Chapter 12

Models and their worlds

Except for this introduction, this chapter is a reprint of an article by Bourbon and Powers (1993). I include it because it is a paragon of testing a hypothesis straightforwardly, rigorously, quantitatively, and conclusively. It shows the clarity with which a hypothesis in PCT can be confirmed or rejected. If it seems surprisingly simple in a place or two, remember that scientific method must be explicit about every step of procedure, no matter how simple it may seem to some.

If you do not wish, at this point, to delve into the kind of detail contained in Chapters 12 and 13, feel free to skip on. You can return when you feel the urge.

As Richard Marken says, the tracking task is simple in the same way as were the little balls and inclined tracks used by Galileo in his seminal studies of the acceleration of gravity. We do not intend the tracking task to show what particular acts people take when they are driving a car or drinking water or building a house or painting a picture. We do intend to say that the tracking is controlled by the *same sort of neural organization* that is used in those other pursuits and all others, too, that act upon the environment. No matter how simple they are, experiments in PCT are remarkable because (1) both person and model produce quantified results that can confirm the match quantitatively, (2) the model is a material, functioning device that *can* produce quantified results, and (3) the model is tested not against an average over many people but against a single person.

In a posting to the CSGnet on 14 September 1995, here is what Powers had to say about the article below:

> In the physical sciences, the common way to test a theory is to examine it as a logical or quantitative structure, and see where you could vary conditions in a way that the theory would have to predict has some new kind of effect, something that hasn't been observed before.
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> You'll see this strategy exemplified in the paper "Models and their worlds". . . . The control-system model is matched to behavior under the condition where a target moves in a regular way and the person makes a cursor track the target. Once the model's parameters are set for this condition, we then change the conditions. First, we vary the regular movements of the target so they become irregular. The same control model, with the same parameters, predicts that the behavior will change in a specific way that maintains the tracking, and in fact the real person does change the behavior in just the same way as the model, quantitatively. Then we introduce a smoothed random disturbance added to the cursor position, so now the position of the cursor depends both on the handle position and on an independent arbitrary variable. The control model predicts that tracking will continue, and that the handle movements will now differ from the cursor movements in a specific quantitative way. When the real person does the same task, the predictions are upheld with good accuracy. So now the control-system model has been challenged twice; it could have failed in either of the latter two experiments. All that would have been necessary to make the model fail would be for the person to have moved the handle in some way other than the predicted way. Since there were no constraints on how the person could move the handle, the success of the prediction was highly significant. It was significant because the model's behavior could have failed to match the real person's behavior. . . .
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> Sooner or later, we would think of a way to change the conditions that results in the model's doing something radically different from the real

person. Rick Marken and I [Marken and Powers, 1989a] did that when we did an experiment in which the sign of the connection between handle and cursor was reversed in a way that gave no sensory indication of the reversal (i.e., no bumps or joggles at the moment of reversal). The model and the person both showed a very similar exponential runaway after the reversals—for the first 0.4 seconds or so. Then the person did something to regain control, BUT THE MODEL DID NOT. So by thinking up the right change of conditions, we succeeded in making the model fail.

Of course that failure was simply a signal that we had to modify the model, which we did. We added a second level of control that could reverse the sign of the first-level control action when a runaway condition was sensed. That naturally restored the model to working order, and it once again was able to predict behavior correctly. So by finding a way to make the model fail, we learned how we could improve the model so it would no longer fail under that set of conditions, and of course continued to work properly under all the other changes in conditions we had already tried.

The article that follows appeared originally in the now-defunct journal *Closed Loop*, 1993, 3(1), 47–72. Another version of it appeared in the *International Journal of Human-Computer Studies*, 1999, 50, 445–461. *Closed Loop*, 1993, 3(1), along with several other issues has been restored and is available as a PDF-file at www.PCTresources.com