Induction, Analogy, Metaphor & Blending

Inductive Reasoning

- How observations and beliefs support other beliefs
- In some ways, opposite of deductive reasoning

  $P \rightarrow Q$

  Q

  Therefore: P is more likely
- Inherently Uncertain
- Adds New Knowledge (unlike deduction)
  - Everyday life
  - Scientific reasoning

Abduction or Specific Induction

- Because conditionals typically express causal reasoning, we often explain q via p (modus ponens)
  - Blown fuses prevent electrical appliances from working
  - Hair dryer has blown fuse.
- But, often need to explain q
  - Hair dryer not working.
  - Blown fuse?
- Abduction – explanation for an event via a causal relationship

Abduction Schema

- Q
- If P then Q
- Therefore: P
- Not logically valid, but useful!

Explanation-Based Learning

- Explain new experiences based on generalizations
- Use generalizations in later reasoning

Q →(explained by)→ $P \rightarrow Q$ →(believe)→ P likely
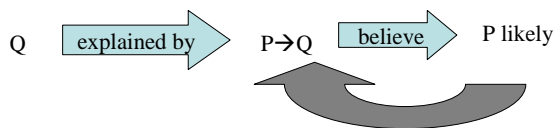
General Induction or Inductive Generalization

- Observe instances have property F and infer all other members of the class have the same property

F(a)   F(b)   F(c)

Therefore: (Ax)F(x)

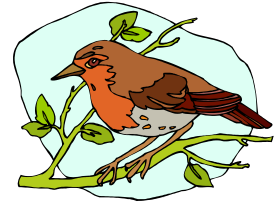- Induction can be descriptive or explanatory

Constraints on Induction

- Induction is inherently fallible
- For any given set of observations, an infinite number of inductive generalizations follow
- All zebras will have stripes until the year 3000 but thereafter become spotted.
- Cognitive processes must constrain the induction process
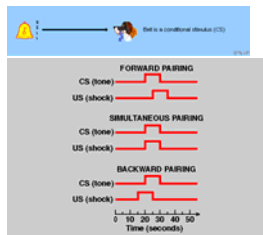 - Similarity, Availability, Framing

Factors that limit Induction

- Expectations
  - Robins have red breasts until the year 7693 and then green breasts thereafter.
  - Robins have either red breasts or green breasts

Constraints on Induction

- Temporal Contiguity
  - Pavlov's Dogs
- Availability of Observations

FORWARD PAIRING
CS (tone)
US (shock)

SIMULTANEOUS PAIRING
CS (tone)
US (shock)

BACKWARD PAIRING
CS (tone)
US (shock)

0 10 20 30 40 50
Time (seconds)

Constraints on Induction

- Similarity
  - Similarity depends on perception, entrenched knowledge, contextual relevance, frames, etc.
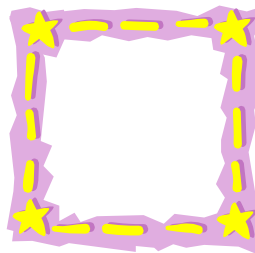
Constraints on Induction

- Frequency
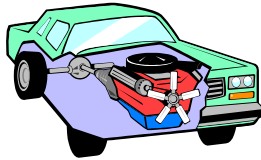 - Golden retrievers are too friendly to be good watchdogs

Constraints on Induction

- Framing
  - Constrains domains hypotheses come from
  - Prevents consideration of implausible hypotheses
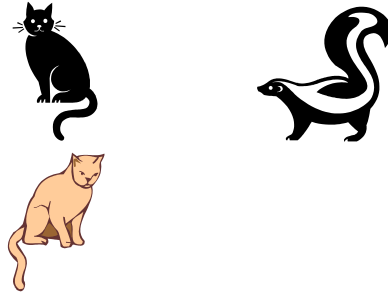 - Can be biologically based

Category-Based Induction

- Categories used to constrain induction
- My Cadillac Seville has a 6-cylinder engine
  - Sevilles?
  - Cadillacs?
  - Sedans?
  - Cars?
  - Vehicles?

Kids Use Categories to Constrain Induction

Factors Influencing Category-Based Induction

- Typicality

  Dogs have a LAA.   Whales have a LAA.

  Mammals have a LAA.   Mammals have a LAA.

- Coverage
  - Average similarity btw exemplar in premise (dog/whale) and category in conclusion (mammal)

Coverage v. Typicality

- Coverage more important than typicality for strength of induction

Dogs have a LAA.   Dogs have a LAA.

Cats have a LAA.   Whales have a LAA.

Therefore: Mammals have a LAA.

Coverage

- People less willing to generalize from an exemplar to a more abstract category than to a less abstract category.

Chimps have a LAA.   Chimps have a LAA.

Primates have a LAA. Mammals have a LAA.

Inductive Strength, Similarity, and Analogy

- Object 1 has properties A and B
- Object 2 has properties A, B, and also C.
- Therefore, it is likely that object 1 also has property C.

- Analogical Reasoning
  - Understanding new situations by projecting knowledge from previous situations of a similar sort

Analogical Reasoning

- Source (Base) Analog – domain you have a lot of knowledge about
- Target Analog – domain you are trying to draw inferences about
- Personification – using concepts relevant to people to reason about other domains

Analogical Reasoning

Source	Target		Source	Target
person	bird		person	bird
chair	tree		chair	?
			house	nest
			backyard	tree

- Heart of Analogy is Establishment of Mappings
  - Mappings – correspondences between domains
- Neal's 2nd set of mappings more complete & coherent

Constraints on Analogical Thinking

- Similarity
- Identification of Consistent Structural Parallels
- Purpose

Structure Mapping

- Overall Similarity
  - Similarity of both attributes and relations
- Relational/Structural Similarity
  - Similarity of relations
- Attributes
  - X is red
  - X is large
- Relations
  - X collides with Y
  - X is larger than Y

Steps in Structure Mapping
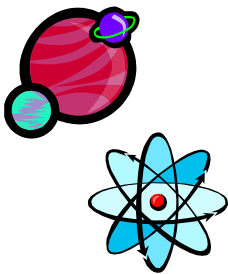
(1) Set up mappings between domains
(2) Discard attributes
   -- hot, massive
(3) Map relations from source to target
   --more-massive-than
   --revolves-around
(4) Observe systematicity
   -- discard isolated relations
   -- keep relations governed by higher-order relations

Analogy & Problem Solving

- Gick & Holyoak
- Duncker's Tumor Problem
- Impenetrable Fortress
- 10% solve problem w/no hints
- 75% solve problem when given Impenetrable Fortress problem and hint to apply it

4

Analogical Problem Solving

- Construct Representation of Source & Target
- Select Source as Potential Analog
- Construct Mapping
- Extend Mappping

Correspondences btw Problems

- *Military Problem*
- **Initial State Goal** – use army to capture fortress
- **Resources** – Sufficiently large army
- **Operators** – Divide army, move army, attack w/army
- **Constraints** – Unable to send entire army along one road safely
- **Solution** – Send small groups along multiple roads simultaneously
- **Outcome** – Fortress captured by army

- *Radiation Problem*
- **Initial State Goal** – use rays to destroy tumor
- **Resources** – sufficiently powerful rays
- **Operators** – reduce ray intensity, move ray source, administer rays
- **Constraints** – unable to administer high-intensity rays from one direction safely
- **Solution** – administer low-intensity rays from multiple directions simultaneously
- **Outcome** – tumor destroyed by rays

Correspondences btw Problems

- *Convergence Schema*
- **Initial State Goal** – use force to overcome a central target
- **Resources** – sufficiently great force
- **Operators** – reduce force intensity, move source of force, apply force
- **Constraints** – unable to apply full force along one path safely
- **Solution** – apply weak forces along multiple paths simultaneously
- **Outcome** – central target overcome by force