3 Lerntheorien

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 (inzidentiell) 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.“

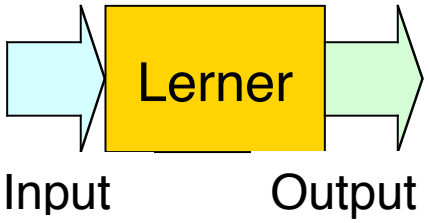
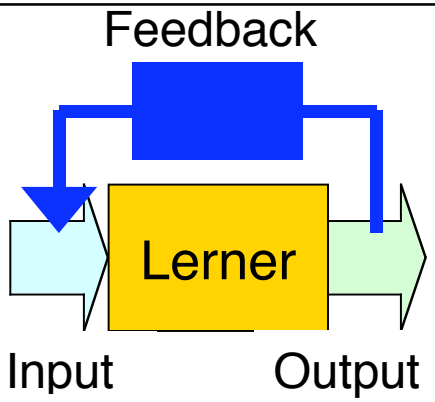
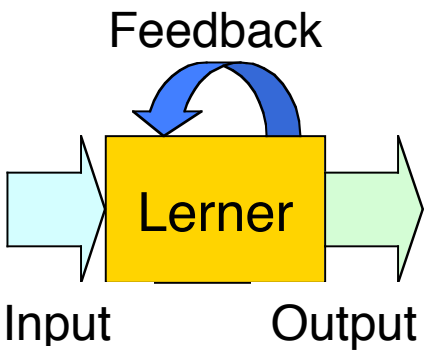
Computergestütztes Lernen und Lerntheorien

- 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 Aktivation *(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 of *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 präsentiertem Material, ...
    - » Beispiele abhängiger Variablen: Punktzahlen, Fehlerzahlen, Antwortrate, Häufigkeit von Antworten, Stärke von Reaktionen, ...

Lerntheorien: Überblick

	Behaviorismus	Kognitivismus	Konstruktivismus
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

3 Lerntheorien

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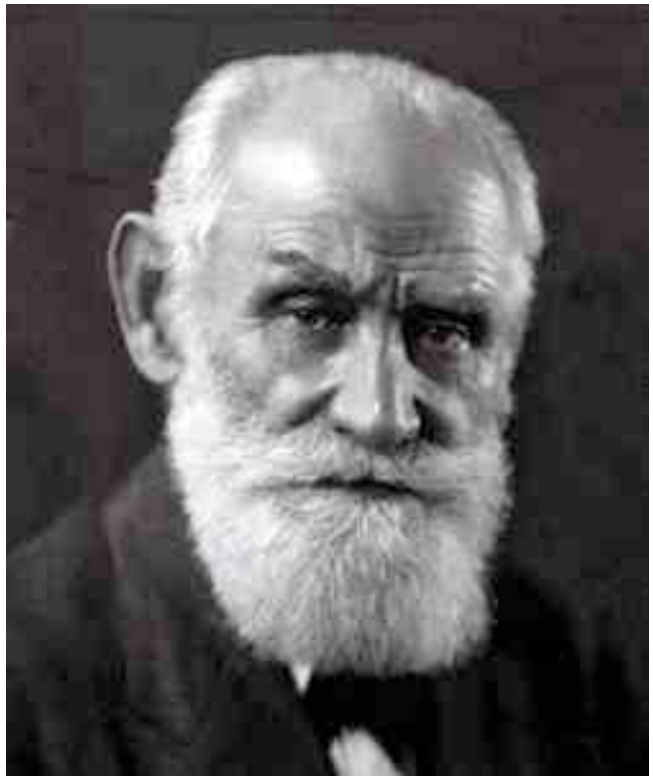
A. Holzinger: Basiswissen Multimedia Band 2, p. 112-132

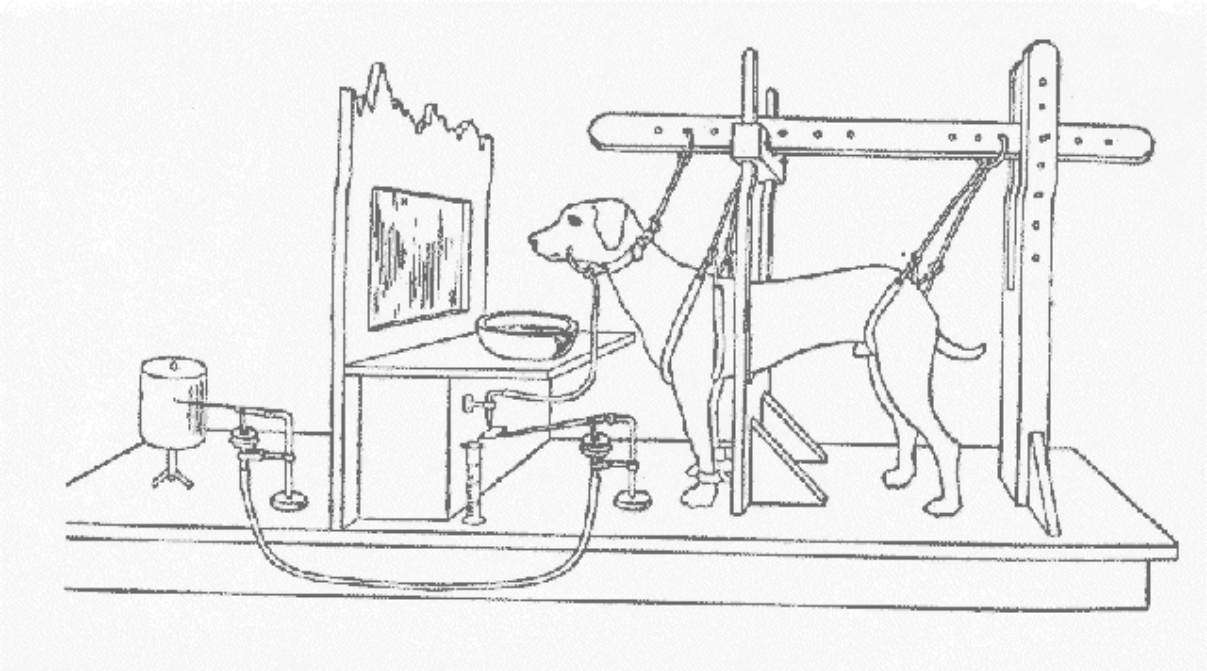
B.R. Hergenhahn, M. H. Olson: An Introduction to Theories of Learning, 6th edition, Prentice-Hall 2001

Classical Conditioning: Ivan Petrovich Pavlov



Ivan Pavlov (1849 – 1936)

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

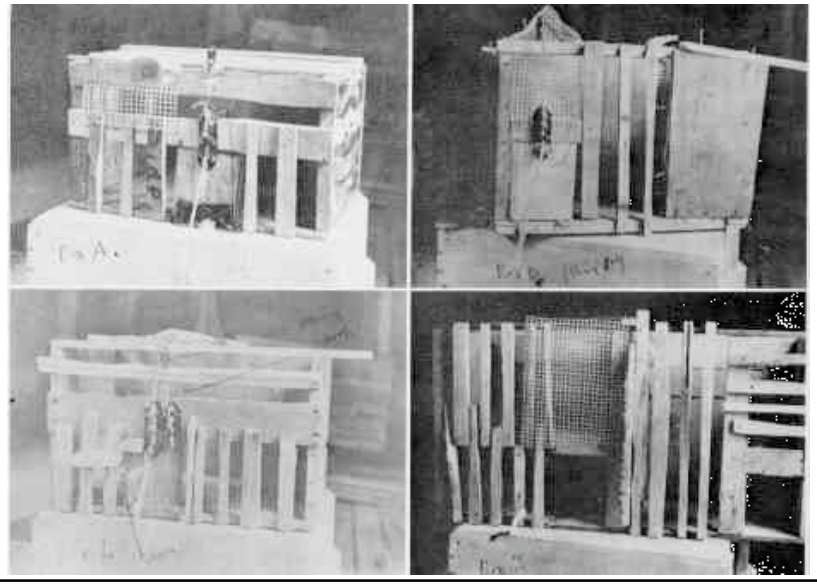
- Behavior
  - is a pattern of *stimuli* and *responses*.
  - can be observed like observations on the environment.
- Goal of behaviorism:
  Elaborate the laws of the relationship between stimulus and response
- ***Learning*** in behaviorism:
  - How to condition the responses of the learning subjects 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)

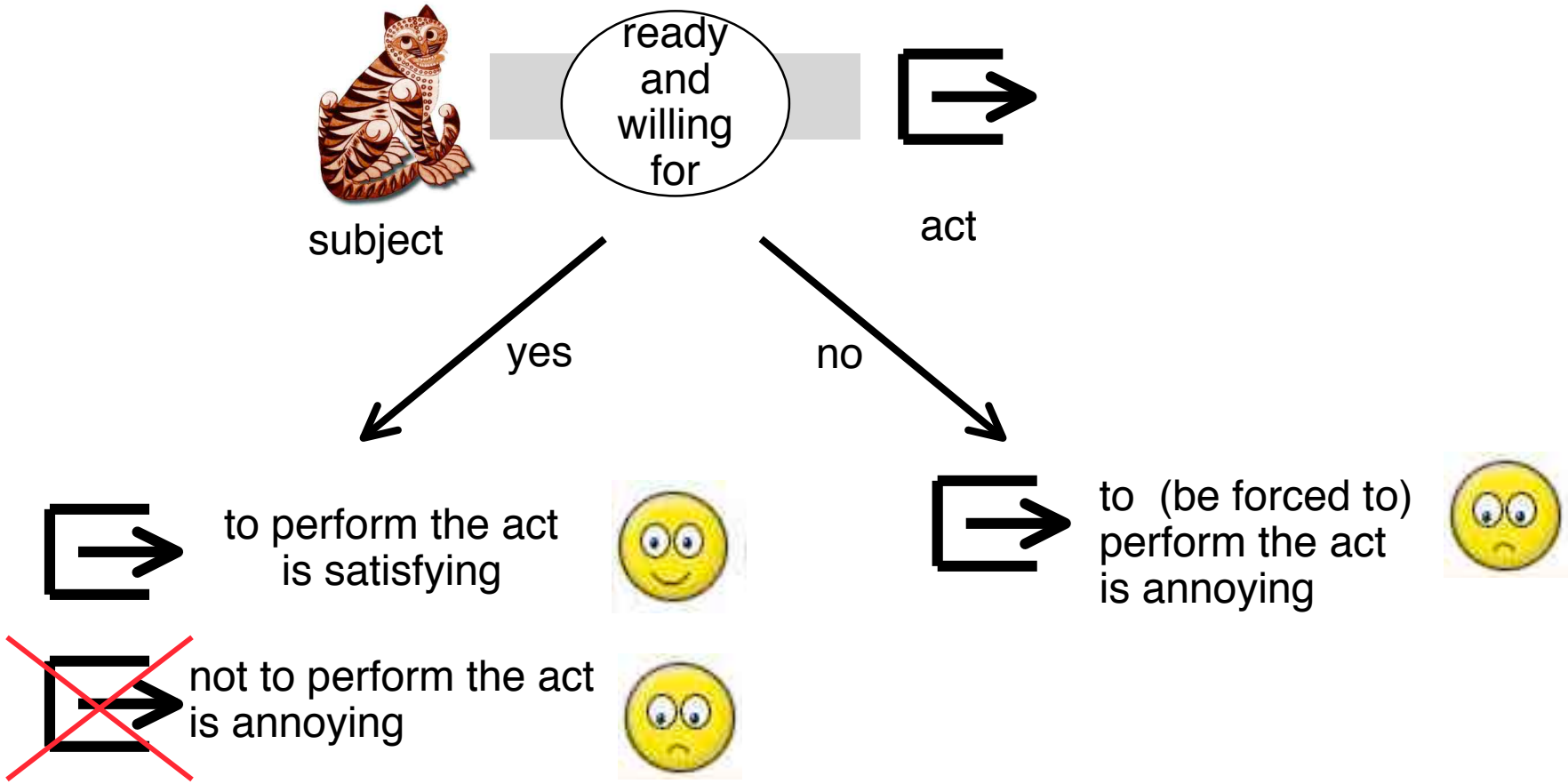
Before the main behavioristic movement!



Thorndike puzzle boxes for cats

Law of Readiness

- Dependency of reaction on internal state of organism:

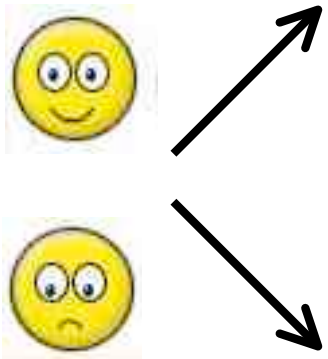


Law of Exercise

- 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

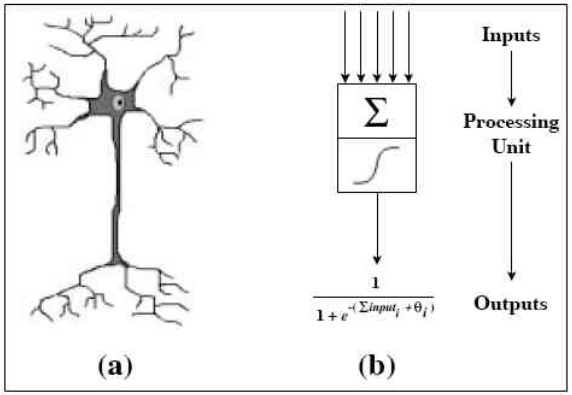
- Response followed by a satisfying state of affairs → strength of connection is increased
  - Rewards
- Response followed by an annyoing state of affairs → strength of connection is decreased.
  - Punishment
- Revised law of effect (1930)
  - reinforcement of connections works
  - punishment does nothing 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: ${}_SH_R$
  - ${}_SH_R = 1 - 10^{-cN}$
  - N = number of reinforcements
- Influence of *drive* (D):
  - ${}_SE_R = {}_SH_R \cdot D$
  - *Excitatory potential* E between S and R: ${}_SE_R$

Clark Leonard Hull
(1884 – 1952)



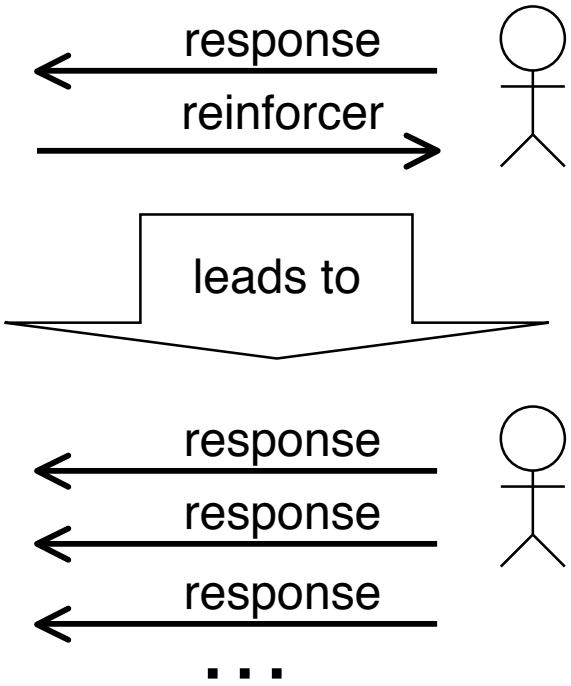
Burrhus Frederic Skinner: Operant Conditioning

- 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."

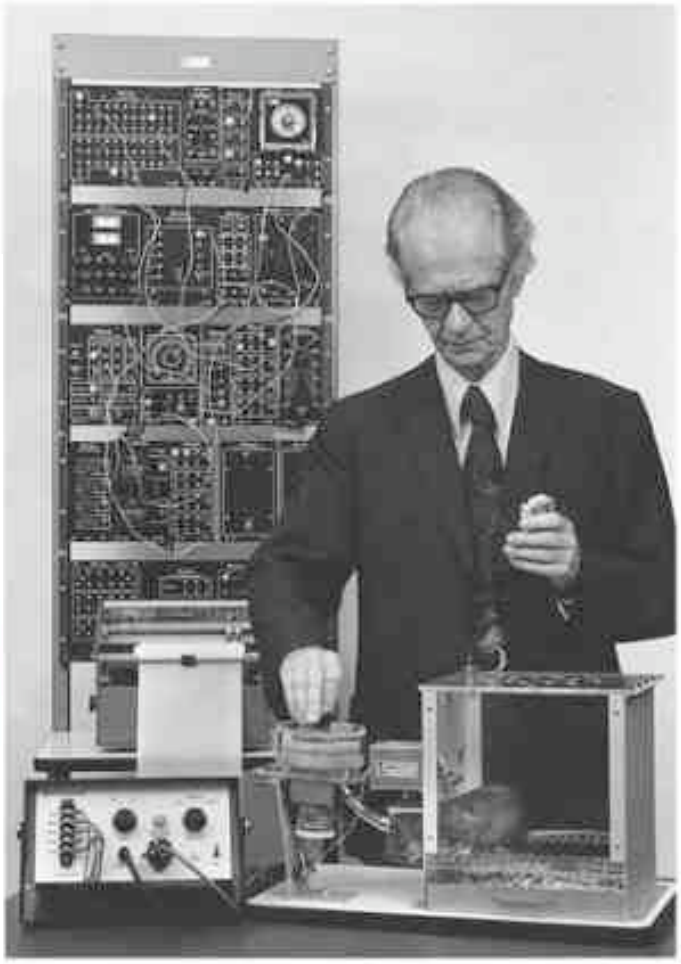


To modify behavior:

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

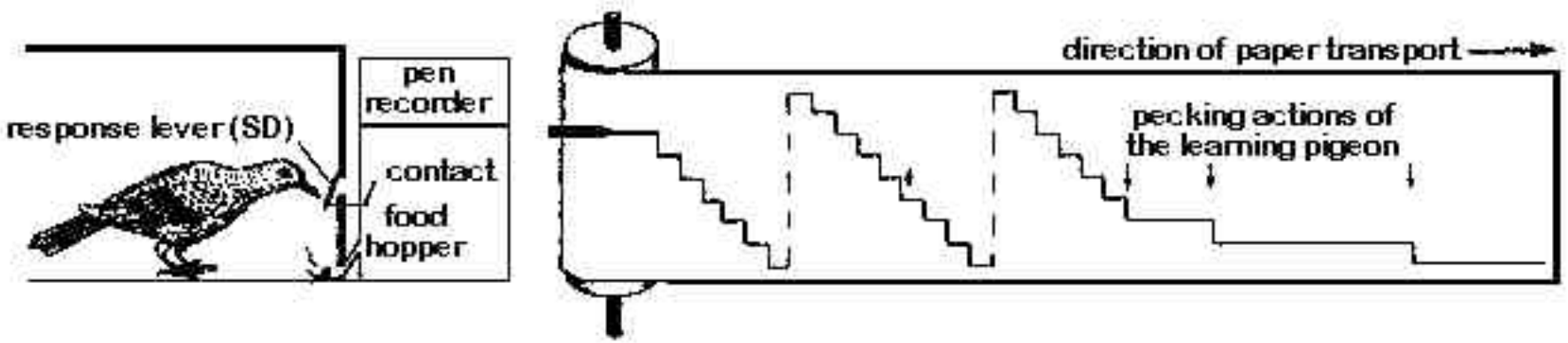
The Skinner Box

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



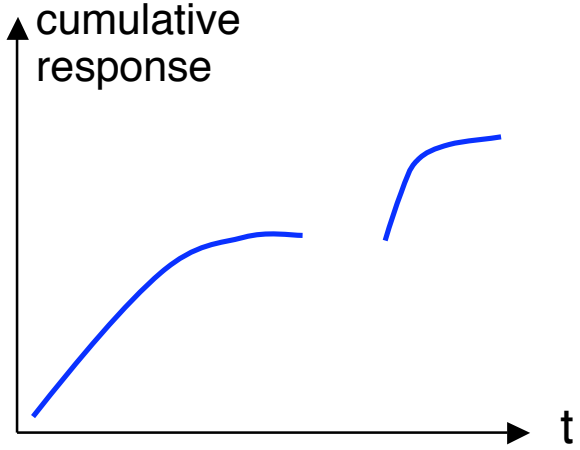
Purely Observational Approach

- Reproducable 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:



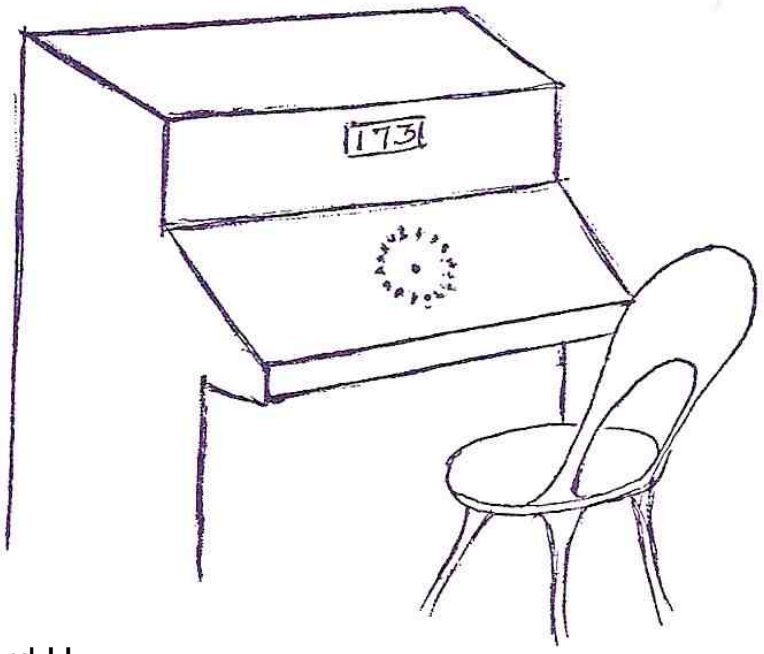
Shaping, Extinction, Recovery

- 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*

  (S^D) → (R) → (S^R)

  Association of interest

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

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

  (S^D) → (R) → (S^R)

  (S^D) → (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

3 Lerntheorien

Literatur:

A. Holzinger: Basiswissen Multimedia Band 2, p. 133 – 145

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

Cognitivism: Historical Predecessors

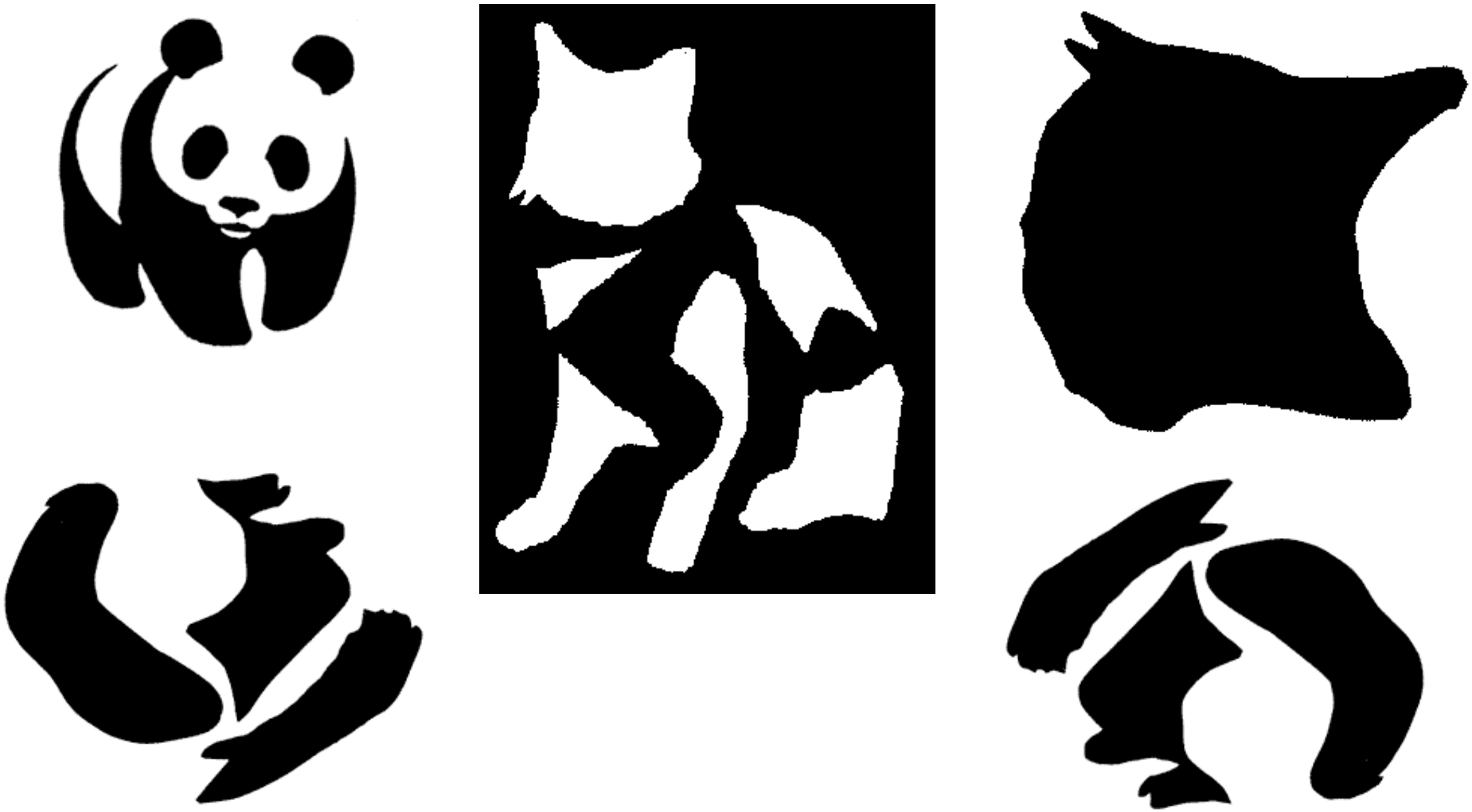
- „At about the same time the behaviorists were attacking introspection in America, a group of psychologists began attacking its use in Germany. This small group of German psychologists called themselves Gestalt psychologists.“ (Hergenhahn/Olson p 247)
  - Introspection (Wundt/Titchener): Study of human 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

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

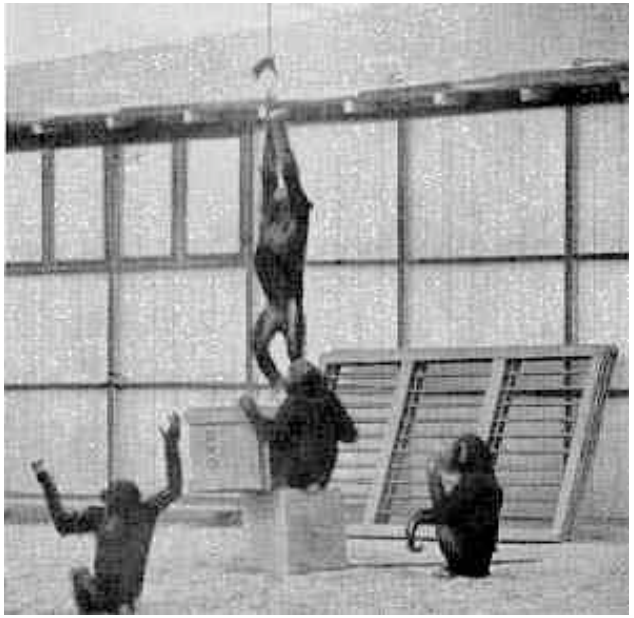
- Physical experience is transformed
  - In perception: according to Gestalt laws
  - In general experience?
- Beliefs, values, needs and attitudes transform experience
- “Do we all live in the same town? Yes, when we mean the geographical, no, when we mean the behavioral ‘in.’”
  - Kurt Koffka, Principles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

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

Wolfgang Köhler: Problemlösen bei Affen

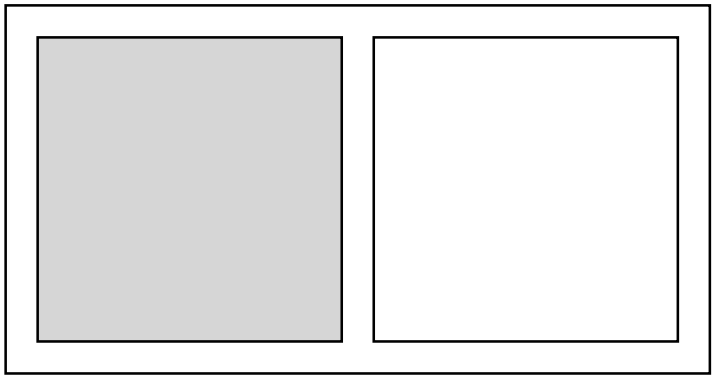
- Experimente mit Schimpansen
  - Verwendung von Werkzeugen, Kombinationen, Umwegen
- Hühner können vergleichbare Probleme kaum lösen!
  - „Insightful learning“

Wolfgang Köhler
(1887 – 1967)

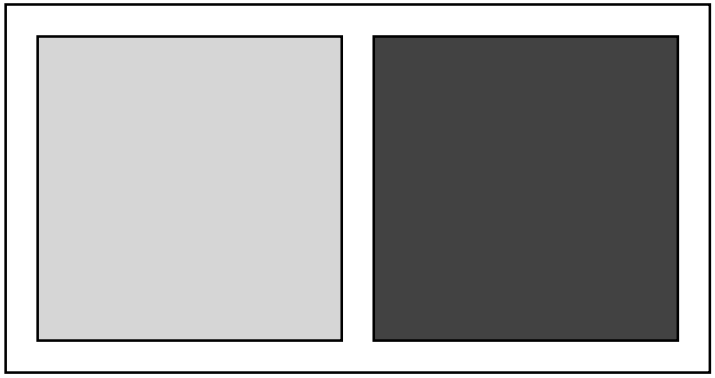


Köhler: Transposition

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

J. S. Bruner
(1915 –)

- 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

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)