Analogical Reasoning

Source	Target
person	bird
chair	tree

Source	Target
person	bird
chair	?
house	nest
backyard	tree

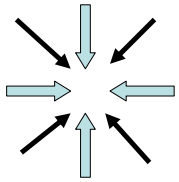
- Heart of Analogy is Establishment of Mappings
  - Mappings – correspondences between domains
- Neal's 2nd set of mappings more complete & coherent

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

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



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

- Convergence schema one of most important aspects of Gick & Holyoak's model of analogical problem solving
- Represents type of problems where this solution will work
- Abstract category in which specific analogues (e.g. tumor problem) are instances
- Construction of this abstract schema considered a 5th step in analogical reasoning

Schema Induction

- Schema Induction
  - Process where implicit features of the analogy are made explicit
- Identify elements in each domain
  - Played role in solution
  - Successfully mapped across analogs
- Gick & Holyoak (1983)
  - Schema induction major contributor to successful transfer across problem domains

Gick & Holyoak (1983)

- Group 1: 2 analogues
- Read 2 strories
  - Military story
  - Firefighting story
- Summarize both stories and tell how they were similar
- Given tumor problem to solve

- Group 2: 1 analogue
- Read 2 stories
  - Either Military story OR Firefighting story
  - Disanalogous story
- Summarize both stories and tell how they were similar
- Given tumor problem to solve

Gick & Holyoak (1983)

- People in 2-analogue group more likely to solve the tumor problem
- The closer people's descriptions of story similarities came to the convergence schema, the more likely they were to solve the tumor problem
- "many smal forces applied together to add up to one large force necessary to destroy the object"
- "in both stories a hero was rewarded for his efforts"
- Schema induction facilitates transfer to other problems

Analogy

- Abstract commonality in face of surface differences
- Bird/Tree Example
  - Understanding natural world in terms of human activities
- Atom/Solar System Example
  - Domains have almost nothing in common
  - Internal relationship is shared across domains
- X-rays/General Example
  - Externally very different problems
  - Convergence schema works to solve them both

Superficial Cues

- Superficial similarity affects retrieval of source analogs
- Gilovich

Gilovich (1981)

- Foreign policy influenced by two salient historical analogies
- Munich (WWII)
  - Misguided strategy to appease Hitler
- Vietnam
  - Intervention in foreign country a huge mistake
- Hypothesis: proposed strategy for new crisis will depend on which source analogue is retrieved for problem solving
  - Munich: solution is to intervene
  - Vietnam: hands off policy favored

Hypothetical Crisis

- Subjects students in political science class focussing on 20th century American policy
- Threatened attack by large totalitarian country (Country A) against small democratic country (Country B)
- Subjects asked to select strategy for US to follow
  - Appeasement
  - Direct miliatry intervention
  - (some intermediate possibilities)

2 Versions of Crisis

Munich
"blitzkrieg"
Refugees flee in boxcars
Through country C to country G

Vietnam
"quickstrike"
Refugees flee in boats
Sailed Gulf of C to country G

Superficial Similarities

- Superficial similarities prompt retrieval of source analog
  PRO: this is helpful
  CON: but what if there are other, potentially relevant analogs that go unnoticed?
- Like all forms of induction, analogy inherently fallible
- Do superficial similarities influence mapping process?
  - Ideally, structural similarities will influence mapping once relevant source analogue has been retrieved

Laser & Lightbulb

- Holyoak & Koh
- Lightbulb Experiment
  - ½ knew radiation problems
  - ½ didn't know radiation problem
  - 80% vs. 10% generated convergence solution
  - Lightbulb → Radiation also worked well

Holyoak & Koh Study

- Why was transfer from tumor problem better for lightbulb problem than military ("army guy") problem?
- Similar Instruments
  - Laser more similar to X-rays than to marching troops
  - This could favor retrieval of relevant analogue
- Complete Structural Mapping
  - Lightbulb problem also shared fragile container with tumor problem

Retrieval Cues: Surface vs. Structural Similarities

- Superficial Similarity – vary instrument
  - Laser vs. Ultrasound
  - Filament needs to be broken vs. fused
- Structural Similarity – vary constraint
  - Fragile Glass vs. Insufficient Intensity

Before Hint

	Surface Cue		
Structural	*Laser*	*Ultrasound*	*Mean*
Fragile-Glass	69%	38%	54%
Insufficient-Intensity	33%	13%	23%
	51%	26%	

Both surface & structural similarity aid retrieval of source analog

After Hint

	Surface Cue		
Structural	*Laser*	*Ultrasound*	*Mean*
Fragile-Glass	75%	81%	78%
Insufficient-Intensity	60%	47%	54%
	68%	64%	

Structural similarity more important for drawing analogical inferences

Implications

- Both surface & structural similarity aid retrieval of source analog
- Structural similarity more important for drawing analogical inferences

Constraints on Analogy

- Interacting Constraints
  - Similarity
  - Structural Parallels
  - Purpose
- "Good" Mapping Relative to Task
- Similarity Context- & Task- Dependent
- Structural Parallels Context- & Task-Dependent

- Which object in the bottom picture corresponds to woman in top picture?
  - Attribute mapping
- Which object in bottom picture corresponds to woman? Man? Groceries?
  - Relational mapping
- Active mapping changes perception of similarities

Figure 5.6
A pair of scenes in which attribute and system mappings conflict for an object. The woman in the picture is receiving food from a man, while the woman in the bottom picture is giving food away to a squirrel. Attribute mapping encourages matching the woman in the top scene to the woman in the bottom scene, but system mapping encourages matching the woman in the top scene to the squirrel in the bottom scene. From Markman and Gentner (1993). Reprinted by permission.

Perception of Similarity Depends on Mapping Process

Pragmatic & Syntactic Constraints

- Hofstadter's Copycat Project
  ABC: ABD :: PQRS: ?
  PQRT
  PQRD
  PQST
- Replace the rightmost letter in an ascending sequence with its alphabetic successor.
- Replace the rightmost letter with a 'D'

Letter String Analogies

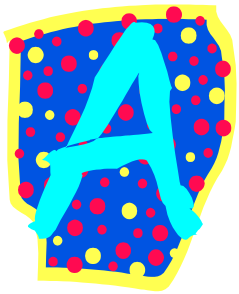
- Letter String Analogies depend on relations among elements
  ABC: ABD::PPQQRRSS:?
  PPQQRRST
  PPQQRRTT

Cluster – multiple tokens of the same single letter type

Replace the rightmost cluster with a cluster composed of its alphabetic successor

Lessons from Letters

- Although toy domain, people bring linear ordering categories to bear
- Varied answers demonstrate "sameness" applies at different levels of abstraction
- Analogical mapping can force reperception of structure in source analog



Analogy & Metaphor

- Importance of Analogical Reasoning Evident in Metaphorical Language
- Metaphoric Language Expresses Covert Analogies

"But I cannot deny my past to which myself is wed
The woven figure cannot undo its thread."
-- Louis MacNeice, *Valediction*