Cognitive Systems

Foundations of Information Processing
in Natural and Artificial Systems

Lecture 8

Problem Solving, Insight, Creativity, GPS

Universität Bremen

Memory and Reasoning

- Problem Solving
- Insight
- Creativity
- Reducing Problems
- GPS

Problem Solving

Problem:

1. A question or situation that presents uncertainty, perplexity, or difficulty

2. ...

3. A question put forward for consideration, discussion, or solution

[The American Heritage Dictionary]

Task:

1. A piece of work assigned by a superior or done as part of one's duties.

Problem Solving ...

... consists of reducing the *problem* to a *task* and then performing the task.

Psychological Approaches to Studying Problem Solving

- Verbal reports / protocols
  - concurrent verbalization
  - retrospective verbalization
- New interpretation of a situation
  - new perception vs. functional fixedness
  - new representation vs. set effects
- Analogy
  - offering hints about how to solve a problem

Example Problem

- Given: a glass of water and a glass with an equal amount of wine
- You transfer a spoon full of water from the first glass to the second; then you transfer a spoon full of mix from the second to the first glass
- Problem:
  is the wine:water ratio in the first glass
  greater, equal, or smaller
  than the water:wine ratio in the second glass
  after these transactions?

Your Solution

Second Example Problem

You look into a mirror almost every day.

- Have you ever thought about why a mirror inverts right/left and does not invert bottom/top?

Your Solution

Insight

Archimedes had the problem of how to determine the volume of a crown so as to determine if it was pure gold or a gold/silver alloy.

He knew how to determine the volume of simple geometric objects, but a handcrafted crown posed a problem

Archimedes knew that gold had a different specific weight than an alloy

Archimedes in the Bath Tub

- When Archimedes stepped into his bath tub he noticed that the water level rose
- This led to his insight into how to determine the crown's volume
- Insight that volume of irregularly shaped body corresponds to volume of displaced fluid which can be measured easily
- Analogy between crown and human body

Non-Insight Problems vs. Insight Problems

- Gradual progress ("getting warmer" – getting closer to the solution) for non-insight problems
  - problems require series of steps whose difficulty can be assessed
  - ability to predict solvability of problem
- Breakthrough *("Heureka")* for insight problems
  - problems require crucial breakthrough that gives a new perspective on the problem
  - solvability can hardly be predicted

Creativity

- Creativity is a novel and relevant process
- Are creative solutions arrived at by different processes than non-creative solutions?

Traditional View on Creativity

Wallas (1926):

- Preparation: people must have some experience with problem to enable creative solution
- Incubation: people need to take some time away from the problem
- Illumination: During or after incubation, a solution shall become clear to the person
- Verification: Although the person has a solution, that solution must be verified as correct

Open Issues with Traditional View

- Problem solving stages cannot be verified
- Can creativity be separated into discrete stages?
- Memories about problem solving process frequently are distorted; e.g. a subject reports the problem solution illuminated him during a dream; other evidence suggests that the solution had been sketched out previously.
- Phenomenological description of events rather than a theory about the process that produces creativity

Alternatives to the Traditional View

- Incubation as release from memory interference
- Incremental continuous rather than discrete insightful process
- Problem finding, examining exactly what the problem is

Incubation as Release from Memory Interference

- Memory interference has been found to sometimes hamper task performance
- Perhaps memory interference sometimes causes poor problem solving performance
- Incubation, or spending time away from the problem, may then allow the person to be released from that interference

Incremental Process

- Some have suggested that creativity is really an incremental, continuous process, rather than a discrete, insightful process
- A person works with or plays around with the situation until a solution is found, and the solution may be a creative one

Problem Finding, Identification

- Problem solving involves an element of problem finding / problem identification
- Creative solutions occur when the person has found – or identified – a new problem, rather than perceiving the same old problem everyone else has been perceiving

Approaches to Reducing Problems

- Search
- Problem analysis
- Divide and conquer
- Analogy making

- For all approaches it is essential to make a vague or ill-defined problem precise or well-defined

General Problem Solver (GPS)

- Newell and Simon devised the GPS, as the first computer simulation of problem solving
- GPS assumed serial processing, STM, LTM, and that heuristics were important for problem solving

GPS

- GPS analyzes a problem to create a goal stack
  - final goal at bottom of stack
  - series of sub-goals on top of it
- GPS uses means-end-analysis (a continuous examination of the difference between current state and goal state, so as to choose best action to decrease that difference
- GPS was quite successful at solving wide range of problems

Difference Between GPS and People

- People are resistant to make moves that take themselves away from the goal, even if that is the only legal move available
- people are reluctant to backtrack, even though backtracking is sometimes necessary to achieve the final goal – GPS backtracks without a hitch
- GPS sometimes gets caught trying to solve sub-goals that are no longer appropriate
- GPS needs well-defined goals and problem spaces before it can do anything

Next week

- **Mental Representations**

  - Analogical Representations
  - Mental Models
  - Preferences