Problem Solving

What blocks solutions?
Problem Solving

- Representation
- Solutions (operations, procedure)
Problem Solving
  – Representation
  – Solutions (operations, procedure)

Often, correct solution obvious from correct representation.
Red Adair

An oil well in Saudi Arabia exploded and caught fire. The result was a blazing inferno that consumed an enormous quantity of oil each day. After initial efforts to extinguish it failed, famed firefighter Red Adair was called in. Red knew that the fire could be put out if a huge amount of fire retardant foam could be dumped on the base of the well. There was enough foam available at the site to do the job. However, there was no hose large enough to put all the foam on the fire fast enough. The small hoses that were available could not shoot the foam quickly enough to do any good. It looked like there would have to be a costly delay before a serious attempt could be made.

However, Red Adair knew just what to do. He stationed men in a circle all around the fire, with all of the available small hoses. When everyone was ready, all of the hoses were opened up and foam was directed at the fire from all directions. In this way a large amount of foam quickly struck the source of the fire. The blaze was extinguished, and the Saudis were satisfied that Red had earned his three million dollar fee.
Imposition of Extra Constraints
9-dot problem

Connect all dots using 4 straight lines without lifting pencil from paper.
9-dot solution
Battleships

Move 4 to form 5 straight rows of 4 ships each.
Solution #1
Reiteration of Problem

Move 4 to form 5 straight rows of 4 ships each.
Solution #2
By handling only one glass, change the arrangement so that no full glass is next to another full glass and no empty glass is next to another empty glass.
Solution: Pour contents of 2nd glass into the 4th glass.
Imposition of Extra Constraints

Constraints suggested by problem
Set Effects
<table>
<thead>
<tr>
<th>Heavenly Bodies</th>
<th>Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>uvnes</td>
<td>rbaes</td>
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<tr>
<td>lpnaet</td>
<td>ohsres</td>
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<td>asrm</td>
<td>astc</td>
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<tr>
<td>tras</td>
<td>astr</td>
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<tr>
<td>onmo</td>
<td>cemi</td>
</tr>
</tbody>
</table>
O T T F F F F S S S S S S
Move just 3 sticks to make 4 squares. Use all 16 sticks.
Solution
Divide into 4 parts that are identical in shape and size.
Solution
Functional Fixedness
Candlestick Problem

Given:

Task: Attach candle to wall

(Duncker, 1926)
Insight vs. Incremental Problems
Judgments of Liklihood of Solution

* Insight problems: man who married dozens of women and is not a bigamist

* Incremental problems: algebra

* Ss gave warm-cold ratings 1-7 every 15 seconds
1 = Cold.....................7 = Warm

<table>
<thead>
<tr>
<th>Insight Problems</th>
<th>Incremental Problems</th>
</tr>
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<tbody>
<tr>
<td>-15 sec</td>
<td>1-2</td>
</tr>
<tr>
<td>-30 sec</td>
<td>1-2</td>
</tr>
<tr>
<td>-45 sec</td>
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<td>-60 sec</td>
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<td>- 45 sec</td>
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<td>1-4</td>
</tr>
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<td></td>
<td>- 60</td>
</tr>
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<td>1-4</td>
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</tbody>
</table>
Failure to Transfer
Radiation Problem

Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the patient, but unless the tumor is destroyed the patient will die. There is a kind of ray that can be used to destroy the tumor. If the rays reach it all at once at a sufficiently high intensity, the tumor will be destroyed. Unfortunately, at this intensity the healthy tissue the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue, but they will not affect the tumor, either. What type of procedure might be used to destroy the tumor with the rays and at the same time avoid destroying the healthy tissue?
Hint 1: Something earlier in lecture may help you
Hint 1: Something earlier in lecture may help you

Hint 2: Remember Red Adair
Military Problem

A small country was ruled from a strong fortress by a dictator. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads led to the fortress through the countryside. A rebel general vowed to capture the fortress. The general knew that an attack by his entire army would capture the fortress. He gathered his army at the head of one of the roads, ready to launch a full-scale direct attack. However, the general then learned that the dictator had planted mines on each of the roads. The mines were set so that small bodies of men could pass over them safely, since the dictator needed to move his troops and workers to and from the fortress. However, any large force would detonate the mines. Not only would this blow up the road, but it would also destroy many neighboring villages. It therefore seemed impossible to capture the fortress.
Gick & Holyoak, 1980

* Solve problem (radiation)

* Read/remember story of one problem (military); later solve problem (radiation)

* Read/remember military, get hint, solve radiation
Gick & Holyoak, 1980

* Solve problem (radiation)

* Read/remember story of one problem (military); later solve problem (radiation)

* Read/remember military, get hint, solve radiation

Hint: In solving problem, you may find that one of the stories you read before will give you a hint for solving the problem
Success at Solving Problem

- no memory task: solve radiation 10%
- remember military: solve radiation 30%
- remember military + hint: solve radiation 75%

(Gick & Holyoak, 1980, 1983)
Life doesn’t provide you with hints
Three attempts to induce transfer

* Subjects told to summarize story in abstract terms

* General Principle provided

* Diagram
General principle given:

The General said: “if you need a large force to accomplish some purpose, but are prevented from applying such a force directly, many smaller forces applied simultaneously from different directions may work just as well.”
Diagram

Plan A

rejected

Plan B

accepted

(Beveridge & Parkins, 1987)
All failed to increase transfer!
Perhaps a single example is insufficient for transfer
Perhaps a single example is insufficient for transfer

* Subjects given two stories

* Subjects wrote down basis for similarity
Perhaps a single example is insufficient for transfer

* Subjects given two stories

* Subjects wrote down basis for similarity

This worked!
Determinants of Transfer Success

* More transfer when schema more abstract

* More transfer when stories more similar

* More transfer with diagram or principle
Moral:

* We think concretely

* For transfer, we need to think abstractly
Abstract Thinking Separates Experts from Novices
Abstract Thinking Separates Experts from Novices

* Experts have more abstract representations

* Experts know more solutions
Abstract Thinking Separates Experts from Novices

* Algebra word problems: those who classify by abstract structure solve better than those who classify by surface structure (content) (Silver, 1981)

* Computer commands: experts classify by computer functions; novices classify by conventional word meanings (Kay & Black)
Blocks to problem solution

- **Imposition of extraneous constraints**
  - suggested by problem
  - suggested by previous problems
  - suggested by tools; functional fixedness

- **Failure to transfer known solution**
  - failure to apply, to see relevance
  - representation too close to original, not abstract enough
<table>
<thead>
<tr>
<th>Temporal</th>
<th>Spatial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stages of manufacturing process</td>
<td>Office for 7 employees</td>
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<tr>
<td>priority</td>
<td>prestige</td>
</tr>
<tr>
<td>order of operations</td>
<td>order of use of reception area</td>
</tr>
<tr>
<td>same/different resources</td>
<td>compatible/incompatible work</td>
</tr>
</tbody>
</table>

(Carroll, Thomas and Mulhotra, 1980)
Monk problem

One morning, exactly at sunrise, a Buddhist monk began to climb a tall mountain. A narrow path, no more than a foot or two wide, spiraled around the mountain to a glittering temple at the summit. The monk ascended at varying rates of speed, stopping many times along the way to rest and eat dried fruit he carried with him. He reached the temple shortly before sunset. After several days of fasting and meditation, he began his journey back along the same path, starting at sunrise and again walking at variable speeds with many pauses along the way. His average speed descending was, of course, greater than his average climbing speed. Prove that there is a spot along the path that the monk will occupy on both trips at precisely the same time of day.

(from Duncker, via Koestler, The Art of Creation)
Radiation Problem

A tumor was located in the interior of a patient’s body. A doctor wanted to destroy the tumor with rays. The doctor wanted to prevent the rays from destroying healthy tissue. As a result, the high-intensity rays could not be applied to the tumor along one path. However, high-intensity rays were needed to destroy the tumor.

(Duncker)