Chapter 1

The Case for the Prosecution: Transfer as an Epiphenomenon*

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Santayana (1905–1906/1982) implied that previous experience can transfer to new situations when he said, "Those who cannot remember the past are condemned to repeat it" (p. 423). Hegel (1832/1982) was closer to the truth saying, "What experience and history teach are this—that people and governments never have learned anything from history, or acted on principles deduced from it" (p. 703).

These two quotes are good summaries of positions concerning transfer of training. The question raised in this chapter is if things people learn can be used by them in new but similar situations. On the one hand, represented by Santayana, is the belief that a major adaptive mechanism of the human species is

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the ability to profit from experience. Humans do this by using previous experiences to advantage in new situations. They *transfer* knowledge to new situations. Santayana is careful not to say that people do profit from history. He only says that, if they don't profit, they will repeat history. The implication of the statement is that transfer is an important human capability.

On the other hand, Hegel is clear. He doesn't believe that anyone ever applied previously learned lessons from history. People, he claims, simply don't transfer what they learn in one situation to another. At first, this proposition is astounding. The progress of human civilization seems a history of transfer where new inventions arise regularly from the application of old principles to new situations. It is hard to believe that people don't transfer learning on a regular basis. It also is hard to believe that transfer is not an important explanatory mechanism for intelligence, cognition, and education, but that is exactly what I will argue.

The argument against transfer becomes more believable when one realizes that universities are full of people who are attempting to make one significant transfer. They are called professors. If a professor can apply what he or she has learned to one new, novel situation, he or she will have earned his keep. The truth is that most professors pass their entire academic careers without a single important novel insight. Novel insights as cases of transfer are probably rarer than volcanic eruptions and large earthquakes. Like any other rare event, important cases of transfer are difficult to study because no one knows exactly when or where they will occur.

Many students of human achievement think the magnificent transfers that advance human civilization really never occur. They argue that all such cases of important transfers are just many cases of smaller advances. The public never notices the smaller advances. The landmark occurs when an entire line of discoveries gets widespread recognition by singling out one link in the chain of discoveries as most significant. That single link gets the credit for all the work that has gone before. One piece of evidence supporting this position is the high frequency of major multiple discoveries, where two people discover the same thing simultaneously.

It is possible to take this line of argument one step further. It can be argued that it is not transfer we want to achieve in the solution of important problems but freedom from transfer. The creative solution to an important problem may depend on freeing the problem solver from interference from old solutions. So the question is, if we want to build creative problem solvers, should we teach people to transfer or teach them to avoid transfer? Two experiences I had illustrate that the answer to that question depends on your point of view.

The first paper I ever heard at a convention was about the operant training of a mentally retarded woman to use money. By using extensive and elaborate methods, trainers taught her to give the correct amount of money to a clerk when she bought something. She acquired these skills and could use them in the token economy in the institution. The staff decided to see if she could use the skills in a 'real' situation. They took the woman shopping in a store where she selected an item she wanted to buy. She approached the clerk to pay for it and became confused. Instead of carefully counting out the amount for the purchase, she simply took all the money from her pocket and handed it to the clerk. The clerk carefully counted out the money for the purchase, showing the retarded woman how to do it. The authors of the paper concluded that the clerk was doing the trainer's job and that additional attention would have to be given to transfer of training. They resolved to conduct at least part of the training in settings where the behavior would be used. To this day, whenever I think of transfer of training, a picture of a retarded woman handing all of her money to a clerk comes to mind.

But when most people talk of transfer of training, they are talking of headier matters, things like the solution of important scientific problems, new insights in philosophy, and drawing important lessons from history. All these are often attributed to transfer of training. I like to think of the following story as a small example of how a lack of transfer can lead to a creative solution to a problem.

Several years ago I found myself on a bus in Germany going from the rail station to my hotel. The bus driver spoke no English, and I spoke no German. This was apparent to me but it must not have been apparent to the bus driver, because he continued to speak in German. His only concession to my ignorance was that, as I looked more confused, he talked louder. Guessing that he was trying to collect the bus fare, I hit on what I considered a highly creative solution to the problem. I reached in my pocket and pulled out all the German money I had and held it out toward him. He smiled approvingly. As he took one coin at a time, he carefully explained to me, in German and pantomime, the denomination of each coin and how the coins added up to the total fare. I have used this technique frequently, and, invariably, I get a lesson in the denomination of the countries currency and the rudiments of simple math. The lesson is always given in the native language of the country that I don't speak or understand. To the best of my knowledge nobody has ever cheated me. People are always helpful and make an effort to be sure I understand what is happening. The method is one I recommend if you find yourself in a country where you don't know the currency and you don't speak the language.

My behavior is obviously similar to the behavior of the retarded woman. I must confess that, until I wrote this, the similarity never occurred to me. I was proud of my creative solution to a difficult problem and have even taught others how to use my method. Why is one case of failure of transfer considered unfortunate while the same behavior in a very similar situation is considered novel and creative? There are probably those who would argue that my behavior really consisted of appropriate transfer of some previously learned skill. The retarded woman's behavior, they would say, was simply a failure of training to transfer. Other than I am writing about these situations, I cannot discover anything that really makes one different from the other.

The point of these two stories is that it is possible to make as strong a case for failure of transfer as it is to build a case for the importance of transfer. As additional evidence, mathematicians generally make their most significant contributions early in life, often in their early 20s. Some even claim that a mathematician will not make a major contribution if he hasn't done it by 30. The explanation of the importance of youth in mathematical achievement is that, by 30, a person has so overlearned standard mathematics it is impossible to see things in a fresh or new way. That is, it is impossible to have a transfer failure. Of course, there are many other examples of people making discoveries because of transfer. Both failure to transfer and appropriate transfer are equally important in major human accomplishment.

I think there is little doubt that major transfers of training important to the future of humanity are rare events, if it is transfer that is important at all. Very little human behavior is novel and of great significance to the future of humanity. For the moment, the question of transfer's importance in human affairs will be ignored. Instead the question is how difficult it is to produce any kind of transfer and whether it is possible to increase the frequency of transfer. If people don't transfer the training they receive to new situations very often, it is reasonable to ask if they can be made to do so. If people seldom transfer skills and if they cannot be taught to transfer, then transfer can have no importance as an explanation of individual differences in everyday behavior. The role of transfer in individual differences would be irrelevant if transfer never occurs. Before considering if transfer occurs, a formal definition of transfer is presented, followed by a brief review of what is already known about transfer.

A DEFINITION OF TRANSFER

Transfer is the degree to which a behavior will be repeated in a new situation. This definition seems simple. How the concept applies to each real situation is what is difficult to specify. In a trivial sense, all repeated behavior must be transferred. Each occasion the behavior occurs is different than the last, even if it only differs in the moment it is performed. Discussions of transfer are usually not concerned with nearly identical situations. If the situations studied are nearly identical, differing only by a short temporal interval, then interest is said to be in learning. If two situations where the same behavior occurs are obviously different in important ways, interest is in transfer.

Two types of transfer are often distinguished. *Near transfer* is to situations that are identical except for a few important differences. A person learns to draw a three-inch line and returns 2 weeks later to learn to draw a five-inch line. Any advantage in learning to draw a five-inch line could be attributed to near transfer from learning to draw a three-inch line. On the other hand, if a person in a list-learning experiment memorized a poem faster because of participation in the list-learning experiment, the transfer would be called *far transfer*. Transfer can be conceptualized as a continuum of situations progressively more different from the original learning experience. The more similar the original learning situation and the new situation, the more likely the transfer is to be called near transfer. The more difficult the original and new situations, the more likely the transfer is called *far transfer*.

Another useful distinction is between specific and nonspecific transfer. In *specific* transfer, the learner transfers the contents of learning to a new situation. Suppose a list-learning experiment taught the states and their capitals. If knowing state capitals was helpful in a later geography course, it would be a case of specific transfer. If list-learning helped in memorizing poetry, the specific content of the original learning experience could have no influence on the later learning of poetry. The act of learning a list in a laboratory teaches *nonspecific* things, like how to use strategies, how to break up practice, or how to maintain motivation. It is general skills or principles that transfer to the new situation in nonspecific transfer, sometimes called *general transfer*.

A more recent distinction between transfer situations drawn mainly by cognitive psychologists goes by several names. The main distinction is between the deep and surface structure similarities of a situation. An example is that all car dashboards give the same information, but that their dial configurations are different. *Deep structure* is the same but *surface structure* is different. On the other hand, an airplane dashboard contains dials similar to a car's, but the information presented by those dials is different. For car and plane dashboards, there is a similar surface structure but a different deep structure.

When transfer is discussed, greatest interest usually is in far, or general, transfer of deep structure and not in near transfer of surface structure. Transfer of general principles between markedly different situations is most important to those who explain individual differences in terms of transfer. It is far transfer of deep structure that most researchers would characterize as typical of highly intelligent behavior and an important adaptive mechanism of the human species. It is also far transfer of deep structure that is most difficult to get.

A HISTORY OF TRANSFER

Transfer has been one of the most actively studied phenomena in psychology. Regardless of orientation, philosophical perspective, or school of psychology, nearly everyone has something to say about transfer. Unfortunately, most of the history of transfer confirms Hegels remark that we seldom learn anything from history. Though there are many well-established experimental findings, they often have been ignored. It, therefore, seems advisable to review briefly the most important parts of the history of transfer.

Thorndike

E.L. Thorndike conducted a classic series of studies designed to assess the degree people transfer. These studies spanned a quarter of a century. One of the first conducted (Thorndike & Woodworth, 1901) in this series illustrates the general findings of this research.

Subjects estimated the area of rectangles between 10 and 100 sq cm. To help in estimation, subjects had three comparison squares of 1, 25, and 100 sq cm. After sufficient practice to produce improvement (1,000 to 2,000 trials) on the original series, subjects got two test series. The first test series consisted of rectangles between 20 and 90 sq cm not included in the original training series. The second test series consisted of shapes other than rectangles, like triangles and circles. On the second test series, errors after training were about 90% as large as errors before training. Thorndike and Woodworth concluded that there was practically no improvement on the general skill of judging the area of figures. Even the identical figures of series 1 showed less improvement than those explicitly trained.

A more convincing analysis compared successively larger squares in the original test series. Thorndike and Woodworth argued that, if subjects learned associations to specific stimuli, there would be no relationship between how well a subject did on one square and how well he or she did on the next larger square. If there was transfer, learning about one square should transfer to the next larger square. Thorndike and Woodworth found there was no relationship between how well subjects did on one square and how well they did on the next. This finding clearly supported a stimulus–response explanation of learning.

The best characterization of the outcome of this study and the whole series of subsequent studies is best given by Thorndike and Woodworth, themselves:

> The mind is...a machine for making particular reactions to particular situations. It works in great detail, adapting itself to the special data of which it has had experience....
>
> Improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it.
>
> Improvements in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case. (pp. 249–250)

The principle, later proved in greater detail, is clear: Transfer is uncommon, but when it occurs at all it is between situations that are highly similar. Transfer occurs, when it occurs, because of common elements in the two situations. The amount of transfer that occurs can be predicted from the proportion of common elements shared by two situations. Learning Latin helps in learning French. Both languages have specific elements in common, since many French words come directly from Latin.

Since the classic Thorndike and Woodworth (1901) experiment there have been literally hundreds, if not thousands, of experiments reaffirming the same point. Transfer is very difficult to obtain. When it is obtained, it is most often between highly similar situations. As a recent, but highly sophisticated variant of Thorndike and Woodworth's experiment, see Homa, Sterling, and Trepel (1981). They came to similar conclusions, particularly with respect to the effects of similarity and degree of training on transfer though their study had a different motivation.

Ferguson

The theory proposed by Ferguson accounts for intelligence using transfer. This theory would appear to be a contradiction to the argument that transfer is not important in intelligence. Because Ferguson defines transfer in a unique way, even if the theory is correct, it does not contradict what I have said about transfer and individual differences.

Ferguson considered learning to be a subclass of transfer. As previously discussed, each learning trial differs slightly from the previous one. If improvement occurs from trial to trial, there must be transfer between trials. Ferguson's theory was most concerned with changes that occur in learning that could be characterized as very near transfer. His position often is cited to support the importance of far transfer in individual differences in intelligence. Nothing could be farther from the truth.

As additional support for this point, Ferguson (1956) cited studies by Fleishman and Hemple (1954, 1955). In these studies, subjects learned (i.e., received many trials on) two tasks: a complex coordination task or a discrimination reaction time task. Subjects also took a comprehensive battery of ability tests. Fleishman found that at different points in learning, different ability tests correlated with performance on the learning tests. In Ferguson's (1956) own words:

> These studies show conclusively that substantial and systematic changes occur in the factor structure of the learning task as practice continues. The abilities involved at one stage of learning differ from the abilities involved at another stage. Thus conclusive experimental evidence exists to support the hypothesis of differential transfer. (p. 127)

(For a different view of these experiments, see Ackerman, 1986, 1987, 1988.)

Ferguson regarded transfer as continuous, producing changes in ability as learning proceeded. He thought discrete conceptions of transfer (the kind discussed in this chapter) were less useful for explaining individual differences than the continuous concept he advanced. Ferguson's theory only considers very close transfer between situations even more similar than Thorndike and Woodworth studied. As such it is probably better classified as a learning theory of individual differences, not as a transfer theory.

The general conclusion must be that Ferguson's theory, though interesting in its own right, has little relationship to the issues considered here. The frequent citation of this theory as support for the importance of transfer in individual differences is unjustified.

EVIDENCE ABOUT TRANSFER

There are several sources of evidence that might be considered to decide if transfer occurs and, if so, under what conditions. A first source of evidence is reviews conducted on the subject. A second source of information is the studies that have been conducted. These studies can be divided into two types: those that claim to find transfer, and those that don't. In the following sections examples of reviews, studies that find transfer, and studies that fail to find transfer, will be considered.

Reviews

There have been several recent reviews concerning transfer. These reviews have generally been exceptionally comprehensive. The opinion of these reviewers, based on all the literature, should be a primary consideration about the importance of the transfer as a cause of individual differences. Reviewers are in almost total agreement that little transfer occurs. Though space prohibits full presentation of evidence cited by these reviewers or even a complete discussion of all the reviews, a few examples will make the case.

Baldwin and Ford (1988) reviewed articles concerned with the transfer of training in the work place. American businesses have a major stake in fostering transfer of training, since they spend up to $100 billion each year to train workers. Yet the estimate is that not more than 10% of training transfers to the job. So business wastes $90 billion each year because of lack of transfer. The transfer discussed by the reviewer is not far transfer but rather near transfer. That is, much of the training reviewed was training a person for a specific job. Even when the person learned specific skills that would be used on the job, there was a failure to transfer the skills to the job.

Perhaps the wide range of literature reviewed by Singley and Anderson (1989) is more pertinent to the issue of individual differences than the job training literature. They reviewed both the theoretical and empirical literature from

Thorndike to the present. They acknowledge evidence for near transfer. But when it comes to general transfer, they conclude: "Besides this spate of negative evidence, there has been no positive evidence of general transfer besides a few highly questionable studies" (p. 25).

They also speculate on the reason general transfer (or far transfer of principles) gets so much continued attention despite so little empirical support. In their words:

> One reason why the notion of general transfer keeps rising from the grave is that it is such an attractive proposition for psychologists and educators alike. It is the one effect that, if discovered and engineered, could liberate students and teachers from the shackles of narrow, disciplinary education. Sustaining these longings is the fact that it is very difficult to prove that something does not exist. There is always another manipulation in the psychologist's tool box to try. (p. 25)

Studies Showing General Transfer

If there has been a failure to show far or general transfer, it is not because of lack of effort. (For the rest of this chapter, I will use the terms *far* and *general transfer* interchangeably. While there are differences in the two types of transfer, there are few differences in the conclusions to be drawn about them.) Studies attempting far transfer number in the hundreds if not thousands. And there are some classics frequently cited as evidence for the existence of far transfer in humans. Those studies are a good place to begin.

Judd (1908) did an early study claiming to show general transfer. Groups of boys threw darts at an underwater target. In one group, the experimenter told the boys about how water refracted light and that the principle of refraction would be useful in hitting the target. The control group boys practiced but got no instruction. The transfer test was hitting targets at different depths. Not surprisingly, the experimental group outperformed the control group on the so-called transfer tests. The results are not surprising, because the experimental manipulation was essentially to teach the experimental group a strategy and to tell them to use it. This hardly constitutes transfer. It does show that the strategy taught was successful at producing improved performance. It does show that subjects follow directions when told to use a strategy. But it does not show anything approaching spontaneous transfer.

An appropriate experiment similar to Judd's might be able to come to this conclusion but several changes in Judd's methodology would have to be made. (It is difficult to know exactly what Judd did, since the full report of this often-cited experiment is only a few paragraphs.) Instruction on refraction of light by water would have to be given in a situation where it was not possible for subjects to make the connection between the experiment and the instruction. The main idea of general transfer is that subjects can and do use a previously learned principle in a new situation. Teaching the principle in close association with testing transfer is not very different from telling subjects they should use the principle just taught. Telling subjects to use a principle is not transfer. It is following instructions.

Another problem with the Judd experiment (and many transfer experiments) is that the experimenter was not blind to subjects' conditions. Subjects were instructed and tested in groups. It appears that the experimenter gave instructions on refraction and tested the subjects for transfer. This is often the case in transfer experiments. If the experimenter is not blind to condition the data may be recorded with systematic bias. More importantly, the experimenter may subtly influence subjects' performance. No transfer experiment should be carried out without using a double blind procedure, particularly experiments assessing general transfer.

A study by Woodrow (1927) is another of the favorites of those who cite the importance of general transfer to intelligence and education. It is obvious that some who cite the study have never read it, because it contains obvious problems. Woodrow is not to blame, because he would not have seen the difficulty when he conducted the study, but modern investigators should have no problem finding the faults.

The purpose of the Woodrow study was to compare the improvement in memorization that would occur with practice in memorization as compared to gains produced by instruction in the general principles and strategies of memorization. Both the training group and the practice group participated for about 3 hours. Nearly half the time, the training group received instruction in principles of memorizing. During that time the experimenter *told* subjects—outright told—that certain strategies would be useful in memorizing certain kinds of material. They were not given practice in using these strategies on the exact kinds of material testing was to be on. So half of the training time was used telling subjects what strategies would be most effective on the test material. Woodrow never allowed subjects to practice the strategies on the material they were tested on, though he told subjects that the techniques they were learning would be useful on that material. For example, subjects were told certain techniques would be useful for memorizing Turkish vocabulary words on the posttest. Subjects practiced these techniques on nonsense-syllable-paired associates during training.

What were the practice subjects doing during this time? While training group subjects were being told the strategy to use on the upcoming posttest, the practice group memorized poetry and nonsense syllables—lots of nonsense syllables and lots of poetry. It is not surprising that, on some posttests, the control subjects got worse and performed more poorly than they had on the pretest. Interference theory was yet to be formulated, so Woodrow can be forgiven for not appreciating the effect of extended practice on the subsequent learning of similar material.

There are further problems with the study. First, all groups performed differently on the pretests, suggesting initial group differences. Second, the control group received no filler task to provide an attentional control. These difficulties are minor compared to the major problems of the study.

What can be concluded from Woodrow's study? What I conclude, as for the Judd study, is that, if you tell subjects about strategies and methods known to improve learning on specific kinds of material, tell them to use those strategies on that material and then follow this instruction with a test of that kind of material, subjects will use the strategy to improve their performance. This hardly constitutes proof of general transfer. It simply shows that subjects at the University of Minnesota in 1927 followed instructions. The implication of this study for education, then, is that a teacher should explicitly list the exact, precise situation to which transfer is desired to occur. As suggested later, that may be exactly correct, but it is not the conclusion proponents of general transfer imply when discussing this study.

Another newer study often cited as an example of general transfer is the study by Gick and Holyoak (1980). Subjects tried to solve the classic Dunker radiation problem. In this problem a tumor must be destroyed by radiation. A single ray would destroy the tumor and the surrounding tissue. Some way must be found to concentrate the X-ray at the location of the tumor without destroying the healthy tissue the ray must pass through. The solution is to give the patient smaller rays from several directions that converge at the cite of the tumor. Only at the place where the rays converge is the tissue destroyed. This problem is hard for even college students to solve.

The study was designed to see if an analogous solved problem would aid in the solution of the radiation problem. Before the radiation problem, subjects heard a story in which a castle is to be stormed by an army. For various reasons a force strong enough cannot be sent to the fortress. Fortunately, roads radiate out from the fortress. The leader of the invading force divides his army into smaller units, each advancing on the castle using a different access road.

There is an obvious similarity between this story and the radiation problem. College students must have trouble seeing this similarity. In the Gick and Holyoak study, they were explicitly told that the first story should serve as a hint in solving the second. Even then, some subjects failed to solve the second problem. When subjects are told that previous material may be useful in the solution of a new problem, it hardly seems reasonable to refer to the solution of the new problem as the result of transfer.

Subjects have not always been explicitly told to transfer. Sometimes instructions are more subtle. Novick (1990) gave subjects three problems. For all problems, subjects got a skeleton of a solution. For the control subjects, all representations were inappropriate for the problem. For the experimental subjects, the middle problem had a correct representation. The representation was a matrix arrangement that could be used to help solve the problem. The middle problem was about making pleasing combinations of five different pairs of pants and five different shirts. All subjects then solved a problem in which five different men had five different illnesses. Based on 10 clues for solving the problem, subjects were to work out the room number and illness of each man. The transfer problem and the second practice problem required different solution methods, but the use of a matrix would be useful (in different ways) in solving both problems. In the experimental group, 75% of subjects used a matrix to solve the problem, while only 21% of control subjects used a matrix in their solution.

Novick interprets the results as evidence for a more general kind of transfer, called *representative transfer*, because subjects transferred a way of representing the problem. The author neglects several factors that would make it surprising if the results had not been as they were. First, the fact that all the experimenter-supplied methods in the control condition were inappropriate might have discouraged the subjects from searching for 'tricks' to use. Second, only one of three experimenter-supplied methods was usable in the experimental condition. The contrast must have made the usable solution particularly salient. Maybe subjects would have tried a matrix even on a problem where it was entirely inappropriate. After all, it was the only method they had that worked during practice. It also appeared that using a matrix is an obvious method of solving this sort of problem. Supporting this point, 21% of control subjects used a matrix to solve the problem though they never saw a matrix in the practice problems. Finally, the high surface similarity between the five-blouse-and-slack problem and the five-patient-and-illness problem must have been a clue to subjects that the two problems had something in common. Unfortunately, no data are given about the number of control subjects who attempted to transfer the incorrect solutions they learned to the transfer problem.

As in most other studies of transfer showing general or representational transfer, examination of the experiment reveals details that make the results so context-sensitive they cannot be generalized beyond the experimental situation. Without showing this effect in other situations, it is unreasonable to conclude that representational transfer is a general phenomenon. The Novick study does not suggest, nor did the author imply, that people's problem-solving ability or intelligence could be improved if we could make them better at representational transfer.

Another recent study claims evidence for transfer in children. Brown and Kane (1988) taught children to transfer general principles from one situation to a different one. For example, in a training problem the child would learn to stack tires on top of each other. The stack of tires let a doll reach a shelf where other tires were to be stacked. The transfer problem required children to stack bales of hay so that a farmer doll could reach a tractor. There were three sets of problems where the general principles (stacking, pulling, or swinging) were the same. The surface structure for each story in the set was different.

The 'trick' used to get children to 'transfer' in this study was that all children got all six problems. If the child was unable to solve a problem, the experimenter demonstrated the solution and then gave the next problem. Children were always asked to repeat the solution to the problem. It is not surprising that children learn the 'rules of the game' over three problem sets. Learning the rules of the game is not what most would consider transfer. This experiment is more a demonstration of rule induction than transfer.

In any event, the results hardly justify the emotional conclusion of the authors that: "Preschool children are *not* extreme Thorndikians: they transfer on the basis of underlying structural similarity; they are not totally dependent on surface features to mediate transfers" (p. 518). This conclusion is particularly interesting because a study of similar design using different stimulus materials involving one of the authors (Campione & Brown, 1974) came to much different conclusions, namely, that: "The results are consistent with the hypothesis that the probability of obtaining transfer from one task to another depends upon the similarity of the task formats" (p. 409). While investigators should be allowed the freedom of changing their minds, it is unusual to see such similar studies interpreted in such diametrically opposite fashions. There is no general transfer, at least for the major conclusions of these two studies.

The amazing thing about all these studies is not that they don't produce transfer. The surprise is the extent of similarity it is possible to have between two problems without subjects realizing that the two situations are identical and require the same solution. Evidently the only way to get subjects to see the similarity is to tell them or to point it out in some not-so-subtle way. The experimental manipulations used in these studies remind me of the field hand who had an uncooperative mule who refused to budge despite his intense urging. The farmer who owned the mule saw the situation, walked over to the mule and struck it squarely between the eyes with a baseball bat. Taking the reins, the farmer gently said, "On," and the mule bolted forward. "The most important thing," the farmer said, "is to get the mule's attention." That seems the case with transfer studies that work. Those studies that don't explicitly tell the subject to transfer all use a trick of some sort to call the subject's attention to the fact that the two problems have the same solution and that the subjects should use the solution in following problems. The experimenter's manipulations have all the subtlety of the farmer's baseball bat. I have not yet found a transfer study where a baseball bat was used, but nearly everything else has been. I have not made a thorough search of the behavior modification literature, so there may even be studies where a baseball bat or its equivalent was used to produce transfer.

Studies That Fail to Show Transfer

Other recent studies that have used more refined definitions of *transfer* have had worse luck in producing transfer. As an example of a study with astounding similarity between problems where subjects fail to show large and reliable transfer effects, consider the study by Reed, Ernst, and Banerji (1974). This study attempted to obtain transfer between two similar problems. *Similar*, in this case, is an understatement. The first problem was the missionary–cannibals problem. Five missionaries traveling through the jungle come to a river with a boat at the landing. The boat holds only three people. On the other side of the river are five cannibals who want to cross the river in the opposite direction. It is evident the boat can be used to relay both missionaries and cannibals across the river, and that, on return trips, missionaries and cannibals must share the boat. The difficulty is that cannibals may never outnumber missionaries or the missionaries will be eaten.

The second problem is the jealous husbands–wives problem and is, in every respect, identical when jealous husbands and wives replace cannibals and missionaries. The solution, of course, is identical for both problems, and the problem space has been worked out in complete detail (Simon & Reed, 1976). When subjects first get the missionary–cannibal problem to solve, and then switch to the jealous husbands problem, there is no significant transfer. When the problems are in the opposite order, there is some transfer, but only when subjects get hints about the similarity of the problems. Despite enormous similarities that are even more salient in some of Reed's later experiments, subjects generally fail to transfer a learned solution to the isomorphic problem. Remember, the subjects were college students! It is astounding that there is no transfer between two such similar situations. If transfer doesn't occur in this study, it seems reasonable to conclude that it will be hard to produce.

Another study, by Reed, Dempster, and Ettinger (1985), shows the same effect in the real-world domain of algebra word problems. In several studies, subjects saw solutions to different kinds of algebra word problems. They then solved either equivalent or similar problems. Equivalent problems were identical except for different numbers, and nothing more. In the similar problems, the solution had to be modified slightly by the subject. Four experiments showed that students could solve equivalent problems only when they had the sample problem available during solution. Subjects infrequently solved the similar condition, even under the best of conditions. One other point: Subjects were all students in a college algebra class that had not yet studied word problems. The result of this study probably wouldn't surprise algebra teachers, but it surprised me. When transfer occurs, it requires heroic efforts to produce and even with draconian measures, the amount of transfer is small.

This is not an isolated study. There are many experiments that show the difficulty of producing transfer (e.g., Reed, 1987, for another by the same author). In each case, the situations are extremely similar, and yet college students fail to transfer learned solutions from one isomorph to another. Though it might be entertaining to go through the many cases where college students fail to notice the similarity between nearly identical problems, there is not space enough for it here. The previous examples should be sufficient to make that point that what often is called transfer seldom is. Studies that show true, spontaneous transfer are rare if they exist at all.

The studies presented in the previous sections are just a small sampling of the studies that have attempted to produce transfer. Several general conclusions seem justified from the data reviewed. First, most studies fail to find transfer. Second, those studies claiming transfer can only be said to have found transfer by the most generous of criteria and would not meet the classical definition of transfer. In all of the studies I am familiar with that claim transfer, transfer is produced by 'tricks' of one kind or another. These 'tricks' most often involve just telling the subject to transfer by using hints or outright suggestions. In more subtle cases, the 'trick' includes manipulations that call the subjects attention, in obvious ways, to what the experimenter expects on the transfer problem. In short, from studies that claim to show transfer and that don't show transfer, there is no evidence to contradict Thorndike's general conclusions: Transfer is rare, and its likelihood of occurrence is directly related to the similarity between two situations.

TRANSFER AND EDUCATION

Two theories of education. There are two classic theories of education. The first, often called the *doctrine of formal discipline*, says that what should be taught are the general principles of learning and problem solving. These principles should be taught explicitly by instruction. But they should also be taught implicitly by selecting material for learning which most exercises the mind by subjecting it to formal discipline. For example, Latin and Greek are good subjects because they require the development of learning skills like memorization and they exercise the mind because of their difficulty.

As is no doubt obvious, this was the basic philosophy of a classical education. Students took courses, not so much for the content to be learned, but for the habits of mind these courses would develop. It was this theory of education that Thorndike set out to discredit in his early transfer studies. And it was this theory of education that Thorndike (1924) later discredited directly when he showed that learning Latin and geometry were no more useful in improving reasoning than other, more utilitarian courses like bookkeeping.

A modern variant of the doctrine of formal discipline accepts that neither specific nor general skills automatically transfer to a new situation. Instead, it is argued, teachers must 'teach for transfer.' Somehow, methods of instruction are to be developed which induce transfer to novel situations. It is hard to understand how a teaching methodology can be developed to promote transfer if it cannot be produced in a laboratory under controlled conditions.

The second theory of education is that if you want somebody to know something, you teach it to them. This is the philosophy of education that

Thorndike and many others since have adopted. This theory is repugnant to many cognitive psychologists and to some educators. To its opponents, the theory suggests that education is little more than the process of training parrots or producing zombie robots who regurgitate facts. The critics also argue that the main benefit of education is the degree learning transfers to new situations, that is, the degree the student can apply what has been learned to new, previously unexperienced situations in a creative way. But this argument denies the facts. To my knowledge, there is no convincing body of evidence showing college professors, to say nothing of high school graduates, regularly apply old learning to new, novel situations. We replay most of our behaviour exactly as we learn it.

I believe, as Thorndike and many others have believed, that we learn essentially what we are taught. Further, differences in effectiveness of education are largely because some are capable of learning more of what is being taught than others. This difference between people is due to biological or environmental differences. I believe the low esteem many cognitive psychologists have for the simple learning position has had a massive, intimidating effect on American education. It has made teachers feel guilty about teaching 'facts' and has prevented the use of rote learning even in appropriate situations.

A recent segment on "60 Minutes" illustrates the polarizing attitudes teachers have against 'simply teaching the facts.' A math teacher, Dr. Sikeston, wrote a series of math books based on the simple theory of education that students should be taught what they need to learn. He surveyed the math curriculum and listed the kinds of problems that students had to know. He then wrote a series of math books that presented these problems from easiest through most difficult and provided constant and regular drill on the earlier learned material. He claimed that his sequence of math books had produced substantial gains in math SAT scores for students who had used them.

The most interesting thing about this segment, ignoring whether these math books produced the kind of gains claimed, was the reaction of professional teachers. At one presentation, a member of the audience who was clearly hostile to the books asked if Dr. Sikeston's goal was to make students into robots who simply spit out math facts. At the other extreme was a teacher not being allowed to use the series in his school because the Texas Board of Education would not approve the books. The teacher was close to tears, because he felt that no other materials would be as effective with the minority students enrolled in his school. Obviously, the issue of which philosophy of education is best is a highly emotional one that polarizes practitioners.

It is not surprising that teachers show extreme attitudes. Cognitive psychologists, and other people who should know better, continue to advocate a philosophy of education that is totally lacking in empirical support. It seems the only way to enlist adherents is by emotional appeals and not empirical facts. Why should the practitioner be expected to come to sensible conclusions about educational philosophy when those who write the books are guided more by their prejudices than by existing data?

In summary, there is almost no evidence to support the educational philosophy of formal discipline or any of its variants. There is no good evidence that people produce significant amounts of transfer or that they can be taught to do so. There is, on the other hand, substantial evidence and an emerging *Zeitgeist* that favors the idea that what people learn are specific examples. Experts are experts because they have learned many more examples than novices. When the expert is studied, the behavior may look mystical and appear to be unexplainable without invoking complex concepts like transfer. However, current evidence suggests all that is necessary to be an expert is time, basic ability, and the opportunity to learn a large body of exemplars by experience.

When I began teaching, I thought it was important to make things as hard as possible for students so they would discover the principles themselves. I thought the discovery of principles was a fundamental skill that students needed to learn and transfer to new situations. Now I view education, even graduate education, as the learning of information. I try to make it as easy for students as possible. Where before I was ambiguous about what a good paper was, I now provide examples of the best papers from past classes. Before, I expected students to infer the general conclusion from specific examples. Now, I provide the general conclusion and support it with specific examples. In general, I subscribe to the principle that you should teach people exactly what you want them to learn in a situation as close as possible to the one in which the learning will be applied. I don't count on transfer and I don't try to promote it except by explicitly pointing out where taught skills may apply.

TRANSFER AND INTELLIGENCE

So far, the relationship between transfer and intelligence has been only implied. Near transfer is not the critical issue with respect to individual differences in cognitive ability. Near transfer occurs in a predictable way and differs across ability groups, as Thorndike and Ferguson both pointed out. There are two issues that need to be addressed with respect to the relationship between intelligence and transfer. The first, and perhaps most important issue, is the degree to which far (or general) transfer explains intelligence. The second issue is the degree to which any kind of transfer, either near or far, is central to an understanding of individual differences in mental ability. Each of these issues will be considered in order.

Does Transfer Account for Intelligence?

Many cognitive psychologists believe that a central deficit among those with low IQs or low school achievement is the inability to transfer. They argue that, if it were only possible to teach low IQ subjects to transfer what they learn to new situations, much of their intellectual deficit would be eliminated. Advocates of this position include practitioners (e.g., Feuerstein, 1980), researchers (Brown & Kane, 1988) and theoreticians (see Singley & Anderson, 1989, for a review of Piaget's research pertinent to this point).

There are several problems with this argument. The first is that there is no convincing evidence that far transfer occurs spontaneously. That point was made earlier. People do not spontaneously transfer even for situations that seem very similar. If there is a general conclusion to be drawn from the research done on transfer, it is that the lack of general transfer is pervasive and surprisingly consistent.

Second, if general transfer does not occur spontaneously, there is even less evidence that it can be taught to occur. In those studies claiming far or general transfer, the result can usually be explained by another mechanism. Sometimes the subject is, directly or indirectly, told what transfer is expected.

The conclusion that must be drawn from the many studies of general or far transfer attempted is that this type of transfer is a rare phenomenon. Most of this research has been done with college students who are at least in the upper half of the IQ distribution. It seems safe to say that transfer is not a phenomenon that will account for a large portion of the variance in intellectual functioning. Just the opposite conclusion seems best. People who know a lot about something are not experts because of their ability to transfer but because they know a lot about something. Chase and Simon (1973) estimated that chess experts have memorized as many as 100,000 chess facts. It seems more likely that the specific information people have learned is what makes them an expert or a novice. Acquiring the large numbers of facts needed to be an expert is based on, among other things, individual differences in basic cognitive ability. Transfer does not appear to be a very important part of this picture.

Medin and Ross (1989) carry this point a step further. Equating reasoning with intelligence, as many cognitive psychologists have in the past, they come to quite different conclusions than their cognitive predecessors. They make three major claims summarized, as follows: (a) reasoning is based on specific examples, not abstract principles; (b) induction (transfer) is not automatic but derives from the way examples are used; and (c) induction (transfer) is conservative. This last point is most important. Conservative transfer protects the learner from overgeneralization. Protection from overgeneralization is adaptive. Far transfers may take the learner out of the appropriate problem space, eliminating information essential for solving the problem (or making the induction). Medin and Ross are arguing that far transfer may be harmful, which is an open contradiction of what most in the field argue.

If general transfer cannot be shown in college students, it seems unlikely that it could play a major role in understanding intelligence. The opposite proposition, namely, that we learn specific facts and patterns of behavior, seems more likely from the evidence available. Understanding intelligence is unlikely to depend heavily on an understanding of transfer. Attempts to increase transfer are unlikely to make appreciable differences in a person's intelligence. Time would be better spent in understanding how specific domains of knowledge are learned, how they can be learned most efficiently, and what restrictions on learning are imposed by differences in basic abilities.

Transfer as an Epiphenomenon

Even if general transfer could be easily shown and amount of transfer was related to differences in IQ, there are still good reasons why transfer is not a cause of differences in IQ. The same reasoning applies to all higher order processes, often called *metaprocesses* (Detterman, 1980, 1982, 1984, 1986), such as transfer, rehearsal, executive processes, and so on. If transfer is found, it is likely there will be individual differences in transfer rate. Low-IQ subjects probably would show less transfer than high-IQ subjects, just as younger subjects show less transfer than older ones (Brown & Kane, 1988). This doesn't mean that these differences in transfer are capable of explaining differences in intelligence. That conclusion is much like claiming a Corvette goes faster than a Chevette because it has a louder engine. The loudness of the engine is a derivative characteristic of the power of the engine. While loudness may be associated with power, it doesn't explain it. If you removed the exhaust system from the Chevette, it would be louder and would go faster. That still doesn't mean that loudness explains speed. In the same way, if teaching transfer improves academic or even IQ test performance, it does not mean that transfer explains either IQ or academic achievement.

Probably transfer, like most complex cognitive processes, is a derivative of more basic processes. Although many have implied it, I know of no one who claims transfer is a basic, elementary, independent process.

Just because transfer can be explained by more elementary processes doesn't mean that it is unimportant or shouldn't be studied. It only means that transfer will not provide a fundamental explanation of individual differences in human ability. It is entirely possible that more complex, derivative processes may be more modifiable than the basic abilities that will account for intelligence.

There is some evidence to support this position from the Western Reserve Twin study (e.g., Thompson, Detterman, & Plomin, 1991). In this study, about 500 twins, about half fraternal and half identical, took tests of intelligence, academic achievement, and basic cognitive skills. Analyses of the relative contributions of heredity and environment suggested that basic cognitive abilities were less affected by environmental factors than were tests of academic achievement. This finding makes a good deal of sense. Basic abilities might be more fixed by biology than more complex, derivative skills affected by instruction. Limits on performance of complex skills are set by the basic abilities used in those skills. Because the skills are complex, it may be possible to use other abilities to compensate for deficient abilities. Biologically determined basic abilities, then, would only set very broad limits on more complex skills. As an analogy, visual acuity may be biologically determined, but even severely visually impaired persons can perform many visual tasks as well as those with perfect sight, because they use other abilities like increased attention to compensate for the visual impairment.

If this analysis is correct, appropriate instruction is extremely important in determining that each person develops to their optimum ability. The goal of education would not be to develop higher order processes but to match a person's abilities to the method of instruction. There have only been a few examples of cases where that has been done (e.g., Conners & Detterman, 1987). The main obstacle is the lack of sound ways of defining basic skills.

POTENTIAL BASIS FOR TRANSFER

The transfer that does occur, mostly near transfer, requires some explanation in terms of more basic processes if transfer is epiphenomenal. There is an emerging consensus that an important step in producing transfer is to make sure subjects notice the similarity between the original and new situation. That is, an important part of transfer, when it occurs, is that subjects attend to the dimensions relevant to the solution of the new problem.

Zeaman and House (1963) made this point when they proposed an attention theory that explained differences in learning and transfer in intellectually normal and mentally retarded subjects. They tested college students and mentally retarded subjects on simple discrimination problems. Subjects learned that a circle was correct each time they saw the choice of a square and a circle. Part of learning the problem was ignoring irrelevant dimensions such as position, color, or texture that might be irregularly associated with the circle. For example, subjects had to learn to ignore that the circle was sometimes red and sometimes green. Zeaman and House discovered the difficulty mentally retarded people have in learning problems like this. It resulted from their inability to notice the correct dimension. Backward learning curves showed that, once mentally retarded subjects found the correct dimension, learning the problem proceeded as fast as for intellectually average subjects. The Zeaman and House attentional theory provides a sophisticated analysis of transfer effects based on the likelihood of noticing the dimensions relevant to transfer. The Zeaman and House position can be regarded as a thorough operationalization of Thorndike's principles of transfer where situational similarity can be exactly specified.

A better illustration of how differences in ability can affect transfer is supplied by the following classroom demonstration. Students first learn a simple two-choice discrimination problem such as the one described above. Once they have learned to make the correct response (choose the circle) on every trial, the experimenter switches to another problem without telling the subject. The correct dimension in the new problem is position. Color and shape are no longer relevant to solution. The correct choice is decided using double alternation such that correct responses are: left, left, right, right, left, left, right, right, and so on. Mentally retarded subjects solve this problem almost instantly, but college students almost never do. This is one of those very few, instructive instances where mentally retarded persons outperform college students. The reason for this difference is that position is a much more salient stimulus dimension for mentally retarded persons than for college students. Here is a case where transfer is negatively related to intelligence.

Attention is not a particularly well-defined construct. Before transfer is fully explained, what Zeaman and House call *attention* would have to be better understood. Explaining one unexplained, complex process by invoking another unexplained, complex process is not a satisfactory answer, as Zeaman and House realized. The main point is that basic processes responsible for detecting, representing, and remembering differences between stimuli probably will be the basic processes implicated in an explanation of transfer. Such processes are very likely to include fundamental operations of perception and memory. Individual differences in transfer will not be explained until there is a more complete explanation of the fundamental operations that compose it.

CONCLUSIONS

Santayana (1905–1906/1982) expressed the general belief that previous experience can transfer to new situations when he said, "Those who cannot remember the past are condemned to repeat it." But Hegel (1832/1982) may have been closer to the truth when he said, "What experience and history teach are this—that people and governments never have learned anything from history, or acted on principles deduced from it." Transfer has been studied since the turn of the century. Still, there is very little empirical evidence showing meaningful transfer to occur and much less evidence showing it under experimental control. There are two points to be made about this observation.

First, significant transfer is probably rare and accounts for very little human behavior. Studies that claim transfer often tell subjects to transfer or use a 'trick' to call the subject's attention to the similarity of the two problems. Such studies cannot be taken as evidence for transfer. We generally do what we have learned to do and no more. The lesson learned from studies of transfer is that, if you want people to learn something, teach it to them. Don't teach them something else and expect them to figure out what you really want them to do.

The second point relates to transfer and other cognitive abilities like strategies, reasoning, and those things often called metaprocesses. These processes are epiphenomenal, because individual differences in them are caused by differences in more basic processes. The study of these epiphenomenal processes has implications for improving instruction. Such epiphenomenal processes, however, have little role in basic explanations of individual differences in intelligence and cognition. Data from the Western Reserve Twin Project and other lines of evidence show that basic cognitive abilities are less affected by environmental sources than academic achievement. This suggests that a basic understanding of mental processes will not necessarily result in more effective instruction. Basic cognitive processes and epiphenomenal derivatives may be more resistant to change than the content of those processes. Knowledge of those processes will help in formulating educational interventions. These interventions will take individual patterns of ability into account in formulating instructional strategies for developing higher order processes.

REFERENCES

Ackerman, P.L. (1986). Individual differences in information processing: An investigation of intellectual abilities and task performance. *Intelligence, 10*, 101–139.

Ackerman, P.L. (1987). Individual differences in skill learning: An integration of psychometric and information processing perspectives. *Psychological Bulletin, 102*, 3–27.

Ackerman, P.L. (1988). Determinants of individual differences during skill acquisition: Cognitive abilities and information processing. *Journal of Experimental Psychology: General, 117*, 288–318.

Baldwin, T.T., & Ford, J.K. (1988). Transfer of training: A review and directions for future research. *Personnel Psychology, 41*, 63–105.

Brown, A.L., & Kane, L.R. (1988) Preschool children can learn to transfer: Learning to learn and learning from example. *Cognitive Psychology, 20*, 493–523.

Campione, J.C., & Brown, A.L. (1974). Transfer of training: Effects of successive pretraining of components in a dimension-abstracted oddity task. *Journal of Experimental Child Psychology, 18*, 308–411.

Chase, W.G., & Simon, H.A. (1973). The mind's eye in chess. In W.G. Chase (Ed.), *Visual information processing*. New York: Academic Press.

Conners, F.A., & Detterman, D.K. (1987). Information processing correlates of computer-assisted word learning in mentally retarded students. *American Journal of Mental Deficiency, 91*, 606–612.

Detterman, D.K. (1980). Understand cognitive components before postulating metacomponents. *Brain and Behavioral Sciences, 3*, 589.

Detterman, D.K. (1982). Does "g" exist. *Intelligence, 6*, 99–108.

Detterman, D.K. (1984). Understand cognitive components before postulating metacomponents, etc.: Part II. *Behavioral and Brain Science, 7*, 280–290.

Detterman, D.K. (1986). Human intelligence is a complex system of separate processes. In R.J. Sternberg & D.K. Detterman (Eds.), *What is intelligence? Contemporary* *viewpoints on its nature and definition* (pp. 57–61). Norwood, NJ: Ablex Publishing Corp.

Ferguson, G.A. (1954). On learning and human ability. *Canadian Journal of Psychology, 8*, 95–112.

Ferguson, G.A. (1956). On transfer and the abilities of man. *Canadian Journal of Psychology, 10*, 121–131.

Feuerstein, R. (1980). *Instructional enrichment: An intervention program for cognitive modifiability*. Baltimore, MD: University Park Press.

Fleishman, E.A., & Hemple, W.E., Jr. (1954). Changes in factor structure of a complex psychometric task as a function of practice. *Psychometrika, 19*, 239–252.

Fleishman, E.A., & Hemple, W.E., Jr. (1955). The relationship between abilities and improvement in practice in a visual discrimination reaction task. *Journal of Experimental Psychology, 49*, 301–312.

Gick, M.L., & Holyoak, K.J. (1980). Analogical problem solving. *Cognitive Psychology, 12*, 306–355.

Hegel, G.W.F. (1982). Philosophy of history, from introduction. In J. Bartlett (Ed.), *Bartlett's familiar quotes* (15th ed.). Boston: Little, Brown and Company. (Original work published 1832)

Homa, D., Sterling, S., & Trepel, L. (1981). Limitations of exemplar-based generalization and the abstraction of categorical information. *Journal of Experimental Psychology: Human Learning and Memory, 7*, 418–439.

Judd, C.H. (1908). The relation of special training to general intelligence. *Educational Review, 36*, 28–42.

Medin, D.L., & Ross, B.H. (1989). The specific character of abstract thought: Categorization, problem solving, and induction. In R.J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 1, pp. 189–223). Hillsdale, NJ: Erlbaum.

Novick, L.R. (1990). Representational transfer in problem solving. *Psychological Science, 1*, 128–132.

Reed, S.K. (1987). A structure-mapping model for word problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*, 124–139.

Reed, S.K., Dempster, A., & Ettinger, M. (1985). Usefulness of analogous solutions for solving algebra word problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11*, 106–125.

Reed, S.K., Ernst, G.W., & Banerji, R. (1974). The role of analogy in transfer between similar problem states. *Cognitive Psychology, 6*, 436–450.

Santayana, G. (1982). The life of reason. Vol. 1. Reason in common sense. In J. Bartlett (Ed.), *Bartlett's familiar quotes* (15th ed.). Boston: Little, Brown and Company. (Original work published 1905–1906).

Simon, H.A., & Reed, S.K. (1976). Modelling strategy shifts in a problem solving task. *Cognitive Psychology, 8*, 86–97.

Singley, M.K., & Anderson, J.R. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press.

Thompson, L.A., Detterman, D.K., & Plomin, R. (1991). Associations between cognitive abilities and scholastic achievement: Genetic overlap but environmental differences. *Psychological Science, 2*, 158–165.

Thorndike, E.L. (1924). Mental discipline in high school studies. *Journal of Educational Psychology, 15*, 1–22.

Thorndike, E.L., & Woodworth, R.S. (1901). The influence of improvement in one mental function upon the efficiency of other functions. *Psychological Review, 8*, 247–261.

Woodrow, R.S. (1927). The effect of type of training upon transference. *Journal of Educational Psychology, 18*, 159–172.

Zeaman, D., & House, B.J. (1963). The role of attention in retardate discrimination learning. In N.R. Ellis (Ed.), *Handbook of mental deficiency*. New York: McGraw-Hill.