**Psychoanalysis, PCT, and the Brain**

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Review Essay. *The Interdisciplinary Handbook of Perceptual Control Theory: Living Control Systems IV*, Warren Mansell, Ed. London, UK. Elsevier/Academic Press. 644 pages.

Readers of this journal are presumably sympathetic to Freud’s dream of a unified science of the brain and the unconscious (Seitler, 2017). And yet an explosion of knowledge in neuroscience and psychoanalysis in the last hundred years has not produced what philosopher of science Thomas Kuhn called a “paradigm.” That would consist of an overarching meta-theory that makes sense of the most important facts in the field and that serves as the source of testable hypotheses for the establishment of new facts. The Neuropsychoanalysis Association has been hard at work on this problem, but its parent disciplines have evolved for so long in parallel universes that there is currently no integrative paradigm in sight that either neuroscience or psychoanalysis would recognize as authoritative.

And yet the seeds of such a paradigm may already exist. Its earliest book-length formulation, I would argue, was William T. Powers’ 1973 classic *Behavior: The Control of Perception*, which at the time of its publication received rave reviews from Carl Rogers, Thomas Kuhn, and other luminaries (Powers, 1973/2005). It has been slow to gain wide recognition, but Powers’ paradigm, now called Perceptual Control Theory (PCT), has given rise to an impressive body of peer-reviewed research in the last forty years or so. The most recent compilation of scientific papers on PCT was published by Elsevier in 2020, entitled, *The Interdisciplinary Handbook of Perceptual Control Theory.* In this review essay, I will discuss some of the chapters of this book and the relevance of PCT for psychoanalysts interested in cognitive science and the brain.

The readability, originality, rigor, and importance of the papers in this volume make purchasing the book a no-brainer for anyone who can afford and benefit from it. To be sure, Elseviers’ list price of $200 is a testimony to corporate greed, but the book’s 644 pages actually deliver a lot more value, chapter for chapter, than much less expensive volumes. Any serious student of motivation, cognition, and behavior who is not already familiar with PCT will wonder how the ground-breaking research surveyed in this book managed to escape their attention until now. Accordingly, if Elsevier’s imprimatur brings this work to a wider academic and clinical audience, the company will have earned its profit.

The second and third chapters of the book shed light on the historical reasons that PCT has been so slow to catch on. Perceptual Control Theory has its roots in work on negative feedback systems dating to the 1920s, which was popularized by Norbert Weiner in his 1948 book *Cybernetics*. What is not generally known, and what these two chapters make clear, is that Weiner’s book was a two-edged sword that both promoted the concept of negative feedback systems (AKA “cybernetic” or “control” or “self-regulating” systems) in the general public, and also undermined its acceptance as a revolutionary new paradigm of the life and behavioral sciences.

The problem, as psychologist Richard Marken and neuroscientist Henry Yin show in their chapters, is that Weiner presented a highly misleading version of control theory that proved to be intuitively appealing but of very little use in understanding behavior or the brain. Weiner uncritically adopted the viewpoint of behaviorism, in which the brain is essentially a black box whose perceptual inputs somehow determine its behavioral outputs. Twenty-five years later, Powers showed why this picture is inadequate, which will be explained below. But the damage was already done and Weiner’s ideas, which did not prove fruitful for psychological or neuroscience research, came to be synonymous with feedback control systems.

The problem with Weiner’s and the behaviorists’ picture is that it neglects the central explanatory role of motivation in understanding the structure and dynamics of the mind and brain. To the extent that neuroscience today embraces control theory at all, it is this impoverished version that has made its way into the textbooks. To illustrate the issues involved, consider one of the simplest examples of a negative feedback system, that of an air conditioner connected to a thermostat. To see the relevance of this example to psychology and neuroscience, let us outline its structure and dynamics using the concepts of motivation, perception, and behavior. As we will see, this is more than a metaphor, since the process of self-regulation operates in essentially the same way in machines and in living organisms, regardless of the terminology one adopts.

The “motivation” or goal of an air-cooling system is to maintain room temperature near the thermostat setting. Its “perception” is the measurement of actual room temperature using a thermometer, and its “behavior” is activation of the air conditioner whenever the room gets too hot.[[1]](#footnote-1) In PCT, motivation is also called the “reference perception,” because a control system continually compares its perception of some variable with the reference or preferred value for the perception. Whenever perception deviates from the reference perception, in this case when room temperature exceeds the thermostat setting, the system activates a behavioral output, in this case a machine that cools the room. The system continues to generate this behavioral output until the perceptual input matches the reference perception, at which point the system turns off the air conditioner.

What was misleading about Weiner’s model of control systems was his conceptualization of the reference perception as part of the environment, rather than the system. To be sure, there is some plausibility to his view in the case of the air-cooling system, where the temperature setting is determined by a human being who is exogenous to the machine. But Weiner’s way of thinking about control does not generalize to living organisms, where the reference perceptions are set inside the system. This is most obvious in the case of drives such as hunger or thirst, which are genetically inherited constituents of animal nervous systems that Powers called “intrinsic reference perceptions.” This is a very serious failure of Weiner’s model, since he certainly intended to provide a general theory of control systems.

In reality, Weiner’s model of control in which the environment determines the system’s behavior only holds for the special case of systems that are not autonomous. In the general case, which includes all living organisms that exhibit control, the system’s outputs are jointly determined by its perceptions of the environment and its reference perceptions, which may be internally generated. This is humorously illustrated by the cartoon of a behavioral scientist training two rats in a Skinner box. One rat says to the other, “We’ve got this guy trained: whenever we press the lever three times, he gives us a pellet of food.” While actual rats admittedly cannot talk, this cartoon reminds us that they are more than stimulus-response machines. Rather, like the scientists who study them, rats are autonomous systems that generate their own reference perceptions. Marken’s and Yin’s chapters in the *Handbook* discuss the pervasive influence of the stimulus-response model in psychology and neuroscience, and the viable alternative provided by PCT.

Perceptual Control Theory finally enables us to make sense of the history of psychology in the last hundred years. While behaviorists have focused on the sensory inputs and motor outputs of behavior—confusingly called “stimuli” and “responses”—psychoanalysts have tended to focus on the inner sources of behavior in drives and motivations. Meanwhile, cognitive neuroscience has focused on the information processing that presumably connects motivation with the sensory-motor processes studied by behaviorists. The problem is that each of these branches of psychology focuses on one aspect of the brain and behavior without understanding the process of control through which the parts work together as a whole.

As Marken (2002) noted in an earlier article, such fragmentation of knowledge is like the proverbial three blind people, each feeling different parts of an elephant. Feeling the tail, one thinks it is a rope; feeling the trunk, another thinks it is a snake; and feeling a leg, the third person thinks it is a tree. As with the entire elephant, the whole of brain and behavior are neither motivation, nor observable sensory-motor phenomena, nor information processing, but the structure and dynamics of control in which each plays a specific part. And the core of any control system—"the comparator function”—is where the parts come together. It is there that perception is compared with reference perception (motivation) and the difference is computed, producing a signal that drives the observable behavioral output until control is achieved.

This more adequate model of control provided by Powers has far-reaching implications. While Norbert Weiner’s model does not illuminate how the brain processes information, Powers’ model does. Let us start with the fact that drives such as hunger and thirst do not directly produce the muscle movements required to find and consume food or water, even in simple organisms like insects. These movements depend on many factors, such as the organism’s changing location in relation to a source of nutrients, the terrain over which it moves, obstacles it encounters, etc. In order for a brain to take account of such complexity and navigate a changing environment to meet an organism’s needs, its circuits must be organized into numerous control systems, each having the thermostat-like structure outlined above, but controlling different variables on multiple levels.

Conceptualizing such a hierarchical structure of control may seem like a daunting task, as daunting as making sense of the tangled interconnections of the quarter of a million neurons in your typical ant’s brain. PCT provides the key for modeling such complexity. Each control system at each level operates like a module with connections to the modules above and below it in the hierarchy. Specifically, the output of each control module (except those at the very base of the hierarchy, which terminate on muscles) becomes the reference signal for one or more control modules below it in the hierarchy. Conversely, every control module (except those at the very apex) sends perceptual input to one or more modules above it in the hierarchy.[[2]](#footnote-2)

This paradigm of modular, hierarchical control—which was first formulated by William T. Powers—provides a template for ordering and modeling the otherwise overwhelmingly complex brain circuitry in living organisms. We can now ask whether it is a scientific paradigm in Kuhn’s sense. There are a number of reasons for saying that it is.

First, hierarchical models of brain circuitry and behavior based on PCT are all testable in at least one fundamental respect. If brains are in fact organized as PCT indicates, control at a given level must take longer than control at any lower level (Powers, 1973/2005). That is because a higher-level module sets the reference signals of lower-level modules and must wait for them to process that information and return updated perceptual input before it can achieve control. This prediction of faster control as one moves down the hierarchy can be rigorously tested by neuroscience research, at least in principle. Any control system module that fails this test cannot be a correct representation of brain circuitry, and the model must be revised accordingly.

That said, such applications of hierarchical PCT to neuroscience are still in their infancy. Henry Yin (2014; 2017) has proposed a model of the basal ganglia based on hierarchical PCT and is engaged in active research on this topic. In two chapters of *The Interdisciplinary* *Handbook of Perceptual Control Theory* (and three additional chapters published online), Erling Jorgensen discusses points of intersection between hierarchical PCT and various neuroscience theories including Hierarchical Temporal Memory (an artificial intelligence project modeled on the human neocortex) and neuroscientist Vadim Glezer’s research on the human visual cortex.

The second reason that hierarchical PCT constitutes a scientific paradigm is its success in robotics and intelligent systems research. Two chapters in the *Handbook* by Rupert Young and Roger K. Moore address these topics. While it may be years before PCT hypotheses about the human brain can be adequately formulated and tested, this paradigm is currently revolutionizing robotics and AI, as these chapters attest.

The third source of empirical validation of PCT is corroborating primate and human infancy research, introduced and summarized in a chapter by Frans X. Plooij (pronounced “ploy”). This body of peer-reviewed research provides quantitative evidence based on chimpanzee observations and surveys of human mothers. It shows that human infants undergo stages of cognitive development—substages of Piaget’s sensorimotor stage—in which the multi-leveled control hierarchy hypothesized by Powers is constructed from the bottom up as the human brain develops during the first twenty months of life.

Going beyond Piaget, Plooij and his associates have also examined the attachment dynamics associated with these stages. Based on this research, Plooij has coauthored a popular baby book, *The Wonder Weeks*, which has been translated from Dutch into ten other languages (Van de Rijt and Plooj, 2017). The book outlines toys, games, and enrichment activities appropriate to each cognitive stage. It also advises infant care providers about the periods of distress and “clinginess” that infants experience when their perceptual hierarchies are periodically reorganized, followed by periods of exhilaration when they discover and want to exercise new capacities.

Finally, hierarchical PCT has been repeatedly verified by introspection in psychotherapeutic settings. The *Handbook* chapter entitled “Method of Levels Therapy” by Warren Mansell and David M. Goldstein provides an authoritative introduction to this topic. Method of Levels (MOL) therapy has similarities to free association and, like psychoanalysis, enables a person to uncover and resolve his or her internal conflicts. Unlike traditional psychoanalysis, MOL is typically a short-term therapy. It can be a valuable addition to any psychodynamic therapist’s tool kit in cases where short term therapy is the only option. Mansell’s and Goldstein’s chapter explains what is unique about the theory and practice of MOL.

A few words are now in order about how PCT may illuminate psychoanalytic topics. The adult “self,” when viewed as coterminous with the whole body, can be equated with the individual’s entire hierarchy of control systems. Less broadly, the self can be construed as the control systems at the very apex of the hierarchy. It is at this highest level that someone thinks about the kind of person he or she is (self-perceptions) and wants to be (reference-perceptions). As with hierarchical control generally, a discrepancy between perception and reference-perception at this level motivates behavior at lower levels in the hierarchy aiming to reduce the discrepancy.

To illustrate such psychodynamics, consider an adult male who was nurtured in infancy by a female and then socialized into a dichotomous (masculine, not feminine) gender ideal. Other things being equal, such a person will experience a chronic discrepancy between his mother introjects (self-perception of his inner “feminine”) and his ego ideal (“not-feminine” reference-perception). This discrepancy, according to a PCT model of masculine gender insecurity, will typically motivate behavior intended to “prove one’s manhood.”[[3]](#footnote-3) In one study utilizing a personality Q-sort and a separate political questionnaire, the displacement of male gender insecurity onto the nation and its military power was conceptualized as the linkage between a “not-feminine” control module and one for perception of the nation at the next level down in the hierarchy (D’Agostino, 2018). This article also proposed possible PCT conceptualizations of dissociation, denial, and “identification with the aggressor,” all involving a loss of neural pathways connecting self-perception modules with traumatic memories.

These applications of PCT to psychoanalytic topics are at this stage largely speculative and tentative. Research is needed to test such theories using a variety of methods, including one from the PCT toolkit called the “test for the controlled variable” (Marken, 2014), which is beyond the scope of this essay. For more on perceptual control theory and psychopathology, see Mansell (2005). For recent research on PCT and clinical practice, see D’Agostino (2019).

In this short review essay, I have discussed only half the articles in the *Handbook*. The volume includes an introductory chapter by Bill Powers written just before he died in 2013 and a concluding article by Warren Mansell on the current state of PCT research, critiques and limitations of the paradigm, and future directions for the field. Other chapters address the limitations of statistical methods in the study of control systems; perceptual control in dyadic animal conflicts; use of PCT in sociology to model large scale cooperation and conflict; protocols in interpersonal dynamics; language and thought as control of perception; and applications of PCT in industrial-organizational psychology.

This book is not for every psychoanalyst. It does not engage psychoanalysis *per se,* and except for the chapters on infant psychology and MOL, it does not address topics of immediate interest to clinicians. But for anyone interested in cognitive science and the brain, this is an important book. If you want a rigorous understanding of the structure and dynamics of motivation, perception and behavior, and of the brain systems that apparently underlie them, *The Interdisciplinary Handbook of Perceptual Control Theory* will be a valuable addition to your library.

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1. More precisely, activation of the air conditioner is the system’s behavioral output. Properly speaking, its overall behavior (what the system is doing) is controlling the room temperature it perceives, which occurs even when the air conditioner is off. That is what Powers meant by calling behavior “the control of perception.” [↑](#footnote-ref-1)
2. For a picture of such interconnections, please refer to vol. 2, issue 2 of this journal, page 58, which shows three modules of such a control hierarchy; presented in D’Agostino (2018). [↑](#footnote-ref-2)
3. Since a person’s mother introjects are a permanent constituent of his personality, it would appear that relief from this inner conflict is only possible by replacing the macho ego ideal with an androgynous one that is compatible with the person’s “inner feminine.” It seems that many males learn this spontaneously, an example of what Powers called “reorganization.” If and when a client is ready to work on their gender ideals, this “natural” solution can serve as a model for a therapeutic outcome. Helping the client come to terms with the inner feminine as it manifests itself in dreams and other products of the unconscious is a specifically psychoanalytic way of facilitating such an outcome (D’Agostino, 2018). [↑](#footnote-ref-3)