

Reasoning and Mental Models

- Mental models
- Naïve physics
- Scientific reasoning

Reasoning about devices



Mental Models

- Mental models allow us to reason about devices
 - Kind of like scripts and schemas discussed earlier
- People often have causal information about the way things work.
 - Used to allow us to get through the world
 - Information may be flawed
- Three types of mental models
 - Logical mental models
 - Analogical mental models
 - Causal models

Logical mental models

- Used to solve logic problems
 - Johnson-Laird
 - Contain “empty” symbols that are manipulated

All Archers are Bankers
 No Bankers are Chemists
 ?

A B
 A B
 A B
 B
 B

A B
 A B
 A B
 B
 B C
 C

All Archers are Bankers
 No Bankers are Chemists
 No Archers are Chemists

Useful primarily for logic puzzles

Analogical mental models

- Sometimes we understand one device by analogy to another.
 - Electricity and water flow

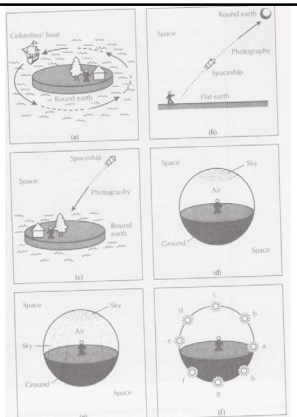
Voltage	<->	Water pressure
Current	<->	Flow rate
Resistance	<->	Width of pipe

What happens to the current in a circuit when the resistance is increased?

Might visualize a pipe being constricted. It would be harder for water to get through the narrower pipe, and so the current would decrease.

Causal Models

- Causal models
 - Vosniadou & Brewer
 - Contain causal information
 - Go beyond what we learn
 - May have flaws



Naïve physics

- What would happen to a ball shot through this pipe?

- People often respond by assuming curvilinear momentum
 - McCloskey and Proffitt
- Even happens if they carry out an action.

- What would happen to a bomb dropped from this plane?

Why do we err?

- Our naïve physics matches our observations
 - The world has friction, and so there are unseen forces that act in opposition to seen forces
 - Our naïve physics is often accurate for things we can do with our bodies
 - Only when we create larger machines do the differences become important.
- Should not be a surprise
 - Newtonian physics is only a few hundred years old
 - Aristotelian mechanics is closer to our daily experience

How deep are our models?

- Shallowness of explanation
 - Keil and colleagues
- People believe they understand more than they do
 - Asked college students about devices
 - Toilet, Car ignition, Bicycle derailleur
 - Said they understood devices
 - Could not actually explain them
 - Why does this happen?
- Knowledge is packed
 - When we know how to use an object and it is familiar, we believe we know how it works.



Scientific reasoning

- Scientific reasoning
 - Combination of abilities
- Hypothesis testing
 - Generate an explanation for some phenomenon
 - Develop an experiment to test the hypothesis
 - Seek disconfirming evidence
- How good are people at this type of reasoning?
 - How good are scientists at living up to this ideal?

Hypothesis testing

- People tend to have a confirmation bias.
 - We seek confirming evidence
- Wason 246 task
 - You are told to find a rule that generates “correct” three number sequences.
 - You are told that 2-4-6 is a “correct” sequence.
 - You search for the rule by testing as many sequences as you want until you are confident you know the rule.

Confirmation bias

- Many people initially assume the rule is “Sequences increasing by 2”
 - They try sequences like “4-6-8” and “13-15-17”
 - These are sequences that would confirm their hypothesis
 - Few people try sequences that would disconfirm their hypothesis (e.g., “1-2-3” or “3-2-1”)
 - The actual rule is “Any increasing sequence”
 - Few people find the correct rule
- Scientists also show a confirmation bias
 - They tend to be more critical of evidence that is inconsistent with their beliefs.
 - This may not be a bad thing (Koehler)

People make good tests

- Despite confirmation bias, adults do seem to understand what would make a good study
 - Will generate tests that vary only one thing at a time
 - Will look for differences based on the factor manipulated
 - Probably has something to do with education
 - Children must learn this skill
 - Still show a confirmation bias
 - If results of study are inconsistent with prior beliefs, people may stick with their prior beliefs.

Summary

- Mental models
 - Logical mental models
 - Analogical mental models
 - Causal mental models
- Naïve physics
 - Physical beliefs sometimes diverge from truth
 - Sufficient to get us around the world
- Scientific reasoning
 - People generate pretty good tests
 - Often show a confirmation bias.