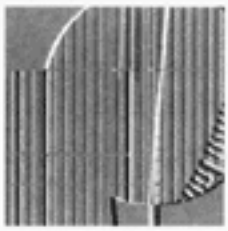
RELIANCE ON SPECIFIC RELEVANT KNOWLEDGE



Introduction

Experience plays a central role in problem solving. Many of the cases we have looked at so far required the problem solver to use knowledge that was very general. That is, besides the information presented with the problem, the problem solutions mainly called on general problem-solving methods. Often we have more specific relevant knowledge that we can use to improve our problem solving. In this section we consider a very important and often-used type of relevant knowledge, the solution of earlier problems.

Suppose you are trying to solve a homework problem for a math (or statistics) class. A very common strategy is to look through the chapter and see if you can find a problem that looks similar to your homework problem. If you can, you might use that problem to help guide you through solving the current one.

This issue of how problem solving transfers to similar problems is a crucial one. Much of education is spent having students solve problems. The goal of this problem solving is not to have the student learn to solve the specific problems given but rather to have students learn to solve related problems. This section addresses the issue of how knowledge of the solution of one problem can affect the solution of a later related problem.

The Influence of Related Problems

To benefit from earlier experience with a related problem, the problem solver must first *access* some knowledge about the earlier problem and then *apply* that knowledge to the current problem. The application or analogical mapping between an earlier situation and a current situation was discussed in the last chapter. Now we consider access: the process by which a problem solver may notice that the current problem is similar to one that had been solved earlier.

The Difficulty of Accessing Relevant Knowledge

Consider the following problem, which was introduced by Duncker (1945) and used in an important set of studies by Gick and Holyoak (1980, 1983). Try to come up with solutions to the 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 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

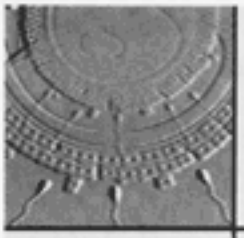
affect the tumor either. What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying the healthy tissue?

There are several possible solutions to this problem, but the one that we will be interested in is what Gick and Holyoak call the convergence solution. In this solution, several machines use the low radiation, but they are placed around the patient and converge simultaneously at the tumor. Thus, the healthy tissue receives only low doses while the tumor receives the sum of several low doses (enough to destroy the tumor). If people are simply given the problem and asked to solve it, about 10% of them offer such a solution.

Gick and Holyoak were interested in how a similar solution in an earlier story might affect the proportion of convergence solutions. They had one group of subjects read the following story, which they called the General story.

> 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.
>
> However, the general devised a simple plan. He divided his army 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 arrived together at the fortress at the same time. In this way, the general captured the fortress and overthrew the dictator.

As you can see, this story uses a solution very much like the convergence solution for the tumor problem. After subjects read and summarized this story, they were asked to solve the tumor problem under the guise of a separate experiment. Given the clear analogy, you might think that performance would be near ceiling. Surprisingly, only 30% of the subjects offered a convergence solution. Moreover, when these same subjects were given the suggestion that they should use the General story, 80% provided a convergence solution. This finding demonstrates that half the subjects could apply the General story to the tumor problem when they were instructed to but did not do so on their own. Many subjects do not spontaneously notice that the General story is similar to the tumor problem. See the box, An Enigma, for some further examples.



AN ENIGMA

Accessing Earlier Problems Is Harder Than It Looks

The difficulty of accessing earlier problems often puzzles students (and even researchers). One reaction has been to try many different ways of presenting the problems to see whether the lack of access found in the earlier studies might be due to some procedural oddities. Although there are ways to overcome access difficulties (discussed in the next section), most of the results have confirmed how difficult it is for problem solvers to access similar earlier problems that are superficially very different. We mention two further findings to help make the problem more concrete to the reader.

First, perhaps the difficulty is that the participants in these studies did not really understand what principle was being illustrated in the story about the General. To check this possibility, Gick and Holyoak (1983, Experiment 2) ended the story with a clear statement of the principle. "The general attributed his success to an important principle: 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." Adding this principle to the story had no effect on performance on the tumor problem (32% before the hint and 80% after the hint).

Second, perhaps the difficulty is that people need to think about the problem and solution in a different way, maybe in more of a picture. To examine this possibility, Gick (1985) presented the General story along

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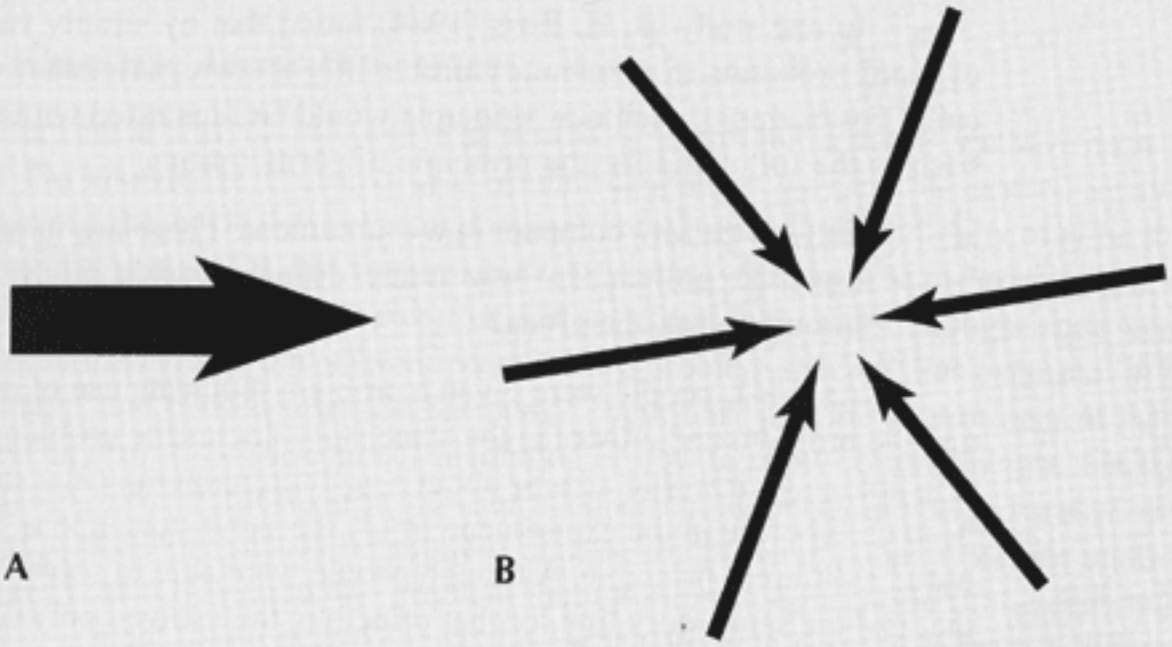
Why is this analogy so difficult for problem solvers to notice? Remember, the problem is solved very shortly after the story is read, and the story and problem do seem rather closely analogous. Given the difficulty in spontaneously noticing the analogy, what do these results mean for more natural problem-solving situations?

These questions are currently the focus of much research, but we may offer some tentative answers. First consider the experiment from the subject's point of view. The subject reads a story about a general who overcomes a dictator through a tricky solution. Then the subject is asked to solve a problem in which a person has a tumor but the radiation machines are too strong or too weak. Given these characterizations of the story and problem, why would one think of the General story as being relevant? In addition, most subjects have knowledge about medical procedures and X rays that they might believe is more relevant to the solution of the tumor problem than is a story about a general.

AN ENIGMA

Accessing Earlier Problems Is Harder Than It Looks *(Continued)*



with the diagrams shown in the figure above. Diagram A was referred to in the story as an illustration of the General's first plan to stage a full assault, and Diagram B was referred to as an illustration of the solution. Participants were told to study the story and diagrams and then to write a summary that included the diagrams. When later asked to solve the tumor problem, performance did not improve. It has been a surprise to many researchers how difficult it is to overcome these access difficulties and has led to a rethinking about how people think back to earlier problems.

More succinctly, a major part of the difficulty with noticing the analogy may be that the story and problem are stored in memory in a content-dependent way. That is, the General story is not stored as a convergence solution that happened to have a military setting but rather as a military story. The convergence solution is embedded within this story, not abstracted out in a way that might make it more available for later noticing. When the subject is trying to solve the tumor problem, which has a medical cover story, the underlying similarity to the General story is masked by the great amount of dissimilarity in the contents. In determining what knowledge might be relevant to the current problem, the memory processes will tend to suggest medical-related knowledge (e.g., see the discussion of spreading activation in memory in Chapter 6).

One possibility is that this finding reflects the difficulty of using knowledge from one domain to solve problems in another. On this view, there should be less content dependence within a single domain. However, even when all the knowledge