


Cognitive Psychology

Problem Solving Stages

Lesson VIII: Problem Solving
module 37



University of Idaho

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Taxonomy of problems

- **Goals and operators**
 - When trying to solve a problem, the problem solver is trying to achieve a particular goal
 - Operators refer to all possible actions / paths a problem solver can take at each point in time
- **Well-structured problems**
 - Clear path to a solution
 - Goals and operators are known
- **Ill-structured problems**
 - Unclear path to a solution
 - Neither the goal, nor the operators, sometimes even the problem itself is clear

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The range of problems

- **Well-structured problems**
 - $4 + 5 = ?$
 - The ratio of blue socks to red socks is 5:1. How many socks do you have to pick blindfolded until you have at least one pair of the same color.
 - Cannibals and missionaries
- **Ill-structured problems**
 - Connect the following three points with four straight lines without moving the pen from the paper.

x	x	x
x	x	x
x	x	x
 - **\$10 challenge: can you do it with 3 straight lines (again, don't move the pen from the paper!)**

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Cognitive Psychology **Problem solving - an overview**

- **How do humans solve problems?**
What are common problem-solving problems?
 - Stages in the problems-solving process
 - Problem solving strategies / heuristics
 - What is insight? Incubation?
 - Problems in problem solving:
Mental set, functional fixedness, transfer
 - Analogies, problem structures
 - What makes an expert problem solver?

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Cognitive Psychology **Stages of the problems solving process**

- **Stage model according to Sternberg**
 - Problem identification
 - Problem definition and representation
 - Strategy formulation / implementation
 - Organization / interpretation of information
 - Resource allocation
 - Monitoring
 - Evaluation

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Cognitive Psychology **Problem definition and representation**

- **The basic problem**
 - The ease of a solution often depends on
 - ... how the problem is phrased (its surface structure)
 - ... and what underlying assumptions are "imported"
- **Applied problems**
 - Most real problems are ill-defined
 - Sometime not even the outcome measure can be agreed upon (e.g., policy making)
 - Examples: how can we improve public education?

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Cognitive Psychology **A sample problem**

- Identify the rule behind each sequence. What is the next number?
- What is the rule behind each sequence?

1 2 3 4 5 6 7 _ ?

1 8 2 7 3 6 4 _ ?

8 5 4 9 1 7 6 _ ?

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Cognitive Psychology **Problem structure**

- **Deep structure vs. surface structure of a problem**
 - The deep structure of a problem refers to the the abstract form of the problem
 - The surface structure of a problem refers to the context and in which the problem is embedded
- **Isomorphic problems**
 - ... are two problems which only differ in their surface structure, but are based on an identical deep structures
 - Example: An accountant can apply his business knowledge to all kinds of enterprises

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Cognitive Psychology **Isomorphic problem structure**

- **Banana vs. milk example**
 - GOAL: you want to cut off a quarter of a banana
 - You first cut the banana in half
 - Then you cut one of the two halves
 - GOAL: you want to get a quarter of a gallon of milk and you only have two large, equal containers of which you don't know the volume
 - First step: you fill each of the containers so that they hold the same amount
 - Second step: you dump the content of one and distribute the remaining content between equally between the two containers
- **Accounting example**
 - An accountant can apply his business knowledge to all kinds of enterprises

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Cognitive Psychology **Problem space (Newell & Simon, 1972)**
[Newell & Simon developed the General Problem Solver]

- **Most well-defined problems can be represented in a problem space**
 - Define the current state
 - Define all possible transitions from one state to another state using the possible operators
 - Define the goal state
- **Problem solving then consists of ...**
 - A path from the current state to the goal state
 - The transitions indicate the operators to be used
 - Computers can use algorithms to find possible paths by trying a huge number of paths
- **Humans often rely on heuristics**
 - *heuristic*: strategy that often works effectively

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Cognitive Psychology **Problem solving strategies**
(efficiency depends on problem representation)

- **Analysis and hierarchical problem solving**
 - Breaking the problem up into sub-problems
 - Solve series of sub-problems until done
- **Heuristics**
 - Means-ends analysis: Reduce distance between current state and goal state
 - Working forward, backward
 - Generate and evaluate
- **Problem solving by analogy**
 - Try to find an analogous problem (isomorphic problem structure) that has been solved
 - Transform the solution to new problem

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Cognitive Psychology **Organization of information**

- **Which piece of information is relevant?**
 - Depending on the state of the problem solving process different parts of the given information are relevant or have to be sought out
- **Reinterpretation of information**
 - Value / interpretation of information can change:
 - Example: the series problem earlier in this module
 - The woman who married 20 men (textbook)

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Cognitive Psychology **Resource allocation and monitoring**

- **Strategic decisions - metacognition**
 - How to allocate time? Energy? Money?
 - Experts emphasize planning stage
 - Novices embark on "local" planning and execution
- **Monitoring**
 - State of the problem solving progress
 - Re-evaluation of problem solving approach
 - Evaluation of distance from goal
 - Estimate of problem completion

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Cognitive Psychology **Evaluation**

- **Is this solution a valid / workable solution?**
 - Checking solution against constraints
 - Reorganization of problem solving steps
 - Cleaning up
- **Feeling accompanying insight - "ah-ha" experience**
 - *Insight*: distinctive and sometimes seemingly sudden understanding of a problem or strategy to solve the problem. Often reconceptualizing a problem in a new way.
 - Pieces "fall into place" - Evaluation feels redundant.

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