

# 3 Lerntheorien

3.1 Lernen



3.2 Behaviorismus

3.3 Kognitivismus

3.4 Konstruktivismus

3.5 Lernen als sozialer Prozess

Literatur:

A. Holzinger: Basiswissen Multimedia Band 2, p. 106-170

B.R. Hergenhahn, M. H. Olson: An Introduction to Theories of Learning, 6th edition, Prentice-Hall 2001

# Was ist Lernen?

- Holzinger:
  - „Lernen ist ein **Prozess**. Mit „Lernen“ bezeichnen wir jede Veränderung unseres Verhaltens (behavior) oder unseres Wissens (knowledge) – unabhängig davon, ob es beabsichtigt oder unbeabsichtigt (inzidentuell) erfolgt.“
  - Wie erkennen wir Veränderung des Wissens? Durch Verhalten?
- G. A. Kimble (1961):
  - „Learning is a relatively permanent change in behavioral potentiality that occurs as a result of reinforced practice.“
  - Must learning always result in a behavioral change? How do we recognize a change in „potential behavior“?
  - How permanent is „relatively permanent“? („neither transitory nor persistent“)  
Is there learning in short-term memory?
  - Incidental learning through experience?
    - » Sensitization, habituation?

# Imprinting

- Konrad Lorenz (1952):
  - Gänseküken gehen eine Bindung zu dem ersten bewegten Objekt ein, das sie in ihrem Leben sehen
  - Spezies-typische Verhaltensänderung (Instinkt)
- Ist das „Lernen“?
  - Oder „unlearned behavior“?
  - nicht durch „reinforced practice“
  - aber durch Erfahrung/ experience
- Mischformen
  - Learned/unlearned
  - Z.B. Fliegen lernen bei Vögeln



# Definition of „Learning“

Hergenhahn/Olson p. 7:

„Learning is a relatively permanent change in behavior or behavioral potentiality that results from experience and cannot be attributed to temporary body states such as those induced by illness, fatigue, or drugs.“

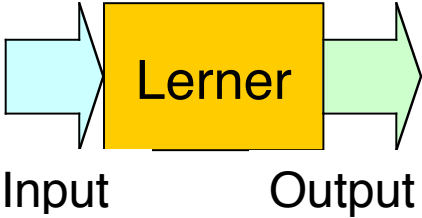
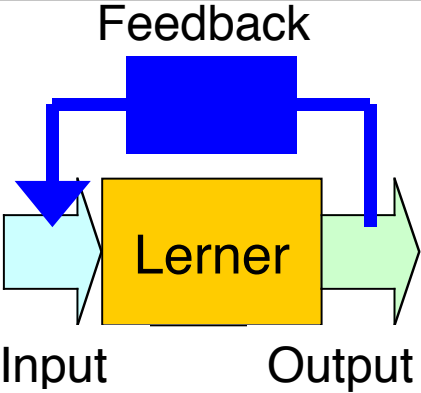
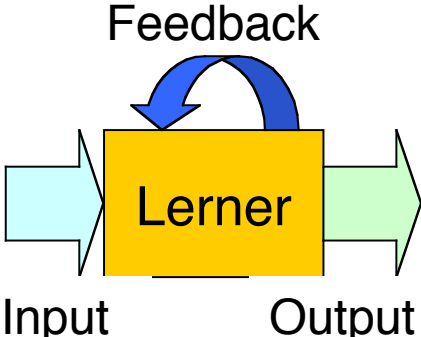
# Computergestütztes Lernen und Lerntheorien

- Computer können das „Lernen“ grundsätzlich **nicht** verbessern.
  - Lernen ist eine Leistung des Individuums.
- Chancen von multimedialem computergestütztem Lernen:
  - Didaktische Aufbereitung
  - Verbesserung von Motivation, Aufmerksamkeit und Aktivierung (*arousal*)
  - Computer ist ein geduldiger „Lernpartner“
- Begleitung durch menschlichen Lehrer fehlt
  - Intuitive Steuerung der Materialauswahl, Lehrmethode, Trainingsstärke etc.
- Lernsoftware
  - Soll sich optimal an Lernprozess anpassen
  - **Jede Lernsoftware basiert auf einer Lerntheorie.**

# Experimentelle Wissenschaft Psychologie

- Lerntheorien sind Modelle zur Erklärung von Experimenten
- Experiment:
  - Basiert auf *operationaler Definition* (messbarer Definition) der Begriffe der Theorie
  - Rahmenbedingungen: Labor, natürliche Beobachtung?
  - Idiographischer oder nomothetischer Ansatz?
    - » Ein einmaliges Subjekt unter vielen Bedingungen; oder:
    - » Viele Subjekte und deren Durchschnittsverhalten (allgemeingültig?)
  - Menschliche oder tierische Subjekte?
  - Abhängige und unabhängige Variablen?
    - » Beispiele unabhängiger (bei Experimentdefinition bestimmbarer) Variablen: Alter und Geschlecht der Subjekte, Art und Qualität von präsentem Material, ...
    - » Beispiele abhängiger Variablen: Punktzahlen, Fehlerzahlen, Antwortrate, Häufigkeit von Antworten, Stärke von Reaktionen, ...

# Lerntheorien: Überblick

	<b>Behaviorismus</b>	<b>Kognitivismus</b>	<b>Konstruktivismu</b>
Ca. entstanden	1913	1920	1945
Lern-Paradigma	Reiz–Reaktion	Problemlösen	Konstruieren
Beurteilung nach	Leistung (Faktenwissen)	Wissen (Konzeptwissen)	Kompetenz (Gesamtproblem)
Signalfluss-Modell			
Softwaretypus	Computer-Aided Instruction (CAI)	Computer/Web-Based Training (CBT/WBT)	Simulation Mikrowelt

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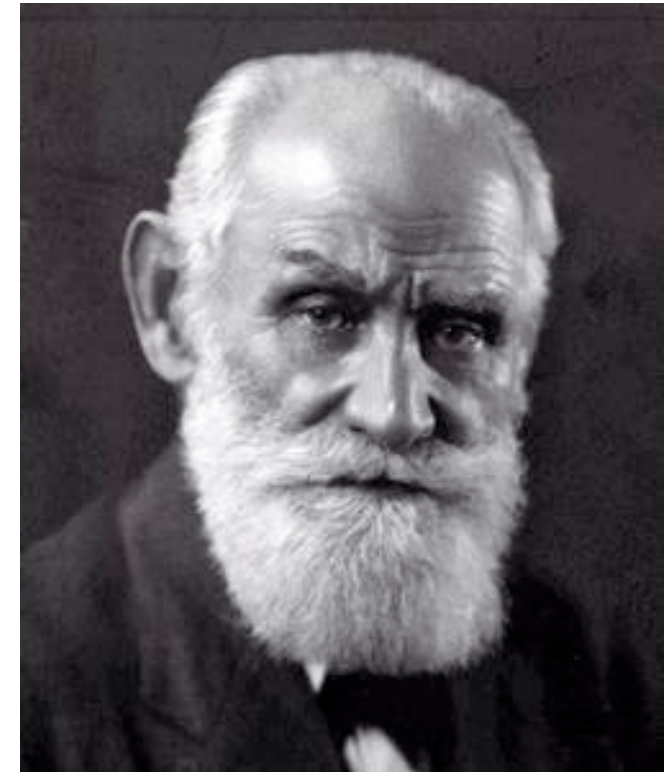
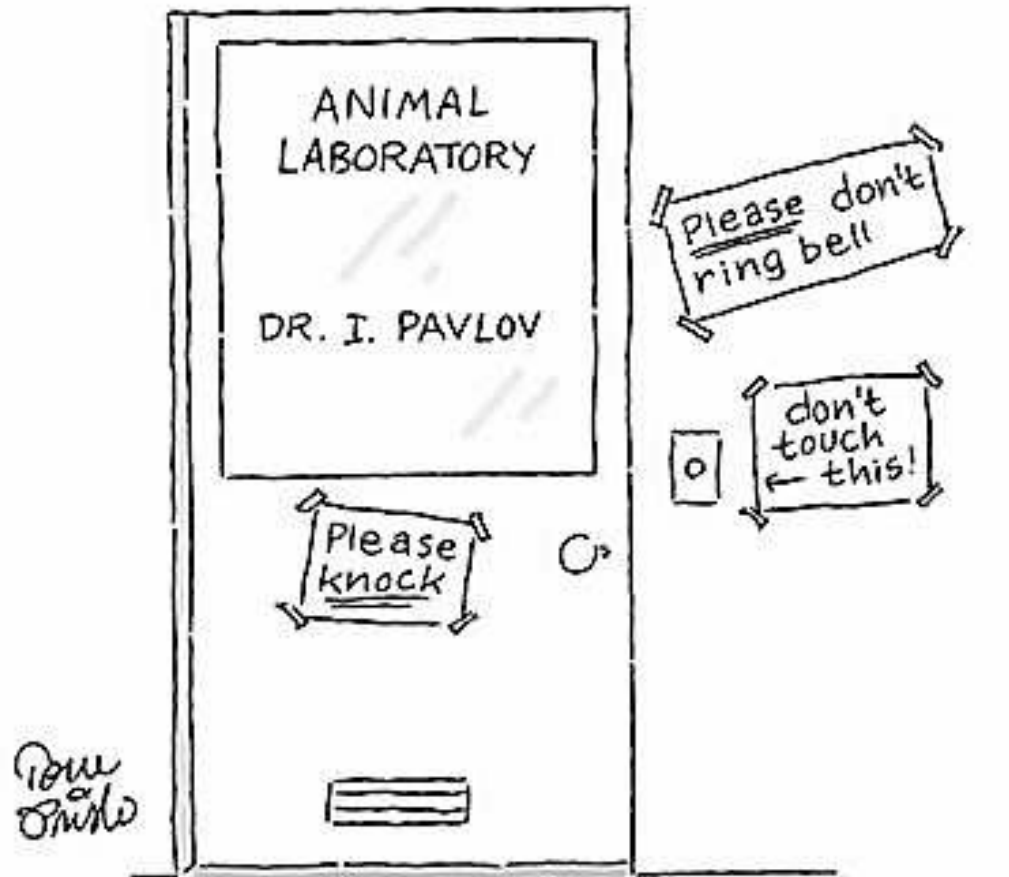
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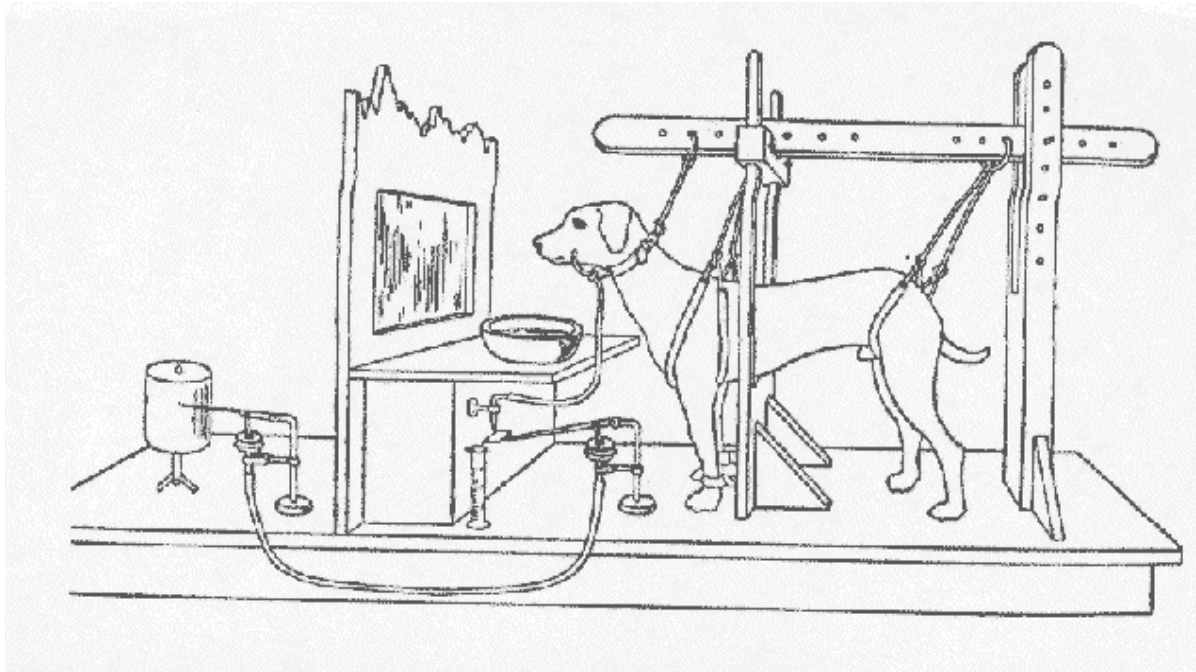
# Classical Conditioning: Ivan Petrovich Pavlov



Ivan Pavlov (1849 – 1936)

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# Conditioning



- Unconditioned behavior:  
US → UR
- Training:  
US + CS → UR
- Conditioned behavior:  
CS → CR

- Unconditioned stimulus (US)
  - e.g. meat
- Conditioned stimulus (CS)
  - e.g. sound
- Unconditioned reaction (UR)
  - e.g. saliva
- Conditioned reaction (CR)
  - e.g. saliva
- CR and UR
  - same quality
  - CR lower magnitude than UR

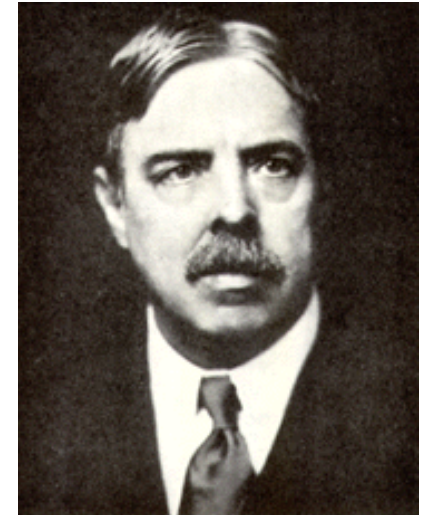
Bild: <http://www.acs.appstate.edu>

# Paradigm of Behaviorism

- Behavior
  - is a pattern of *stimuli* and *responses*.
  - can be observed like observations on the environment.
- Goal of behaviorism:  
Elaborate the laws of the relationship between stimulus and response
- **Learning** in behaviorism:
  - How to condition the responses of the learning subjects to certain stimuli
  - Human being seen as a “black box”
- Learning environment in behaviorism:
  - Provides stimulus-response pairs

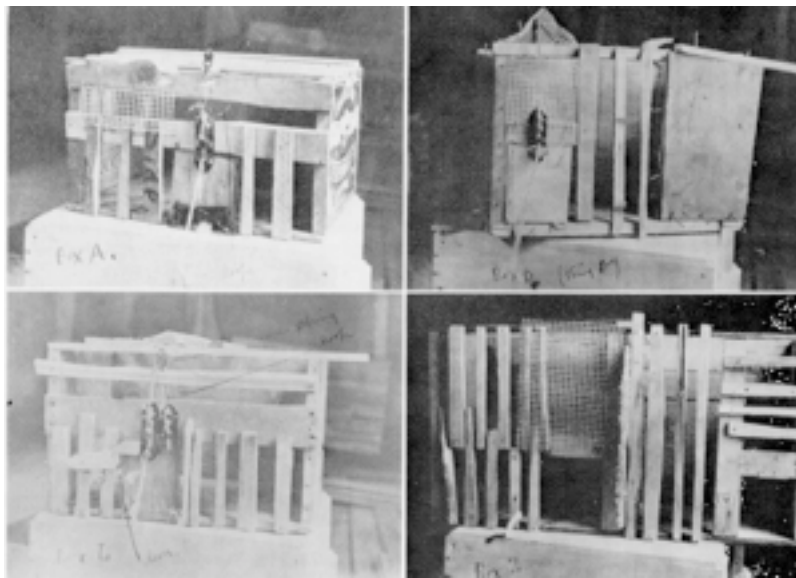
# Edward Lee Thorndike: Connectionism

- Connection = neural connection between stimulus and response
- Assumption: All mammals learn in the same manner
  - Trial-and-error experiments with animals (e.g. cats and monkeys)
  - There is no reasoning involved in learning
- Learning is incremental, not insightful



Edward Thorndike  
(1874 – 1949)

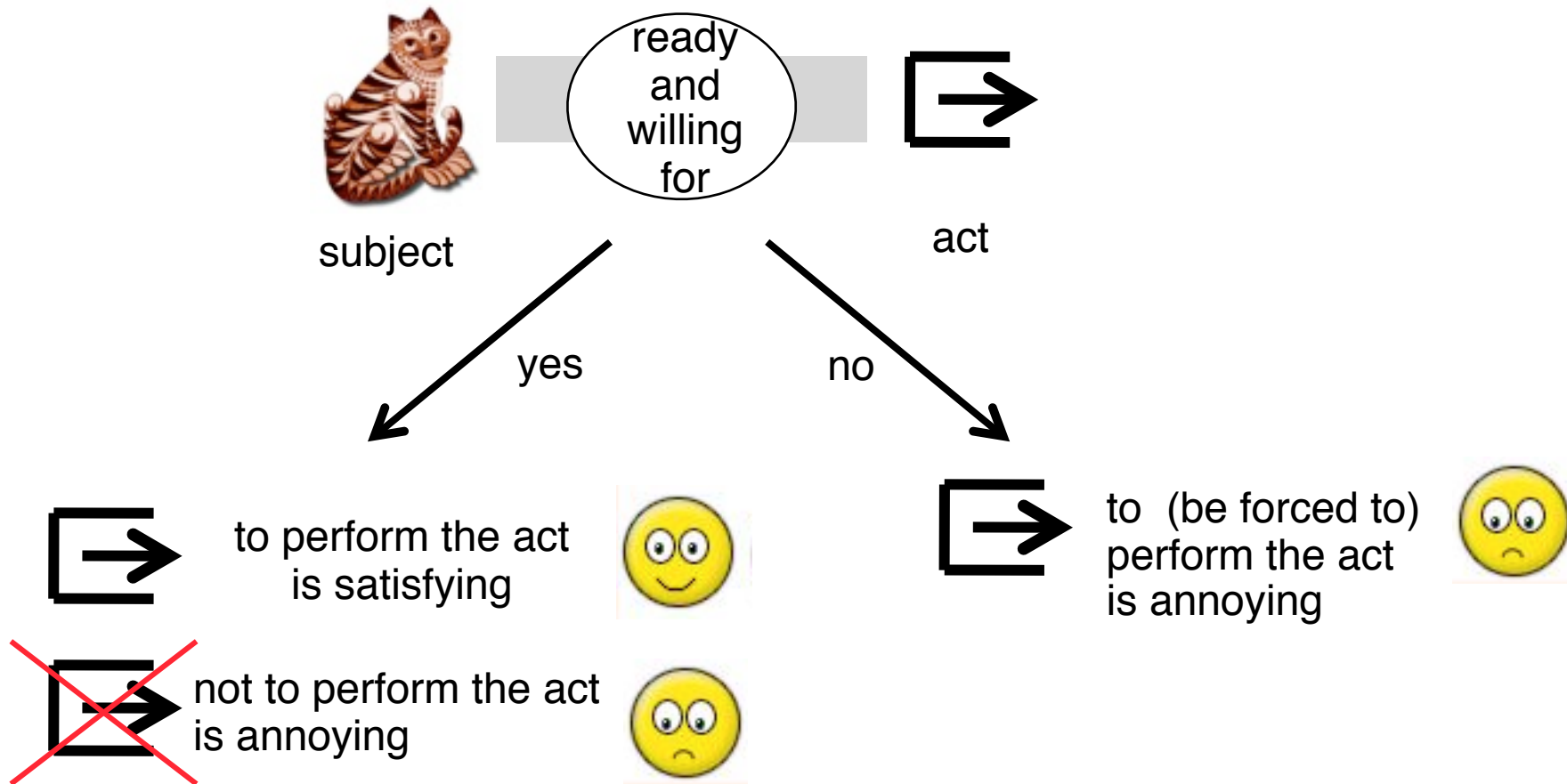
*Before the main  
behavioristic  
movement!*



Thorndike puzzle boxes for cats

# Law of Readiness

Dependency of reaction on internal state of organism:

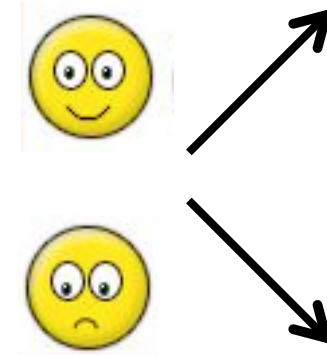


# Law of Exercise

- Law of use:
  - Connections between a stimulus and a response are strengthened as they are used
- Law of disuse:
  - Connections between a stimulus and a response is weakened when the connection is not used
- Strong emphasis on practice
  - Basis for „drill-and-practice“ software
- Thorndike 1929, Congress of psychology
  - „I was wrong.“
  - Revocation of the law of exercise!
  - Only minor effects provable in extensive experiments

# Law of Effect

- Response followed by a satisfying state of affairs  
→ strength of connection is increased
  - Rewards
- Response followed by an annoying state of affairs  
→ strength of connection is decreased.
  - Punishment
- Revised law of effect (1930)
  - reinforcement of connections works
  - punishment does nothing to the strength of a connection

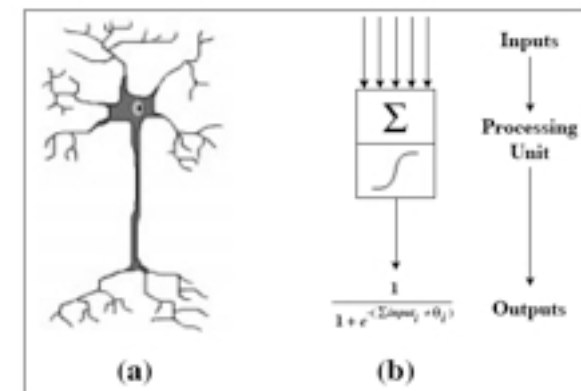


# Clark Leonard Hull: Mathematical Learning Theory

- Mathematical explanation of adaptive behavior
  - Stimuli = input variables (S)
  - Responses = output variables (R)
  - Intervening (non-observable) variables
- Strength of connection:
  - *Habit strength* H between S and R:  ${}_S H_R$
  - ${}_S H_R = 1 - 10^{-cN}$
  - N = number of reinforcements
- Influence of *drive* (D):
  - ${}_S E_R = {}_S H_R \cdot D$
  - *Excitatory potential* E between S and R:  ${}_S E_R$



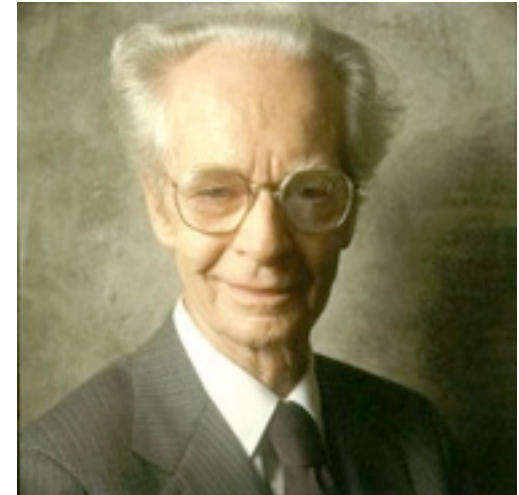
Clark Leonard Hull  
(1884 – 1952)





# Burrhus Frederic Skinner: Operant Conditioning

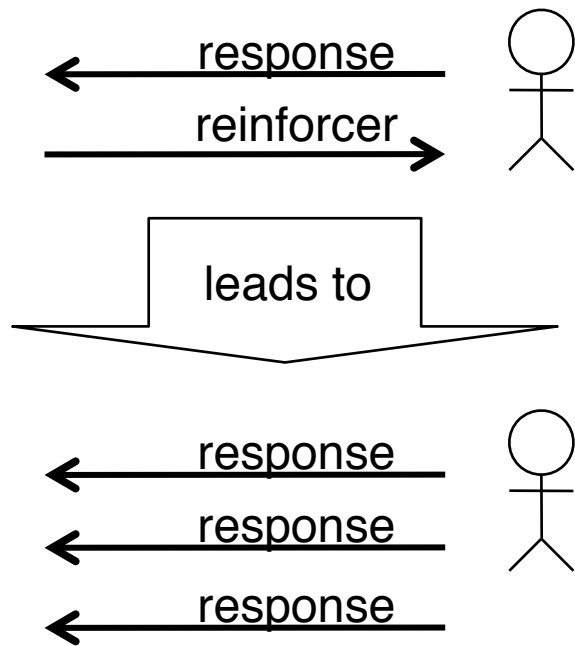
- Radical behaviorism
  - Rejects to use terms like “drive”, “motivation”
- Behavior
  - Respondent behavior
    - » Elicited by known stimulus
    - » Controlled by its causes
    - » “type S” conditioning (Pavlov-like)
  - Operant behavior
    - » Not elicited by known stimulus but emitted by organism
    - » Seems to appear spontaneously
    - » Controlled by its consequences
    - » “type R” conditioning (operant conditioning)
    - » Probability of certain behavior is modified according to consequences



B.F. Skinner  
(1904 – 1990)

# Principles of Operant Conditioning

- A response followed by a reinforcing stimulus tends to be repeated.
- A reinforcing stimulus is anything that increases the rate at which an operant response occurs.
  - “The only defining characteristic of a reinforcing stimulus is that it reinforces.”

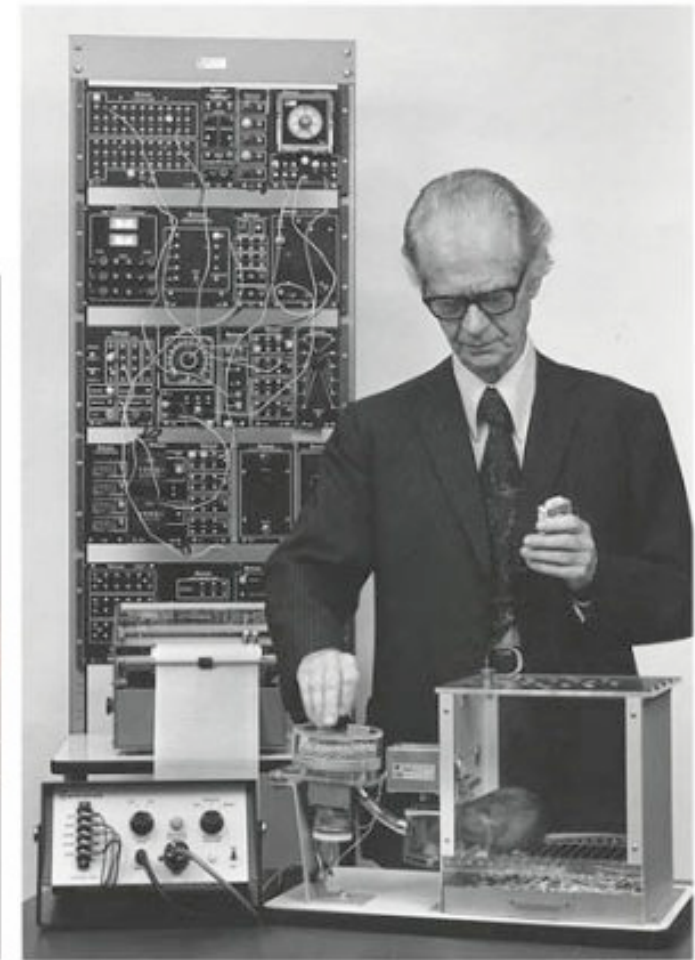


To modify behavior:

- Find something that is reinforcing
- Wait until desired behavior appears
- Immediately reinforce!

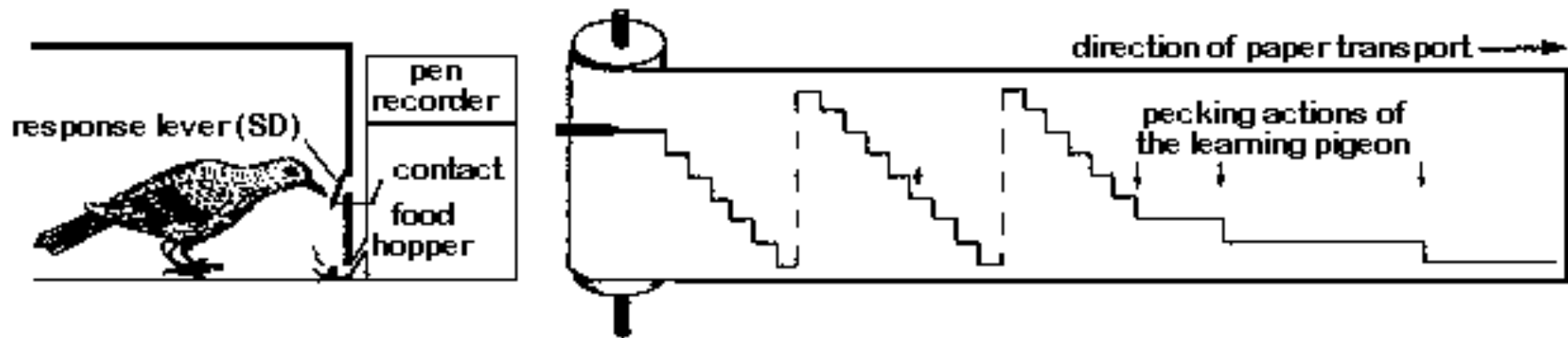
# The Skinner Box

- Grid floor (can be used for electric shocks)
- Light
- Lever
- Food cup (reinforcement)



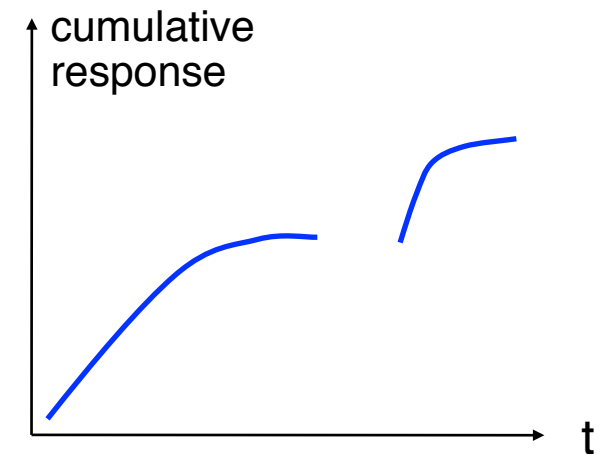
# Purely Observational Approach

- Reproducible experimental conditions like in experimental physics
  - “A pigeon is brought to a stable state of hunger by reducing it to 75 percent of its weight when well fed. It is put into an experimental cage for a few minutes each day. A food hopper attached to the cage may be swung into place so that the pigeon can eat from it. A solenoid and a timing relay hold the hopper in place for five sec. at each reinforcement.” (B.F. Skinner)
- Automated collection of data:



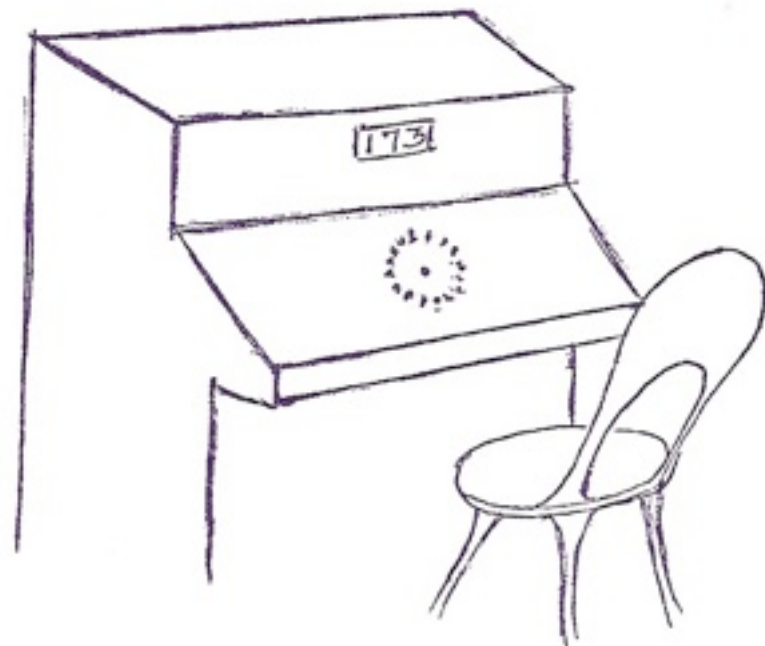
# Shaping, Extinction, Recovery

- Over time, step-wise reinforcement of behaviors *shapes* behavior.
- Example: Learning pigeons to turn clockwise
  - First: Any clockwise movement is reinforced
    - » Differential Reinforcement
  - Further on: Behavior increasingly similar to target behavior is reinforced
    - » Successive approximation
- Extinction: Removal of reinforcement
  - Gradual process
- Spontaneous Recovery
  - Learned behavior reappears if animal is brought back to experimental situation



# Superstitious Behavior

- What happens if the reinforcement appears randomly, *independent of what the subject animal is doing?*
- Animal tends to repeat the (random) behavior just before reinforcement
  - Bob its head, turn in a circle, stand up on back legs, ...
  - „Rituals“ to influence good luck?
- Human superstitious behavior:
  - Baseball player adjusting his hat
  - Lucky charms
  - ...



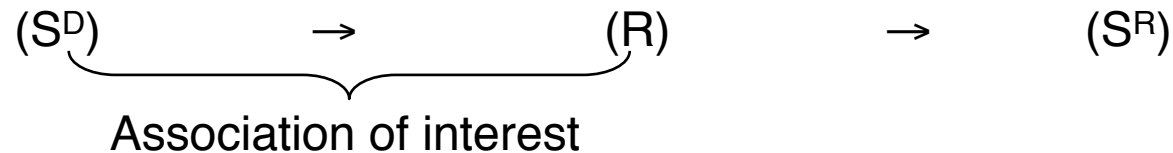
John C. Wright, Stanford U  
(nach P. Watzlawick)

Der vielarmige Bandit

# Discriminative Operant, Chaining

- Combination of cause- and effect-based conditioning
- Example:

Light switched on → animal presses lever → food is dispensed  
*discriminative stimulus* → *operant response* → *reinforcing stimulus*



- Chaining:  
Reinforcing stimulus of one response acts as discriminative stimulus for another response
- Example:

in test chamber → orient toward lever → sight of lever → approach lever → ...

(S<sup>D</sup>) → (R) → (S<sup>R</sup>)  
 (S<sup>D</sup>) → (R) → ...

# Punishment

- Punishment:
  - Response removes something positive or adds something negative
- Estes (1944)
  - Comparison how to remove a learned response (in rats)
    - » by „extinction“ (no further reinforcement)
    - » by punishment (electric shock)
  - Punishment turned out as effective only in a very short time range, in the long run no more effective than „extinction“
- Other arguments against punishment:
  - Transfers only negative advice
  - Causes unfortunate byproducts
  - Justifies inflicting pain
  - Elicits aggression
  - Replaces one undesirable response with another undesirable response
- Skinner: Short term effect of punishment reinforces the punisher.



# Criticism of Behaviorism

- No consideration of the quality of mind states
  - Same approach to human beings and animals
  - Stimulus-response as the main paradigm
- Memory seen as a passive storage unit
  - Just reproduction
  - No active processing
- Use of animal experiments
- Simplistic teaching concepts
  - Learning software concentrating on factual knowledge
  - No development of problem-solving skills

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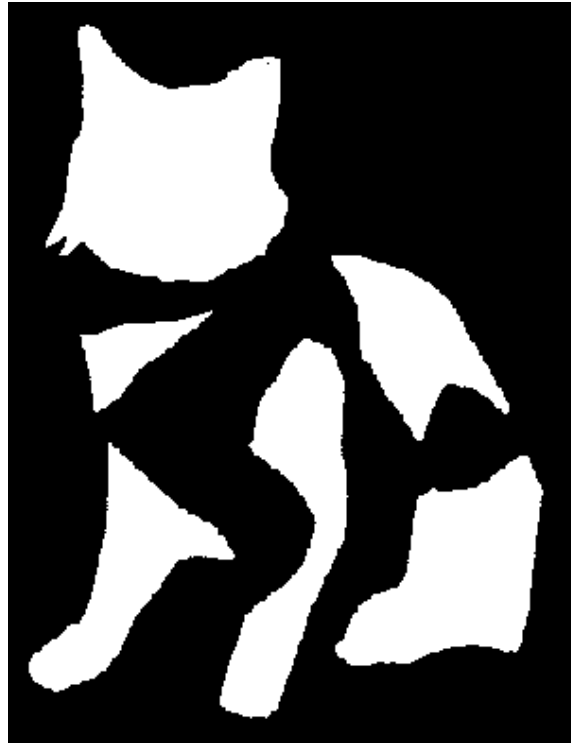
# Cognitivism: Historical Predecessors

- „At about the same time the behaviorists were attacking introspection in America, a group of psychologists began attacking its use in Germany. This small group of German psychologists called themselves Gestalt psychologists.“ (Hergenhahn/Olson p 247)
  - Introspection (Wundt/Titchener): Study of human consciousness and “unbiased observation”
- “The Gestaltists”
- Kurt Lewin (1890 – 1947):
  - Field theory of human motivation
  - All psychological facts a human experiences make up a person’s *life space*.
  - The totality of these events determines behavior at any given time.
  - A person exists in a continually changing field of influences, and a change in one of them affects all the others.
  - Active role of the brain: acts on sensory information

# Gestaltpsychologie

- *Gestalt*: (Edgar Rubin 1886 – 1951)
  - Bestehend aus *Form* (äusserer Begrenzung) und *Figur* (erkanntes Objekt)
  - Figur hebt sich ab vom *Grund*
  - „Das Ganze ist mehr als die Summe seiner Teile.“ (Aristoteles)
- *Gestaltgesetze*: (Max Wertheimer 1880 – 1943)
  - Zentrales Gesetz: *Prägnanzgesetz*  
(„Gesetz der guten Gestalt“, „Gesetz der Einfachheit“)
  - Jedes Reizmuster wird so gesehen, dass die resultierende Struktur so einfach wie möglich ist.
  - Eine Figur ist „gut“, wenn sie aus Teilelementen heraus erkennbar ist.

# Gesetz der Geschlossenheit / Law of Closure



[http://www.doit.gmu.edu/inventio/issues/Spring\\_2004/Coppola1\\_print.html](http://www.doit.gmu.edu/inventio/issues/Spring_2004/Coppola1_print.html)

# Gesetz der Vertrautheit / Law of Familiarity

- Human perception groups elements which give a known meaning.
- Several different interpretations of the same information are possible.



# Subjective and Objective Reality

- Physical experience is transformed
  - In perception: according to Gestalt laws
  - In general experience?
- Beliefs, values, needs and attitudes transform experience
- “Do we all live in the same town? Yes, when we mean the geographical, no, when we mean the behavioral ‘in.’”
  - Kurt Koffka, Principles of Gestalt Psychology, 1935



Beispiel (nach Koffka):  
Reiter über den Bodensee  
Bild: Brunnen in Überlingen

# Wolfgang Köhler: Problemlösen bei Affen

- Experimente mit Schimpansen
  - Verwendung von Werkzeugen, Kombinationen, Umwegen
- Hühner können vergleichbare Probleme kaum lösen!
  - „Insightful learning“



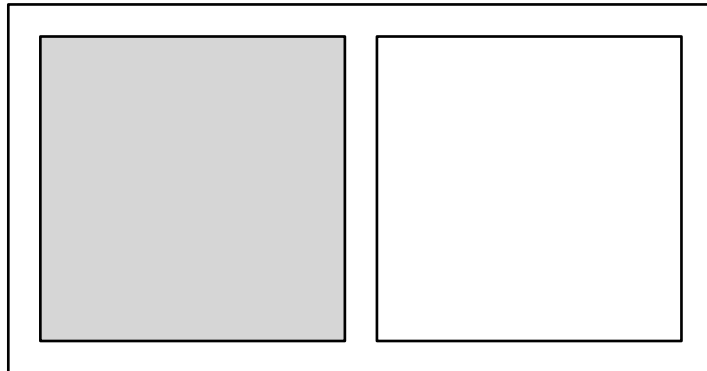
Wolfgang Köhler  
(1887 – 1967)



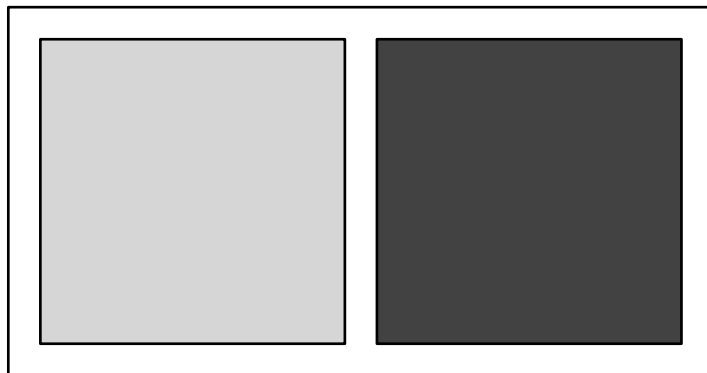


# Köhler: Transposition

An experiment beyond stimulus-response connections:



Stimuli during Preliminary Training:  
Animal is fed only on light grey surface



Stimuli during Transposition Test:  
Which surface is preferred, light or dark grey?

Transposition: Principle learned in one problem,  
applied to another problem

# Grundparadigma des Kognitivismus

- Mit Kognition (*cognition*) bezeichnet man jeden mentalen Prozess, der mit den zentralen Elementen *Erkennen* und *Wissen* zu tun hat.
- Beispiele:
  - Begriffsbildung (*conception*)
  - Wahrnehmung (*perception*)
  - Wiedererkennen (*recognition*)
  - Schlussfolgern (*reasoning*)
- Im Mittelpunkt des Kognitivismus stehen individuelle Denk- und Verarbeitungsprozesse.
- Lernen ist eine *Wechselwirkung* zwischen externem Informationsangebot und einer intern vorhandenen Wissensstruktur.
- Lernen ist *Verarbeitung von Information zu Wissen*.

# Jean Piaget: Development of Intelligence

- Studies of variables influencing test performance of children
  - Almost constructivist approach (see later)!
- Intelligence:
  - Approximation to conditions optimal for survival of the organism
  - Changes dynamically with environment and maturity of organism
- Schemata:
  - *Schema* = potential to act in a certain way
    - » E.g. “grasping”
  - *Content* = particular manifestations of a schema (in response to specific stimuli)
    - » Overt manifestations (e.g. reflexes, physical reactions)
    - » Covert manifestations (thinking)



Jean Piaget  
(1896 – 1980)

# Assimilation, Accommodation, Equilibration

- Cognitive structure of an organism:
  - Number of available schemata
- Assimilation:
  - New experiences are integrated into existing schemata
- Accommodation:
  - Developing new ways to deal with previously unknown events (knowing)
  - Modification of the cognitive structure (learning)
- Example:
  - 4 months baby dealing with its first experience of a rattle
  - Assimilation: A thing which can be grasped
  - Accommodation: After many attempts, developing the new concept of “something which makes noise when shaken”
- Equilibration:
  - Organisms have a tendency to create an harmonious relationship between themselves and their environment.

# Stages of Intellectual Development (Piaget)

Certain mental abilities *tend* to appear at certain stages of development

- Sensorimotor Stage (Birth to about 2 years)
  - Absence of language, only dealing with “here and now”
  - Towards the end of the stage: object permanence
- Preoperational Thinking (2 to 7 years)
  - Preconceptual Thinking (2 to 4 years)
    - » Rudimentary concept formation, transductive reasoning
  - Period of Intuitive Thought (4 to 7 years)
    - » Intuitive problem solving, conservation not yet developed
- Concrete Operations (7 to 11/12 years)
  - Complex operations, as long as problems are concrete and not abstract
- Formal Operations (11/12 years to 14/15 years)
  - Logical thinking, dealing with hypothetical situations

# Optimal Conditions for Learning

- Presented information must be familiar to some extent
  - To enable assimilation (understanding)
- Presented information must be different from existing knowledge
  - To cause accommodation (learning)
- Learning Dilemma:
  - *Learning depends on failure.*
- Experiences should be moderately challenging
  - Individually master-tailored learning experience
  - Adapted to the cognitive structures available in the learner
  - Ideally, one-to-one relationship between teacher and pupil

# Jerome S. Bruner: Kategorien und Konzepte

- Wahrnehmung und Entscheidungsprozesse beruhen auf *Kategorisierung*
  - Kritische Attribute, Kombinationen, Gewichtungen, Toleranzen
- Konzepterwerb:
  - Erkenntnis, welche Dinge zu einer Kategorie gehören
- Merkmale von Lernen:
  - Aneignung neuer Information (abweichend vom Vorwissen)
  - Umwandlung (Transformation) für die Anwendung auf neue Aufgaben
  - Bewertung (Evaluation), ob Aneignung und Umwandlung adäquat
- Weiterführende Ideen:
  - Entdeckendes Lernen
  - Soziale Aspekte des Lernens (Reziprozität)
- Wird oft auch dem Konstruktivismus (siehe später) zugeordnet



J. S. Bruner  
(1915 –)

# Robert Gagné: Behaviorism & Cognitivism

- Eight phases of learning:
  - Signal learning (similar to Pavlov's theory)
  - Stimulus response (similar to Thorndike's Instrumental Conditioning)
  - Chaining (as described by Skinner)
  - Verbal association
  - Discrimination learning
    - » Different/identical responses to different stimuli
  - Concept learning
    - » Generalization, classes, categories
  - Rule learning
    - » Being able to demonstrate some defined behavior (e.g. calculating)
  - Problem solving



Robert M. Gagné  
(1916 – 2002)