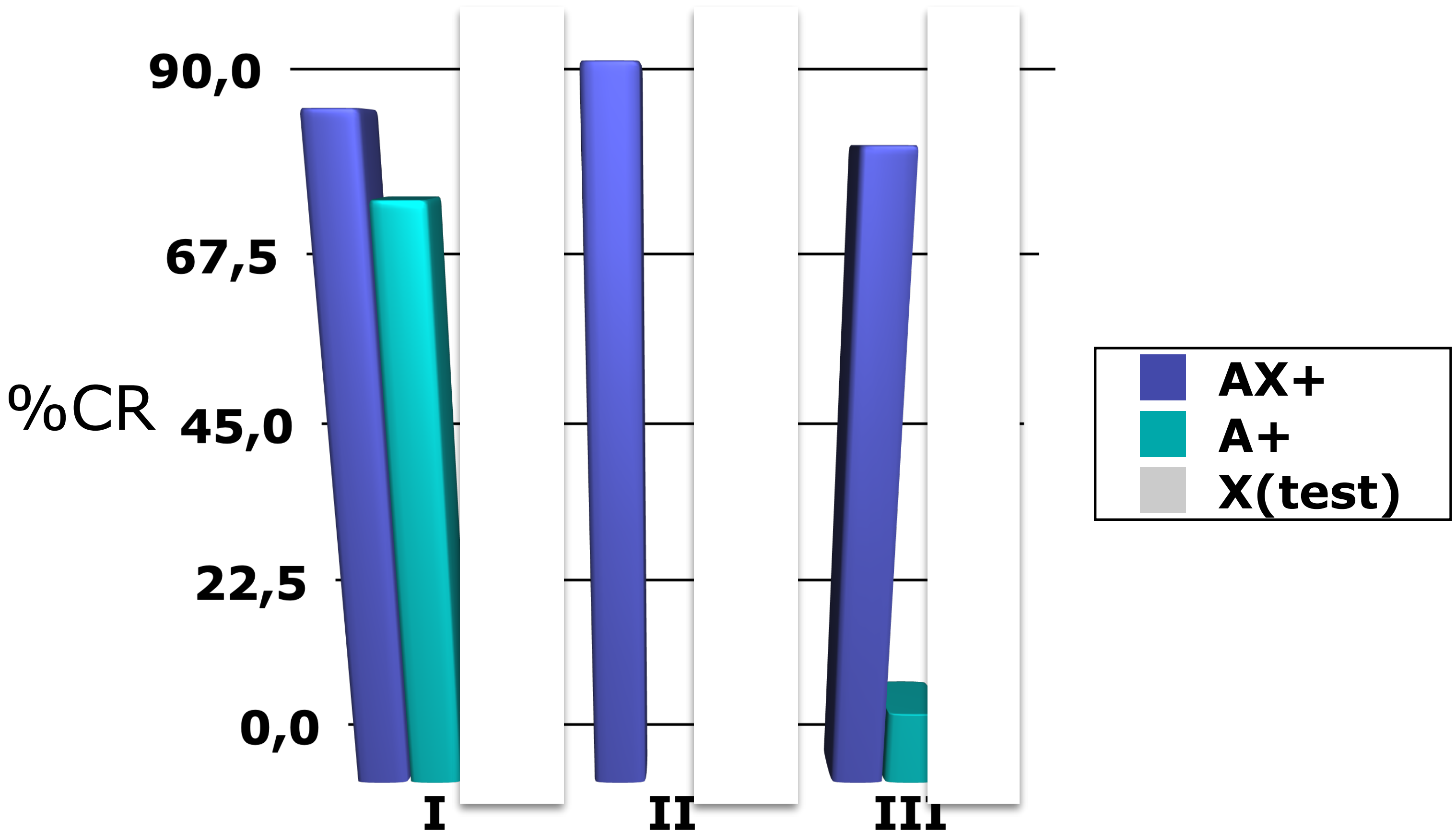




Leal-Campanario et al. (2006) PNAS

Nictitating membrane conditioning (Gormezano)

More problems: blocking in eyeblink conditioning



3 groups of 20 rabits. US 100 msec 4.5 mA shock. CS A: flashing light, CS X: tone. AX+, 1000 trials. A+ 200 trials. X 16 trials

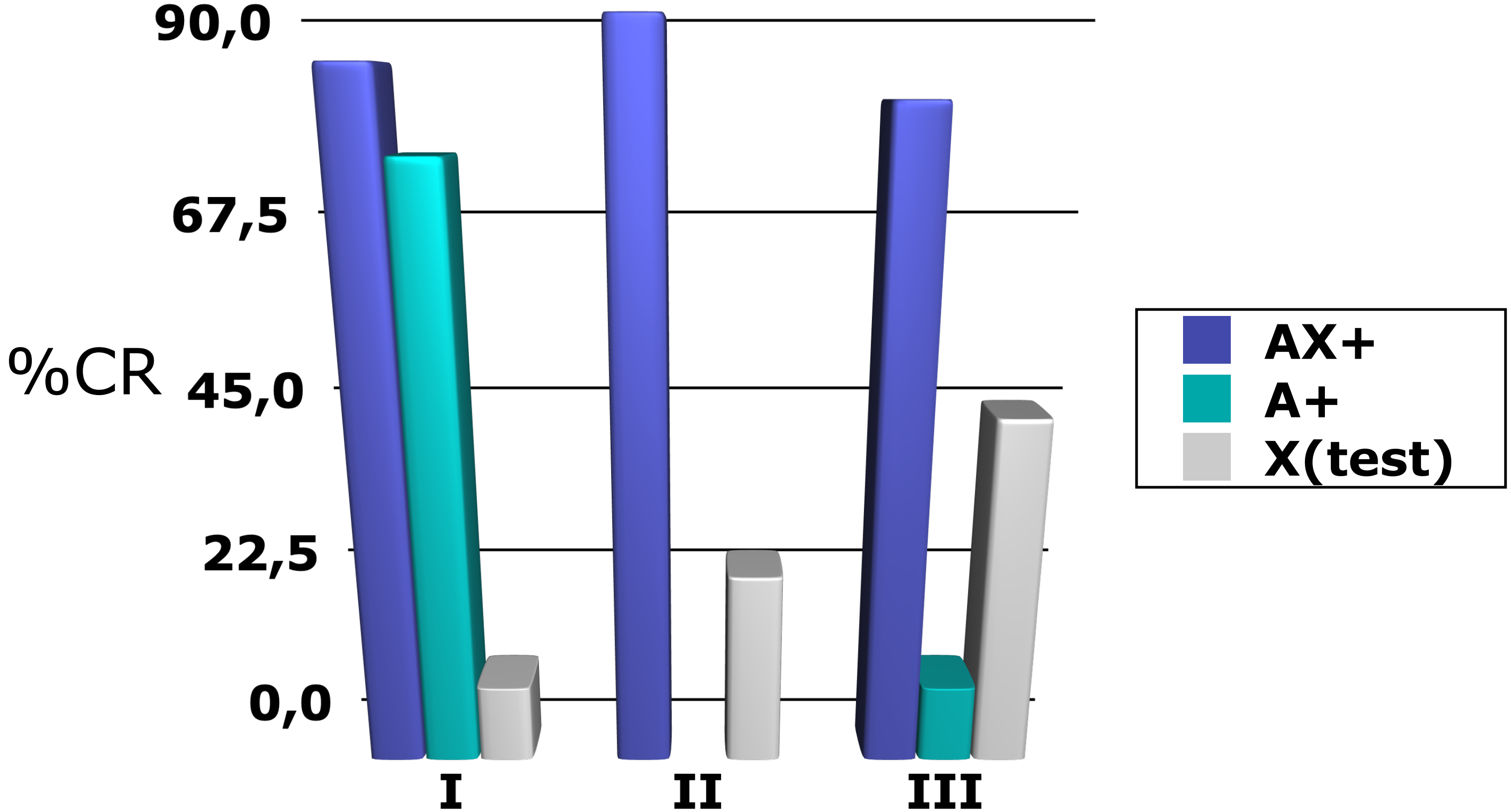
I: training AX+ (200 trials), **A+** (200 trials, interspersed)

II: training AX+ (200 trials), Control condition

III: training AX+ (200 trials), **A-** (200 trials, interspersed)

Wagner & Saaverda, 1969

More problems: blocking in eyeblink conditioning



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II: training AX+ (200 trials), Control condition

III: training AX+ (200 trials), **A-** (200 trials, interspersed)

Wagner & Saaverda, 1969

Kamin's blocking

Training	test:		
CS_A + US	$CS_A \longrightarrow$	CR	
CS_B + US	$CS_B \longrightarrow$	CR	
CS_A + US	$CS_A \longrightarrow$	CR	
$CS_A + CS_B$ + US	$\not\longrightarrow$	CS_B	CR

Learning to CS_A "blocks" learning to CS_B

Overexpectation

Training test:

CS_A + US $CS_A \longrightarrow$ CR

CS_B + US $CS_B \longrightarrow$ CR

Initially:

$CS_A + CS_B$ + US $CS_A + CS_B \longrightarrow$ CR

After additional presentations:

$CS_A + CS_B$ + US $CS_A + CS_B \not\longrightarrow$ CR

Two effective CSs presented together causes extinction

The behavioral law of associative competition:

- Rescorla & Wagner (1972)

$V_{ab} = V_a + V_b$

$\Delta V_i = \alpha_{cs}\, \gamma_{us}\, (\lambda - \Sigma_j\, V_j)$

Animals only learn when events violate their **expectations**