Ways of Solving Problems

1. **Means-end analysis**
   Problem solving as search
   Start, goal, operators
   Subgoals, heuristics, hill-climbing, backtracking,

2. **Analogy**
   Solve a problem by analogy to old problem
   Tendency to miss abstract similarities between problems

3. **Brainstorming**
   Divergent vs. Convergent thinking

Pitfalls of Problem Solving

1. **Functional Fixedness**
   Bias to see only familiar use of thing

2. **Mental Set**
   Bias to solve problems in a particular way that has worked in the past

3. **Wrong representation**

4. **Start at wrong point**
   Forward and Backward reasoning
Inducing Structure

Rearrangement problems require the rearrangement of objects to form a new relation among them. In problems of inducing structure, by contrast, the relation is fixed and the problem is to discover it. Some objects are given, and the task is to discover how they are related. For example, series extrapolation problems consist of a series such as 1 2 3 4 6 5 6 ____. The task is to find the next element of the series. Notice that there are two series in the example. One is the ascending series 1 2 3 4 5 6; the other is the descending series 8 6 ____. So the correct answer is 4. Similarly, the answer to the letter series in Table 12.1 is E.

Another example of inducing structure is analogy problems like Merchant : Sell :: Customer : Buy. The instructions might indicate that the analogy should be labeled true or false, or the last word could be replaced by a blank, with instructions to fill in the word that best completes the analogy. Analogical reasoning is of particular interest because of its use in intelligence tests. The Miller Analogies Test, which is widely used for admission to graduate school, is composed exclusively of verbal analogies. Other ability tests, such as the Graduate Record Exam (GRE) and the Scholastic Aptitude Test (SAT), include analogies among the test items.

The psychological processes used in solving an analogy or series extrapolation problem involve identifying relations among the components and fitting the relations together in a pattern (Greeno, 1978). The importance of discovering relations among the terms of an analogy is illustrated in a model proposed by Sternberg (1977). There are four processes in Sternberg’s model:

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**BOX 12.1**

**Pair of crafty inmates melt way out of jail**

SALINAS (AP)—Two crafty inmates used a length of shower pipe, a sheet and a wall socket to melt an unbreakable plastic window and escape from Monterey County’s new jail, officials said Wednesday.

A sheriff’s deputy said the pair escaped Tuesday night after using a makeshift cutting torch to reduce part of the cell window to mushy goo.

Lt. Ted Brown said the inmates wrapped a sheet around a piece of flattened shower pipe, wired the contraption and plugged it into a wall socket.

The gizmo heated up and the inmates pressed it against the window until its edge had melted away, Brown said.

Then they snapped a leg off the cell bed, placed it into the newly burned hole, pried out the entire window and skipped to freedom, Brown said.

Hill-climbing will not do

Hill-climbing
So near & yet so far
Table 12-3

The Problem:

Parade-Dispersion Story

A small country was controlled by a dictator. The dictator ruled the country from a strong fortress. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads radiated outward from the fortress like spokes on a wheel. To celebrate the anniversary of his rise to power, the dictator ordered his general to conduct a full-scale military parade. On the morning of the anniversary, the general's troops were gathered at the head of one of the roads leading to the fortress, ready to march. However, a lieutenant brought the general a disturbing report. The dictator was demanding that this parade had to be more impressive than any previous parade. He wanted his army to be seen and heard at the same time in every region of the country. Furthermore, the dictator was threatening that if the parade was not sufficiently impressive he was going to strip the general of his medals and reduce him to the rank of private. But it seemed impossible to have a parade that could be seen throughout the whole country.

The Solution:

The general, however, knew just what to do. He divided his army up into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal, and each group marched down a different road. Each group continued down its road to the fortress, so that the entire army finally arrived together at the fortress at the same time. In this way, the general was able to have the parade seen and heard through the entire country at once, and thus please the dictator.

tumor's sensitivity; the lack of such a chemical substance makes this a dead end as well. Correct solutions, on the other hand, used the third approach, often by developing an analogy to some other, better understood situation.

Gick and Holyoak (1980) adapted this problem to an in-depth study of problem solving by analogy. In one of their experiments (which we have just simulated here), subjects read the Parade story, then solved the Radiation problem. In case you didn't notice, there are strong similarities between the problems—the Parade story can serve as an analogy in helping you solve the Radiation problem. Yet Gick and Holyoak found that only 49% of the subjects who first solved the parade problem found this analogy as they worked on Duncker's radiation problem. A different initial story, the Attack-Dispersion problem (see bottom of Table 12-4), provided a stronger "hint" about the radiation problem—fully 76% of these
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 the tumor all at once at a sufficiently high intensity, the tumor will be destroyed. Unfortunately, at this intensity the healthy tissue that 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?

**Attack-Dispersion Story**

A small country was controlled by a dictator. The dictator ruled the country from a strong fortress. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads radiated outward from the fortress like spokes on a wheel. A general arose who raised a large army and vowed to capture the fortress and free the country of the dictator. The general knew that if his entire army could attack the fortress at once it could be captured. The general’s troops were gathered at the head of one of the roads leading to the fortress, ready to attack. However, a spy brought the general a disturbing report. The ruthless 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 be able to move troops and workers to and from the fortress. However, any large force would detonate the mines. Not only would this blow up the road and render it impassable, but the dictator would then destroy many villages in retaliation. It therefore seemed impossible to mount a full-scale direct attack on the fortress.

**Solution to the Radiation Problem:**

The ray may be divided into several low-intensity rays, no one of which will destroy the healthy tissue. By positioning these several rays at different locations around the body, and focusing them all on the tumor, their effect will combine, thus being strong enough to destroy the tumor.

**Solution to the Attack-Dispersion Story:**

The general, however, knew just what to do. He divided his army up into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal, and each group marched down a different road. Each group continued down its road to the fortress, so that the entire army finally arrived together at the fortress at the same time. In this way, the general was able to capture the fortress, and thus overthrow the dictator.

they worked on the radiation problem. Fully 92% of the “hint condition”
Although there is no direct evidence for this hypothesis, it is the one to which most creative thinkers seem to subscribe (Ghiselin, 1952).

The facts that the mechanisms of dreaming produce fantastic rearrangements of recently activated items in memory (Breger,
A—fill jug B, subtract C twice from it, then subtract A from it to yield the necessary amount (subtracting A can be done before subtracting 2C, of course). Subjects with such a set or Einstellung generally failed to notice the far simpler solution possible for problems 6 and 10, simply A — C. That is, about 80% of the subjects who saw all 10 problems used the lengthy B — 2C — A method for these problems, compared to only 1% of Luchins' control group subjects, who saw only problems 6 through 10. Clearly, the control subjects had not developed a set for using the lengthy method, so they were much more able to find the simpler solution. Furthermore, only 5% of the control subjects failed to solve problem 8. This was a remarkable result since the “negative set” subjects, those who saw all 10 problems, performed very poorly on problem 8—fully 64% failed to solve it correctly. These subjects had such an orientation toward the method they had already developed that they were surprisingly unable to generate a method that would work on problem 8 (note that B — 2C — A does not work on this problem). Greeno's (1978) description here is very useful—by repeatedly solving the first seven problems with the same formula, subjects learned an “integrated algorithm.” This algorithm was strong enough to bias their later solution attempts and prevent them from recognizing the simpler solution.
Another demonstration of functional fixedness is an experiment by Duncker (1945). The task he posed to subjects is to support a candle on a door, ostensibly for an experiment on vision. The problem is illustrated in Figure 8-14. On the table are a box of tacks, some matches, and the candle. The correct solution is to tack the box to the door and use the box as a platform for the candle. This task is difficult for subjects because they see the box as a container, not as a platform. Subjects have greater difficulty with the task if the box is filled with tacks, reinforcing perception of the box as a container.

These demonstrations of functional fixedness are consistent with the interpretation that representation has its effect on operator selection. For instance, in Duncker's candle problem, subjects had to represent the tack box so that it could be used by the problem-solving operators that were available to them.
DIVERGENT PRODUCTION TESTS.

Try the following items, which are similar to Guilford's (1967) Divergent Production Tests.

1. Here is a simple, familiar form: a circle. How many pictures of real objects can you make using a circle, in a one-minute period?

   ![Circle](image)

2. Many words begin with an L and end with an N. List as many words as possible, in a one-minute period, that have the form L_____N. (They can have any number of letters in between the L and the N.)

3. Suppose that people reached their final height at the age of 2, and so normal adult height was less than a meter. In a one-minute period, list as many consequences as possible that would result from this change.

4. Here is a list of names. They can be classified in many ways. For example, one classification would be in terms of the number of syllables; SALLY, MAYA, and HAROLD have two syllables, whereas BETH, GAIL, and JOHN have one syllable. Classify them in as many ways as possible, in a one-minute period.

   BETH  HAROLD  GAIL  JOHN  MAYA  SALLY

5. Here are four shapes. Combine them to make each of the following objects: a face, a lamp, a piece of playground equipment, a tree. Each shape may be used once, many times, or not at all in forming each object, and it may be expanded or shrunk to any size.

   ![Shapes](image)

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   | | | |
   | | | |

   ideas that are remote from one another. Creative people can take far-flung ideas and combine them into new associations that meet certain criteria.
REMOTE ASSOCIATES.

For each set of three words, try to think of a fourth word that is related to all three words. For example, the words ROUGH, COLD, and BEER suggest the word DRAFT, because of the phrases, ROUGH DRAFT, COLD DRAFT, and DRAFT BEER. (The answers are at the end of the chapter.)

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHARMING</td>
<td>STUDENT</td>
<td>VALIANT</td>
</tr>
<tr>
<td>FOOD</td>
<td>CATCHER</td>
<td>HOT</td>
</tr>
<tr>
<td>HEARTED</td>
<td>FEET</td>
<td>BITTER</td>
</tr>
<tr>
<td>DARK</td>
<td>SHOT</td>
<td>SUN</td>
</tr>
<tr>
<td>CANADIAN</td>
<td>GOLF</td>
<td>SANDWICH</td>
</tr>
<tr>
<td>TUG</td>
<td>GRAVY</td>
<td>SHOW</td>
</tr>
<tr>
<td>ATTORNEY</td>
<td>SELF</td>
<td>SPENDING</td>
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<tr>
<td>MAGIC</td>
<td>PITCH</td>
<td>POWER</td>
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<tr>
<td>TYPE</td>
<td>GHOST</td>
<td>STORY</td>
</tr>
</tbody>
</table>

Prince...
Which Method Is Best? We have seen that problems can be represented by symbols, lists, matrices, hierarchical tree diagrams, graphs, and visual imagery. Naturally, some problems cannot be represented by some of the methods. The Buddhist monk problem will not fit into a matrix, for example. However, as we saw in the case of Keren’s coin study, some problems have several possible representations. Now that you have been exposed to six different representational formats, try Demonstration 8.5.

Which method works best for this problem? Schwartz (1971) examined

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**Demonstration 8.5 Representations of Problems.**

Read the information and answer the question at the bottom of the page. (The answer is at the end of the chapter.)

Five people are in a hospital. Each one has only one disease, and each has a different disease. Each one occupies a separate room; room numbers are 101–105.

1. The person with asthma is in Room 101.
2. Mrs. Jones has heart disease.
3. Mrs. Green is in Room 105.
4. Mrs. Smith has tuberculosis.
5. The woman with mononucleosis is in Room 104.

What are the room numbers for the others?