# PCT for the Beginner

by

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Perceptual Control Theory (PCT for short) is a theory of behavior. The basic idea is this: people (and other organisms) act on their surroundings, the environment, so as to control the effects the environment is having on them. This is the exact opposite of the main theory that has been used by the life sciences, including neurology, biology, and a large part of psychology, for at least 200 years. The oldest traditional theory, and still the most widely used, says that the environment near organisms stimulates their senses, causing the organisms to respond -- to behave -- as they do. PCT says instead that organisms generate actions affecting the environment near them, thus altering that environment and creating or changing experiences at many levels in the way desired or intended by the organism. The difference between these theories is a matter of which is viewed as being in control: the organism or the world outside the organism. According to PCT, the organism is the controller. It controls what happens to itself, by acting on the external world. This control succeeds when the environment is not too extreme (using PCT does not require abandoning common sense).

## How control works

To control something, in PCT, is to act on it in such a way as to bring it to a predetermined state and keep it there. "Controlling" is not the same as influencing, affecting, determining, or causing something, because those words can be used properly even if nothing is brought to or kept in a predetermined state. PCT control is not a simple straight-line effect: it is the result of a closed loop of causes and effects in which an action is varied to make its perceived result match a specified state. If a disturbance occurs that tends to change the perceived result, a PCT control system will alter its action in just the way

required to cancel most of the effect of the disturbance, so the result doesn't change significantly. This can be illustrated by an example.

In PCT it is proper to say that the driver of a car controls several variable aspects of the car -- examples are its speed and its position on the road in the left-right or lateral direction. Let's focus on control of lateral position, which we call "steering the car."

The driver's means of control is the steering wheel and its linkage to the front wheels and tires of the car. By turning the steering wheel, the driver creates a force acting on the car that moves it to the left or to the right. But that is only one influence on the car's path. There are many other influences including crosswinds, tilts in the roadbed, bumps in the road, soft tires, misaligned wheels, and the car's own inertia. The steering wheel's influence on the car's path is the only one the driver can vary; all the others happen independently.

For the car to continue in a straight line, the steering wheel must be turned left or right just enough to create a force opposed to and equal to the current sum of all the independent influences. The driver doesn't try to prevent those disturbances from acting -- instead, the driver uses the steering wheel to add a force that always just cancels the sum of all the other forces. That's how "negative feedback control", the basis of PCT, works. The controller monitors whatever is being controlled and acts directly on it to keep the perception from changing by more than a small amount. This kind of controller doesn't even need to know what caused the deviation from the intended condition.

The "closed loop" of causation is made up of four main components. Inside the system there is a signal that comes from sensory receptors, standing for the current state of the external condition to be controlled. Second, there is comparison of the perception against an internal standard called a "reference signal" which defines the intended state of the perceived condition. Third, this comparison creates a difference signal or error signal that is amplified by the system's

output equipment to produce an action that depends on the amount and direction of difference. And fourth, in the outside world the action affects the environment so as to alter the condition being controlled (the feedback effect), which brings us back where we started. This circular arrangement of simple cause-effect components keeps the perception closely matching the reference signal, even a changing reference signal, and the overall effect is no longer simple causation.

Prior to the invention of the theory of negative feedback control, there was only one way to handle this circle of causation: break it up into a lineal sequence of cause-effect events. First the driver sees the car's position (the perception) deviate from the desired position (the reference condition). The deviation causes the hands to move the wheel and create a force on the car (the output action). Then the force on the car, added to all external forces, causes the car to move sideways (the feedback effect that closes the loop). That changes the perception, and so on around and around.

That approach is satisfactory in all respects but one: it doesn't describe what actually happens. If you drive or watch a driver, you don't see a sequence made up of steering movements alternating with observations of the car's position. You see both happening at the same time. While the driver is turning the steering wheel, the perceived position of the car is changing. As the car's position approaches the correct position, the steering wheel comes smoothly to a final steering angle where it becomes constant. Everything is changing or stops changing at almost the same time. The components of this system do not take turns acting; they all act at once. The control-system engineers of the 1930s (and some of their predecessors back into the 19th Century) found the mathematics that could handle this closed loop of simultaneous causation without having to change it into a fictitious sequence.

## The significance of PCT

The behavior of other people is a series of continuous actions which we

observe. We can see the actions and various immediate effects those actions have on the world. We can't see so easily what those actions are controlling. A boy in the hallway of a school is trotting along, sometimes bumping into other people. But what perception is being controlled by that running? Perhaps the perception is a prediction of when the boy is going to reach his next classroom (a calculated future based on present perceptions): if he continues running he estimates that he can get there just before the bell. If he does bump into someone else, that impedes his progress, so he speeds up, maintaining his perception of when he will arrive in class at the reference condition "just in time." And so he does, unless some teacher stops him and scolds him for running. Then there is a problem: he needs to walk to satisfy the teacher and stay out of trouble; he needs to run to get to class on time and stay out of trouble. He can't walk slowly and run fast at the same time. This sort of conflict explains much of the stress of being in school.

With PCT in mind, we can analyze and understand many familiar situations in new ways. Instead of seeing behavior as a reaction to stimuli or a result of planning actions and then blindly carrying them out, we see it as a process of controlling perceptions, many perceptions at the same time, and at many levels of organization. But before such advanced ideas are considered, the first step in understanding PCT is just to grasp the closed loop of processes that make control possible. Actions make some aspect of the world come to a new state, and actions are produced by the difference between what is perceived and what is intended to be perceived. These two processes, the first one outside and the second inside the organism, work simultaneously. We see only the outside part of this process in others; we experience the inside part, but nobody else experiences it, when we ourselves behave. Understanding this simple fact of life can make a great deal of difference in how we understand and treat other people.