CHAPTER TWO

THE PSYCHOLOGY OF EVERYDAY ACTIONS

During my family's stay in England, we rented a furnished house while the owners were away. One day, our landlady returned to the house to get some personal papers. She walked over to the filing cabinet and attempted to open the top drawer. It wouldn't open. She pushed it forward and backward, right and left, up and down, without success. I offered to help. I wiggled the drawer. Then I twisted the front panel, pushed down hard, and banged the front with the palm of one hand. The cabinet drawer slid open. "Oh," she said, "I'm sorry. I am so bad at mechanical things."

Falsely Blaming Yourself

I have studied people making errors—sometimes serious ones—with mechanical devices, light switches and fuses, computer operating systems and word processors, even airplanes and nuclear power plants. Invariably people feel guilty and either try to hide the error or blame themselves for "stupidity" or "clumsiness." I often have difficulty getting permission to watch: nobody likes to be observed performing badly. I point out that the design is faulty and that others make the

same errors. Still, if the task *appears* simple or trivial, then people blame themselves.[1] It is as if they take perverse pride in thinking of themselves as mechanically incompetent.

I once was asked by a large computer company to evaluate a brand new product. I spent a day learning to use it and trying it out on various problems. In using the keyboard to enter data, it was necessary to differentiate between the the "return" key and the "enter" key. If the wrong key was typed, the last few minutes' work was irrevocably lost.

I pointed this problem out to the designer, explaining that I myself had made the error frequently and that my analyses indicated that this was very likely to be a frequent error among users. The designer's first response was: "Why did you make that error? Didn't you read the manual?" He proceeded to explain the different functions of the two keys.

"Yes, yes," I explained, "I understand the two keys, I simply confuse them. They have similar functions, are located in similar locations on the keyboard, and as a skilled typist, I often hit "return" automatically, without thought. Certainly others have had similar problems."

"Nope," said the designer. He claimed that I was the only person who had ever complained, and the company's secretaries had been using the system for many months. I was skeptical, so we went together to some of the secretaries and asked them whether they had ever hit the "return" key when they should have hit "enter." And did they ever lose their work as a result?

"Oh, yes," said the secretaries, "we do that a lot."

"Well, how come nobody ever said anything about it?" we asked the secretaries. After all, they were encouraged to report all problems with the system.

The reason was simple: when the system stopped working or did something strange, the secretaries dutifully reported it as a problem. But when they made the "return" versus "enter" error, they blamed themselves. After all, they had been told what to do. They had simply erred.

Of course, people do make errors. Complex devices will always require some instruction, and someone using them without instruction should expect to make errors and to be confused. But designers should take special pains to make errors as cost-free as possible. Here is my credo about errors:

If an error is possible, someone will make it. The designer must assume that all possible errors will occur and design so as to minimize the chance of the error in the first place, or its effects once it gets made. Errors should be easy to detect, they should have minimal consequences, and, if possible, their effects should be reversible.

Misconceptions of Everyday Life

Our lives are filled with misconceptions. This should not be surprising: we must frequently deal with unfamiliar situations. Psychologists love errors and misconceptions, for they give important clues about the organization and operation of our minds. Many everyday misunderstandings are classified as "naive" or "folk" understandings. And not just plain folk hold these misconceptions: Aristotle developed an entire theory of physics that physicists find quaint and amusing. Yet Aristotle's theories correspond much better to common-sense, everyday observations than do the highly refined and abstract theories we are taught in school. Aristotle developed what we might call naive physics. It is only when you study the esoteric world of physics that you learn what is "correct" and are able to understand why the "naive" view is wrong.

ARISTOTLE'S NAIVE PHYSICS

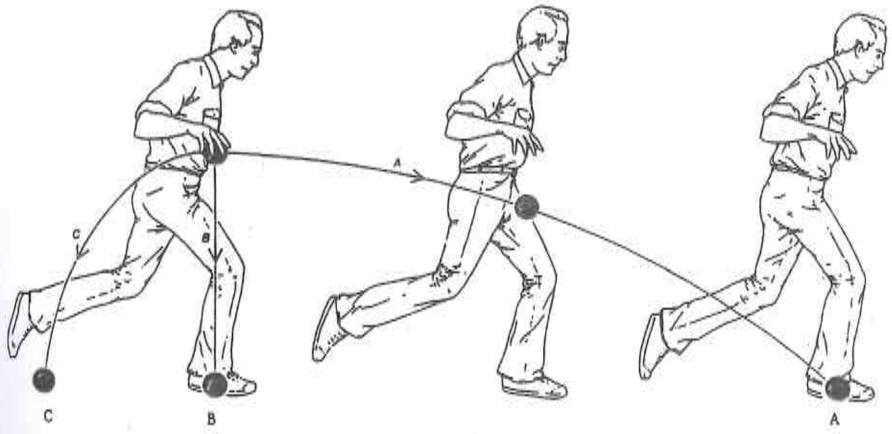
For example, Aristotle thought that moving objects kept moving only if something kept pushing them. Today's physicist says nonsense: a moving object continues to move unless some force is exerted to stop it. This is Newton's first law of motion, and it contributed to the development of modern physics. Yet anyone who has ever pushed a heavy box along a street or, for that matter, hiked for miles into the wilderness, knows that Aristotle was right: if you don't keep on pushing, the movement stops. Of course, Newton and his successors assume the absence of friction and air. Aristotle lived in a world where there was always friction and air resistance. Once friction is involved, then objects in motion tend to stop unless you keep pushing. Aristotle's theory may be bad physics, but it describes reasonably well what we can see in the real world. Think about how you might answer the following questions.

1. I take a pistol and, carefully aiming it on a level, horizontal line, I fire a bullet. With my other hand, I hold a bullet so that the bullet in the pistol and the one in my hand are exactly the same distance from the ground. I drop the bullet at the same instant as I fire the pistol. Which bullet hits the ground first?

2. Imagine someone running across a field carrying a ball. As you watch, the runner drops the ball. Which path (a, b, or c in figure 2.1) does the ball take as it falls to the ground?[1]

The physicist says the answer to the bullet problem is trivial: both bullets hit the ground at the same time. The fact that one bullet is traveling horizontally very rapidly has absolutely no effect on how fast it falls downward. Why should we accept that answer? Shouldn't the speeding bullet develop some lift—sort of like an airplane—so that it will stay up a bit longer because it is kept up by the air? Who knows? The theory of physics is based upon a situation where there is no air. The popular misconception is that the pistol bullet will hit the ground long after the dropped bullet; yet this naive view doesn't seem so strange.

2.1 **A Running Man Drops a Ball.** Which path does the ball take as it falls to the ground, path A, B, or C? When this question was asked of sixth-grade students in Boston schools, only 3 percent answered A, the right answer; the others were evenly divided between B and C. Even high school students did not do well: of forty-one students who had just studied Newtonian mechanics for a month and a half, only 20 percent got the right answer; the others were almost equally divided between B and C. (The study was performed by White & Horwitz, 1987. The figure is reprinted from *Intuitive Physics* by McCloskey. Copyright © 1983 by *Scientific American*, Inc. All rights reserved.)



In the case of the falling ball, our prediction is that the ball will drop straight down. In fact, the falling ball follows trajectory A (figure 2.1). As it is carried by the runner, it is set into horizontal motion. It then maintains the same forward speed upon being released, even as it also falls to the ground.[3]

Naive physics—and naive views of psychology and other fields—are often sensible, even if wrong. But at times they can get us into trouble. Yet we must have a way to digest the unfamiliar, for people are explanatory creatures.

PEOPLE AS EXPLANATORY CREATURES

Mental models, our conceptual models of the way objects work, events take place, or people behave, result from our tendency to form explanations of things. These models are essential in helping us understand our experiences, predict the outcomes of our actions, and handle unexpected occurrences. We base our models on whatever knowledge we have, real or imaginary, naive or sophisticated.

Mental models are often constructed from fragmentary evidence, with but a poor understanding of what is happening, and with a kind of naive psychology that postulates causes, mechanisms, and relationships even where there are none. Some faulty models lead to the frustrations of everyday life, as in the case of my unsettable refrigerator, where my mental model of its operation (figure 1.9 *A*) did not correspond to reality (figure 1.9 *B*). Far more serious are faulty models of such complex systems as an industrial plant or passenger airplane. Misunderstanding there can lead to devastating accidents.

Consider the room thermostat. How does it work? Here is a device that offers almost no evidence of its operation except in a highly roundabout manner. We walk into a room and feel too cold: so we walk over to the thermostat and set it higher. Eventually we feel warmer. Note that the same thing applies to the temperature control for a cooking oven (or a pottery kiln, or an air conditioner, or almost any device whose temperature is to be regulated). Want to bake a cake, but the oven is off? Set the oven thermostat and the oven gets to the desired temperature. Is the room too hot? Set the thermostat on the air conditioner. Fine, but how does the thermostat work?

If you are in a cold room, in a hurry to get warm, will the room heat more quickly if you turn the thermostat all the way up? Or if you want the oven to reach its working temperature faster, should you turn the temperature dial all the way to maximum, then turn it down once the desired temperature is reached? Or to cool a room most quickly, should you set the air conditioner thermostat to its lowest temperature setting?

If you think that the room or oven will heat (or cool) faster if the thermostat is turned all the way to the maximum setting, you are wrong. You hold a folk theory of thermostats. There are two commonly held folk theories about thermostats: the timer theory and the valve theory. The timer theory proposes that the thermostat simply controls the relative proportion of time that the device stays on. Set the thermostat midway, and the device is on about half the time; set it all the way up and the device is on all the time. Hence, to heat or cool something most quickly, set the thermostat so that the device is on all the time. The valve theory proposes that the thermostat controls how much heat (or cold) comes out of the device. Turn the thermostat all the way up, and you get maximum heating or cooling.[4]

The correct story is that the thermostat is just an on-off switch. It treats the heater, oven, and air conditioner as all-or-nothing devices that can be either fully on or fully off, with no in-between states. The thermostat turns the heater, oven, or air conditioner completely on—at full power—until the temperature setting on the thermostat is reached. Then it turns the unit completely off. Setting the thermostat at one extreme cannot affect how long it takes to reach the desired temperature.[5]

The real point of the example is not that some people have erroneous theories; it is that everyone forms theories (mental models) to explain what they have observed. In the case of the thermostat, the design gives absolutely no hint as to the correct answer. In the absence of external information, people are free to let their imaginations run free as long as the mental models they develop account for the facts as they perceive them.

Blaming the Wrong Cause

"Look at this!" my colleague exclaimed to me, "My computer terminal is broken. The library did it! Every time I connect it to the library catalog I have trouble. Now I can't even use the terminal to read my computer mail anymore."

"That doesn't make sense," I replied. "You can't even turn on the

power to the terminal. How could a computer program possibly do that kind of damage?"

"All I know," he said, "is that everything was working fine until I tried to look up an author in the library catalog using that new library program, and then my terminal stopped working. I always have trouble with that program. And this is simply too much of a coincidence to be anything else."

Well, it was a coincidence. It turns out that the power supply to the terminal had burned out, a fact that had nothing to do with the computer program. Coincidence is enough to set the causal wheels rolling.

Earlier I suggested that people have a tendency to blame themselves for difficulties with technology. Actually, the point is a bit more complicated. People do tend to find causes for events, and just what they assign as the cause varies. In part people tend to assign a causal relation whenever two things occur in succession. If I do some action *A* just prior to some result *R*, then I conclude that *A* must have caused *R*, even if, as in the example above, there really was no relationship between the two. The story is more complex when we intend an action to produce a desired result and fail, and there are problems when we have done the action through some intermediate mechanism.

Just where do we put the blame for failure? The answer is not clear. The psychology of blame (or, to be more accurate, of attribution) is complex and not fully understood. In part, there seems to have to be some perceived causal relationship between the thing being blamed and the result. The word *perceived* is critical: the causal relationship does not have to exist; the person simply has to think it is there. Sometimes we attribute the cause to things that had nothing to do with the action. And sometimes we ignore the real culprit.

One major aspect of the assignment of blame is that we frequently have little information on which to make the judgment, and what little we have may be wrong. As a result, blame or credit can be assessed almost independently of reality. Here is where the apparent simplicity of everyday objects causes problems. Suppose I try to use an everyday thing, but I can't: Where is the fault, in my action or in the thing? We are apt to blame ourselves. If we believe that others are able to use the device and if we believe that it is not very complex, then we conclude that any difficulties must be our own fault. Suppose the fault really lies in the device, so that lots of people have the same problems. Because everyone perceives the fault to be his or her own, nobody wants to admit to having trouble. This creates a conspiracy of silence, maintaining the feelings of guilt and helplessness among users.

Interestingly enough, the common tendency to blame ourselves for failures with everyday objects goes against the normal attributions people make. In general, it has been found that people attribute their own problems to the environment, those of other people to their personalities.

Here is a made-up example. Consider Tom, the office terror. Today Tom got to work late, slammed the door to his office, and yelled at his colleagues. "Ah," his colleagues and staff said, "there he goes again. He's so excitable—always gets mad at the slightest thing."

Now consider Tom's point of view. "I really had a hard day," Tom explains. "I woke up late because when my clock radio turned on, I tried to hit the snooze bar to give me five minutes' more sleep; instead I reset the time so that I overslept for a whole hour. That wasn't my fault—the radio's badly designed. I didn't even have time for my morning coffee. I couldn't find a close parking spot because I was late. And then because I was in such a rush I dropped my papers all over the street and got them dirty. Then when I went to get a cup of coffee from the office machine, it was all out. None of this was my fault—I had a run of really bad events. Yes, I was a bit curt with my colleagues, but who wouldn't be under the same circumstances? Surely they understand."

But Tom's colleagues see a different picture. They don't have access to his inner thoughts or even to his morning's activities. All they see is that Tom yelled at them simply because the office coffee machine was empty. And this reminds them of another time when the same thing happened. "He does that all the time," they conclude, "always blowing up over the most minor events." The events are the same events, but there are two different points of view and two different interpretations. The protagonist, Tom, views his actions as sensible responses to the trials of life. The onlooker views Tom's actions as a result of his explosive, irascible personality.

It seems natural for people to blame their own misfortunes on the environment. It seems equally natural to blame other people's misfortunes on their personalities. Just the opposite attribution, by the way, is made when things go well. When things go right, people credit their own forceful personalities and intelligence: "I really did a good job today; no wonder we finished the project so well." The onlookers do the reverse. When they see things go well for someone else, they credit the environment: "Joan really was lucky today; she just happened to be standing there when the boss came by, so she got all the credit for the project work. Some people have all the luck."

In all cases, whether a person is inappropriately accepting blame for the inability to work simple objects or attributing behavior to environment or personality, a faulty mental model is at work.

LEARNED HELPLESSNESS

The phenomenon called *learned helplessness* may help explain the self-blame. It refers to the situation in which people experience failure at a task, often numerous times. As a result, they decide that the task cannot be done, at least not by them: they are helpless. They stop trying. If this feeling covers a group of tasks, the result can be severe difficulties coping with life. In the extreme case, such learned helplessness leads to depression and to a belief that the person cannot cope with everyday life at all. Sometimes all that it takes to get such a feeling of helplessness is a few experiences that accidentally turn out bad. The phenomenon has been most frequently studied as a precursor to the clinical problem of depression, but it might easily arise with a few bad experiences with everyday objects.

TAUGHT HELPLESSNESS

Do the common technology and mathematics phobias result from a kind of learned helplessness? Could a few instances of failure in what appear to be straightforward situations generalize to every technological object, every mathematics problem? Perhaps. In fact, the design of everyday things (and the design of mathematics courses) seems almost guaranteed to cause this. We could call this phenomenon *taught helplessness*.

With badly designed objects—constructed so as to lead to misunderstanding—faulty mental models, and poor feedback, no wonder people feel guilty when they have trouble using objects, especially when they perceive (even if incorrectly) that nobody else is having the same problems. Or consider the normal mathematics curriculum, which continues relentlessly on its way, each new lesson assuming full knowledge and understanding of all that has passed before. Even though each point may be simple, once you fall behind it is hard to catch up. The result: mathematics phobia. Not because the material is difficult, but because it is taught so that difficulty in one stage hinders further progress. The problem is that once failure starts, it soon generalizes by self-blame to all of mathematics. Similar processes are at work with technology. The vicious cycle starts: if you fail at something, you think it is your fault. Therefore you think you can't do that task. As a result, next time you have to do the task, you believe you can't so you don't even try. The result is that you can't, just as you thought. You're trapped in a self-fulfilling prophecy.

The Nature of Human Thought and Explanation

It isn't always easy to tell just where the blame for a problem should be placed. A number of dramatic accidents have come about, in part, from the false assessment of blame in a situation. Highly skilled, well-trained people are using complex equipment when suddenly something goes wrong. They have to figure out what the problem is. Most industrial equipment is pretty reliable. When the instruments indicate that something is wrong, one has to consider the possibility that the instruments themselves are wrong. Often this is the correct assessment. But when operators mistakenly blame the instruments for an actual equipment failure, the situation is ripe for a major accident.

It is spectacularly easy to find examples of false assessment in industrial accidents. Analysts come in well after the fact, knowing what actually did happen; with hindsight, it is almost impossible to understand how the people involved could have made the mistake. But from the point of view of the person making decisions at the time, the sequence of events is quite natural.

At the Three Mile Island nuclear power plant, operators pushed a button to close a valve; the valve had been opened (properly) to allow excess water to escape from the nuclear core. In fact, the valve was deficient, so it didn't close. But a light on the control panel indicated that the valve position was closed. The light actually didn't monitor the valve, only the electrical signal to the valve, a fact known by the operators. Still, why suspect a problem? The operators did look at the temperature in the pipe leading from the valve: it was high, indicating that fluid was still flowing through the closed valve. Ah, but the operators knew that the valve had been leaky, so the leak would explain the high temperature; but the leak was known to be small, and operators assumed that it wouldn't affect the main operation. They were wrong, and the water that was able to escape from the core added significantly to the problems of that nuclear disaster. I think the operators' assessment was perfectly reasonable: the fault was in the design of the lights and in the equipment that gave false evidence of a closed valve.

Similar misinterpretations take place all the time. I have studied a number of airline accidents. Consider the flight crew of the Lockheed L-1011 flying from Miami, Florida, to Nassau, Bahamas. The plane was over the Atlantic Ocean, about 110 miles from Miami, when the low oil pressure light for one of the three engines went on. The crew turned off the engine and turned around to go back to Miami. Eight minutes later, the low pressure lights for the remaining two engines also went on, and the instruments showed zero oil pressure and quantity in all three engines. What did the crew do now? They didn't believe it! After all, the pilot correctly said later, the likelihood of simultaneous oil exhaustion in all three engines was "one in millions I would think." At the time, sitting in the airplane, simultaneous failure did seem most unlikely. Even the National Transportation Safety Board declared, "The analysis of the situation by the flightcrew was logical, and was what most pilots probably would have done if confronted by the same situation."[6]

What happened? The second and third engines were indeed out of oil, and they failed. So there were no operating engines: one had been turned off when its gauge registered low, the other two had failed. The pilots prepared the plane for an emergency landing on the water. The pilots were too busy to instruct the flight crew properly, so the passengers were not prepared. There was semi-hysteria in the passenger cabin. At the last minute, just as the plane was about to ditch in the ocean, the pilots managed to restart the first engine and to land safely at Miami. Then that engine failed at the end of the runway.

Why did all three engines fail? Three missing O-rings, one missing from each of three oil plugs, allowed all the oil to seep out. The O-rings were put in by two different people who worked on the three engines (one for the two plugs on the wings, the other for the plug on the tail). How did both workers make the same mistake? Because the normal method by which they got the oil plugs had been changed that day. The whole tale is very instructive, for there were four major failures of different sorts, from the omission of the O-rings, to the inadequacy of the maintenance procedures, to the false assessment of the problem, to the poor handling of the passengers. Fortunately, nobody was injured. The analysts of the National Transportation Safety Board got to write a fascinating report.

I've misinterpreted signals, as I'm sure most people have. My family was driving from San Diego to Mammoth, California, a ski area about 500 miles north: a ten- to twelve-hour drive. As we drove, we noticed more and more signs advertising the hotels and gambling casinos of Las Vegas, Nevada. "Strange," we said, "Las Vegas always did advertise a long way off—there is even a billboard in San Diego—but this seems excessive, advertising on the road to Mammoth." We stopped for gasoline and continued on our journey. Only later, when we tried to find a place to eat supper, did we discover that we had taken the wrong turn nearly two hours earlier, before we had stopped for gasoline, and that we were on the road to Las Vegas, not the road to Mammoth. We had to backtrack the entire two-hour segment, wasting four hours of driving. It's humorous now; it wasn't then.

Find an explanation, and we are happy. But our explanations are based on analogy with past experience, experience that may not apply in the current situation. In the Three Mile Island incident, past experience with the leaky valve explained away the discrepant temperature reading; on the flight from Miami to Nassau, the pilots' lack of experience with simultaneous oil pressure failure triggered their belief that the instruments must be faulty; in the driving story, the prevalence of billboards for Las Vegas seemed easily explained. Once we have an explanation—correct or incorrect—for otherwise discrepant or puzzling events, there is no more puzzle, no more discrepancy. As a result, we are complacent, at least for a while.

How People Do Things: The Seven Stages of Action

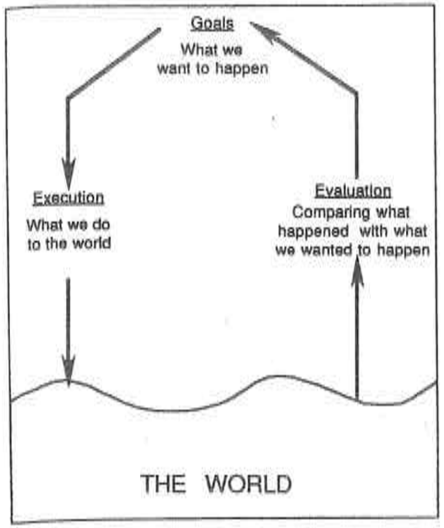
I am in Italy, at a conference. I watch the next speaker attempt to thread a film onto a projector that he has never used before. He puts the reel into place, then takes it off and reverses it. Another person comes to help. Jointly they thread the film through the projector and hold the free end, discussing how to put it on the takeup reel. Two *more people come over to help, and then another. The voices grow louder, in three languages: Italian, German, and English. One person investigates the controls, manipulating each and announcing the result. Confusion mounts. I can no longer observe all that is happening. The conference organizer comes over. After a few moments he turns and faces the audience, which has been waiting patiently in the auditorium. "Ahem," he says, "is anybody expert in projectors?" Finally, fourteen minutes after the speaker had started to thread the film (and eight minutes after the scheduled start of the session) a blue-coated technician appears. He scowls, then promptly takes the entire film off the projector, rethreads it, and gets it working.*

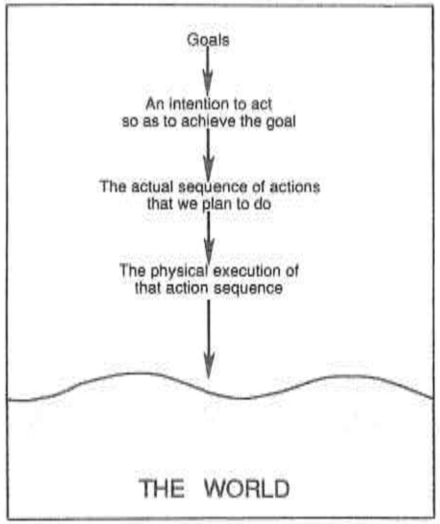
What makes something—like threading the projector—difficult to do? To answer this question, the central one of this book, we need to know what happens when someone does something. We need to examine the structure of an action.

The basic idea is simple. To get something done, you have to start with some notion of what is wanted—the goal that is to be achieved. Then, you have to do something to the world, that is, take action to move yourself or manipulate someone or something. Finally, you check to see that your goal was made. So there are four different things to consider: the goal, what is done to the world, the world itself, and the check of the world. The action itself has two major aspects: doing something and checking. Call these *execution* and *evaluation* (figure 2.2).

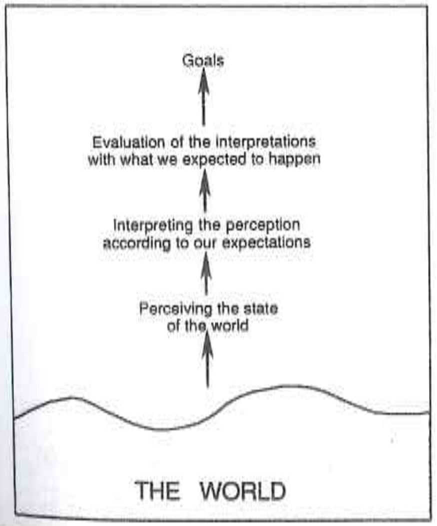
Real tasks are not quite so simple. The original goal may be imprecisely specified—perhaps "get something to eat," "get to work," "get dressed," "watch television." Goals do not state precisely what to do—where and how to move, what to pick up. To lead to actions goals must be transformed into specific statements of what is to be done, statements that I call *intentions*. A *goal* is something to be achieved, often vaguely stated. An *intention* is a specific action taken to get to the goal. Yet even intentions are not specific enough to control actions.

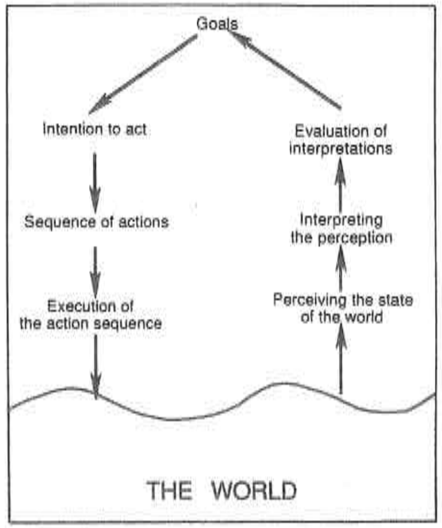
Suppose I am sitting in my armchair, reading a book. It is dusk, and the light has gotten dimmer and dimmer. I decide I need more light (that is the goal: get more light). My goal has to be translated into the intention that states the appropriate action in the world: push the switch button on the lamp. There's more: I need to specify how to move my body, how to stretch to reach the light switch, how to extend my finger to push the button (without knocking over the lamp). The goal





2.2 The Action Cycle (above left). Human action has two aspects, execution and evaluation. Execution involves doing something. Evaluation is the comparison of what happened in the world with what we wanted to happen (our goal). **2.3 Stages of Execution** (above right). Start at the top with the *goal,* the state that is to be achieved. The goal is translated into an *intention* to do some action. The intention must be translated into a set of internal commands, an *action sequence* that can be performed to satisfy the intention. The action sequence is still a mental event: nothing happens until it is *executed,* performed upon the world. **2.4 Stages of Evaluation** (below left). Evaluation starts with our *perception* of the world. This perception must then be *interpreted* according to our expectations and then compared *(evaluated)* with respect to both our intentions (from figure 2.3) and our goals. **2.5 Seven Stages of Action** (below right).
The stages of execution from figure 2.3 (intentions, action sequence, and execution) are coupled with the stages of evaluation from figure 2.4 (perception, interpretation, and evaluation), with goals common to both stages.





has to be translated into an intention, which in turn has to be made into a specific action sequence, one that can control my muscles. Note that I could satisfy my goal with other action sequences, other intentions. If someone walked into the room and passed by the lamp, I might alter my intention from pushing the switch button to asking the other person to do it for me. The goal hasn't changed, but the intention and resulting action sequence have.

The specific actions bridge the gap between what we would like to have done (our goals and intentions) and all possible physical actions. After we specify what actions to make, we must actually do them—the stage of execution. All in all, there are three stages that follow from the goal: intention, action sequence, and execution (figure 2.3).

The evaluation side of things, checking up on what happened, has three stages: first, perceiving what happened in the world; second, trying to make sense of it (interpreting it); and, finally, comparing what happened with what was wanted (figure 2.4).

There we have it. Seven stages of action: one for goals, three for execution, and three for evaluation.

- Forming the goal
- Forming the intention
- Specifying an action
- Executing the action
- Perceiving the state of the world
- Interpreting the state of the world
- Evaluating the outcome

The seven stages form an *approximate model*, not a complete psychological theory. In particular, the stages are almost certainly not discrete entities. Most behavior does not require going through all stages in sequence, and most activities will not be satisfied by single actions. There must be numerous sequences, and the whole activity may last hours or even days. There is a continual feedback loop, in which the results of one activity are used to direct further ones, in which goals lead to subgoals, intentions lead to subintentions. There are activities in which goals are forgotten, discarded, or reformulated.[7]

For many everyday tasks, goals and intentions are not well specified: they are opportunistic rather than planned. Opportunistic actions are those in which the behavior takes advantage of the circumstances. Rather than engage in extensive planning and analysis, the person goes about the day's activities and performs the intended actions if the relevant opportunity arises. Thus, we may not go out of our way to go to a shop, or to the library, or to ask a question of a friend. Rather, we go through the day's activities, and if we find ourselves at the shop, near the library, or encountering the friend, then we allow the opportunity to trigger the relevant activity. Otherwise, the task remains undone. Only in the case of crucial tasks do we make special efforts to ensure that they get done. Opportunistic actions are less precise and certain than specified goals and intentions, but they result in less mental effort, less inconvenience, and perhaps more interest.

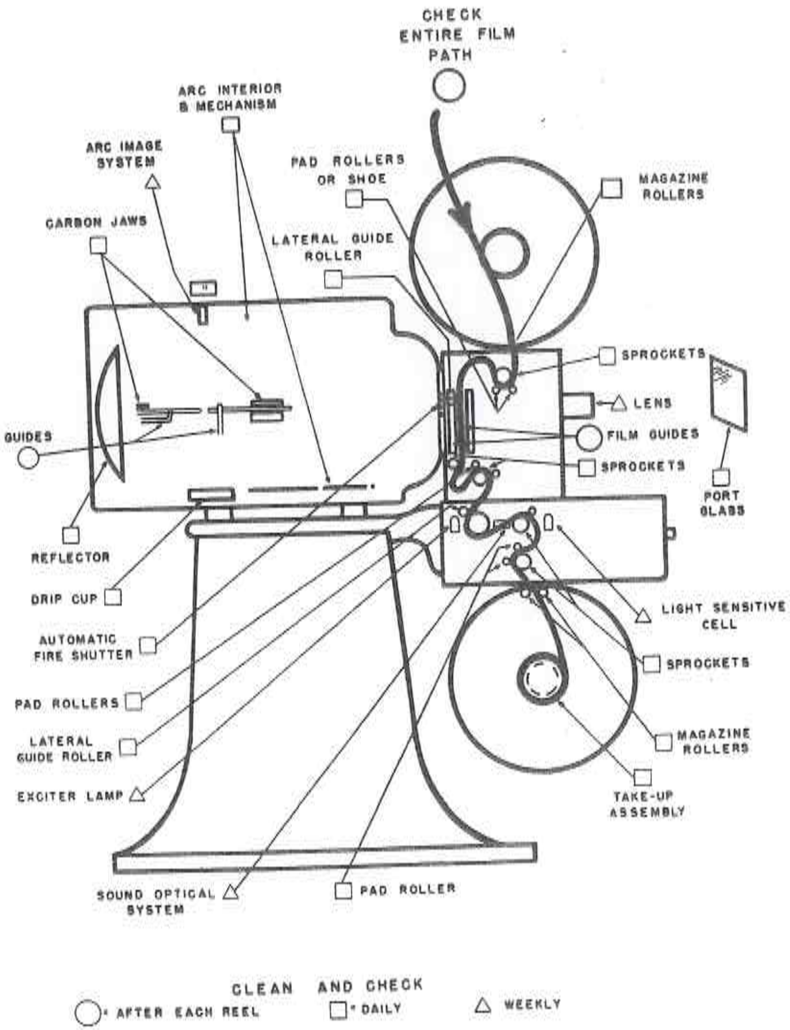
The seven-stage process of action can be started at any point. People do not always behave as full, logical, reasoning organisms, starting with high-level goals and working to achieve them. Our goals are often ill-formed and vague. We may respond to the events of the world (in what is called data-driven behavior) rather than to think out plans and goals. An event in the world may trigger an interpretation and a resulting response. Actions may be executed before they are fully developed. In fact, some of us adjust our lives so that the environment can control our behavior. For example, sometimes when I must do an important task, I make a formal, public promise to get it done by a certain date. I make sure that I will be reminded of the promise. And then, hours before the deadline, I actually get to work and do the job. This kind of behavior is fully compatible with the seven-stage analysis.

The Gulfs of Execution and Evaluation

Remember the movie projector story? People's problems threading the projector did not come from a lack of understanding of the goal or the task. It did not come from deep, subtle complexity. The difficulty lay entirely in determining the relationship between the intended actions and the mechanisms of the projector, in determining the functions of each of the controls, in determining what specific manipulation of each control enabled each function, and in deciding by the sights, sounds, lights, and movements of the projector whether the intended actions were being done successfully. The users had a problem with mappings and feedback, as they would have with the projector in figure 2.6.

The projector story is only an extreme case of the difficulties faced in the conduct of many tasks. For a surprisingly large number of everyday tasks, the difficulty resides entirely in deriving the relationships between the mental intentions and interpretations and the physical actions and states. There are several *gulfs* that separate mental states from physical ones. Each gulf reflects one aspect of the distance between the mental representations of the person and the physical components and states of the environment. And these gulfs present major problems for users.[8]

2.6 Threading the Movie Projector. The dark line at the right shows the path of the film. This picture doesn't tell the whole story, for the several loops of film have to be threaded just right, neither too loose nor too taut. (From *Projectionist's manual,* Department of the Army and the Air Force, May 1966.)



THE GULF OF EXECUTION

Does the system provide actions that correspond to the intentions of the person? The difference between the intentions and the allowable actions is the Gulf of Execution. One measure of this gulf is how well the system allows the person to do the intended actions directly, without extra effort: Do the actions provided by the system match those intended by the person?

Consider the movie projector example: one problem resulted from the Gulf of Execution. The person wanted to set up the projector. Ideally, this would be a simple thing to do. But no, a long, complex sequence was required. It wasn't at all clear what actions had to be done to accomplish the intentions of setting up the projector and showing the film.

Self-threading projectors do exist. These nicely bridge the gulf. Or look at VCRs. They have the same mechanical problem as film projectors: the videotape has to be threaded through their mechanism. But the solution is to hide this part of the system, to put the task on the machine, not the person. So the machinery bridges the gulf. All the user has to do is to plop in the cartridge and push the start button. It's a pity the film companies are so far behind. Well, in a while it won't matter. There won't be any film, just videotape.

THE GULF OF EVALUATION

Does the system provide a physical representation that can be directly perceived and that is directly interpretable in terms of the intentions and expectations of the person? The Gulf of Evaluation reflects the amount of effort that the person must exert to interpret the physical state of the system and to determine how well the expectations and intentions have been met. The gulf is small when the system provides information about its state in a form that is easy to get, is easy to interpret, and matches the way the person thinks of the system.

In the movie projector example there was also a problem with the Gulf of Evaluation. Even when the film was in the projector, it was difficult to tell if it had been threaded correctly. With VCRs all you have to know is whether the cartridge is properly inserted into the machine. If it isn't, usually it won't fit right: it sticks out obviously, and you know that things are not right.

But VCRs aren't perfect, either. I remember a conference speaker who pushed the start button on the VCR and told the audience to watch the screen. No picture. She fiddled with the machine, then called for help. One, then two, then three technicians appeared on the scene. They carefully checked the power connections, the leads to the VCR, the circuits. The audience waited impatiently, giggling. Finally the problem was found: there wasn't any tape in the VCR. No tape, no picture. The problem was that once the cartridge door to that particular VCR was shut, there was no visible way to tell whether it contained a tape. Bad design. That Gulf of Evaluation sunk another user.

The gulfs are present to an amazing degree in a variety of devices. Usually the difficulties are unremarked and invisible. The users either take the blame themselves (in the case of things they believe they should be capable of using, such as water faucets, refrigerator temperature controls, stove tops, radio and television sets) or decide that they are incapable of operating the pesky devices (sewing machines, washing machines, digital watches, digital controls on household appliances, VCRs, audio sets). These are indeed the gadgets of everyday household use. None of them has a complex structure, yet many of them defeat the otherwise capable user.

The Seven Stages of Action as Design Aids

The seven-stage structure can be a valuable design aid, for it provides a basic checklist of questions to ask to ensure that the Gulfs of Evaluation and Execution are bridged (figure 2.7).

In general, each stage of action requires its own special design strategies and, in turn, provides its own opportunity for disaster. It would be fun, were it not also so frustrating, to look over the world and gleefully analyze each deficiency. On the whole, as you can see in figure 2.7, the questions for each stage are relatively simple. And these, in turn, boil down to the principles of good design introduced in chapter 1.

- *Visibility.* By looking, the user can tell the state of the device and the alternatives for action.

How Easily Can One:

Determine The Function of the Device?

Tell What Actions Are Possible?	Tell if System is in Desired State?
Determine Mapping from Intention to Physical Movement?	Determine Mapping from System State to Interpretation?
Perform the Action?	Tell What State the System is In?

2.7 Using the Seven Stages to Ask Design Questions

- *A good conceptual model.* The designer provides a good conceptual model for the user, with consistency in the presentation of operations and results and a coherent, consistent system image.
- *Good mappings.* It is possible to determine the relationships between actions and results, between the controls and their effects, and between the system state and what is visible.
- *Feedback.* The user receives full and continuous feedback about the results of actions.

Each point provides support for one or more of the seven stages of action. The next time you can't immediately figure out the shower control in a motel or work an unfamiliar television set or stove, remember that the problem is in the design. And the next time you pick up an unfamiliar object and use it smoothly and effortlessly on the first try, stop and examine it: the ease of use did not come about by accident. Someone designed the object carefully and well.