Principles of Learning

Habituation

- Definition: Decrease in behavioral response to a repeated, harmless stimulus over time.
- General Features:
  - Occurs with non-associative learning—no reward or punishment involved.
  - Response decreases faster with frequent, rapid repetitions.
  - The weaker the stimulus, the faster habituation occurs.
- Dishabituation:
  - Sudden recovery of response after presentation of a new or strong stimulus.
  - Example: You stop noticing the hum of a refrigerator—until someone slams a door.
- Rate and Duration:
  - Short-term habituation fades quickly (minutes to hours).
  - Long-term habituation lasts days or weeks and involves synaptic changes in sensory neurons (less neurotransmitter released).

Sensitization

- Definition: Increased response to a stimulus following an intense or noxious event.
- General Features:
  - Also non-associative.
  - Even mild stimuli can trigger strong responses afterward.
  - Serves an adaptive, protective function.
- Dual Process Theory:
  - Behavior reflects a balance of habituation processes (inhibitory) and sensitization processes (excitatory) in the nervous system.
  - Explains why we can show both decreased and increased responses depending on context.
- Priming:
  - Exposure to a stimulus influences later responses unconsciously (e.g., seeing "yellow" makes you recognize "banana" faster).
- Perceptual Learning:
  - Improved ability to distinguish between stimuli through experience.
  - Example: Wine tasters learn subtle differences in flavor notes.
- Spatial Learning:
  - Forming cognitive maps of environments (e.g., Tolman's rat maze experiments).
  - The hippocampus is key for encoding spatial relationships.

- Constraint-Induced Movement Therapy (CIMT):
    - Rehabilitation method where the functional limb is restrained to force use of the impaired limb.
    - Based on experience-dependent plasticity—the brain reorganizes through repeated practice.

Generalization

- Stimuli and Outcomes:
    - Responding similarly to stimuli that are similar to the conditioned one.
    - Example: Fear of a white rat generalizing to white fur or Santa beards (Little Albert).
- Gradients and Discrete-Component Networks:
    - Generalization gradient: Strength of response decreases as stimulus becomes less similar to the original.
    - Discrete-component network: Models learning where each stimulus component is represented separately (no generalization).
    - Real learning systems fall between continuous generalization and discrete categorization.

Discrimination Learning

- Definition: Learning to respond differently to similar stimuli when only one is associated with reinforcement.
    - Example: Dog salivates to a tone of 1000 Hz but not to 1200 Hz.
- Errorless Discrimination Learning:
    - Introduces the non-reinforced stimulus very gradually to minimize errors.
    - Prevents frustration and extinction bursts.
- Negative Patterning:
    - Responses to individual stimuli are reinforced, but the combined pattern is not (or vice versa).
    - Demonstrates ability to learn non-linear associations (e.g., light + tone → no food).

Concept Formation

- Concepts, Categories, Prototypes:
    - Concepts = mental groupings of similar objects/events.
    - Categories = sets of stimuli with shared characteristics.
    - Prototype = best or “average” example of a category.

    - Example: A robin fits the prototype of “bird” better than a penguin.
- Stereotypes:
    - Social application of categorical thinking; overgeneralized expectations.
- Discrimination Training:
    - Used to teach boundaries between categories (e.g., “cat” vs “dog” images).
    - Involves feedback-based learning to strengthen categorical rules.

Classical Conditioning

Behavioral Processes

- Elements of Classical Conditioning:
    - Unconditioned Stimulus (US): Naturally elicits response (food).
    - Unconditioned Response (UR): Natural reaction (salivation).
    - Conditioned Stimulus (CS): Initially neutral (bell).
    - Conditioned Response (CR): Learned reaction to CS (salivation to bell).
- Appetitive vs Aversive Conditioning:
    - Appetitive: Learning about pleasant outcomes (food, affection).
    - Aversive: Learning about unpleasant ones (shock, fear).
- Extinction:
    - Gradual weakening and disappearance of CR when CS is repeatedly presented without US.
    - Involves inhibition, not unlearning—can show spontaneous recovery later.
- Compound Conditioning & Overshadowing:
    - Two stimuli presented together compete for associative strength.
    - The more salient (stronger) cue “overshadows” the other.
- Blocking:
    - Prior learning of one CS-US association prevents learning of a new CS when both are presented together.
    - Demonstrates learning depends on prediction error.
- Error-Correction Learning (Rescorla-Wagner Model):
    - Learning = change in association strength $\propto$ (predictive error).

      $$\Delta V = \alpha\beta\,(\lambda - \Sigma V)$$

    - If the outcome is fully predicted, no new learning occurs.
- Probabilistic Categorization:
    - Learning to make predictions when cues are unreliable.
    - Models real-world uncertainty (e.g., weather prediction).

Brain Areas

- Cerebellum:
  - Essential for timing and coordination of conditioned responses.
- Purkinje Cells:
  - Inhibitory neurons in cerebellar cortex that suppress motor responses; reduced activity during conditioned blink.
- Interpositus Nucleus:
  - Stores associations between CS and US in eyeblink conditioning.
- Inferior Olive:
  - Provides “error signal” from unexpected US to update learning.

Clinical Applications

- Tolerance:
  - Repeated drug use in same environment → body anticipates effects → conditioned physiological counter-response.
- Extinguishing Drug Addiction:
  - Exposure therapy presents drug-related cues without drug, weakening conditioned craving.
- Baby Albert:
  - Demonstrated conditioned fear: loud noise (US) → crying (UR); paired with white rat (CS) → fear of rat (CR) and other furry objects (generalization).

Operant Conditioning

Behavioral Processes

- Thorndike’s Cats:
  - Law of Effect—behaviors followed by satisfaction are strengthened; those followed by discomfort are weakened.
  - Cats learned to escape puzzle boxes faster over trials.
- The Skinner Box:
  - Automated environment to measure lever-press or key-peck behavior under controlled reinforcement.

- Discriminative Stimuli, Response, Outcome (S–R–O):
  - S = signal that response will produce a particular outcome.
  - Example: “Open” sign (S) → enter store (R) → food (O).
- Shaping & Chaining:
  - Shaping: Reinforcing successive approximations toward a target behavior.
  - Chaining: Linking discrete behaviors into a sequence where each step cues the next.
- Reinforcers & Punishers:
  - Reinforcer: Increases behavior likelihood.
  - Punisher: Decreases it.
  - Positive = add stimulus; Negative = remove stimulus.
- Primary Reinforcers & Negative Contrast:
  - Primary = innate (food, water, warmth).
  - Negative contrast: Preference drops when a high-value reinforcer is replaced by a lower-value one.
- Secondary Reinforcers:
  - Neutral stimuli paired with primary reinforcers (money, praise).
- Token Economy:
  - Behavior-modification system using tokens exchangeable for rewards; effective in classrooms and therapy settings.
- Differential Reinforcement of Alternative Behavior (DRA):
  - Reinforce acceptable alternative to a problematic behavior while withholding reinforcement for the undesired one.
- Operant Conditioning Paradigms:
  - Free-operant: Continuous responding (Skinner box).
  - Discrete-trial: Each response clearly separated (maze run).
- Reinforcement Schedules:
  - Fixed Ratio (FR): Reinforcement after fixed number of responses.
  - Variable Ratio (VR): After varying number—produces high, steady rate (slot machines).
  - Fixed Interval (FI): After fixed time—produces scalloped pattern.
  - Variable Interval (VI): After variable time—steady moderate rate.
- Behavioral Economics:
  - Examines how response rates change as “costs” (effort, delay) and “values” (reward size) vary.
  - Elastic demand: behavior drops when cost rises; inelastic: persists (e.g., addiction).
- Delay Discounting:
  - Tendency to devalue rewards delayed in time; steep discounting = impulsivity.

Brain Areas

- Dorsal Striatum:
  - Links stimuli with responses; important for habit formation.

- Orbitofrontal Cortex:
    - Represents value of expected outcomes; updates when contingencies change.

Applications

- Addiction:
    - Drugs reinforce behavior via dopamine release; cues become powerful discriminative stimuli.
    - Both classical (cue reactivity) and operant (drug seeking) processes interact.
- Pathological vs Behavioral Addiction:
    - Pathological: Dependence on substance altering neurochemistry.
    - Behavioral: Compulsive engagement in rewarding behavior (gambling, gaming) despite harm.
    - Both show tolerance, withdrawal, and cue-triggered craving.