Controlling

Perceptual Control Theory is about controlling. It's not about responding to stimuli, or planning actions and then carrying them out; it's not about effects of traumatic incidents on later behavior; it's not about particular things people do under particular circumstances. It's not about attitudes or habits or beliefs or tendencies. It's not about predicting. It's just about one kind of behavior that we can see people carrying out, called controlling.

Controlling is important because in the natural world only living organisms can do it. Many things in the nonliving world respond when things happen to them—a baseball hit by a bat flies enthusiastically through the air; a mousetrap responds to a touch by snapping shut. Many things in the nonliving world show complex patterns of behavior—iron filings on a card leap into arcs and loops when a magnet is brought underneath the card; stars form from dust and gas in a galaxy and go through complex life cycles ending in gigantic bangs or dark and silent whimpers. Nonliving things even reproduce themselves, as when a seed crystal in a solution creates an ever-growing tree of crystals of the same kind.

But none of these nonliving things can control anything. None of them can change their actions on something else to make the outcome repeat or remain the same in a changing environment. None of them can have or carry out intentions concerning what is to happen to them. Controlling is a unique process, unique to life (except, of course, for artificial control systems, built by living ones to imitate their behavior).

It's therefore important to understand this process called controlling, and that is what we will spend the first part of this book doing.

There are three basic functions that controlling requires: action, perception, and comparison. Let's take them up one at a time (although it's impossible to speak about *only* one at a time).

Action

If a person is to control something, the person has to be able to affect whatever it is that is to be controlled. Affecting it requires some sort of action that involves the use of muscles or glands. Much of controlling requires producing an action that has an effect on the physical environment. Much action requires producing internal effects that nobody else can see, as in swallowing. Among all the effects that a given action might have, the only immediately pertinent one is an effect that changes the thing being controlled.

There's a difference between merely affecting something and controlling it. You can affect the path of a car going down the road by turning the steering wheel, but to control the path of the car you have to have a particular effect, not just any effect. Turning the wheel has to keep the car on the road rather than running it into a wall or an oncoming truck. Of course the car could be steered into the wall or the truck; it's all a matter of which possible effect is to be controlled.

The interesting thing about controlling something is that *you can't plan the actions needed for control beforehand.* When you take a

bath, you can't just plan out how much to turn the hot and cold faucet handles and then execute the plan. If you do that, the bath is going to end up too hot or too cold. You have to be willing to turn the faucet handles whichever way is needed: If the water is getting too hot, you turn on more cold water or less hot water. It's the same for steering a car; you can't plan the steering wheel movements in advance. If a little wind blows the car too far to the left, you have to turn the wheel right; there's no choice if you want the car to stay on the road. But unless you have some stupendous secret way of predicting the weather all the way down to the local wind velocity and direction at 10:07 A.M. tomorrow, you are simply going to have to wait for 10:07 A.M. tomorrow to see which way and by how much you end up turning the steering wheel, if at all. So controlling can't be about planning actions.

The reason it can't is that the world is not really as consistent and predictable as it seems to be. Winds blow, bumps in the road pass under your wheels, objects move around, your own body doesn't go exactly where you expect, and each little error adds to previous errors cumulatively. The temperature of water in the pipes is always changing, just with time or because other people are using the same water supply. One door sticks when another swings free; one door is heavy and another is light. When you pick up a glass to take a sip of beer, the glass is lighter the next time you pick it up. When you reach for your socks in the morning, they're never in exactly the same place or oriented with the heels on the same side.

We think that our lives are full of repetitive and familiar actions, but to say that we do "the same thing" every day is only a way of speaking. When we brush our teeth, get dressed, eat breakfast, drive or take a bus to work, deal with customers or bosses, return home, eat dinner, watch TV, and go to bed, we probably never produce the same actions two days in a row. What we're doing is causing certain *controlled consequences of action* to repeat, but the only way we can manage to do that is to *change* our actions exactly as required in the brand-new world that we encounter every minute of the day.

Human actions that we can see from outside a person are tremendously variable; it is *only their consequences* that repeat, more or less. But if actions were not variable, if they did not vary exactly as they do vary, in detail, the same consequences couldn't possibly repeat. The reason is that the world itself shows a lot of variation, and for every variation, our actions have to vary in the opposite way if any particular consequence of acting is to occur again and again. *Controlling means producing repeatable consequences by variable actions.*

Perception

A funny scene that moviemakers often use shows us a driver and a passenger in a car, driving down a crowded street. The driver is chatting away to the passenger at a great rate, eyes fixed firmly on the passenger, while the passenger looks in horror at the double-parked buses and oncoming trucks into which the car is doomed to plow in the next second. Both the passenger

and the audience are thinking, *"For God's sake, look at the road!"*

In studies of driving behavior, it's been observed that men will look away from the road (in light traffic or none) for perhaps one and a half seconds before looking back; women a little longer. Apparently, being able to perceive where the car is relative to its environment is considered fairly important in driving. All the moviemaker has to do is stretch out the time the driver isn't looking at the road to four or five seconds, and every driver in the audience will start tensing up.

Obviously, perception is important for control. But what is perception? It's only what our senses tell us about the world. It's some sort of representation in our brains of what is going on outside us and inside us, a report on the status of things that exist or are happening. Most of what we perceive isn't involved in control—watching the moon rise, observing the leaves of trees blowing in the wind, seeing a football player score a goal, contemplating the same old mess in the garage. Perception is a passive taking-in, an input. What does it have to do with acting on the world?

To repeat, why should perception be so important for control? It's not needed for turning the steering wheel as the car careens around the hairpin turns on a mountain road—you could do that blindfolded, couldn't you? Your muscles are still working. Sometimes you do things without using perception, like tossing your coat toward a chair without looking, but those are cases where the outcome isn't very important. When you're planning to step into a bathtub, you don't just turn the faucet handles by

a particular amount, wait for the tub to fill, and step in. You *feel* the water temperature, and keep feeling it and adjusting the faucet handles so the temperature will be just right when you commit your defenseless skin to full immersion. When you drive a car, particularly in traffic or on a mountain road, you look where you're going almost continuously. On that twisty mountain road with cars coming around every blind corner you don't look away for even *one second.*

The general rule is that if you want to control something, you have to perceive it. This doesn't mean just perceiving that something exists, as in looking out the windshield and noticing that there's a road out there. It means perceiving exactly the aspect of the world that is supposed to be under control. You don't care what color the road is or whether it's four lanes wide or six; when you're trying to stay in your lane, you're looking at the relationship of the front of the car to the lane, and trying to keep that visual picture in a certain configuration that you know means you're in your lane. You can't do that blindfolded; you can't do it without watching what's going on nearly all the time. When you're filling your bath, you don't just perceive that the water looks wet and sloshy; you specifically use your temperature sensors to report on the current temperature of the water because that's what you're controlling, temperature.

Perception tells us the current status of whatever it is we're trying to control. Without that information, received continuously or at frequent intervals, we can't control anything. Perception is just as important as action, for controlling.

Comparison and Error

Suppose a driver is whizzing along the highway and notices that the front of the car is about six inches from the ditch and getting closer. The driver's action of turning the steering wheel has put the car in that position, and the driver perceives it in that position. The question that naturally comes to mind is, "So what?"

If everything continues as it is going, the driver's perceptions will faithfully report the overlap of the edge of the ditch by the car's fender, then a tilt of the world as the car slides into the ditch, then the world upside down, then rightside up, accompanied by various sharp blows reported by other senses, until whatever the result is has finished happening. What is missing from this picture?

What is missing is the difference between what the driver *is* perceiving and what the driver would far prefer to be perceiving. When you learn to drive, the first thing you learn after getting the car into motion is how the road should look relative to the front of the car as you see it from the driver's seat. Somehow this image remains in your head and as you drive along you are continually comparing how the scene *does* look with how it *should* look. If the way it does look is shifted to the right of how it should look, you turn the wheel leftward until there is a match again. A left shift leads to a rightward turn of the wheel. Once you learn this relationship it becomes automatic; you don't have to think it out any more. You have constructed an automatic control system that will, as long as you're looking, keep the actual

perception matching the appearance you know it should have. When you do that, the car settles down into its lane and stays there. The "appearance you know it should have" is called a reference perception, or reference condition, or reference state because it is with reference to this internal information that you judge the perception as too little, too much, or just right; too far left, too far right, or dead on; too hot, too cold, or perfect. If differences exist, we call them "errors" in PCT. Error doesn't mean "blunder" or "mistake"; it just means a *difference between what is being perceived and what is intended to be perceived.*

You get something else free: If a crosswind springs up, or the road tilts, or you hit a bump, or a front tire goes soft, the car will tend to veer to one side. But that will cause a difference, an error, between the position of the road that you perceive and the reference picture you carry in your head for how the road *should* look. The same little automatic control system, comparing the real perception with the reference perception, will turn the wheel the opposite way, resisting and in fact correcting the effect of the disturbance, any disturbance, without any instruction to do so. You may be listening to the radio or talking to your passenger, and not even notice what this simple control system is so kindly doing for you—as long as you keep one eye on the road.

Two pieces of information are needed for the comparison process: the actual state (as perceived) of whatever is being controlled, and the target or goal state for that perception that is intended or desired, the reference perception. This reference

perception or target is also called an *intention*. The picture of the car in its lane that you carry in your head is the picture you *intend* to perceive (If you've been reading philosophy, you may know some other meanings for the word *intention*. While you're reading this book, please forget them. We're talking about the first meaning that my dictionary gives: the act of determining that some event or result will occur).

So intentions come into control. Intentions define what *is to be brought into experience or is to continue to be experienced.* This is not quite the same as predicting what is going to happen. When you make a prediction, you assume that the events that follow the prediction are caused by natural laws or the behavior of other things and people over which you have no control, including what you have already done yourself. A gambler predicts that the dice will show a six on the next throw. But if the gambler has control of the dice, the other players will not treat the bet as a prediction; they will treat it as cheating. They will find the electromagnet under the table and throw it and the gambler out into the street, if he is lucky.

When you control something like the path of a car, you have continuously in mind some particular conception of the right position in the lane. This picture of the right path isn't like a prediction; it's like a target or a blueprint. The way the car is traveling can be compared continuously with the way it is supposed to be traveling, and the steering wheel can be moved all during the trip to keep the car where it is supposed to be in its lane. Even if you aren't conscious of the reference image at

all, you still know when the actual image is wrong and when it's right. *Something* knows about the reference image.

There is no prediction involved in the destination of the trip; that is normally known all during the trip. If a road is closed, the car is not deflected to some other destination; the steering wheel is turned to steer the car by whatever routes are open until it reaches the intended destination. Even though many unpredictable problems can arise as a driver goes to work, one would be well advised to bet that the car will get there by *some* means.

When you fill the bath, you have in mind a particular temperature that you want to feel. If the temperature you feel is higher than that, you add cold water or reduce the hot water input; if lower, you do the opposite. While the bath fills you are continuously or repeatedly doing this comparison, and continuously or repeatedly acting to maintain a match between the actual perception and the reference perception. You aren't *predicting* that the temperature will be right; you're *making* it be right, by controlling it.

Obviously, the result of comparison is information about a difference or error between actual and reference perceptions, and this information is the basis for the action that corrects the difference.

Circular Causation

One reason that control was not recognized as a special phenomenon long ago is that it seems to do violence to cause

and effect. Psychology and biology, when trying to be sciences, have always tried to follow the lead of physics, and in physics no object behaves unless something else makes it behave by pushing on it or otherwise having some effect on it. Engineering also suggested the same thing; classical machines moved only as they were made to move by flowing or falling water, expanding steam, blowing wind, or unwinding springs. Any object, Isaac Newton said, continues in a state of rest or uniform motion unless acted upon by some external force. For most behavioral sciences that was a good enough concept on which to found a science of animal and human behavior.

As a result, when psychologists and biologists looked for explanations of behavior, they looked at the environment surrounding an organism. Blow a puff of air onto a person's bare eyeball, and the person will blink almost every time. Stick a pin into someone and the person will often yell "OUCH!" and will most likely jerk away from the pin. Show a person a picture of a tasty dessert, and the person (according to people who sell advertising) will probably salivate and rush to the store to buy some. Treat a child badly, and the child will (if you believe everything you read) quite often grow up to rob convenience stores. So the problem of explaining behavior, as well as predicting and controlling it, became simply a problem of finding out how people typically react to the forces, literal or figurative, applied to them by their environments. If you want to control behavior, all you have to do is find out which parts of the environment are causing the behavior, and manipulate the environment.

This is how the sciences of behavior started out thinking about behavior, but while these ideas were forming there were dissenters who saw something else going on.

The chief problem with explaining behavior in terms of environmental causes has always been that we can see more behavior than causes. It's all very well to call every behavior a "response," but unless you can pair up some specific stimulus with each response, that is more an assertion of faith than an observation. The opponents of the environmental-causation principle could show innumerable examples of actions for which no stimulus, no external cause, can be found—apparently spontaneous behavior, such as Beethoven's composing his 5th Symphony. More specifically, many examples could be found in which a person acted as if toward some predetermined end, as in the way one drives a car to Philadelphia. It is very difficult to point to the environmental causes that explain why each car converging on Philadelphia on any given day is being driven in that direction instead of some other. The best you can do is guess there's something about Philadelphia that stimulates drivers to go in that direction. And you would make that guess only if you already believed that all behavior had to be explained by something in the environment.

The idea of spontaneous behavior was criticized, ridiculed, and opposed with violently emotional arguments by those who called themselves scientists. Even St. Thomas Aquinas had insisted that nothing moves of itself in the natural world. The only Prime Mover Unmoved was God, and everything else in

determined not by the environment, but by something we are calling a reference condition, something inside the person that defines a particular state of a perception and sets it up as a target or an intention against which actual perceptions are to be matched. We saw how a comparison of actual and reference perceptions leads to information about the difference, and how the difference leads to actions that affect the world in the way needed to eliminate the difference, to correct the error. So even without putting up a red flag, we were talking about a closed causal loop.

It should be apparent by now that if we just accept what we observe and experience and try to understand it, ignoring all the other theories and guesses and principles that people have used to explain how these kinds of behavior work, we can begin to comprehend controlling as a real and basically simple process. If, as your understanding grows, you start to wonder how such a simple explanation could possibly have been overlooked during the whole history of the behavioral sciences, I can only say that once you get a wrong concept in your head, it is very hard to see through it.

Anyway, this idea really hasn't been overlooked; many scientists and philosophers have in one way or another seen circular causality and intentional behavior as having basic importance. They just weren't considered to be in the mainstream of science.

Chapter 2

Perceptual Control

In which we see that behavior is the process by which we act on the world to control perceptions that matter to us