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# *Closed Loop*

## *Threads from CSGnet*

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*Front cover*

# *Closed Loop*

## *Threads from CSGNet*

Summer 1993 Volume 3 Number 3

Edited by Greg Williams, 460 Black Lick Rd., Gravel Switch, KY 40328

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Members of the Control Systems Group receive Closed Loop quarterly. For more information, contact Ed Ford, 10209 N. 56th St., Scottsdale, AZ 85253; phone (602)991-4860.

CSGnet, the electronic mail network for individuals interested in control theory as applied to living systems, is a lively forum for sharing ideas, asking questions, and learning more about the theory, its implications, and its problems. The "threads" in each Closed Loop, stitched together from some of the net's many conversations, exemplify the rich interchanges among netters. Some issues of Closed Loop also feature research reports by netters, in hopes of initiating new conversations.

There are no sign-up or connect-time charges for participation on CSGnet. The Internet address is "CSG-L@UIUCVMD" while CSG-L@UIUCVMD is the Bitnet address. Messages sent to CSGnet via these addresses are automatically forwarded to over 120 participants on five continents, as well as to hundreds of NetNews (Usenet) sites where CSGnet can be found as the newsgroup bit.listserv.csg-l. CSGnet also can be accessed via CompuServe, AT&T Mail, MCI Mail, or any other computer communication service with a gateway to Internet or Bitnet. For more information about subscribing to CSGnet, contact Gary Cziko, the network manager, at G-CZIKO@UIUC.EDU, phone him at (217)333-8527, or send a FAX to (217)244-7620.





# *Visions and Revisions*

*Bob Clark:* Receiving *Closed Loop* led me to realize that I really should get back in touch with the current state of the work that Bill Powers and I developed together some 30 years ago.

I have been using, applying, and developing these early concepts on my own during this period. In beginning to post to CSGnet, I offer some comments on issues (3) and (4) of *Closed Loop*.

My main comment on (3) is about the lack of discussion of the hierarchical levels that could /would be involved! Instead, much of the discussion recapped the standard arguments for/against governmental control—especially of the economy. It seems to me that a more precise and accurate definition of the original hierarchical Orders would be very helpful.

*Closed Loop* (4) seems to me to go around and around because of insufficient recognition of the role of the engineer in designing and operating his/her system (whether it be "open loop" or "closed loop"). Indeed, many discussions omit the critical role of the observer, the experimenter, engineer, etc. I once co-authored a paper on a related subject: "A Systems View of Psychophysiological Experimentation," presented to the New York Academy of Sciences in 1964. Not a very good paper, but it points out some of the levels of interaction normally omitted from discussion.

The key in (4) seems to me to lie in the phrase—mentioned several times in the discussion—"point of view." The professional engineer takes his/her own role for granted: it is not part of the system he/she is designing. In his/her design work, he/she has, as noted in the discussion, full access to all aspects of his/her work and hence can use the terminology as he/she sees fit. But the moment the engineer is included, most of his/her hierarchical structure is in action!

*Greg Williams:* I, for one, am happy that Bob Clark has joined the net. His experience of several years of ruminations regarding living control systems—in parallel and independent of Bill Powers' ruminations—should enrich the dialog (two eyes are better than one, and all that). Go to it, Bob!

*Gary Cziko:* I have had several interesting phone conversations with Bob Clark over the past few months. I am very pleased that two of the three original developers of Perceptual Control Theory (PCT) are now on CSGnet (the third, Robert L. McFarland, has passed away).

*Bill Powers:* Welcome, Bob. You're right that the discussion of control-system engineering would have benefited from speaking about the levels, but the main problem as I saw it was trying to get a control-system engineer to see that his diagram and the PCT-type diagram are really the same. Obviously, my attempt didn't work. Our friend eventually signed off the net, wishing us luck but saying that as an engineer he simply *had* to think of controlled variables as outputs. Sound familiar to you?

Bob and I developed the basic control-system model in the years from 1953 to 1960. I have never properly acknowledged his part in this development, which was major.

I spent a couple of years trying to find a hierarchy of perceptions written as words, and layers of words, and dependency and inclusiveness relationships among words. Bob knows all about this: he went through it with me, putting as much energy and ingenuity into it as I did (Two Years Before the Blackboard—remember, Bob?). It was Bob who finally characterized what we were doing as "castle building"—building hypothetical dream-castles in the air, out of words. The insight that put an end to this futile project came out of the air between Bob and me: it was not the words we should be looking at, but the perceptions to which they point, which are not words. Control systems control perceptions, not the names of perceptions (unless one is specifically controlling for the construction of sentences and so on). And even a *word* is a nonverbal perception, in the final analysis. It is just a signal, distinguishable from other signals but having no inherent meaningfulness or special properties that other perceptions don't have.

This is what finally put us on the track of the hierarchy. The relationships and typings we were looking for were not to be found in the words we used, but only through looking at words as pointers and trying very, very hard to become conscious of the experiences, the nonverbal experiences, to which the words referred. Bob and I were both highly verbal people, used to communicating in words and pretty good at it, so this was a very difficult and drawn-out exercise. It required wrenching apart the words from their meanings, so that the meanings could be apprehended alone, without the words. I don't think either of us really understood at first what it was that we were trying to do. But when we came up with a "level," it was a nonverbal level for certain. Since then, I have seen that what we then took to be unitary levels merged types of perceptions we had not yet distinguished from each other. I think Bob considers my 11 levels too many; I suspect they are too few. But that's another subject. The central point is that separating words from meanings is no easy task and carries no assurance of being right in any final sense, but it is the essential *kind* of thing that must be done even to know what is meant, in PCT, by the term "perception."



Bob and I came up with general principles, but they were principles of control and hierarchical relationship, not generalizations about any particular perceptions (or words) at any particular level. The specific structure of the hierarchy that was proposed did not come from generalization, but from detailed examination of real examples as we discovered and explored them. There is no generating principle that will tell you, given knowledge of the nature of level n, what level n + 1 ought to be. The content of each level, insofar as we were able to characterize any level, was found empirically.

*Bob Clark:* My orientation is one of trying to clarify and simplify the basic structure of the hierarchical array of perceptual control systems. In the process, I noticed the discussion of thermostatic systems in *Closed Loop* (4), which seemed to end rather inconclusively. Further thought about thermostats led me to notice that they not only provide a convenient illustration of a control system (I've used them repeatedly for this purpose), but also can provide a tie-in illustration of a hierarchical structure of systems, couched in terms familiar to most people these days. As I developed these relationships, I found that I was using some familiar words that are usually taken for granted but could well have their basic definitions clarified—especially from the hierarchical-structure standpoint.

I selected thermostatic systems because they are familiar to many people, and because they include the basic elements of negative-feedback control systems. That is, they include: 1. a means for detecting a variable; 2. a means for affecting that same variable; 3. a means for subtracting the magnitude of that variable from some "preset" value, with a resulting positive difference acting to produce a positive output from the second "means." This is the usual combination of components composing a negative-feedback control system. Such a system need not have a continuous output to achieve its result. It is interesting to observe that "continuity" is, in part, a matter of "viewpoint." Thus, if a thermostatic system is observed over a period of several hours, its control approximates continuity.

The thermostatic system is a "one-way" system, as usually presented with a furnace, etc. That is only one of several limitations it suffers. Another "one-way" system is a living muscle fiber! It can only pull, not push.

The thermostatic system can also be used to illustrate other aspects of control systems—and other forms of control system. Before thermostatic systems were developed, people kept warm in the winter. My father had a coal-fired furnace that had a damper that adjusted its operation. Too cold, open the damper; too warm, close the damper. And it was a fairly continuous operation.

Where was the control system? Clearly, the situation was livable, although not as convenient as one might like. Obviously, there was a control system in operation, where the temperature (where?) was the controlled variable, even though the control was accomplished by adjusting the rate of heating.

But where was the control system? Without a person, the temperature was not controlled—but also, without a damper and a fire box, the temperature was not controlled. Some person *decided* whether action was needed, and in which direction. He/she then used his/her (lower-order) muscle systems to affect his/her *environment* according to his/her *understanding* of that environment.

What about "his/her environment"? This usually refers, perhaps vaguely, to the physical surroundings outside his/her skin. But someone else might have been available and have been asked to "open the damper" or "turn up the furnace."

Then where was the control system? A person could "do it himself or herself" or "ask someone else." Having made his/her *decision,* he/she used his/her lower-order systems to get his/her desired result. Were there two (or more?) levels of control involved, the "other person" and the "furnace"? Thermostatic systems now take the place of the "other person," and they are much more efficient and convenient.

For those who are familiar with thermostats, most of this is unnecessary. But what about those whose *environment* does not include *understanding* of control systems? You must have seen people turn the setting up higher and higher when the room doesn't warm up fast enough. The furnace was already at full speed, so raising the setting had no immediate effect. Later, however, the room was too warm, and the setting was reduced. This is "over-control"—the system is oscillating!

Notice the importance of the *time* scale of the person versus the "response time" of the system.

This illustrates the difference between regarding the assembly of parts as a control system rather than simply as a group of connected parts. Such a difference in *viewpoint* can result in a difference in behavior. Often these differences have little effect, but sometimes they are very important!

Both viewpoints are valid and result in the same mathematical representation. However, one is more useful for using the system, the other for modifying the system.

Several words have been italicized above: *decides, understanding, environment, choice, decision, viewpoint, time.* These words and their associated concepts are used routinely and seem to be readily accepted. However, each of them is very important and merits closer examination.

And how does each relate to a hierarchy of control systems?



Let us turn to the simplest description of a control system: the "logical box." This is a "black box" without the paint. The box can take many forms, but careful examination reveals that it has four unique connections between the world outside the box and whatever is within the box:

Number 1 is normally taken for granted. It is the cord that plugs into the wall outlet. When unplugged, the box is inert; it responds in no way to any kind of treatment—or mistreatment. The box requires some source of energy. It can be outside the box or inside the box. It is essential.

Number 2: This connection, when "disturbed," does nothing. However, it is observed that Number 4 changes its condition in a manner related to the disturbance of Number 2. The nature of the relevant disturbance at Number 2 (temperature, pressure, voltage, radiation, etc.) might be hard to determine. Likewise, the nature of the related changes in number 4 might be hard to identify.

Number 3: This connection similarly affects Number 4 and can respond to a disturbance different from the one affecting Number 2.

Number 4: As long as the box retains its energy source and *both* Number 2 and Number 3 remain constant, this connection (Number 4) is very difficult to disturb—perhaps impossible to disturb, short of destruction of the box.

As described, this box is not a control system. It does nothing until some specific disturbance is applied to either Number 2, or Number 3, or both. However, if some connection is provided in the *environment* of the box, such that the operation of Number 4 serves to reduce the disturbance of Number 2, then we have a control system acting to control (or at least tend to control) the disturbance of Number 2. In this case, we find that the same disturbance applied to Number 3 results in a corresponding change in Number 4, such that the disturbance of Number 2 is (very nearly) the same as that applied to Number 3. Of course, by suitable modification of the *environment,* the operations of Number 2 and Number 3 could be interchanged or otherwise modified.

This stylized and abstract description is consistent with the usual descriptions of negative-feedback control systems. It is presented here to emphasize that such a *system is defined exclusively* in terms of its *input* and *output* characteristics as it interacts with its *environment.* In addition, to act as a control system, it must respond to another *input,* serving as a *reference signal,* originating outside the system. Note that this says nothing about the nature of any of these three connections or the environment, nor about how they might be interconnected inside the box.

This box acts ("behaves") by controlling its perception, which consists of the disturbance to which it responds and controls.

The Test for the Controlled Variable applies directly to the box.

As presented here, some important items are italicized. These will be clarified later by discussion of their relations and implications in terms of the concept of a hierarchical structure of negative-feedback control systems.

*Bill Powers:* Bob, in your generalized four-port black box, rather than defining input 2 as affected only by a disturbance, I recommend saying that it is affected by the state of some external variable, so the output of port 4 depends on the state of the variable at port 2. Now we can distinguish the case in which there is an external link from port 4 to the variable at port 2 from the case in which there is a link from an independent variable to the variable at port 2. This also lets you define a "disturbance that doesn't disturb"—the independent variable might or might not affect the state of the variable at port 2, because the output from port 4 could change enough to cancel the effect the independent variable would have when acting alone. So you can distinguish the existence of a physical causal link from the kind of effect obtained by varying the cause.

*Bob Clark:* Bill, regarding the four-port black box, of course one can describe the situation in terms of its being "affected by the state of some external variable." However, if one is curious about some particular box, it must be intentionally "disturbed" if one is to discover the nature of one (or more) external variables it might be controlling. While discussion in terms of "states of variables" is certainly possible, I find a more experimental approach more useful. I also think some people are unfamiliar with the word "state" in this sense.

You suggest a difference between the case where there is an external link between terminals 4 and 2 and the case where an independent variable is applied to terminal 2. The experimenter, being outside the box, can observe any external connections. And any disturbance from the experimenter is (really, by definition) an "independent variable."

I am intrigued by the question of the boundary between the box and its environment. To the experimenter, it is quite clear. The environment includes everything except what is inside the box. But what does the box perceive? Its behavior is the control of its perception. But what does it perceive? Only the disturbances of those connections that cross the walls of the box. And its output actions reflect the differences between disturbances affecting terminals 2 and 3. In addition, some kind of connection must exist outside the box, not perceptible by the box, but observable by the experimenter. If these relations are not found, the box does not act as a negative-feedback control system.

These considerations seem to me to be applicable to many nonliving systems, and the use of nonliving systems as extensions of human systems is impressive.



Since I have been out of touch for over 25 years, much has been done that I've not seen. I have Bill's important book *Behavior: The Control of Perception, Introduction to Modern Psychology: The Control-Theory View,* and the collection of Bill's papers. Reading between the lines of some of the posts on the net, I get the impression that certain key concepts need examination.

I have been feeling the need for revisions and additions to the original hierarchical structure for some time. As I remember it, we expected the early publications (by Powers, Clark, McFarland, and others) to lead to further developments and modifications. Bill further elaborated and presented those concepts. It is my impression that Bill did not, and does not now, consider *Behavior: The Control of Perception* to be complete and final. However, there seems to have been little discussion of possible changes in the original hierarchy. Rather, there seems to have been discussion of various interesting and important applications and related ideas.

Here, I am summarizing some of the ideas that have interested me over the years. Many of these points can and should be developed and, perhaps, modified. Certainly, I consider all of them open to review and discussion. I recognize that they are based on—and limited by—my own experiences and conclusions. To me, much of this material is self-evident. My purpose here is to organize these observations and relate them to the basic concepts of hierarchical control systems, making them available to others for further development. I hope that these ideas and approaches will be found intriguing, leading, in turn, to further modifications, elaborations—and alternatives!

I am minimizing explanations so as to emphasize the overall structure, viewpoints, and modifications of the hierarchy suggested here.

I begin with a *Decision Making Entity* (DME). This concept seems to have been overlooked, except for an implied inclusion in the "reorganizing function." That function, so far as I know, has never been analyzed in terms of its structure, capabilities, limitations, and relation to the hierarchy. Rather, "under what conditions" and "how to improve results" have been studied. These are important, of course, but where and how these activities occur and how they relate to a hierarchical control system are the subjects of this presentation.

Making *decisions is* an everyday occurrence for most of us. Most are routine ("Do you want cheese on your hamburger?" "What's the best way to Chicago?"), but some involve complex analysis ("How do I get funds for this project?" "Who will be willing to act as editor?") and can reveal unexpected conflicts. "Who," or "what," makes decisions and "where" they are made have received little or no attention.

It is tempting to identify this Entity as the "self" or the "ego," or by a similar label. However, such terms tend to include additional concepts such as "personality," "character," and other aspects of the individual. They might include guidelines commonly used by the individual in making his decisions. These anthropomorphic concepts tend to be derived from previous decisions leading to conclusions and assumptions used as the basis of decisions and actions. These are important, of course, but are excluded from the concept of the DME.

The Decision Making Entity, as here understood, can act without being bound by past decisions. It frequently uses them because they are readily available and alternatives may be overlooked. It has the ability to be arbitrary. It can change past decisions if they are accessible to the DME. Access can be limited by a combination of previous decisions. Consistency among decisions is not intrinsic. It is capable of contradictory actions!

*Definition of the DME:* The Decision Making Entity is defined in terms of its connections (inputs and outputs) and its capabilities.

*Connections available: Input A,* information about the current condition of physiological systems, including (a) information about the operating condition of the organism, and (b) information about conditions outside the organism. *Input B,* information about past events—memories, recordings, whatever. This includes both verbal and nonverbal events. The distinguishing feature of this connection is that the information is all from past time, although "past" can be very close to "present." These events can range from the remembered mosquito bite to the remembered discussion of "Real Reality," and so forth. *Reference Levels C,* information specifying the acceptable operating condition of the organism, A(a). These are the "intrinsic levels" of other net discussions. *Outputs D,* information acting throughout the hierarchy. Usually, but not necessarily, outputs act by selecting inputs to the higher-order levels of the hierarchy, leaving the details to the remaining lower-order structures. These outputs can be considered from two different viewpoints: as outputs from the DME, and as inputs to the many parts of the hierarchy. Thus, they act as reference levels throughout the hierarchy.

*Capabilities:* Directing *attention*, including (a) selecting the information, Input A, to be controlled; (b) selecting information from past events, Input B, for comparison with the current situation; (c) comparison of the current and projected ("anticipated") situations with acceptable magnitudes of the variables selected for control—especially intrinsic variables, C, when they are relevant. Everyday situations usually do not directly involve intrinsic variables. Decision making, including (a) selecting outputs (D) to be used by the DME as reference levels for the hierarchy; (b) activating the selected outputs for controlling the selected systems.



*Conditions required:* In order to direct its attention and make its decisions, the organism must be conscious. Unconscious means that the DME is unable to receive information from its inputs. However, the remainder of the systems can be functional, operating on the basis of the most recent settings of their reference levels. There are several interesting situations that can occur: sleep, coma, paralysis, trauma, etc. These, and others, are worth separate discussion.

These connections define a negative-feedback control system. The stated capabilities are unique to the DME and critical to its operation.

In this view, the feedback signals include two categories of information: A(a) about the current operating condition of the physiological systems, and A(b), about the surrounding environment. These signals are compared to levels selected from memory, B, and applied as inputs to the hierarchy. In addition, the first group, A(a), is compared with the intrinsic reference levels, C, for possible action. The output function consists of the entire hierarchy, D.

The DME is able to direct attention to any group, subgroup, or combination of available memories and compare the projected results with any other combination of available memories, as well as with any related intrinsic levels. It is able to combine selected memories for application as reference levels throughout the hierarchy, as required for the selected action. The entire set of feedback signals available to the DME is the set of *perceptions, controlled by behavior,* as discussed by Bill in *Behavior: The Control of Perception.*

Each of the following contrasting views is useful—"correct," if you please depending on what your purposes might be.

First, *the DME's view of the world*—a stimulus-response (S-R) view. The DME looks "down" its hierarchy for ways to maintain and improve its well-being. The DME acts, like any control system, when it detects a difference between current perceptions and reference perceptions. It examines available alternatives, based on current data combined with projected results of alternative actions. It selects and then applies its selections as reference levels where needed throughout the hierarchy. The DME has no need to "know" anything about the details of the control systems it is using. It merely applies its output signal(s) where needed, and the systems respond. This applies not only within the organism, but equally to using other individuals or groups of individuals as means to accomplish the selected results. This can be as simple as making requests or giving orders—if the others have already internally decided to accept and act on such requests/orders. The DME acts like an individual trying to maintain and improve his/her circumstances.

Second, *the hierarchical control system's view of the world*. Viewing the world in terms of hierarchies of control systems covers an amazing

range of observations and leads to additional study and analysis. The concept of higher-order control of lower-order systems through setting their reference levels is particularly simple and useful. In this view, "behavior" consists of counteracting, or opposing, any disturbance of its controlled variables. That is, it consists of detecting a difference between current perceptions and reference perceptions. A disturbance, uncontrolled at one level, tends to result in disturbance at a higher level. However, this structure has no way to change its reference level—nor does it have a way to change its organization. Its memories are retained in the form of established structures and fixed reference levels. It cannot examine memories with a view to selecting alternative ways to achieve its control. Its high-order reference levels are based on "remembered" events, but there is no way to "project" or "anticipate" alternatives for possible application to a given situation.

This *problem* arose in our early discussions as we sought to define higher levels. How can the changing behavior of an individual be described when he or she is blocked? Analysis working upward through the lower orders assumed (implicitly) a set of fixed reference levels, especially at the higher levels.

How could these be changed? How could the system be "reorganized"? An ad hoc "reorganizing system" was proposed. Without actually being stated, its definition amounted to "whatever is needed in order obtain these results." Bill has discussed this concept in several places, but it seems to me to be incomplete. I am familiar with this view, since I was deeply involved in the early developments leading ultimately to *Behavior: The Control of Perception,* as well as to papers and discussions among others. In my own life, I have found and continue to find this viewpoint very useful in many ways. But it is not the only view that I find useful.

In fact, what seems to be needed is the DME as suggested here. I find that combining the DME approach with the hierarchical view provides some additional answers and leads to some revisions of the hierarchy.

The overall objective is control of perception, as genetically required. A hierarchy of control systems is the means to that end. In the following suggestions, the guiding concept of the hierarchy, "higher-order goals are accomplished through setting reference levels for lower orders," is retained.

I. *Zero Order—Intrinsic Systems.* These are the physiological systems underlying the Decision Making Entity. They include all systems providing neural inputs directly to the DME. They report the operating condition of the organism for comparison with intrinsic levels for control action through the hierarchy. Some of these systems might, themselves, be feedback control systems (I have in mind some of the hormonal systems), but they are controlled only indirectly through the



hierarchy. Zero Order systems also include direct neural signals representing the conditions of the external environment—typically, the usual five senses.

II. *First Order.* Control of individual muscles (or muscle fibers, if you prefer). This remains essentially the same as the original First Order. The signals, of course, are neural intensities serving as feedback signals derived from the tensions of the individual muscles. Bill *(Behavior: The Control of Perception,* pp. 82 ff.) discusses this in depth from several standpoints. From the DME's view, this Order controls individual muscles. It is a "follower" system—it simply reproduces (within its capabilities) the reference signal(s) provided.

III. *Second Order.* Control of "configurations." At this level, they are considered "static," that is, temporal variables are unspecified. Combinations of muscle systems are typical examples, but this Order need not be limited to muscle systems. Our original concept, elaborated by Bill *(Behavior: The Control of Perception,* pp. 99 ff.) "Second Order, Sensations" appears to combine parts of "Zero Order" and "First Order" as presented here. In the present treatment, Second Order is pretty much the same as Bill's "Third Order, Configuration Control" *(Behavior: The Control of Perception,* pp. 115 ff.). Muscle systems are convenient and typical examples. Bill includes the perception of "objects" within this category *(Behavior: The Control of Perception,* pp. 125 ff.). He notes the "invariance" of combinations of sensations that can be perceived as "objects." "Invariance" implies, at the minimum, some degree of short-term memory to provide continuity—invariance. From the DME's view, this Order does not include control of objects. In general, each configuration would be multidimensional, expressible in vector or matrix terms if desired. As output systems controlled by the DME, these are "follower" systems like First Order systems.

IV. *Third Order.* Control of sequence. Bill *(Behavior: The Control of Perception,* Chapter 11) assigns this to Fifth Order, much as we did originally. Bill places a Fourth Order, "transitions," ahead of his Fifth Order. In the present treatment, Third Order controls the sequence of Second Order, static configurations, much like the frames of a movie. The frames could be rearranged by the DME by means of Third Order systems. Of course, there are intrinsic limitations, but the concept remains. These are also "follower" systems.

V. *Fourth Order.* Control of temporal variables. As I recall our discussions, these variables were never made explicit. They seem to have been included within sequences, although no direct statement was made to that effect. Bill (Behavior: The Control of Perception, Chapters 10 and 11) seems to include these variables implicitly without recognizing them. His concept of "transitions" also seems to include temporal Variables implicitly. Here, "temporal variables" refers to such

items as "fast," "slow," "tempo," "frequency" (of oscillations), and the like. For example, the DME can apply the same tempo to a variety of situations—it appears to be an independent parameter of systems in action. The importance of these variables seems to be generally taken for granted—but otherwise ignored. I have found it very useful to pay attention to, and control, this Order of variables.

VI. *Fifth Order.* Control of—and selection of—skills. Typically, muscle skills. Skills consist of temporal sequences of configuration produced by combinations of muscle tensions. Control of variables of speed, tempo, and other temporal variables is important. This Order concerns individual motor skills. This is also where the perception of "objects" belongs. The world and its contents are treated as a multiplicity of inanimate objects. For example, bowling requires a ball and an alley, while using a sequence of positions performed with selected timing. Simpler skills include walking, running, etc. These are motor skills where nothing is needed but the physical equipment and the DME's decision. This is a general characteristic of Fifth Order systems.

VII. *Sixth Order.* Control of interpersonal relationships. This Order recognizes the differences between inanimate objects and independent active entities. This includes animals and, especially, people. The DME seeks its objectives through controlling these independent entities. Often, it acts as though they were stimulus-response systems. This frequently works, since many of these otherwise independent entities have decided to accept suggestions and requests as commands. When it doesn't work, the DME seeks alternative methods to reach its goals.

Control of communication could be considered for designating Sixth Order. However, this would focus on the skills used, Fifth Order, rather than the goals of Sixth Order. Communication is essential to the control of interpersonal relationships. Without some form of communication, other individuals are treated as inanimate objects.

Study of the content of communications, whether nonverbal or verbal, can help clarify the Orders of the hierarchy as well as perceptions of the DME. Topics discussed by people in everyday conversation and items published in the media are useful for this purpose.

*Modes of Sixth Order.* The topics communicated can be grouped according to the levels of the hierarchy:

Zero Mode of Sixth Order. Illness and similar topics are very common. People often have little knowledge of their own anatomy and physical structure. But they talk about it a great deal.

First Mode of Sixth Order. Aside from reports of sore muscles, there seems to be little direct discussion of muscle systems.

Second Mode of Sixth Order. Configurations appear as comments on "posture," positions needed for various skills, and the like.

Third Mode of Sixth Order. Here is discussion of the sequences of



configuration needed to obtain desired results. This includes sequences of positions forming movements required for a skill.

Fourth Mode of Sixth Order. Variables of tempo, rhythm, etc. Aside from discussions of sports events, musical concerts, and the like, these variables seem to receive little explicit attention.

Fifth Mode of Sixth Order. Much attention is directed to all sorts of muscle skills. Generally, several lower-order considerations are discussed, although not always explicitly. "How-to" books are very popular, usually involving most of First through Fifth Modes of Sixth Order. This Mode includes all concepts of the nature of the physical world. Math and theoretical analysis are also here. Everyday discussions commonly show very little understanding of present day physical science, math, and experimental methods. Well-known errors in logic are commonly accepted as valid.

Sixth Mode of Sixth Order. This Mode concerns methods and topics of communication among individuals and groups. Discussion of these topics, of course, uses the lower Modes as needed. Illustration from personal experiences are frequent (Third, Fourth, and Fifth Modes). Reports of activities of public and private individuals and organizations are common. Examples, analogies and similes are used very frequently. Public speaking and teaching skills and methods lie in this Mode. Rules and regulations used to establish acceptable performance appear here. Games, organizations, social customs ("social controls"), laws, police, etc. are within Sixth Mode of Sixth Order. As Fifth Mode does for the Physical World, this Mode includes all theories of behavior—whether magical, mystical, intuitive, or scientific, whatever that means! Everyday routine communications reflect the concepts of popular behavioral theories. Perceptual Control Theory also is in this Mode.

Seventh Mode of Sixth Order. This Mode concerns control of one's own behavior to accomplish higher-order objectives. It uses the concepts and methods of Sixth and Lower Orders for these purposes. Although there is relatively little discussion of these subjects, it does occur. This Mode has a corresponding Seventh Order of control.

VIII. *Seventh Order.* Self image and DME. Self image includes all aspects of the individual's capabilities and organization. To examine one's self image requires review of one's remembered actions and interactions as they relate to one's view of individual behavior. This review would tend to include, but perhaps not "require," extrapolation to possible future situations and events. Such imagined results can be compared to objectives at all levels, with underlying emphasis on intrinsic levels.

This discussion leaves a great many questions unanswered, and equally many fascinating subjects for investigation. I hope that this condensed outline and analysis will be found useful.

*Greg Williams:* Bob says: "The DME is able to direct attention to any group, subgroup, or combination of available memories and compare the projected results with any other combination of available memories, as well as with any related intrinsic levels." Why might the DME direct attention to certain memories, rather than others, at some particular time? Bob, do you have a theory of attention "selection" other than the broad viewpoint that the DME tries to "improve its well-being"? Is there some calculus for tradeoffs among various possible ways to "improve" (more or less)?

It seems to me that your proposal would require the DME to run "imagination connection" trials on the alternative actions at a particular time to "examine" and "select" some of them for actual performance. Maybe the DME wouldn't need to "know" details about the parts of the hierarchy which would then actually be used, but it appears that it would have to be able to "see" the results of such use "in imagination," prior to actual performance, in order to have a basis for decision making. Or do you have different notions about how the selection process occurs? I'm trying to understand the basics of your model at this point; perhaps I'm headed in the wrong direction. Please clarify.

It appears to me that the DME is basically directed (not completely random) reorganization. Is that a fair characterization? In the past, I've been attracted to the idea that there are *both* random and directed types of reorganization possible in humans—the former can get you to a solution (eventually, usually) when the latter has no clue on how to direct, but when it works, the latter is usually quicker. The problem has been in figuring out a working model for directing—hence, my questions above. Fleshing out the mechanism(s?) of your DME's decision making would be very helpful.

*Rick Marken:* Bob proposes an addition to the Hierarchical Perceptual Control Theory (HPCT) model: a Decision Making Entity (DME). I don't know what data motivate the addition of a DME, but perhaps it has to do with Bob's claim that "Making *decisions* is an everyday occurrence for most of us.... 'Who,' or 'what,' makes decisions and 'where' they are made have received little or no attention."

I prefer to look at decisions as the conscious results of conflict. So the cause of decision making is already a part of the model. So is the means of dealing with conflict: reorganization. We flip a coin and do one thing (produce one perception), and we tolerate the error resulting from not doing the other (producing the other perception). A better way to solve such conflicts is to "go up a level," one of the great therapeutic experiences (speaking subjectively) one can have, and a sure cure for the everyday conflicts (decisions) that are the natural result of never achieving a perfectly organized control hierarchy.



The study of decision making has been popular in conventional psychology because it is an inherently statistical phenomenon. If you offer people choices between almost equally attractive perceptions, coin-flipping (statistics) is the only approach (if you don't go up a level and see the choice itself as arbitrary; but if you did that, you would be kicked out of the experiment). There might be something interesting to be learned about hierarchical control and reorganization through the study of decision making (conflict). But I think we must have very good models of the "elements" of decision making—conflict, in particular—before we can make a coherent stab at decision making (which, as I said, is probably reorganization—of the conscious variety—to settle, not necessarily resolve, a conflict).

I think that I could get a better grasp of Bob's DME proposal if he (or anyone) could propose some experimental tests for evaluating this addition to HPCT.

*Bill Powers:* Bob, you say: "It is my impression that Bill did not, and does not now, consider *Behavior: The Control of Perception* to be complete and final." Right you are. You go on to say that "there seems to have been little discussion of possible changes in the original hierarchy. Rather, there seems to have been discussion of various interesting and important applications and related ideas." I'm glad to see you opening up the discussion. 'The" hierarchy is a figment of my imagination, building on *our* imagination. For most of the levels I've proposed, the only backing for the specific definitions is anecdotal and subjective. As far as I'm concerned, these or any other levels won't be "facts" until we have put them to experimental test.

I've always felt that defining the levels scientifically is a large project which should begin by experimentally verifying that people can control variables of many different kinds—anything anyone can think of, without regard to levels. Even the most obvious variables should be put formally to The Test, just so we can write down the parameters of control and say that we have in fact observed such-and-such a variable to be under control by a human being. This would be a beautiful thesis, or series of them. On the other hand, maybe it should be the kind of project to which all control theorists contribute, the way astronomers put in some duty-time measuring double star angles and separations (the three well-spaced observations required to determine the orbital elements, needing, in many cases, 1000 years to complete).

Once we have a base of hundreds of certified controlled variables, we can begin to try to put them into order. If there really is a hierarchy, the variables will fall into classes, and the classes will be related in a hierarchical way. That is, *in* order to control a variable of one level, it will be necessary to vary a controlled variable of a lower level. And of

course the only way to vary a controlled variable arbitrarily is to alter the reference signal for the system that's controlling it. Showing that this is the case leads to a new series of experiments.

When this project is done, will become a science. We will have advanced from Galileo to Newton.

In the meantime, of course, we can argue. But without experimentation, arguments are just a pastime.

I agree with Rick Marken about decisions: they represent conflicts. Unless there were at least two competing goals to satisfy, there would be no need to make a decision. You would just do whatever is required to achieve the single goal. More commonly, there are multiple goals involved in behavior, but we have learned to organize our actions (as a result, largely, of resolving conflicts in the past) so that all of the goals can be satisfied at once. When that is the case, again no decisions are needed.

At the level I call "programs," symbol-handling processes occur which I characterize as a network of choice-points. There are tests for conditions, with the choice of a branch being determined by a rule applied to the results of the tests. The term "choice" seems to imply a decision, but in fact there are no decisions at this level either. The conditions encountered at each choice-point, plus the rules, completely determine the path to be followed next. Only when there is ambiguity or when the rule is self-contradictory (calling for more than one mutually exclusive path to be followed) is anything like a decision required. If you have an algorithm for making decisions, you don't have to decide anything!

Note that operations occurring between choice-points are sequences, lists of reference levels to be brought about in order. Sequences are the next level below programs. Programs are concerned *only* with applying rules to select branches, as I use the term here. They involve "flow control," as they say in programming manuals. The parts of computer programs that consist only of one instruction following another belong at the sequence level here, not the program level.

If we eliminate programs—the execution of algorithms for choosing paths—from decision-making, what is left? As far as I can see, only the cases in which for some reason we wish to do two contradictory things at once. At that point, we must reorganize or simply suffer the paralysis of conflict.

Bob, I think that you and I agree on this, at least to an important extent. You say: "The Decision Making Entity, as here understood, can act without being bound by past decisions. It frequently uses them because they are readily available and alternatives may be overlooked. It has the ability to be arbitrary." This arbitrariness has the flavor of reorganization. But so far, at least, I have not considered systematic re-



organization. Anything that could be called systematic, it seems to me, belongs in the already organized hierarchy. At the level of logic, systematic consideration of previous choices and possible alternatives is an algorithm. As such, it can be reduced to rules governing selection of paths connecting sequences or lists of behaviors, where by behaviors, I mean controlled perceptions of the consequences of acting. When we remove all algorithms by putting them into the program level of the hierarchy, all that is left of decision making is the arbitrary part: making a change for no reason.

You basically say that the DME receives perceptions either from lower systems that are in the normal mode, receiving information that comes ultimately from interoceptive or exteroceptive sensors, or from lower systems that are in the imagination mode, deriving their perceptual signals from memory. Then you speak of *"Reference Levels C,* information specifying the acceptable operating condition of the organism, A(a). These are the "Intrinsic Levels" of other net discussions." This makes the DME look even more like the reorganizing system, with reference signals specified genetically. You also speak of *"Outputs D,* information acting throughout the hierarchy." This is typical of the reorganizing system as I perceive it. However, I think that your DME includes both learned hierarchical systems and the unlearned system that I call the reorganizing system. When a "decision" is reached, it must entail some sort of action, and to create any systematic action, a higher-level system must adjust reference signals for lower-level systems. Furthermore, since nature never trusts an organism's output to do what it is supposed to do, the consequences of the action must be perceived by the level issuing the reference signals, so that the reference signals can be varied until the perceived result is the intended one. If this control process takes place in an organized way, it must be due to a learned system.

In my concept of the reorganizing system, I have extracted the arbitrary non-systematic kind of action from the hierarchy as a whole and given it a separate existence of its own as a built-in aspect of the organism that functions from the beginning of life. We used to call this the Negentropy System. I gave up the word because it implies things I don't believe. I now just call it the reorganizing system.

Regarding capabilities, I will accept as part of the reorganizing system the direction of attention. The rest I have incorporated into the hierarchy itself. I am not sure what attention is for. We need to do some experiments to find out. The comparison of current and projected magnitudes of variables with acceptable magnitudes is simply the operation of any control system at any level ("projected" magnitudes require the imagination connection). That kind of operation is adequately handled by the "canonical" control-system diagram and, when intrinsic vari-

ables are not involved, is simply the operation of the learned hierarchy of control systems. I allocate intrinsic variables and intrinsic reference signals strictly to the reorganizing system, whose actions are arbitrary and random and serve to alter connections and weights in the learned hierarchy. That is how the learned hierarchy becomes organized.

With regard to your "Decision making, including (a) selecting outputs (D) to be used by the DME as reference levels for the hierarchy; (b) activating the selected outputs for controlling the selected systems," I handle all of this in the higher levels of the hierarchy, but I leave decision making (as an arbitrary process) out of it.

You say: "*Conditions required:* In order to direct its attention and make its decisions, the organism must be conscious. Unconscious means that the DME is unable to receive information from its inputs. However, the remainder of the systems can be functional, operating on the basis of the most recent settings of their reference levels. There are several interesting situations that can occur: sleep, coma, paralysis, trauma, etc. These, and others, are worth separate discussion." I have formed a similar idea of consciousness (beginning with our discussions of 35 years ago). However, I begin with awareness (which I think you include). Awareness is the capacity of the reorganizing system to receive information, regardless of its kind. I have proposed that when awareness is receiving information selectively from a portion of the hierarchy, the result is what we call consciousness. This allows us to distinguish between one phenomenon that remains the same no matter where it is applied—awareness—and another that changes its form depending on the source of perceptual signals received in awareness—consciousness. Consciousness always takes on the character of the control systems to which awareness is connected.

Thus an apparent rule that seems to fit experience: you cannot be conscious of systems that are in the conscious mode. Instead, you are conscious of the lower-order world of perceptions received by those systems, and you experience those perceptions with the conscious interpretation typical of the level (or levels) at which awareness is connected. This interpretation appears to be an objective property of the world.

Any system in the hierarchy can operate in the conscious or unconscious mode. In the conscious mode only, it is subject to reorganization.

Implied by this model is the possibility that awareness can be selectively connected to particular levels in the hierarchy. When that is the case, you experience the world consciously as that level perceives it, but you are unaware of applying any interpretation to the perceptions. Instead, you see those perceptions simply as part of the world. If you are operating in the logic or program level, you see the world as full of choice-points and alternatives, with natural rules that define a path



through the choice-points. On the other hand, if you are operating in the relationship level, you see a world in which everything is related in some way; you see the constraints that make independent objects and events maintain a certain constancy of interaction.

And while you are attending from the viewpoint of relationships, you are not aware of any higher levels of perception and control. They are still operating, and if you ask yourself why you are paying attention to relationships, you will come up with higher-level reference signals—what you hope to accomplish by attending to relationships. That is, you can often "go up a level" and realize that higher-level control processes were active all the time, even when not in consciousness. But as soon as you do that, you are no longer seeing a world of relationships. The nature of the conscious world changes as you move awareness from level to level.

I think that this proposal is related to your concept of "modes." However, I do not see these modes of consciousness as being modes of just one level, your DME. I see them as resulting from awareness moving from one place in the hierarchy to another. When one is attending to a lower level of perception, higher processes are still operating but they are not operating consciously. By your postulate, all modes would entail consciousness of the highest-level processes. Maybe you're right. But I think experience argues against this view. At any rate, I think your picture is worth trying on for a fit.

You say: "This *problem* arose in our early discussions as we sought to define higher levels. How can the changing behavior of an individual be described when he or she is blocked? Analysis working upward through the lower orders assumed (implicitly) a set of fixed reference levels, especially at the higher levels." This is no longer a problem in the hierarchy as I currently conceive it (since 1973). Higher reference levels are no longer fixed, except at the highest level. At intermediate levels, lower-order reference signals are varied as needed to provide a higher-level system with the perceptions it needs to match its own reference signals—which in turn are being varied as required by still-higher systems. You might ask Rick Marken for his spreadsheet demonstration of this arrangement; it will run on Lotus 1-2-3 or Excel. It shows how a three level hierarchy with six systems at each level can simultaneously control three levels of perceptual variables, despite random disturbances from the environment, and despite considerable interaction among the controlled variables at each level.

You ask: "How could these be changed? How could the system be 'reorganized'?" They (reference levels) no longer require reorganization to be changed. Reorganization is now needed only when the learned systems are not capable of maintaining intrinsic variables at their reference levels (as a byproduct of their actions). Since the model

now includes many "intellectual" functions such as classifying, ordering, reasoning, application of principles, and control of system concepts, all of which are learned, the reorganizing system does not have to carry out any rational processes.

You say: "In fact, what seems to be needed is the DME as suggested here. I find that combining the DME approach with the hierarchical view provides some additional answers and leads to some revisions of the hierarchy." I think you will find that the levels I have added (categories, sequences, programs, principles, and system concepts) contain much of what you want to put into the DME. I agree that such functions are required. I have simply broken them out into specific levels of functions, while reserving the arbitrary reorganizing part to a separate non-hierarchical system. I don't say that's right. It's just what I have done.

I have several arguments with your proposed levels, but will pass them up for just one clarification concerning your Fourth Order, temporal variables. For quite a long time after we parted, I considered just the sequence level in the position where you put it, above configurations. Then I realized that there are really two kinds of sequence variables, one exemplified by the second-hand of a dock, and the other by the notes of a melody.

The second-hand of a clock gives rise to a perception of continuing angular motion, d/dt(angle). With angle as a configuration perception, the new perception is simply its time derivative. As such, it has a value at all times, in present time, which can change in magnitude as the angular (or other) velocity increases or decreases.

This is quite different from the temporal progression in the successive notes of, say, "Taps," which can be played slowly or more quickly. In the case of the melody, there is no simple motion signal, but the sense of a specifically ordered progression of different sensations, one following the other. What matters is not so much the speed, but the ordering in time—which note follows which.

On realizing this difference, I introduced the "transition" level, which is basically derivatives (and perhaps derivatives of one variable relative to another). This level went just above configurations, and is where stroboscopic as well as continuous motion or change is perceived. That left the sequence level to cover just the temporal ordering of lower-level variables, including transitions. I called this the "event" level, where an event was supposed to be a short familiar temporal pattern of perceptions of transitions, configurations, sensations, and intensities (you omit intensities).

Only a couple of years ago, Gary Cziko brought up some more examples of temporal variables in which only the ordering is important—in language, for example, the ordering of words. Here the temporal pattern is not evident, for an ordering is quite independent of how long it takes elements to occur and of the spacing between elements. This struck me as different from an event, in which there is a stereotyped unitary pattern that forms a single package in perception. So the sequence level ended up being split once again, the event level now meaning only brief "packaged" temporal patterns recognized as single things like the bounce of a ball, with pure sequential ordering—lists—being moved to a higher level.

We can discuss the rest of your proposals for levels later. I expect that others will have questions and comments, too. I am glad to see the subject opened up again, because I don't like the sensation of having my hypotheses converted into Gospel. I think that by trying to boil down all propositions to the basic underlying operations and connecting them with experience, we can arrive at an agreeable set of levels for experimental test. Maybe the reason that there has been so little questioning of my definitions is that nobody saw any conflicting alternatives and thus didn't feel compelled to make a decision!

*Bob Clark:* Greg, as usual, it is much easier to raise questions than to answer them. This is to be expected, since the questioner regards the world from his or her own viewpoint combined with his or her available store of ideas.

Also, Rick prefers "to look at decisions as the conscious result of conflict.... the means of dealing with conflict: reorganization." He notes: "A better way to solve such conflicts is to 'go up a level."' Rick further seems to accept the view that decision making "is an inherently statistical phenomenon."

In response to your questions, comments, and remarks, let me point out that I am concerned with the process of decision making. Statistically, the only common element among people is that they all make decisions. Methods, reasoning, procedures, etc. can differ drastically from one person to another.

To me, decision making is a peculiarly individual matter. For this phrase to have meaning, there must be at least two alternatives available. This implies at least a minimal conflict in that they cannot both be selected. The alternatives need not be particularly important (although they could be). There must be some way in which they can be examined. There must be some basis for selection. And there must be some entity capable of putting all of this together.

We already have all of these elements except the Decision Making Entity—which is implied in Chapter 15 of *Behavior: The Control of Perception,* since something somewhere must operate the diagrammed switches. In fact, my view of the relations among the DME, current perceptions, and memories might be regarded as an extension of the

concept Bill illustrated with two single-pole double-throw switches. Using this diagram, these switches are controlled by the DME—one of its major functions.

In addition, the Recording Function (would this term be better than "memory"?), can be considered a multi-dimensional recorder, including not only all perceptual signals, but also all consciously imagined combinations, projected conclusions, and decisions. When examined (imagination), the memories are much like multi-dimensional video tapes. These memories are not necessarily logically related, nor otherwise coherent. They might arise simply through some accidental event that provides some connection (a "reminder") to the specific remembered event. It could be an odor, a face, a sound, an idea, a word, etc. Or it could be a problem ("conflict"?) with recognizable aspects bringing related memories to mind.

The Recording Function is mostly undirected, but the DME can make it more easily available by consciously assigning some kinds of labels to suitable recordings. How do you learn the name of someone you have just met? However, many "labels" are acquired more or less accidentally. Thus, the word "chocolate" easily brings an image (images?) to mind. But there are many forms of labels: the appearance of a house, a date, a period of time, and so on. There are many ways to locate specific memories.

Most memories are inactive most of the time. (What a confusion, otherwise!) They appear to be "forgotten" until some form of "reminder" occurs. (I have been intrigued by the questions that "pop" into mind in response to answers on the television show "Jeopardy.")

A great many of the decisions needed are simple, requiring very little attention or analysis. A very rapid (perhaps on the order of a few milliseconds) switching might occur between alternative memories when little analysis is needed and anticipated conclusions are quickly formed. These alternatives are selected for their relevance, often simply by being "reminded" of similar situations. But the DME might find more thorough investigation necessary in seeking a satisfactory selection. This tends to be related to the level in the hierarchy involved—as implied by Rick Marken's remark about "going up a level." Thus, in ordinary situations, the DME can make its selection quickly.

So the Recording Function records conclusions and decisions. These are more likely to pertain to high-level situations, where a previously formed conclusion/decision can provide a quicker response. "I'll push the button the instant I perceive a flash of light," rather than, "There's a flash of light, what do I do now?" Or, "The moment the light turns green, I'll hit the throttle," which results in a fast response.

The DME's attention is directed by the need to select among alternatives. The characteristics of the situation serve to remind the memory



which recording to present. It is interesting to observe that the DME cannot direct its attention to its own acts as it is performing them. Its only information about its own activity (self-knowledge?) is through examining the relevant memories. These are not necessarily readily available.

By and large, these are mostly ordinary and familiar observations, but they seem to have been left out of much behavioral discussion.

Greg, you note: "It appears to me that the DME is basically directed (not completely random) reorganization." In its origins, the Reorganizing Function was proposed to explain the observation that individuals change their behavior when faced with a conflict—especially if it is hard to resolve. However, that is an "outsider's" viewpoint. To the DME involved, it is not intrinsically different from any other decision-making situation. Available alternatives (including, perhaps, violent movements or whatever) are reviewed, and the behavior offering the most promising anticipated results is put into operation. To the outsider who might not even suspect the alternatives available, this will tend to appear "random," that is, "unpredictable."

Bill, you start by saying: "The' hierarchy is a figment of my imagination, building on our imagination." And you require an "experimental test.... verifying that people can control variables of many different kinds." Here we have two concepts (at least): "variables" and "control." In *Behavior: The Control of Perception,* "variable" is defined as "an entity identified by characteristics of the location at which it is measured, and having a number or a continuum of detectably different states. A meter-reading associated with a physical phenomenon." My *Webster's Unabridged Dictionary* includes (after eight definitions as an adjective) "noun. 9. something that may or does vary; a variable feature, factor, or the like, 10. Math. a. a quantity or function that may assume any given value or set of values. b. a symbol that represents this. 11. logic. (in the functional calculus) a symbol for an unspecified member of a class of things or statements." Also: "vary" specifically includes the concept of "change" or "alter."

Here we have two distinctly different definitions: one, a "feature," "characteristic," or the like that can have a changing "value" or "magnitude"; and two, a "member of a class." The first implies continuing identity of the variable, the second is not concerned with possible changes in the individual "member," as long as it qualifies for its "membership."

All of these verbal structures (theories) are critically dependent on mutually accepted definitions. I think we both, with physical science and math backgrounds, tend to use the first definition. However, those with backgrounds in psychology, sociology, etc. tend toward the second.

Here I think we are considering a "variable" to be (from the Glossary in *Behavior: The Control of Perception)* a 'Perceptual Signal: The signal emitted by the input functions of a system; an internal analogue of some aspect of the environment." I think you would include "combinations of perceptual signals represented by neural signals" as additional variables. I would also include signals arising from memory. All of these are generally available to the DME.

Can people "control" such signals? In some ways, this is the very heart of the subject of behavior—we see people doing things to themselves, to their surroundings, and to other people, followed by assorted consequences. Note the temporal implication of "doing things." Is this "control"? Perhaps, but it seems to me that "control" implies "intent" to produce some change. The act might be inappropriate, or ineffective, but if the result is somewhere near the intention, some degree of "control" appears to have been achieved. This seems to be circular, and "begging the question." That is, if the result has not been achieved, there has been no control. On the other hand, if the result occurs, it could have been purely coincidental.

How do we measure "intent" so that it can be related to "result"?

Correlation alone is insufficient evidence. There are many examples of strong correlation between variables, without need to assume "intent." Consider the phototropism shown by many plants. The plant bends toward the light and its well-being improves. Fairly well-identified laws of biochemistry and physics are sufficient explanation. "Control" here? I don't think so. It appears to me that "control" is a peculiarly human concept that becomes pertinent only after certain stages of development. Interestingly, it seems to me that a great deal of history, philosophy, ethics, and psychology (in the generic sense) relates very directly to matters of "control." Thus we have agriculture for food, clothing for insulation, weapons for game (and warfare!), politics, science, and theories. Always someone is seeking to act in such a way that the things he/she cares about (his/her "perceptions," of course) become, and remain, somewhere near the states he/she seeks for them.

This is the essence of a feedback control system and is completely familiar to nearly everyone. *Except* that they look at the pieces of the loop without putting it together as a system! How many people understand the operation of a thermostatic control system in feedback-system terms? They use such systems as "on/off" switches. And they are usually satisfied. They just haven't learned the viewpoint and somewhat specialized language that PCTers find useful. I find them useful too, and I believe most others will, as well, if they take the trouble to learn at least the key parts of PCT.

Bill, you "agree with Rick Marken about decisions: they represent conflicts." To me, "represent" signifies equivalence; that is, when A



"represents" B, they are interchangeable. To me, "decisions" are quite different from "conflicts." In an earlier post, I pointed out the need for alternatives in order for a "decision" to be needed. I agree, of course, that when "all of the goals can be satisfied at once.... no decisions are needed." And none are made. Yes, conflicts imply needs for decisions—and decisions that have been made imply preceding conflicts resolved. Note, incidentally, that some conflicts are very incidental and are settled easily and quickly, so that the operation of the DME can easily be overlooked.

Bill, you say: "At the level I call 'programs,'... processes occur... a network of choice-points.... choice of a branch... determined by a rule... The term 'choice' seems to imply a decision, but in fact there are no decisions at this level either. The conditions... completely determine the path... Only when there is ambiguity or when the rule is self-contradictory... is anything like a decision required. If you have an algorithm for making decisions, you don't have to decide anything!" Yes, of course. But surely these networks, algorithms, etc. come from somewhere and are retained somewhere for application if needed. I call this "somewhere" the memory, created by the Recording Function. The choice-points you speak of, I would term past decisions remembered and applied in the present: recordings of decisions made at some previous times and retained in effect unless considered for review.

You say: "If we eliminate programs... from decision-making... we must reorganize or... suffer... conflict." Well, yes—that's what I'm talking about. Whenever decisions have already been established, whether by accident or careful study, no decision is needed, and the DME's attention is directed elsewhere. Of course, the pre-existing decision might be found wanting and need revision. Then the DME would re-examine the situation.

Regarding your reorganizing system, I point out the DME has the ability to be arbitrary. Indeed, it does have the "flavor of reorganization." After all, the organization to be reorganized consists of a network of previously made decisions. Note that the DME has access to all recordings and can project—"imagine"—anticipated outcomes that can be used as the basis for decision, ultimately using intrinsic reference levels as criteria. If previous selections have not worked out, the DME can arbitrarily select an alternative or alternatives.

Bill, you say: "This is typical of the reorganizing system as I perceive it." I did not set out to examine either the reorganizing system or the process of reorganization. I was intrigued by observing that I am very frequently making "small" (?) decisions.

There seems to be some question as to exactly how much, or "what," is included within the DME and/or the reorganizing system. I recall, of course, the Negentropy System. And I agree—it implies too much.

Indeed, to me, the same is true of the "reorganizing system." The term seems to imply some kind of complex, highly structured entity operating in mysterious ways to resolve conflicts—especially those involving intrinsic systems. I like your phrase "a built-in aspect of the organism that functions from the beginning of life." "Life" might be too broad—there are many forms of life that seem (to me) to lack some of the structures necessary for meaningful decision making. (Specifically, some form of Recording Function, and perhaps other items must be available for operation of a rudimentary DME.) I am tempted to suggest the need for some form of central nervous system as a minimum prerequisite.

I think our concepts in the areas of attention, awareness, and consciousness are quite similar. The biggest difference seems to relate to your treatment of the reorganizing system, which seems to include memory, imagination, anticipation, and, possibly, selection (among alternatives).

Bill says: "I think that this proposal is related to your concept of 'modes.' However, I do not see these modes of consciousness as being modes of just one level, your DME." These statements indicate that I have failed to communicate the locations of "modes" within the hierarchy and of the DME. The DME, as I see it, is not a "level" of the hierarchy. It is a separate entity, operating *on the* hierarchy, which is itself located within the memory. Bill, you speak of awareness moving from one place in the hierarchy to another. It is the DME that is "aware."

"Modes" are suggested as a convenient way to regard the contents of Sixth Order. They help to identify and organize the contents of Sixth Order. Defining Sixth Order as "control of interpersonal relationships" opens the door to a great variety of possibilities. With communication clearly an important aspect of interpersonal relationships, it occurred to me to observe the content of everyday conversations (in terms of Orders of control). I was surprised and pleased to find the concept of Modes very helpful in clarifying my ideas about higher levels. The content and structure of Sixth Order and higher orders need further refinement and discussion.

Bill says: "Higher reference levels are no longer fixed, except at the highest level. At intermediate levels, lower-order reference signals are varied as needed to provide a higher-level system with the perceptions it needs..." This is pretty much a restatement of the hierarchy concept. This works nicely as long as the structure is fixed, and the results are acceptable. Thus, these portions of the structure can run on "automatic," and the attention of the DME can be elsewhere.

And he says: "Reorganization is now needed only when the learned systems are not capable of maintaining intrinsic variables at their ref-



erence levels." They include "many 'intellectual' functions such as classifying... all of which are learned—the reorganizing system does not have to carry out any rational processes." *Exactly!* And none of them are "put into the DME." Where are they? To me, they are in the memory—indeed, they, the learned systems, are much of the content of the memory. To a large degree, what you have called the reorganizing system, I prefer to call the DME, with access to the memory and minimal content and capabilities. The DME can perceive recordings, can compare them, can project their implications—by using methods, rules, algorithms, etc. taken from other recordings. The rationality of the DME is determined by the content of its available recordings. In some situations, existing recordings might include "rules" that interfere with the availability of needed recordings and, perhaps, the DME's attention-directing capability.

One of my primary suggestions for modifying the levels of the hierarchy involves temporal variables. I find the treatment of time as an underlying independent variable necessary throughout the structure. At lower levels, it is implicit, because Third Order events, actions, etc. occur "over time," but that is taken for granted. As I examined sequences for parameters for their control, I found that temporal variables became evident. Bill suggests "transitions" as an alternative. This is a logically appealing category. However, such an abstract category does not suggest specific controllable variables to me.

In human activities, I find many temporal variables of importance. Tempo is certainly one, but so also are such items as rhythm, acceleration, deceleration, pauses, and delays. The lowest level where these variables become important is for manual skills (my suggested Fifth Order). Throwing a ball not only requires a certain sequence of configurations of selected muscles, etc., but the timing must be correct! Indeed, change the timing, and you get a different result! Fifth Order, skills, requires control of temporal variables in addition to sequences, etc.

Bill, you refer to Gary Cziko and "temporal variables in which *only* the ordering was important—in language." In communication of nonpersonal matters, this (the *"only")* might be true. When personality, attitude, intent, motivation, etc. are part of the communication, spoken language requires control of temporal variables. Consider temporal variations in emphasis, tempo, rhythm, pitch, loudness, and enunciation (the mechanics of speech) for spoken language.

It seems to me that there are several situations where control of temporal variables is critically important. For example, skills in speaking. When working with adult stutterers (with McFarland), it became apparent to me that some forms of stuttering result from inadequate control of the time relations among the vocal systems.

*Time scale is* a fundamental concept—I don't know just where it belongs. But consider the changes in interpretation and analysis when the time scale moves from microseconds, to milliseconds, to tenths of seconds, to minutes, to hours, to days, to decades, etc. Consider the fastest-acting neural control system on a millisecond scale. Sequences of events are easily traced around the loop in terms of a series of straight-through operations. Change the time scale to fractions of a second, and, behold! It works as a unit—a feedback control system! *Both views are right!* When larger-scale, slower interactions are examined, games, perhaps, or economics, one can follow the signals as they follow their pathways and interact to become an operating control system. Problems that arise tend to be solved by changing the parameters of the system components. Or by changing the connections. The instructions are changed, personnel are replaced, etc. Most everyday problems are being handled pretty well (?) already. Over the last 20 (?) years, management theory began talking about "management by objectives" (often misapplied). More recently, there has been the "team" concept (also not well-understood). These ideas are not well-developed at this time, and the utility of the feedback-control-system concept is not yet clearly perceived. But makeshift alternatives are being used. It appears that one of the reasons that control-system theory is not generally applied is that longer time-scale needs are being satisfied fairly well without explicit control-system analysis.

At the dose of his post, Bill refers again to "experimental test." I'm not at all sure that is the relevant consideration. Theoretical structures tend to be accepted or rejected not only on the basis of formal test, but also on the basis of convenience and applicability. After all, the main advantage of the heliocentric theory of the universe is the simplicity of the computations. What a mess when earth-centered! But, correctly done, the results are indistinguishable.

When a decision is needed (a choice between/among alternatives), the DME examines ("imagines") related experiences from memory. It considers conditions (remembered) that might limit the selection(s). Anticipated results (projected through imagination) are compared with the objectives for acceptability. The DME could combine selected procedures sequentially or use an average (weighted, perhaps) of the imagined procedures. These imagined procedures are used by the DME as structured inputs to the corresponding levels of the hierarchy. Under ordinary conditions, this might take only a small fraction of a second. But if the situation is complex (and time permits), extensive investigation and study might be used before finally selecting the procedure. The whole process is so familiar and quick that it is easily overlooked.

This very general summary becomes more meaningful when applied to real people in real situations. I saw a figure-skating contest (pairs)



last night. *Very* complex activities—mainly muscle skills, but commentators reported some of the personal interactions that can play a part. I was struck by the situation when a *disturbance* occurred, a fall to the ice. This is a very complex situation: the planned sequence, with its timing requirements, has been suddenly interrupted. This appears to require extensive reworking of the many systems involved. However, the response—compensating movements—was within a fraction of a second! Clearly, the skaters had available, almost instantly, an alternative procedure. It was designed both to avoid injury and to continue the program. Most of these skaters had 10 or more years of practice. If you have ever tried to ice skate, you know that much of early experience involves learning how to fall without bruises. Thus the experienced skaters have a large supply of alternative memories that can be quickly applied when needed. Notice, while this involves much "repetition," this is *not* "reinforcement," rather it is acquiring a repertoire of alternative variations of performance.

In terms of Orders of the hierarchy, such a contest certainly involves interpersonal relationships (my suggested Sixth Order) and, in various degrees, all lower orders. In performance, the selected relationships are played out. But in discussing the contest, communication skills are used. Here, words are used to represent perceived variables at several levels. The ice, the skates, and the arena are (more or less) objects that can be considered among the Second Modes of Sixth Order. The movements, with their timing, would be Third and Fourth Modes. The combination into skilled performance could be Fifth Order. Overall, there are the personal interactions of the skaters in a framework of competition. Here we have Sixth Mode of Sixth Order. This analysis can be carried further and applied to other activities.

If we want our ideas to be used, we must show where they help solve other people's problems, that is, help them achieve the goals they are already working on. What are their motives, their higher-order objectives? We should show where Perceptual Control Theory fits into and contributes to their ideas. We should compliment them on their knowledge and insights.

Behavior perceived as attack results in defense, retreat, or return of attack. Such conflicts might be fun for the winner, but they often result in losses on both sides. Examples abound.

Experimenters must begin with some kind of theory as a guide to experimental design in any field. Each has several alternatives: try to validate some theory (not necessarily his or her own), try to invalidate some theory (likewise), try to determine interesting parameters (perhaps a recipe for a candy), or just do something for "the heck of it."

Why are experimental studies undertaken? Perhaps a student needs a thesis topic. It will be subject to assorted approvals. To maximize

probability of approval, it should fall within the range of currently acceptable ideas in that area.

Perceptual Control Theory is in competition with various other theories, some of which (in economics? in sociology?) are rudimentary indeed. But those other theorists tend to be interested in finding ways to support and defend their ideas. PCT people show the same behavior. What is needed is to change from "conflict" to "cooperation," or at least neutrality. (There are several ways to resolve a conflict.) Some attention could be directed toward strategies of interaction, using communication skills to "make friends and influence people" (Dale Carnegie, of course). Theories and ideas gain acceptance by being useful, not by winning arguments. Regarding PCT vs. other theories, PCT can describe and analyze the behavior of their opponents, while the others can only describe PCT behavior by misunderstanding, overlooking, discarding, etc. various common observations. Bill has listed some of them. These remarks are very condensed, but I think my viewpoint is clear—at least to PCTers.

*Bill Powers:* Bob, in talking about your "modes," you appear to take an external view of someone else's organization. That is, you seem to be looking for levels that will apply to "psychological" aspects of a person, to explain the how and why of that person's behavior. I'm taking a different viewpoint my definitions of levels are meant to describe how the world appears from the standpoint of the person, regardless of the context. When I speak of "system concepts," I'm referring not just to things like a self or a personality or a character, but to *all* system concepts. To a physicist, for example, there exists something called physics, a discipline. This is, of course, a perception. The entity called physics, I have proposed, is a concept built from a set of principles and generalizations, which both provide the material within which the entity physics is perceived, and which, as goals, are specified by the goals we have for physics—that is, for what kind of entity we want it to be. The principles and generalizations, in turn, are built out of a set of rational, logical, reasoned mental processes that I call, generically, "programs." In a set of programs, we can discern general principles; at the same time, the principles we wish to maintain in force determine what programs we will select to use.

My intention in proposing these levels of perception was to provide a framework within which we might understand all human experiences, no matter what they are about. If the subject matter is one person's experience of other individuals, then what I call "system concepts" would correspond to what you term "personality," and perhaps what I call "principles" would correspond to your "character," and my "programs" to something like "habits" or "abstract skills" or "intelligence."



These are ways of perceiving other people. But these general classes of perception and control include more than our experiences of other people. As I said, they include all experiences of all kinds. To a manager, the system concept called "my company" is as much an entity as "my children." To a patriot, "my country" is a real living entity. To a sociologist, "society" is a system concept with as much reality as "self." And to a chemist, chemistry is an entity with characteristics that depend on principles that are implemented as programs, without any organisms in the picture.

So what I am most interested in are the general classes of experience, not specific contexts in which we might give them more specialized names. The concepts of "character" and "personality" are inventions, but they are examples of fundamental classes of perception shared by the educated and the uneducated alike, and constant across cultures (I sincerely hope).

*Bob Clark:* Firing long-range weapons provides an example of the importance of the "speed of feedback." When guns were first used on targets that were beyond visual range, results were poor. Soon "spotters" were introduced to report the results. Thus, the gun became more accurate. This combination can be regarded as a negative-feedback control system, even though the return signal is relatively slow compared to the speed of the projectile. It does not permit control of each shot, but provides improved control of the overall performance of the gun.

Without spotters, feedback was slow indeed; hours to days were needed to get reports. Adding spotters reduced the delay, providing much faster feedback. Self-guided weapons are now available: cruise missiles, smart bombs. These work better yet, with much faster corrections. With these capabilities, they correct for aiming errors, possible movement of the target, and varying winds.

Analysis is influenced by the time scale selected. When times of the order of seconds are of interest (approximately the time needed for the projectile to arrive), there is no control without self-guidance. Here, open-loop analysis applies. Events are followed around the loop without treating the system as a whole. When events are examined in terms of the time for firing the gun several times (several minutes), closed-loop analysis applies to each firing of the gun as the assigned target is followed. Assuming the necessary components are present, either closed- or open-loop analysis may be suitable, according to the time scale of interest.

A primary question for any control system is: "What is the perceptual variable being controlled?" In this case, it is the point of impact of the projectile. This variable is a combination of several perceptual variables used to specify location in terms that can be communicated to the

gun crew. The observer's conscious attention is required in combining and communicating this information.

This system, assembled for the purpose of controlling the impact of a projectile, can be used as a general example of feedback systems. These observations may help in the analysis of other systems where the separate operations are unclear. Each of the parts of a control system can be identified: the feedback function is the spotter (plus communication equipment); the output function is the gun (plus the powder, projectile, aiming devices, and crew); the reference signal is the target (provided by higher command, the "Decision Making Entity"); and the comparator is the human (or a specialized device) determining the size and direction of the error provided to the crew to adjust the aim of the gun. For a time scale fast enough to observe these events as they occur, analysis can emphasize any one of the components. A mathematical equivalent of each of their separate operations can be written. For a time scale so slow that the system has come to equilibrium, analysis concerns the operation of the entire system as a unit. This is equivalent to solving the equations for the controlled variable in terms of the reference signal (and system parameters). The result is the familiar form used to describe the operation of a closed-loop feedback system.

The preceding discussion has been in rather mechanical, abstract terms. Regarding the people operating the system, each one is primarily concerned with his/her own part in the detailed sequence of events, rather than with the combined operations as a feedback system. Each person uses the skills needed for the immediate purposes. He or she selects and applies them as he or she understands their function in the larger organization. He or she also coordinates them with his or her individual internal conditions and needs.

The commanding officer, using a time scale suitable to his/her needs, regards each combination of gun, crew, and spotter as one of the parts of his/her output function. To him/her, each "rifle squad" is a simple straight-through system: he/she assigns the target, and the system performs. This can be considered as a stimulus-response system with its performance improved by adding a negative-feedback loop. This treatment, however, omits the events in between the "stimulus" and the "response." For some purposes, it is adequate.

The above is an example of a control system with two levels. Selecting suitable response times helps separate and identify the different levels. By adding another level of command, we have a three-level system. For the gun crew's spotter, the time scale would be of the order of minute, the time to fire a few shells. The commanding officer is concerned with the operation of his/her several guns. His/her time scale would be from minutes to hours, and, in turn, the higher commander works with larger-scale tactics/strategy and even longer time scales; to him or



her, the individual gun and crew with its assigned target is simply a tool to be used. He or she is concerned with larger-scale results.

Consider, in passing, what happens when the chain of command is bypassed and higher-order corrections are introduced too early!

Memory, expressed in several forms, is essential to the operation of this system. Some of the data are in the form of maps and instructions. Some are in the form of the aiming and firing mechanism of the gun. Some are in the form of remembered procedures and instructions. Some are in the form of remembered orders "from above." And so on.

In fact, the entire set of concepts, ideas, procedures, and skills are all located within the memories of the participating individuals. Each must have available, as a minimum, those portions of the operation that apply to him or her. Perhaps this could be simulated with high-speed computers and software, but the operating components must all be included in some form. Although the mechanical requirements are relatively modest, the memory capacity and programming to provide for automatic selection among many alternative actions is mind-boggling!

Each participant must direct his attention to the assigned task, while "simultaneously" "paying attention" to several other variables, especially those in his or her immediate environment. This requires frequent shifting of attention among several perceived variables.

*Bill Powers:* Bob: a very nice analysis, with lots of interesting observations. One thing your examples about "synthetic" control systems show is how crude control actually is when an organization tries to imitate individual control systems. But even an organization wouldn't think of computing how to aim the gun and firing it without looking to see where the shell landed.

One minor quibble. You say that "the reference signal is the target (provided by higher command, the 'Decision Making Entity"); and the comparator is the human (or a specialized device) determining the size and direction of the error provided to the crew to adjust the aim of the gun." When the commander says, "Put a warning shot just in front of them," the aiming point is not the target, but a point that bears a specified relationship to the target position. So it's the relationship between the impact point and the target that is the reference signal, and it exists only in someone's head prior to the shot.

An added observation: in order to adjust the gun position over repeated shots, the error must be turned into a new gun position. In order to get the final error as small as possible, you need a high loop gain. But if you have a high loop gain, an error of +50 yards would lead to a large correction, and the next error might be -500 yards. The solution is to use a slowing factor, such that only a constant fraction

of the computed correction is actually applied on any one trial. In that way, you can have high loop gain and accuracy, without instability of control. The Same principle applies in spinal control loops with transport lags.

*Dag Forssell:* I was fully trained in the Swedish Army Artillery. A behaviorist might listen to Bob Clark and hear him say that this is a chain of cause-effect happenings. We in PCT notice the *multiple* iterations required to arrive at the target and can see the similarity with the iterative calculations of Rick Marken's spreadsheet model. We *can* see that the difference is quantitative, not qualitative, since we see the error signals at work, pulling in some (hopefully correct) direction, and we know that the process works well even without perfectly planned and executed output functions.

*Bob Clark* Bill, I am surprised by your reaction to one of my remarks. You say that I "seem to be looking for levels that will apply to 'psychological' aspects of a person, to explain the how and why of that person's behavior." This suggests that I *begin* by selecting "psychological" aspects, *then* search for lower-order systems (variables?) that might fit. To the contrary, I begin with the lower-order variables. Thus, I look for perceptual variables that use combinations of selected skills (including their related lower-order variables). With a rather large assortment of these perceptual variables, the question is one of assigning useful labels. Labels are needed to facilitate their selection and application, both for use as sources of sets of reference signals and for communication. Labels are preferred that will be generally understood and thus communicate to more people.

I am basing my analysis on your very important observation that *behavior is the control of perception,* and that perceivable variables are the heart of the structure. I might have overlooked some important aspects of the situation—I am sure you will point out where my suggestions can be improved.

*Bill Powers:* There's a subtle difference between "sequential" and "lagged" control. Bob Clark gave an example of truly sequential control: lob a shell, wait for the spotter to see where it lands, wait for the spotter to send the message back to the gun site, lob another shell, etc.

Lagged control is like aiming a fire hose. The water shoots through the air and lands somewhere. The fireman is watching where the water lands and corrects his/her aim according to the error between perceived and intended landing spots. There is water continuously flowing and continuously landing, and the fireman is continuously monitoring the landing spot. There is always water leaving the nozzle at the same time



that water is landing on the fire, at the same time that the fireman's eyes are seeing the water landing, at the same time that the fireman's muscles are altering the aim of the nozzle. The processes in various parts of the loop are all going on at the same time, literally simultaneously—even if it takes two or three seconds for any one drop of water to fly through the air and land on the fire, and a hundred nanoseconds for the image of the water landing on the fire to reach the fireman's eyes, and 50 to 200 milliseconds for the image to be converted into a perceptual signal, and an error signal, and a new muscle tension.

The second case is the most common in human behavior, although there are valid examples of the first (corresponding by e-mail, for example).

Many analysts of human behavior have confused sequential control with lagged control. They assume that while a stimulus is occurring, everything else in the control loop is on hold until the stimulus finishes its pattern. Then, with the stimulus input finished, the response commences, goes through its pattern, and stops. At that point the effect of the response alters the stimulus conditions, with neither stimulus nor response occurring. Finally, the next stimulus occurs and the sequence begins again.

Even inside the nervous system, this same erroneous image seems to be used. A neuron fires, sending an impulse along a fiber to its end, where the impulse triggers off the next impulse in line. The maximum number of input-output events per second therefore seems to depend on the time it takes for an impulse to travel through the nervous system to a muscle.

In reality, there can be anywhere up to 10 or so impulses traveling along the same nerve fiber at the same time (length of path, say 0.5 meters, divided by speed of travel, say 50 meters per second, times impulse frequency, 1000 per second or more). The maximum number of input or output pulses per second is set by the maximum impulse rate, regardless of transit time through the nervous system. If you count redundant paths carrying similar information, the maximum rates are even higher than that.

This confusion is the result of trying to describe a dosed-loop process in words. Using words, we can say only one thing at a time. We can't be talking about input processes while we're also talking about output processes and the processes in between, or the effects going on in the external part of the loop. So language forces us to describe first the input, then the comparison, then the output, then the effect on the environment, then the effect on the input again, as if this were a sequence of mutually exclusive events. If one lets words dictate thought, the mental image of the process will have the same sequential nature, leading to incorrect analyses and failed predictions.

*Bob Clark:* "Anticipation" has been used without being really tied to PCT very well. A common example: the time when you got on an elevator, pressed the "up" button, and it went down. This is quite upsetting the first time it happens, because your remembered experiences lead you to expect—"anticipate"—it to follow the button's label. There are other common experiences of many sorts. (Such as going up—or down—stairs and finding one step, more or less, than was expected.) The point here is that "anticipation" and its related concepts are common occurrences.

What does anticipation consist of? It begins with the existence of a situation where there is a goal to be achieved. The Decision Making Entity examines the memory for ways to reach that goal. There could be an established procedure—a set of related reference signals—that needs only to be put into operation. Absent such an established method, the DME "looks" for an alternative that appears to result in reaching that goal. It (the DME) selects a promising procedure and uses that remembered set of reference signals. The DME might be using a previously successful procedure, or it might be extrapolating from remembered events. Either way, future events are expected, that is, "anticipated."

Anticipation dearly plays a significant part in a decision to "go to Paris." And the DME finds in available memories (including maps, travel agents, etc.) the procedures needed. These procedures are then used to provide suitable reference levels as inputs for the systems needed. In this situation, various skills are needed: communications to assorted people, handling money and tickets, passports, etc., etc. Variables of configuration, sequence, and time must be included. And all of these involve suitable control of the lower-order muscle skills. Bill, I think this is consistent with your view, but you have stated it in such abstract terms that some of this might be overlooked. It is very helpful to have the concepts of temporal variables, skills, etc. available in addition to that of configurations.

It seems to me that the concept of "Intentionality" recognizes that people make decisions (action by something I call the Decision Making Entity), selecting future events/situations to be achieved. E.g., I got in the car with the "intent" of going to the dentist. I "anticipated" little or no traffic and expected the car to perform as it has in the past. I remember the route and the conventions regarding other cars. To me, "Intention" is a Sixth Order concept—one uses available skills to accomplish higher-order purposes. Is this a problem?

Bill, I think your "minor quibble" about gun-aiming is more serious. The new "aiming point" is the "new target" for the gun crew. The target for the crew is no more, no less than that ordered by the commander. To specify it in terms of the preceding target might be a convenient shorthand way to communicate the position of the new target.



It seems to me you are following events around the loop, resembling open-loop analysis. Using a time scale including several shots, appropriate to the view of the commander, high loop gain should improve the resulting accuracy. Examining the series of events, we begin with the first shot. It misses by some amount, and the location of the impact is reported by the spotter. If the spotter is very sensitive, this location could be reported in feet or inches, although yards might be sufficient. The aim is then adjusted by the crew to whatever accuracy the equipment permits. High gain means that the aim is corrected very precisely. However, the second shot could be off considerably if, for example, there is a gust of wind, the target moved, or whatever. But high loop gain would still tend to minimize the error, instead of creating an over-correction. An over-correction might occur if the gun controls were not properly calibrated. As I understand it, a bracketing procedure is often used to calibrate the gun controls.

Indeed, the "bracketing" concept is useful in any situation (exploration, experimentation) lacking accurate or reliable data.

My statement that "Analysis is influenced by the time scale selected," would have been more clear as "Whether open-loop or closed-loop analysis is appropriate depends on the time scale selected."

Closed-loop analysis is appropriate for a time scale in which the firing of the gun is completed before the higher-order system (the commander's system) can respond. The loop gain has little effect on this analysis, because the loop serves as part of the commander's output function. The gain of the loop determines the accuracy with which the output signal follows the reference signal. Loop gain is determined by combining the sensitivity of the spotter with the sensitivity of the gun aiming equipment.

In the open-loop analysis, the concept of "high loop gain" does not apply. There is no "loop" to have a "gain." It particularly does not apply to the gunner alone. The gunner adjusts the aiming equipment according to the correction called for by the spotter. If the report is "100 meters too far," the gunner makes the corresponding correction (perhaps aiming two degrees lower); the spotter reports again, etc.

Which view is more useful depends on the purpose of the analysis. The commander's view, with its longer time scale, uses closed-loop analysis; the spotter's view uses open-loop analysis.

Dag comments: "A behaviorist might listen to Bob Clark and hear him say that this is a chain of cause-effect happenings. We in PCT notice the *multiple* iterations required to arrive at the target and can see the similarity with the iterative calculations of Rick Marken's spreadsheet model." I am not familiar with the Marken spreadsheet, but I can infer the general nature of the demonstration. The iterations are, of course, steps in the correction process. When observed with a longer

time scale, these iterations disappear; at a shorter scale, they become more obvious. Purely a matter of viewpoint and choice of time scale for observation.

Bill, your example of the fire hose for "lagged" control seems to work very well. But I don't think the fire chief cares which form of control it is as long as the water lands where *he or she* specified. The chief uses a time scale of perhaps minutes, vs. the seconds needed for the water to flow.

The existence of conflict depends not so much on the nature of the perceptual signals as it does on the relative time scales. Thus, the "gun crew plus spotter" is controlling the point of impact of the shell, and so is their commander in assigning the target. If the commander observes excessive spread in the pattern, he or she might make changes in the lower-order system. He or she might, for example, adjust the position of the spotter to improve his or her sensitivity. Both systems are concerned with the same perceptual signal, but their output systems operate differently.

As suggested, "conflict" occurs when the time scales overlap. If the spotter is repeatedly moved to a new position before the operations from the preceding position have been completed, a loss of accuracy (perhaps temporary) results. Some forms of stuttering provide another illustration. If the individual attempts to correct the formation of his phonemes too soon, i.e., before completing a word or phrase, stuttering is unavoidable. Many other examples are readily found.

Bill, in your words: "I'm taking a different viewpoint: my definitions of levels are meant to describe how the world appears from the standpoint of the person, regardless of the context. When I speak of 'system concepts,' I'm referring not just to things like a self or a personality or a character, but to *all* system concepts. To a physicist, for example, there exists something called physics, a discipline. This is, of course, a perception. The entity called physics, I have proposed, is a concept built from a set of principles and generalizations, which both provide the material within which the entity physics is perceived, and which, as goals, are specified by the goals we have for physics—that is, for what kind of entity we want it to be. The principles and generalizations, in turn, are built out of a set of rational, logical, reasoned mental processes that I call, generically, 'programs.' In a set of programs we can discern general principles; at the same time, the principles we wish to maintain in force determine what programs we will select to use."

"Programs we will select"—who, or what, does the selecting? The DME?

Your selection of these higher-level structures reflects your extensive knowledge, together with the application of a high degree of logical skill and reasoning. However, what about those who are not as knowl-



edgeable? How do they manage? What are the categories, etc. that they form and live by? When they interact with other people, what are the concepts they use? How can we talk to them without some common language?

Bill, I am troubled by your move from your Fifth Order, control of sequence, to discussion of "concepts." Are these concepts derived from combinations of lower-order perceptual variables? If so, how? And which? Does the operation of these concepts include setting reference levels for Fifth Order and/or lower-order perceptions? How, and by what is this done?

In the Glossary of *Behavior: The Control of Perception,* I find: 'Perception: A perceptual signal (inside a system) that is a continuous analogue of a state of affairs outside the system." Finding no special definition of "concept" in that Glossary, I consult my dictionary: "concept, n. 1. a general notion or idea; conception. 2. an idea of something formed by mentally combining all its characteristics or particulars; a construct." I think that's essentially what you mean. What are the perceptual components of "concepts"? It seems to me that this term is too broad and vague a category to be assigned as an Order of control in the hierarchy.

Also, for "entity," as in "entity called physics," above. Not in the Glossary. Dictionary: "entity, n. 1. something that has a real existence; thing. 2. being or existence, esp. when considered as distinct, independent, or self-contained." This is how I use "entity" in "Decision Making Entity."

Your view of "physics" seems to differ from mine. To me, a physicist, it is not "a" concept, rather it is a specialized language, including its own special words, syntax, etc. It is an assemblage of definitions, observations, methods, procedures, formulas, derivations, etc., etc. I find these in various locations in my memory—given suitable situations, they are available to select for use, or whatever. In one way or another, any of the lower-order perceptual variables might be pertinent. But it does not seem to me to serve as a "concept."

Concerning "what kind of entity we want it [physics] to be," I don't have any particular "goals" for "physics." It is "set of tools," very useful for certain purposes, but irrelevant for others.

My proposal is to assign control of temporal variables to Fourth Order, placing sequence at Third. Sequences have temporal aspects which are perceivable and controllable. Combinations of sequences with temporal variables, also perceivable and controllable, form skills. These provide new sets of perceivable and controllable variables. Skills can be selected: "Shall we dance the waltz, or the tango?"

You say: "My intention in proposing these levels of perception was to provide a framework within which we might understand all human experiences, no matter what they are about. If the subject matter is

one person's experience of other individuals, then what I call 'system concepts' would correspond to what you term 'personality,' and perhaps what I call 'principles' would correspond to your 'character,' and my 'programs' to something like 'habits' or 'abstract skills' or 'intelligence.'" The "correspondence" you suggest appears to be limited to a similarity in position in the sequence of levels in the hierarchy.

To me, "personality" refers to a group of perceptual variables with names that are convenient because they are commonly "understood" by ordinary people. They relate to short-term interactions and include such perceptual variables as "friendly," "helpful," "dominant," etc. What you call "system concepts" draws pretty much a blank, except among those with unusual information and experience. Logical, yes, but the connection with perceptual variables is not clear to me.

To me, "character" refers to another group of perceptual variables. These variables also have names that are "understood" by ordinary people. They relate to identifiable, therefore perceptual, underlying forms of behavior displayed in repeated interactions. Examples include such concepts as "honest," "reliable," "thorough," "careless,"—they are not necessarily favorable. What you call at this point "principles," in the sense you seem to intend, also draws pretty much a blank, except among those with special knowledge as above. Logical, again yes, but what is the nature of the "perceptual variables" from which they are derived, or *for* which they might provide reference signals?

Similar comments apply to your "programs." "Habits," "abstract skills," and "intelligence" I would treat quite differently. To me, these raise important questions not included *in* my present comments.

You emphasize: "These [referring to my proposed terminology] are ways of perceiving other people." Yes, but they are also ways of perceiving yourself. We agree that one cannot observe (perceive) one's own acts during the performance of those acts. However, this does not prevent their perception by examination of recent (perhaps very recent) memories of those same acts.

*Bill Powers:* Bob, I wasn't accusing you of beginning with psychological constructs and then filling in lower-level systems. My point is different.

Sometime between 1960, when we parted company, and 1973, when *Behavior: The Control of Perception* was published, a change in my thinking about the levels seems to have occurred. Or maybe, being on my own, my direction of thought became clearer. This all seems to be clearer now that you're describing your hierarchical concepts once again.

At any rate, the "pre" idea was much like yours, that we were attempting to characterize human beings by identifying levels of control with various aspects of human functioning. Somewhere in that 13 years, I realized that this was not the right problem.



As I now think about it, the problem in understanding human nature is not so much to understand human beings as to understand the world that human beings experience. In this world, I include not only the three-dimensional world around us, complete with living color, stereo sound, smellivision, and so forth, but also the "inner" world of imagination, memory, thought, reasoning, understanding—the whole world of inner commentary on sensory experience. In short, the world of experience includes everything experiencable, whether we think of it as being "inside" or "outside."

This world, to the best of my knowledge, originates in signals emitted into the nervous system by sensory receptors. That observation seems fundamental to me; to deny it would be to wreck the entire structure of physical theory, which I do not propose to do just yet. There is no way for the state of the world outside the nervous system to be registered in the brain without first appearing as a set of raw unanalyzed sensory signals. Nothing by way of information about the outside universe can get into the brain in any other way.

This means that the world we experience must consist of sensory signals and other signals derived from them. The "other signals derived from them" include the totality of what we can experience, from the taste of chocolate to Fermat's Last Theorem, as well as our experienced "interest" in that Theorem, if any, and any "thoughts" we might have about it. Nothing is exempt.

When I say "it's all perception," this is what I mean. We live inside a nervous system, and all we know is what goes on inside that nervous system. Even our idea of the existence of the nervous system exists as a set of neural signals, perceptions. The physical world outside us is a network of hypotheses existing in neural networks in the brain. Part of this neural hypothesis is a conjecture to the effect that there is an objective physical world outside our sensors. Sciences like physics and chemistry are very well worked out neural hypotheses. At bottom, they rest on sensory experience and all that the brain can make of such experiences. Our very attribution of physical theory to objective phenomena is itself a phenomenon in the brain.

This changes the problem. Now the problem is to classify all of experience, not just experiences of other people. We might perceive another person driving a screw into a piece of wood as showing a "skill" type of control, but this leaves unexplained the screwdriver, the screw, the piece of wood, and the relations among them. Those are also perceptions, and they are being controlled. The term "skill" refers mainly to something about the person's organization, but to explain how a skill like that is carried out, we have to explain the screw, screwdriver,

wood, and relationship as well. The perceptual organization needed to represent these four things explains their existence for the actor; the actor's behavior is explained, in PCT, as control of these perceptions. Whether we characterize that control as constituting a "skill" is more or less beside the point. If we can explain the behavior in terms of controlling perceptions of wood, screw, and screwdriver individually, and in terms of adjusting those controlled perceptions to maintain control of a particular space-time relationship among them, we have explained "skill," too. But we have also explained how any person interacts with the world, whether the immediate world contains other living systems or not.

What I attempted to do with my definitions of levels was to represent the way the world seems to appear to us—meaning to myself as a representative human organism. This was very much an idiosyncratic first try, and it has undergone revisions as I have attempted to refine the descriptions. The process involved was quite unscientific, in that I didn't take any polls or do any objective experiments. I simply looked and listened and felt and tried to understand what was going on from the standpoint that I was an observer watching the outputs of neural data-processing functions. "What am I taking for granted?" I asked over and over. What is it that I'm doing or experiencing that is so familiar and so self-evident that I don't even recognize it as a perception? What part of my experiences am I setting aside as having some special status, or treating as the background of more important things, or brushing out of the way so I can look at something more interesting?

The "relationship" level was a latecomer to the hierarchy. I had spent a lot of time looking for relationships between one perception and others, and between action and perception, but it took years for me to realize that relationship *itself is* a perception. The same is true for all of the levels added or modified since 1960. I had spoken for years about the "principles of control," without realizing that principles can't exist unless we perceive them, and to perceive them we necessarily have to have principle-perceiving functions. Similarly for "physics." What is physics, that I can know it exists? It's a perception, of course. If I couldn't perceive such a thing, it wouldn't exist for me. So what sort of thing is it? I have proposed calling such things "system concepts," for lack of any better term. And what other sorts of experiences are of that same sort? There are many, once you realize that this *is* a sort of perception.

I think that the key to understanding how I think of the levels is to get into a mode of observation in which, as they say in Washington nowadays, "everything is on the table." No thought, no concept, no background perception can be let go because it "doesn't count." Everything noticeable counts. Everything noticeable is evidence about



what at least one brain is doing. If you accept the basic premise that the experienced world begins as a set of unanalyzed sensory signals, the only conclusion is that everything noticeable is activity in a brain, and hence it has to have a place made for it in a model of a brain.

I don't think that I've characterized the higher levels of perception very well. The most I hope to get across by the terms I use is the approach, the idea of calling into question everything we normally take for granted, all of the operations and perceptions that we use in thinking about and acting on something *else. I* don't think we'll arrive at a consensus on the levels until more people go through this very personal sort of exploration and report their findings.

On a different topic, Bob says: "The new 'aiming point' is the 'new target' for the gun crew. The target for the crew is no more, no less than that ordered by the commander." Yes, there are two levels of control involved here. Considering only the commander's level, the target always remains the same: the position where the shell is intended to land. The error is the amount by which the gun crew misses the target. The commander must alter the target position given to the gun crew *slowly,* however, to avoid treating dispersion in the pattern of shots as a systematic error.

Bob also says: "It seems to me you are following events around the loop, resembling open-loop analysis." This is indeed difficult to convey accurately. Loop gain is in fact the product of all amplification factors encountered in one trip around the closed loop, so calculating it seems like following events around the loop. To get high loop gain when there are transport delays in the loop, one must also use dynamic slowing of error corrections, a low-pass filter. With the filter in place, the behavior of the system at low frequencies is just as though no transport lag existed. So even though all real systems do entail such lags, they can be neglected! A difficult point to get across.

And: "Whether open-loop or closed-loop analysis is appropriate depends on the time scale selected." I don't think this is quite right. If one does an analysis on a short time scale where delays are visible, but neglects dynamic effects, a control system with a loop gain more than -1 will be incorrectly predicted to be unstable. The existence of large negative loop gains can be explained in a sequential analysis only if the proper low-pass filtering is taken into account—and it is usually not taken into account in open-loop analyses.

Consider a control system in which the controlled quantity is equal to the output of the system, the input function has a gain of 1, and the output function has a gain of 100. If there are lags in this system, as there are in all real systems, you would predict on that basis alone that the system would go into violent overshoots increasing without limit by a factor of 100 on every iteration. But now add a slowing factor

that follows the rule: on each iteration, calculate the new output, and then let the actual output change by 1% of distance from the previous amount to the new calculated amount. This is a low-pass filter that does not alter the final steady state. The system will suddenly become stable; in fact, it will bring the error down to 1% in a single iteration! The effective long-term loop gain is still 100, so errors will be kept small over the long run.

If you try to eliminate the overshoots in this sequential system by just lowering the output gain to less than 1, the result will be stability, but the error remaining at equilibrium will be 50% of the value of the reference signal on the average. So you get stability, but almost no control. The high-gain system with the low-pass filter will counteract errors slightly more slowly, but will eliminate 99% of their effects. The low-gain system without filtering will counteract disturbances instantly, but will cancel only half of their long-term effect.

So there is a difference between closed-loop and open-loop analysis that is independent of the time-scale.

And you say: "I don't think the fire chief cares which form of control it is as long as the water lands where *he or she* specified. The chief uses a time scale of perhaps minutes, vs. the seconds needed for the water to flow." My point was that all components of a closed-loop system of this sort are operating literally simultaneously; they don't take turns acting, with no action between. This is how the nervous system works; sensors are generating signals at literally the same time that actuators are producing forces.

And finally: "As suggested, 'conflict' occurs when the time scales overlap. If the spotter is repeatedly moved to a new position before the operations from the preceding position have been completed, a loss of accuracy (perhaps temporary) results." With proper design, the system would work better if the spotter were moved immediately, rather than waiting for the previous results to come in. This would be the right strategy if the calculations were being continuously averaged over several shots, as would be necessary to distinguish random from systematic errors.

On another topic, you say: "What about those who are not as knowledgeable? How do they manage? What are the categories, etc. that they form and live by?" I see your point and agree that it has to be considered. My levels are intended to describe categories of experience that all people (and even animals) employ without any training or knowledge. All people perceive and control relationships, by my account. They also perceive and control categories, sequences, logical functions, etc., not by thinking about it but simply by having the world presented to them in such terms by the *basic* equipment of their own brains. I don't know how to put it better than that.



You also say: "Bill, I am troubled by your move from your Fifth Order, control of sequence, to discussion of 'concepts.' Are these concepts derived from combinations of lower-order perceptual variables? If so, how? And which?" The levels as of now (February 1993) are (1) intensity, (2) sensation, (3) configuration, (4) transition, (5) event, (6) relationship, (7) category, (8) sequence, (9) program, (10) principle, and (11) system concept. Each one, when analyzed into components that are not just smaller groups of the same level, proves to be a function of perceptions of the next lower level (or lower still). So a system concept like physics is drawn from perceptions of many physical principles, while principles are drawn from perceptions of many specific logical/mathematical operations, and so on down the list.

As to *how* a perceptual function of one level combines lower-level perceptions, I have no idea. The nature of the functions must be very complex at the higher levels, or at least of a kind that we can't analyze now. The apparent dependencies were arrived at from analysis of experience, much as we can see that configurations are composed of sets of sensations. Also it was helpful to ask how we would go about maintaining a perception of any given level against disturbances—how, for example, we would maintain the principle of honesty. To perceive ourselves as honest, we set reference signals for certain programs of action and thought which we call reasoning or analysis or procedures. None of this is very firm; I'm just reporting how it seems to me after as close an inspection as I can carry out. Other people's opinions are obviously needed.

I chose the term "system concept" with the emphasis on "system," not "concept." In my view, "concept" falls within the range of meaning of "perception," because it's something we can experience as occurring or existing. I could have said "system perception." It just means the sense of an organized entity of some sort being present, the kind that is composed of principles, generalizations, heuristics, characteristics, whatever you want to call them. Perceiving a specific person whom you know well leads to this sort of system concept or perception—the impression of a particular person, a personality, a system. Shoot, how am I suppose to be more specific about an idea that's not very clear to begin with?

You go on to say: "To me, a physicist, it [physics] is not 'a' concept, rather it is a specialized language, including its own special words, syntax, etc. It is an assemblage of definitions, observations, methods, procedures, formulas, derivations, etc., etc." Yes, that's what I mean by a system concept. The very fact that you can, without enumerating, refer to all of its components as some sort of bringing-together into an "assemblage" of a variety of more specific elements shows that you have formed a conception of physics as a unified system of ideas,

definitions, observations, methods, procedures, etc., with the "etc." indicating that the picture includes much that is not enumerated. "Physics" is clearly a system concept quite different from "religion" or "family." Enumerating the lower-level details of these other system concepts would entail quite a different list.

When you say, "I am a physicist," the "I" being indicated is associated with the system concept of physics. For the moment, the center of awareness is operating from that position. But when you say "I am a father," the system concept is the one we refer to as "family," and the "I" now takes on new characteristics associated with a different system concept.

Or at least that makes a good story.

As to other differences, let's just go along with them for now. I'm feeling a bit overloaded.

*Bob Clark:* Bill, I was preparing for a final edit of another post on levels when I received your latest post. I am pleased, but not surprised, to find our primary views of "the world" have remained identical over the years: "This world, to the best of my knowledge, originates in signals emitted into the nervous system by sensory receptors." And: "This means that the world *we* experience must consist of sensory signals and other signals derived from them. The 'other signals derived from them' include the totality of what we can experience, from the taste of chocolate to Fermat's Last Theorem, as well as our experienced 'interest' in that Theorem, if any, and any 'thoughts' we might have about it. Nothing is exempt." Also: "When I say 'it's all perception,' this is what I mean. We live inside a nervous system, and all we know is what goes on inside that nervous system."

Given this viewpoint, with which I completely agree, there are several pertinent problems.

You report that your "pre" idea was "attempting to characterize human beings by identifying levels of control with various aspects of human functioning." That does not quite fit my recollection, but we probably need not resolve the matter at this time.

My present views have developed irregularly over the years. They have been modified since you and I were in contact in 1987, and further developed since I met Greg Williams in 1988. Some of the ideas I have been presenting recently are still being revised. I certainly expect further changes as discussions proceed—just as I think you also expect.

In your most recent post, you have restated your current view: "Now the problem is to classify all of experience, not just experiences of other people. We might perceive another person driving a screw into a piece of wood as showing a 'skill' type of control, but this leaves unexplained the screwdriver, the screw, the piece of wood, and the relations



among them." (An aside: in my view, "skill" is not a "type of control," rather it is a combination of perceptual variables that includes perception of objects (screwdriver, etc.), the one using the tool, the location of the several objects, and the sequence of events and interactions required in order to "drive a screw into a piece of wood." This "combination of perceptual variables" includes several less-complex skills, such as reaching for the screw, placing it in the required position, etc. This entire combination could be referred to as "driving a screw, etc.," which is one among many muscle skills that can be used to accomplish higher-order purposes. Thus, "skill" is a category of perceptual variables, selected for purposes related to interactions with other people and distinguished from lower-order variables by combining them (sequences of muscle tensions combined with temporal variables) to form the specific skill selected. Perhaps that is not an "explanation," but I think it is "understandable," and I hope that it communicates something of my view of Fifth Order.) You use two familiar, frequently used words: "understanding" and "explanation." Exactly what does each "really" mean? I find my dictionary of little help here—let me try to define them: "Explanation" seems to consist, at a minimum, of being classified, that is, placed in a category. That category might or might not pre-exist, but to be useful, it probably should contain more than one element.

Is a dog "explained" by having its breed specified? Or by naming its species? Or by its genealogy? How about its physiology, or neural systems? Of course not. Neither is "control of a perceptual variable" "explained" by pointing out that its actions resemble those of a negative-feedback system.

Instead of "explaining" some thing, activity, system, or whatnot, I prefer "description" of parts and their connections with each other and with other items. "Interactions" among the parts and with other items describe its "behavior." I am pretty sure that this is what you mean.

"Understanding" is the goal of every teacher for his or her students. For me, too. However, it seems to me that there are two aspects to this concept: internal and external. The "internal" aspect is displayed by simply asking, "Do you understand this matter?" If "Yes" is the reply, this signifies that there is no perceived recognition of inconsistency within another's internal array of information (perhaps after modification to include the new material). The "external" aspect is more complicated, being displayed by asking the other party to "solve" a problem that requires "proper" use of the material to obtain "the" solution. If the result is "acceptable," it indicates (does not "prove") that the comparable parts of each party's systems are in agreement. This is desirable, of course, because further discussion is facilitated, possibly leading to revision (perhaps by both participants).

It is interesting that I have had the experience of saying "Yes" to the question, but finding that the external test reveals some degree of "misunderstanding." Indeed, I think that most people have had this experience in one form or another. "Consistency" is demonstrated by this procedure, but not necessarily consistency with other parts of either party's systems.

Since our views of the lower levels are rather similar (with the possible exception of my Fourth Order, temporal variables), we move to higher levels.

Here I seek controllable, perceivable variables that are formed by combining lower-order variables. It occurred to me that muscle skills can be regarded as sequences combined with temporal variables. There are many such perceivable combinations. Some are relatively "simple," like walking, pressing fingers on buttons, pulling rubber bands, etc. And some are very complex skills, like vocalizing, running, throwing, dancing, acrobatics. Thus muscle skills, a group of perceivable, controllable combinations, can be assigned to Fifth Order, "skills." Such muscle skills are readily perceived not only in others, but also in oneself. Many are learned, some probably have genetic origins. In the process of learning how and when to use them, variations of many sorts are explored. Such experiments and their results are recorded (as "memories") as they occur. Thus, they remain generally available for later use.

What comes next? What would be the nature of Sixth Order activities composed of controllable, perceivable variables based on combinations of lower-level variables, especially skills of Fifth Order? As I was seeking to distinguish Fifth Order from Fourth Order, there was a tendency to consider interactions between/among individuals. Thus, with Fifth Order assigned to skills, Sixth Order could include all activities using combinations of skills for purposes requiring control of interpersonal interactions. Examples include games, competition, cooperation, government, dubs, businesses, and entertainment. In addition, language, mathematics, philosophy, systems, principles, and programs are included here. Here we find all theories, whether of the natural world, the world of imagination, the world of behavior, etc., including Perceptual Control Theory.

People generally have some sort of structured views of the nature of their surroundings and how to achieve their objectives. Their methods might be based on gross misunderstanding, superstition, or whatever, but they are sufficient for most people most of the time.

Communication, complex combinations of many muscle skills, taking many forms, is used throughout interpersonal interactions for many purposes. Should this be considered another level? In examining that possibility, it occurred to me to pay attention to everyday conversations among my friends and associates. Much conversation pertains



to Zero Order systems—health, sensations of temperature, and physiological events. There was discussion of combinations of sensations perceived as "objects." In turn, sequences forming postures, movements, etc. were of interest. These various combinations were used for ordinary, customary purposes of communication.

As "topics of communication," these might be called "Modes" of Sixth Order, corresponding to Orders of control, without themselves being control systems. Topics relating to skills would be Fifth Mode of Sixth Order. Those relating to communication and other interpersonal variables would be Sixth Mode of Sixth Order. The Modes do not function as control systems, but they assist in analyzing the structure and performance of the systems.

Continuing these observations, one finds comments about personalities and characters of individuals. What does this mean in terms of perceivable variables? The dictionary answers these questions rather well: 'Personality: 1. The visible aspect of one's character, as it impresses others: 'He has a pleasing personality.' This looks as though it could belong to Sixth Mode of Sixth Order, but it seems to me to go a bit further. Thus, we have people who are actors, behaving to portray varying personalities, emotions, etc. They appear to be controlling their behavior to produce certain interpretations by those around them. Being "pleasing," "friendly," "courteous," "hateful," whatever, can be controlled, even if contrary to the performer's own internal feelings. Thus "personality variables" can be regarded as controllable, perceivable variables in the performer's own repertoire. Interestingly, because combinations of skills are needed to display these variables, the time scale needed to perceive these variables is moderately long vs. the time needed for demonstrating lower Modes. "Character: 3. moral or ethical quality, 4. qualities of honesty, courage, or the like; integrity." Other definitions seem too inclusive or specialized. I think this does pretty well. Here, there is another increase in the time scale. While personality can sometimes be demonstrated in a matter of minutes, character requires observation of several incidents distributed over a much longer period.

These topics, "personality" and "character," are sufficiently different from each other and the other Modes of Sixth Order that they could be treated as Seventh and Eighth Modes of Sixth Order. Their importance in forming "images" of other people also suggests assigning them to Seventh and Eighth Modes of Sixth Order. This assignment would imply the existence of Seventh and Eighth Order Control Systems, based on corresponding perceptual variables.

This discussion suggests that something like "self image" could be considered Ninth Mode of Sixth Order, with corresponding Ninth Order control system. This treats personality and character as impor-

tant components of self image, in addition to all other perceptions of whatever composes one's "self."

Where and how the DME, "Decision Making Entity," would relate to this structure is postponed for the present.

I am not very confident that the above distinctions among personality, character, and self image are appropriate, but they might be useful for discussion.

Conceived, I think, as a truly general theory of behavior, PCT should apply not only to observations of the behavior of other people, but also to ourselves, both individually and in the process of constructing a theory of behavior. "Personality" and "character" certainly can be used for describing other people.

On examining my memories of my own behavior, I find that I can generally perceive even these high-order variables in my own remembered behavior. Perhaps more important, I find that, if I care to, I can generally change my behavior. This might take more time than I like, but my perceived and changed behavior has become more nearly what I sought.

Further revisions are certainly needed. Perhaps most important, PCT should be applied to problems of general interest.

*Martin Taylor:* On reading Bob Clark's set of levels and comparing it with that of Bill Powers, I am for the umpteenth time reminded of the great difference between the internal view and the analyst's view of a hierarchy. Maybe I am being unfair, but Bob's sounds to me like the view one would see from the outside, rather than a description or model of what goes on inside an organism, whereas Bill's seems addressed to the mechanism inside the organism (again seen by an outside analyst).

Bill's levels deal with different kinds of perceptual input functions (PIFs). They speak, from the analyst's viewpoint, about what the organism *might* be controlling, and they have been developed by an organism that has attempted to consciously perceive what is normally unconsciously controlled. It is an empathetic view. Each level exists because there is a requirement for a different kind of perception, and the differences among the levels are (if I understand correctly) only in the perceptual input functions characteristic of the different levels (I can imagine that the output functions also differ, but I don't remember that being talked about).

Bob's levels strike me as speaking to what a social contact might perceive of a person; no single elementary control system (ECS) would act at a "skill" level, unless I greatly misunderstand what is meant. An external observer can see skill, and the performer, *looking from another viewpoint,* can assess his or her own skill, but no skill-level control



system can be extracted from a hierarchy. Maybe Bob can describe a skill-level elementary control system and prove me wrong. But I can't at the moment imagine "skill" as a level of control in the way that I can imagine "sequence" or "program."

Bob, you say: "As I was seeking to distinguish Fifth Order from Fourth Order, there was a tendency to consider interactions between/among individuals. Thus, with Fifth Order assigned to skills, Sixth Order could include all activities using combinations of skills for purposes requiring control of interpersonal interactions. Examples include games, competition, cooperation, government, clubs, businesses, and entertainment. In addition, language, mathematics, philosophy, systems, principles, and programs are included here." All of this is external, isn't it? You are talking about the applications for which Sixth Order systems would be used, not what Sixth Order systems do, or how they are constructed. Perhaps what you are saying is that Sixth Order ECSs individually contain language models, games models, cooperation models, etc. that they use in forming their perceptual functions. Such models are, indeed, possible. Symbolic artificial intelligence depends on them. But do they belong as intrinsic components of individual ECSs?

I think I have become more sensitive recently to the importance of separating the external (analyst or observer) viewpoint from the internal viewpoint. Many of the issues raised in recent postings seem to hinge on a failure to note, and sometimes on a tendency to mix, the two viewpoints. The organism can control what it can perceive, and it cannot perceive its feedback paths, other people's perceptions or references, or its own outputs. But the analyst can perceive feedback paths and the outputs of other organisms and can develop implausible theories that *require* the organism to perceive them. S-R theory cannot work if it requires the organism to control R, for example. The analyst can see that under relatively undisturbed conditions, there is a moderately consistent relationship in an experiment between S and R, as the analyst perceives them, and makes the unjustified claim that the subject produces R as a result of perceiving some transform of S. But the fact that the analyst can perceive both doesn't mean the subject can.

Many posters to the net, myself included, fall into the trap of writing about something the analyst can see as if it were something the analyzed organism can see, and asserting or assuming that the analyzed organism uses that property in some way. I don't know how to avoid this problem it is built into our language. Seeing that the problem exists is one way to avoid being caught by it. Sometimes.

*Rick Marken:* Excellent post, Martin! I think that the difference between Clark's and Powers' levels might be based on more than the

internal/external distinction, but your discussion of that distinction was brilliant. I agree with you that it is probably the essence of the difference between the PCT and the conventional perspective on behavior.

*Bill Powers:* Bob says: "You use two familiar, frequently used words: 'understanding' and 'explanation.' Exactly what does each 'really' mean? I find my dictionary of little help here—let me try to define them: 'Explanation' seems to consist, at a minimum, of being classified, that is, placed in a category." The problem with this sort of definition is that all you get is a claim that the thing to be explained is like (or at least classified with) something else, which generally is also unexplained. Then Bob says: "Instead of 'explaining' some thing, activity, system, or whatnot, I prefer 'description' of parts and their connections with each other and with other items." I like this better. To explain a phenomenon is to describe its operation at a lower level. So models are explanations of the phenomena that they reproduce. Then: "The 'external' aspect [of "understanding"] is more complicated, being displayed by asking the other party to 'solve' a problem that requires 'proper' use of the material to obtain 'the' solution. If the result is 'acceptable,' it indicates (does not 'prove') that the comparable parts of each party's systems are in agreement." Yes, the question when someone says, "I understand what you mean" is just what the other person's understanding is. This is the basic problem of communication.

Bob, you say that "'skill' is not a 'type of control,' rather it is a combination of perceptual variables..." This might be a difference between our approaches that I hadn't recognized. My levels are supposed to be types of controlled perceptual variables and, by implication, the systems that control them. When I label one level "programs," I don't mean just a level where programs are executed. I mean a level where we perceive *what program is being carried out*, and continually correct errors if we perceive a deviation from the correct program. An example would be watching people play cards. After a while, watching the play proceed, you recognize the rules in effect, and say, "Ah, they're playing five-card stud." Then, if someone violates a rule of five-card stud, you can perceive the error and (unwisely perhaps) point it out to the players to get them to conform to the rules. A rule is a form of program. To say "combination of perceptual variables" doesn't tell us much unless you say what kind of combination you're talking about.

You say: "Thus, 'skill' is a category of perceptual variables..." I agree with that: it is a perception at the level of categories in my definitions of levels. The category level is where we use one perception (here the noise or series of marks, "skill") to refer to a collection of perceptions of lower order.



*Bob Clark:* Bill and Martin, instead of making specific comments on your recent posts, I am offering comments of a more general nature.

Martin, you have focused on a general concept: "viewpoint." In view of your remarks, I am trying to summarize my (present) orientation in the following. This turns out to be much more difficult than I expected—and probably will change with additional review.

*My general view.* Quoting Bill: "We live inside a nervous system, and all we know is what goes on inside that nervous system." As I noted in an earlier post, that is also my viewpoint.

*Categories.* When I investigate what I have available ("inside that [my] nervous system"), I find several easily identified categories. Many other categories can be used as desired. I find the following categories particularly convenient and useful:

1. "Decision Making Entity" (DME; "Center of Awareness"). This is the entity that "uses" viewpoints. "I" is not used because it tends to include too much. This entity can direct its attention to any of the neural signals entering the central nervous system. It can shift its attention rapidly from one signal (or group of signals) to another. It also can select which of the available signals has its attention at any given time. It responds to "built-in" reference levels by selectively "paying more attention" to some signals than to others.

2. "Recording Function"; "Memory"; "Conscious". This is the entity that forms records of signals to which attention is directed. Attention can shift fast enough that it appears that all signals are recorded. Mere "exposure" to perceivable events seems to be insufficient for remembering. Conscious attention, i.e., perception, appears necessary. Teachers, parents, supervisors, etc. are invariably concerned that their students "pay attention."

3. "Perceptual Signals"; "Attention". These are the signals to which the DME's attention may be directed. From time to time, the DME selects them from the available signals. These form two groups: a. "Sensory signals" reporting the current condition of all physiological systems with neural connections to the central nervous system. They can form various combinations, resulting in production of additional, derived, sensory signals. b. "Imaginary signals" are recorded sensory signals and other recorded signals as selected by the DME. The imaginary signals include all perceptual signals derived from recordings. Generally, they are organized in some manner by the DME for convenience and accessibility. Such organization will distinguish between those coming from "external sources" and those coming from "internal sources." When selected by the DME for examination, they resemble audio-visual-sensory recordings. They normally run from past time events toward the present, and the DME can extrapolate them to future time. Likewise, memories can be combined in various ways, both

sequentially and simultaneously. In this respect, they resemble editing of videotapes.

4. "Output Signals." These signals are recorded in the memory together with the corresponding perceptual signals. After review, the DME determines the "desired" effects on the perceptual signals. The DME then applies the remembered perceptual signals to the corresponding output systems. They act as "reference signals" for the systems connected to them. Effects are determined by the nature of the systems to which they are connected. The DME cannot directly perceive these signals (they are not "incoming"), but their effects are determined by observing corresponding perceptual signals.

5. "Comparator Function." The DME makes its selections on the basis of comparison of the "desired" effects with the anticipated results offered by alternative sets of imaginary signals in relation to current sensory signals (and their combinations).

*Viewpoints regarding the hierarchy.* Martin, I have already been thinking about pointing out alternative views of the basic feedback-control system. However, you have focused on a more general concept: "viewpoint." When I apply that concept to a minimal system, I find five identifiable viewpoints. Perhaps others can be found. Different viewpoints might call for different classifications and definitions of the hierarchical levels/Orders.

1. The "User's" view. The User's DME selects the desired condition (activity, etc.) of his/her own system, as it relates to its surroundings and applies the indicated reference signals. The User observes the resulting activity, etc. for possible deviation from intended performance. If deviations are observed, corrections are applied as indicated. The corrections are selected from memory, including anticipation, analysis, and theory (as the User understands them). This process continues as long as results are acceptable. If the results are not within limits, changes might be needed in the remembered structures. Although the concept of a hierarchy is not essential for the usual User, it can be very helpful when there is difficulty in finding adequate results.

2. The "Engineer's" view. This view is "objective," in that the Engineer treats the subject as external to himself or herself, omitting the part(s) he or she plays in this activity. The Engineer studies the details of the various elements of the system(s) and their interconnections. Each element is evaluated in terms of the relation(s) between its input(s) and its output(s), expresses them in logical/mathematical terms, and analyzes the results. If this is unacceptable, modifications of one or more elements and/or interconnections are examined for possible alternatives. The Engineer supplies standards of performance selected from his/her memory by his/her DME. In this process, the Engineer's DME controls the activity. Although the concept of a hierarchy is not essential for the



usual Engineer (many are quite successful without it), it can be very helpful in more complex and multi-dimensional situations.

3. The "Outsider's" view. The Outsider, that is, his/her DME, is observing the activities of another "living-behaving" entity. His/her information about that entity is derived exclusively from his/her own input systems—sensory, as modified and interpreted by his own established internal systems. He/she uses his/her knowledge to construct a description of the internal structure of the other entity. All of this activity, together with the conclusions, is stored in his/her memory and continues to be available for future application, modification, etc. These activities might include discussions, etc. with other Outsiders. Although the concept of a hierarchy is not essential for the usual Outsider/Observer, it can be very helpful in analysis and interpretation of results.

4. The "Experimenter's" view. This view is also "objective," in that the Experimenter treats the subject as external to himself or herself. He or she assumes that the subject's reference levels are determined by the Experimenter's instructions combined with the subject's pre-existing decisions. The Experimenter selects and applies some action to the subject's externally accessible inputs. The results are interpreted in terms of whatever behavioral theory he/she wants to apply, Although the concept of a hierarchy is not essential for some experimental purposes, it can be very helpful both in experimental design and interpretation.

5. The 'Theorist's" view. The Theorist pays attention to all of the views listed above, as well as any others that can be proposed. He/she resembles the Experimenter in searching for confirmation or denial of proposed theoretical and/or analytical ideas. The User's and Outsider's views provide additional data for evaluation of proposals. The Engineer's view provides guidelines as to the logical and technical limitations that are intrinsic to the external surroundings. Although the concept of a hierarchy is not essential for some theoretical purposes, it offers the most inclusive and effective theoretical framework I know of.

Two views of hierarchical levels/Orders. These are both Theorist's views:

1. Bill Powers' view: "My levels are intended to describe categories of experience that all people (and even animals) employ without any training or knowledge." Bill is concerned with "categories of experience."

2. In my own approach, I have focused on the perceptual signals as they combine to form the hierarchy. "Hierarchy" is defined in *Behavior: The Control of Perception,* page 78: "This model consists of a hierarchical structure of feedback control organizations in which higher-order systems perceive and control an environment composed of lower-order systems; only first-order systems interact directly with the external world. The entire hierarchy is organized around a single concept: con-

trot by means of adjusting reference-signals for lower-order systems." I am concerned with categories of perceptual signals as they combine to form a hierarchy of perceptual signals.

*Martin Taylor:* Bob's "Engineer's" viewpoint is fine, but in using it, the engineer must try to empathize with the many viewpoints that occur at all places within the system. If point A is a perceptual signal that has as part of its input a sensory signal B, the engineer cannot assume that every variation in B is reflected exactly in A. The question must be "what does A see of the variation in B" before the engineer can properly assess what will happen at A. None of Bob's viewpoints seem to me to be of the class that I might call "internal."

From the outside view, there is a complex in the world that seems to be what the "subject" is controlling. It is the experimenter's view of the putative controlled environmental variable (CEV). The theorist outsider can also "see" the subject's perceptual signal that is the actual controlled variable. As far as the subject is concerned, that signal *is* the CEV. It is all that the ECS in question can know about the state of the world.

There are various kinds of "outsiders," as Bob has pointed out. One of them is the DME, which views all sorts of signals in the hierarchy. All outsiders use their own perceptions, rather than the one actually being controlled by the observed ECS. It is from the outsider's viewpoint that we can see a dichotomy between the CEV in the world and the perceptual signal. The subject cannot see it.

The outsider, who might be using very precise measuring instruments, can see that there are discrepancies between the state of the putative CEV and the state of the derived perceptual signal, even if the total perceptual input function is correctly interpreted. These discrepancies have to do with the resolution of the perceptual system. The subject might not be able to detect that any individual discrepancy exists, but he or she might be able to detect the possibility that discrepancy exists, by virtue of the success of control. (This is much the same in principle as the way astronomers judge the numbers of meteor craters on the moon that are smaller than they can see, or the way ecologists judge the number of species not yet identified.)

The perceptual signal, in this way of looking at things, does not define the CEV. It defines the operations on the sensed world that create the CEV, but the CEV is a structure in the world, not in the mind. It is a conceptual structure that mirrors the mind, and it might not be detectable to anyone else than the mind that created it, but, nevertheless, it is in the world, not in the mind. For example, a CEV might be "the distance between my fingertip and my nose." Forgetting the irregularities of skin and the like, there is a perceived value for that CEV—the



perceptual signal that corresponds to it. If I hold up my finger, I might perceive that distance as stable (or nearly so, with a slow drift), but I know from other information that if I could only see it, there is a rapid oscillation in the distance. Someone with a laser interferometer could probably measure fluctuations that are not in my perceptual signal. But I would say that they are in the CEV that the perceptual input function determines. So, the CEV is not defined by the perceptual signal; it is represented by the perceptual signal. It is defined by the perceptual input function.

There's a hidden issue here, one that relates to reorganization. There is no CEV that corresponds to the function that causes the actions of the subject to control an intrinsic variable. Reorganization controls the control operations, but it does not work on any perceptual signal in the usual sense: a perceptual signal based on a function of sensory input variables. Reorganization works, but it works only because the behavior of the world (unperceived) is factually stable over periods longer than the time it takes to reorganize. That factual stability can be inferred from the success of the reorganization. It cannot be perceived (I'm tempted to say "in principle," but I don't know if I could argue that). An outsider with a perceptual function that operated over a long time scale (I include memory here) could perceive the stability that permits reorganization to happen. Likewise, with a normal perceptual signal and its corresponding CEV, an outsider could perceive discrepancies between the CEV and the perceptual signal that represents it, even though the user of the perceptual signal cannot. But, as with reorganization, the user of the perceptual signal might possibly infer that there is a factual discrepancy.

I realize that the word "factual" in the above paragraph raises its own issues about boss reality and the like. I assume that all such issues are resolved against the solipsist position.

*Bob Clark:* Perhaps the following will clarify my earlier post.

The Engineer's goal seems to be the construction, at least in principle, of an assembly of hardware (or equivalent computer-cum-software) that performs the same way that a human (or, perhaps, a simpler organism) does.

Some Engineers approach this in terms of levers, gears, pulleys, etc. arranged so that inputs ("disturbances"?) at certain locations result in movements at other locations. By adding suitable "leading" terms (time derivatives) and "lagging" terms (time integrals), these systems can be made quite effective for specified applications.

The PCT Engineer, if that is a suitable term, bases his/her design on the properties of negative-feedback control systems. These are combined into a hierarchical structure, HPCT, assembled and modified to

operate according to his/her desires. The Engineer proceeds by selecting from his/her inventory of memories, including physical and other principles, in order to bring his/her proposed structure into correspondence with his/her view of human behavior.

The design might include "recording and playback" capability, as well as ability to "reorganize" itself. In principle, these are both included in HPCT.

The following remarks bring up another subject, one that can lead, I think, to some very interesting and helpful results.

Over the last 10 days, I have tried to write this material from several different viewpoints. Each is pertinent and interesting, but it tends to become too long and complicated for a reasonably short post. This viewpoint appears to offer a framework that can be used to explore additional important (useful) subjects.

The Decision Making Entity (DME) can be considered from several viewpoints. Each is interesting, but the Theorist's is the most general, and it might be the most useful. This viewpoint is defined here by paraphrasing and quoting from *Behavior: The Control of Perception* (page 18).

The HPC Theorist proposes to construct a "model of the brain's internal organization" where "observed behavior is deduced... from the way in which these internal entities interact with each other and the external world." These entities have been chosen not only to "behave properly," but also to fit anatomical hints about the nervous system, physical models of the organism and its environment, subjective experience, and elementary mathematical logic.

1. Primary concepts: greatly condensed summaries of *Behavior: The Control of Perception.*

A. "Behavior is the control of perception"; "perceptual variables."

B. The negative-feedback control system and its intrinsic properties.

C. The hierarchical structure of negative-feedback control systems.

D. Problem-solving programs: fixed instructions with choice-points.

E. Intrinsic variables (genetically determined).

F. Reorganization: change in the properties or number of components.

G. Memory: recording and playback switches.

These concepts, with their analysis and development, cover a remarkably large range of human (and other) activities. However, this structure is largely fixed in form, changing only by the addition of new recordings or reorganization. Problem-solving programs, including associated choice points, are composed of recordings. They are derived from combinations of recordings and/or reorganizations. New programs result only from new/rearranged recordings and reorganization. This results in limited flexibility, leading to several problems.



2. Possible problems.

A. Minor changes in behavior might be needed because of inadequate or "incorrect" problem-solving programs. Reorganization is unnecessary and not initiated.

B. Minor changes in behavior might be needed because of inadequate or "incorrect" recordings. Reorganization is unnecessary and not initiated.

C. An operator is needed to control the recording-playback switches.

D. A source of reference levels is needed at the top of the hierarchy.

E. Arbitrary action is observed in the absence of intrinsic error.

F. Initiative is observed but not explained in present PCT.

G. Anticipation of unexpected events is observed but not explained in present PCT.

H. Errors, accidents, and misdeeds are observed but assignment of responsibility is not provided in present PCT.

I. Subjective reports ("User's view") of the processes of selecting among alternatives are not described in present PCT.

J. An "Observer's view" of subjects' unexpected actions is not described in present PCT.

A Decision Making Entity (DME) is proposed as a partial solution to these problems. The concept seems to be generally taken for granted and accepted by many people—including most (if not all) of those on CSGnet. Such acceptance is demonstrated by the frequent use of the first person singular. "DME" is proposed as a name for this concept when personal associations are removed, leaving nothing but the process of selecting from among alternatives for action. It offers a straightforward way to solve some of the above problems, and possibly others, by the addition of a single element with its associated capabilities and characteristics. This concept is consistent with several others discussed in *Behavior: The Control of Perception,* and it helps clarify the operations and relations within HPCT, as summarized above.

3. Operation of the DME: summary.

A. Reacts to attention-getting events.

B. Searches for relevant memories (by association and/or content).

C. Compares their anticipated results.

D. Selects those preferred on the basis of selected guidelines.

E. Puts them into effect by using them as reference levels for selected Orders within the hierarchy.

These and other topics can be discussed separately. Enough for now.

*Martin Taylor:* Bob says: "A Decision Making Entity (DME) is proposed as a partial solution to these problems. The concept seems to be generally taken for granted and accepted by many people—including most (if not all) of those on CSGnet. Such acceptance is demonstrated

by the frequent use of the first person singular." Count me among the nonacceptors. Your DME sounds very much like the old homunculus who sits behind the sensors and effectors, manipulating. How does it work? Does it have its own little hierarchy?

*Bob Clark:* Martin, from my ("Observer's") viewpoint, your latest post is equivalent to two decisions: 1. "Count me among the nonacceptors" is equivalent to your having decided that the first person singular does not refer to a Decision Maker. 2. The posting of your decision to the net is equivalent to a second decision.

Who, or where, is the "me" included in your post and involved in creating it? Please explain your alternative(s), with or without using PCT. Remember, I am assuming a situation where both the established "nodes" or "choice-points" are, for any reason, unable to provide a "decision," and intrinsic error is neither present nor anticipated.

My dictionary gives "homunculus, n. 1. a diminutive human; midget. 2. a fully-formed, miniature human body believed, according to some medical theories of the 16th and 17th centuries, to be contained in the spermatozoon." I don't think you intend the term "homunculus" to be taken literally per the definition above. More important, in my posts I have tried to restrict the capabilities of the DME to those without which it could not perform its defining function: making decisions. Can any of these be omitted? Should any others be added?

How does the DME work? See my earlier posts. Here is another attempt to describe the essential characteristics of a Decision Making Process—a DME in operation.

It is assumed that no built-in automatic branch-point is available, no intrinsic error currently exists, and no intrinsic error is anticipated. I have tried to limit this description to those items without which decisions cannot be made. Thus, the proposed items are these:

Current perceptions. The DME selects the signals to which it directs its attention. They are selected from among the incoming neural signals available. These signals are available for use as feedback signals if needed.

Current objectives (reference levels, etc.), if not already in operation, are selected from recordings of past decisions, events, etc.

Past perceptions: recordings (memories). The DME finds recordings both by named addresses and by similarities of content. They could result from simple "recognition" ("reminders"), or (more or less) extensive searches for relevant material.

The recordings found are examined for relevance and possible application ("feasibility") to current perceptions (perceived situation).

5. The recordings are further examined, by imagination, for anticipated future effects as they relate to current, relevant reference levels.



The entire hierarchy is available to serve as the output function for the DME. In ordinary situations, only limited, selected portions will be needed.

On the basis of the above examinations, etc., the DME selects and activates a recording. The DME's selection can be arbitrary. The recording selected can consist of revised and/or combined recordings.

If this is a "homunculus," so be it.

For the Perceptual Control Theory of behavior to be complete, it seems essential to me that "decision making activities" are included somehow.

In addition, I think that these elements are consistent with most, if not all, of the ideas either stated or implied in Behavior: The Control of Perception.

Finally, to repeat: please let me know your (Martin's) procedures for making ordinary decisions, and what part (?) of you (Martin) does it.

*Martin Taylor:* Bob asks: 'Who, or where, is the 'me' included in your post and involved in creating it? Please explain your alternative(s), with or without using PCT." Two questions and an assumption. I recognize the existence of consciousness in me, and I extend you the courtesy of assuming it exists in you. I have no explanation of it, other than the simple presumption that its content must be based on signals in the hierarchy, and that it is not itself such a signal. Consciousness is a multi-dimensional experience. "Me" is an element of consciousness.

The assumption: that this is a "User's" viewpoint. What I mean by a "User's" viewpoint is that you can take account of only the signals accessible at that point. The User's viewpoint of an ECS is not that of a person within whom the ECS operates. It is consideration of what is accessible at some point within the ECS often the perceptual signal, but possibly one of the other signals. Your DME does not have a User's viewpoint of the action hierarchy. It has access to signals from all over the hierarchy.

What is a "decision" *within* the control hierarchy? It must happen at the program level or above (assuming Bill Powers' set of levels). Below the program level, there might well be multiple means to achieve any particular perceptual signal value, but the variation of means must be caused by differences in the reactivity of the world. The increase of difficulty (I sometimes say "impedance") of one lower-level control might mean that a higher-level perception is brought under a control by an entirely different set of actions. This is not "decision" as I understand it. It is a natural consequence of there being a non-linear system with more (in this situation) degrees of freedom for output than there are perceptual degrees of freedom being controlled at a high level.

Something nearer "decision" can occur within the hierarchy below the program level, when possible actions are played through imagination loops in various ECSs. I suspect that this happens all the time, and is not switched. The effectiveness or otherwise of this imaginary control might affect the real gains of different ECSs, resulting in different real patterns of action when the imaginary control is actualized. Again, there is the appearance of decision without any actual decision.

At the program level, "decision" is intrinsic to the level. It is the nature of the program level to select among sequence reference levels, and there, decisions have an explicit place within the hierarchy. I would think that they would be accessible also at higher levels. But that's pretty high in the hierarchy.

If you are talking about a Powers type of hierarchy, you must be talking about the program level or above, because below this level there are no choice points. The PIFs do not permit them.

How does one "anticipate" intrinsic error? One can't even perceive it when it does occur, according to Powers. I don't think it is relevant to the issue of the DME.

You say: "I don't think you intend the term 'homunculus' to be taken literally per the definition above." No, of course not. One of the reasons that behaviorist psychology became popular in the early years of this century was that people saw that most of the 19th-century psychological theories were recursive. To explain what a human did, they in effect passed the results of sensory processing to a "little man in the head" who decided which levers to pull and push to make the muscles work. All of the issues of the psychology of the human were incorporated within the LMITH, and he was usually called "the homunculus."

You also say: "The DME selects the signals to which it directs its attention. They are selected from among the incoming neural signals available. These signals are available for use as feedback signals if needed." On what basis is this selection made? What is the perception that the DME is controlling by means of varying its choice of neural signals? "For use as feedback signals" in what control loop?

And: "The entire hierarchy is available to serve as the output function for the DME. In ordinary situations, only limited, selected portions will be needed." So the hierarchy is the environment on which the DME operates, exactly as does the Powers reorganizing system? Your seven characteristics certainly seem to indicate this. But how does the DME itself operate? Is it controlling anything? If so, what can it be controlling but its own perceptions? And if it is controlling its own perceptions, do not the same considerations apply to it as to the main hierarchy: it is a hierarchy of perceptual control systems, needing a sub-DME to make decisions on its behalf, such as what signals in the hierarchy to attend to?



"If this is a 'homunculus,' so be it." Well, it still sounds like one, in that it solves an acknowledged problem within the control hierarchy by replicating the problem at a new level. The recursion, as with the original psychological conception of the homunculus, is potentially infinite.

"For the Perceptual Control Theory of behavior to be complete, it seems essential to me that 'decision making activities' are included somehow." Yes, but why must they be outside the control hierarchy? Isn't the program level adequate? Remember that in the Powers system, perceptual input functions may accept any neural signal as input, though in our diagrams and analyses we usually consider only the perceptual signals of the next lower level of control.

"Finally, to repeat: please let me know your (Martin's) procedures for making ordinary decisions, and what part (?) of you (Martin) does it." If I knew that, I would join the ranks of those making pronouncements about the truth of the world, and I might be rich in the bargain.

Look, my problem with the DME as an entity isn't a matter of faith that everything can be solved within the main hierarchy (though I like to think that true, and it is one reason I continue to think of local reorganization instead of postulating a separate reorganizing system). My problem with the DME is that it seems to do the same kind of job within the main hierarchy that the main hierarchy does in the outer world. That means that the DME must need its own DME, which needs its own DME, which.... In other words, introducing the DME does not seem to solve the problem it addresses. If I misunderstand what the DME is supposed to be, then I'm quite happy to retract all I have said. But I have indeed read your postings, and refrained from comment for lack of time. I simply didn't want silence to be taken as acceptance when you made that an issue.

*Bob Clark:* Martin, thanks very much for your prompt and thoughtful reply to my last post.

Before turning to your specific remarks, I'd like to state "where I'm coming from." It seems to me that the present theory is incomplete in certain respects, and that it would be much more useful if ways could be found to improve it. Here I point out two places where it is incomplete:

1. Behavior: The Control of Perception, Chapter 5, Memory, pages 220 ff., and Figure 15.3 showing two position switches. Here, the four possible combinations of the switches are described in terms of "modes." After discussing these modes, we find on page 224: "Note how skillfully I bypassed the question of *what* flips the memory switch. 'One' flips it! I plead guilty to obfuscation—the model obviously lacks some details which I am not now prepared to supply."

2. Chapter 13, Higher Levels, pages 173 ff.: "I must now account for choice of particular system concepts as ninth-order reference levels, and I can't." Also: "So I must say for the time being that this is my model of behavioral organization, as far as it concerns the ongoing performance of a competent adult human being. I must leave questions unanswered, hoping that others will find this approach interesting enough to expand upon and modify." Then: "Another possible—even probable—source of ninth-order reference levels is *memory."* Further: "The solution that I prefer for this problem involves a discussion of learning of a particular type, and so will be presented later." This "learning of a particular type" is, of course, the reorganizing system, genetically determined and operating outside the hierarchy with intrinsic error providing the driving force. See Chapter 14, Learning. (Incidentally, this system was originally proposed as the "Negentropy System," with essentially the same properties as the present "reorganizing system." It was proposed in order to account for observed changes in the operation of the systems composing the hierarchy. It was regarded as operating "outside" of the hierarchy—without definition of "outside."

The "one" in the first item above is regarded as existing, somehow, somewhere. I am suggesting a more meaningful name that will help identify the "items" needed to accomplish the indicated results. Perhaps Decision Making Entity (DME) is not the best name for this, but some equivalent seems to me unavoidable. I have previously listed seven items which seem to me necessary for the DME to perform its switching function effectively.

The DME is proposed in order to account for certain observable events called, perhaps loosely, "decisions." Many of these are readily accounted for in terms of the existing hierarchical structure, including preset "choice-points," as discussed in *Behavior: The Control of Perception,* Chapter 14, Learning, pages 177 ff.: 'Programs are fixed lists of instructions (reference levels for lower-order systems in human beings) with choice point in the lists. Both memory and present-time inputs are important elements.... the same list of operations remains in use, and... the subprograms may retain their same organization. All that changes is the path followed through the network of contingencies, *all possible paths being determined when the writing of the program is finished."* (Italics added by me.)

Although a mature adult might have adequate programs to cover all possible situations, it seems unlikely. It seems especially unlikely for an infant, where a major part of its learning consists in learning such programs.

Operation of the reorganizing system might account for those "decisions" when an intrinsic error exists. "Decisions" made in the absence of intrinsic error require other operations.



Martin, you say: "Consciousness is a multi-dimensional experience." I'm afraid I don't know what this means. To me, "consciousness" refers to the condition of the perceptual systems. If they are in working order, the individual is "conscious." I think this is consistent with the following (*Behavior: The Control of Perception,* page 200): "Consciousness consists of perception (presence of neural currents in a perceptual pathway) *and* awareness (reception by the reorganizing system of duplicates of those signals, which are all alike wherever they come from)."

Martin, you also say that "'me' is an element of consciousness." Is "me," then, a subgroup of perceptual signals assigned the label "me"? In the same sense as the "tree in the yard"? Is it always passive? Is it sometimes active? In what manner, subject to what conditions, if any?

You say: "What I mean by a 'User's' viewpoint is that you can take account of only the signals accessible at that point." "Point" in the hierarchy, or "point" in time, or both?

"It is consideration of what is accessible at some point within the ECS, often the perceptual signal, but possibly one of the other signals." If "it" refers to the "User's" viewpoint, I don't understand this statement either.

"Your DME does not have a User's viewpoint of the action hierarchy." Since I don't understand your definition of User's viewpoint, I cannot comment.

"It has access to signals from all over the hierarchy." Yes, this is what I said.

You ask: "What is a 'decision' *within* the control hierarchy?" Your discussion here seems to consist largely of a description of the ordinary operation of the hierarchy, using its existing choice-points at whatever levels might be required. I am concerned with situations in which problem-solving programs are, perhaps, incomplete or otherwise unable to provide needed solutions. But, at the same time, no intrinsic error exists.

"If you are talking about a Powers type of hierarchy, you must be talking about the program level or above, because below this level there are no choice points!' So I am suggesting a situation where there is no suitable "program" available, with or without pre-existing choice-points. Perhaps this is rare, although at early stages of development there might be rather few effective "programs." Here is where a DME might produce action before any intrinsic error develops.

"How does one 'anticipate' intrinsic error? One can't even perceive it when it does occur, according to Powers." Martin, do you agree that it is possible to "anticipate" some possible future events? Do you plan your posts before sending them? In giving a talk, do you plan for possible questions or interruptions? Is a toothache an intrinsic error? Do you remember having one? Or any other intrinsic error? Do you go to

the dentist to avoid a future toothache? Do you take action to avoid repeating a situation involving an intrinsic error?

Also: "What is the perception the DME is controlling by means of varying its choice of neural signals?" It is controlling its perception of the overall situation as it relates to an unexpected event. This includes its examination of those memories that seem to be related.

And: "... in what control loop?" In whatever control loop has a problem, but lacks a pre-existing problem-solving program.

After referring to my sixth point, you offer: "So the hierarchy is the environment on which the DME operates, exactly as does the Powers reorganizing system? Your seven characteristics certainly seem to indicate this But how does the DME itself operate? Is it controlling anything? If so, what can it be controlling but its own perceptions?" Very pertinent and important questions.

First, the DME has a strong resemblance to the 'Powers reorganizing system." It differs in that it only operates with respect to those perceptions that have its attention, whether selected arbitrarily or in response to some attention-getting event. This is in contrast to the reorganizing system, which is in contact with all intrinsic signals all of the time.

Second, as long as the established hierarchy has no problems, the DME need not be active, but it is capable of arbitrary action, perhaps "curiosity."

Third, its primary source of material to use as inputs to the hierarchy is the contents of the memory. There is little discussion, in *Behavior: The Control of Perception* or otherwise, of the contents of the memory. But, after all, without the memory there really is no hierarchy beyond the genetically determined neural pathways. Note, again, that the reorganizing system output seems to be arbitrary, if not entirely random, making no use of contents of the memory.

Fourth, after either the reorganizing system or the DME acts, the DME can review (in imagination) those actions as they were recorded in the memory. They can then be described in terms of a "problem-solving program," complete with choice-points. Indeed, this additional program becomes available for future use. It seems to me that this is pretty much the way these problem-solving programs come into being.

Thus, the DME needs no hierarchy of its own. When there is a problem, it provides assistance to the hierarchy based on selection from the contents of the memory.

In our early work, Bill and I were both greatly concerned with possible circularity or other recursive properties of the developing theory.

The DME requires at least the beginnings of a recording function and the formation of memories. These are included, as noted above and in Behavior: The Control of Perception Chapter 15, Memory, within the present theoretical structure.



Martin, you say that your "problem with the DME is that it seems to do the same kind of job within the main hierarchy that the main hierarchy does in the outer world." If I thought so, I, too, would reject the DME concept. Instead, I see it as playing a critical part in the development of the hierarchy.

I hope that I have shown you where and why I think the DME concept offers a useful extension of the original theory.

Thanks again for your interest, questions, and ideas.

I've been essentially out of touch with PCT developments and discussions for some 25 years! Migawd, Bill published his book in '73, and I've been away from Chicago since 1968! (There was a brief correspondence with Bill in 1987.) Indeed, I only learned of Bill's book from Greg Williams in late 1988! Greg was also kind enough to provide me with a copy of Robertson's book. These contacts have led me to join the CSG and the net. I am still not familiar with the several viewpoints represented by the members of the Group.

However, during those years I have been applying the ideas Bill and I initiated, adding my observations, and developing my viewpoints, while engaged in other activities. I have had opportunities to work with and study a variety of organizations (including business, manufacturing, lobbying, political, government, sales, tax exempt, etc.). I have been in a position to participate in and observe their operation, planning, viewpoints, concepts, etc. I have also played a major part in the formation and operation of several organizations.

I find that having the underlying concepts of a hierarchical array of feedback control systems readily at hand has been very useful in all of these activities, enabling me to participate at whatever level interested me.

Currently, I am exploring possibilities for involvement with local business, school, and government activities. I don't yet know how it will work out, but it should be interesting! It is intriguing to observe how ordinary people doing ordinary things recognize and use the concepts underlying Pa without any need for formal technical, scientific ways to communicate them.

Propagation of these theories is not my primary purpose—rather, I hope to find ways to assist people in achieving their goals. I expect that they will gradually find that certain PCT terms and concepts are helpful.

*Bill Powers:* Bob, I no longer think of intrinsic error as limited to purely physiological variables. For example, the presence of chronic significant error signals in any control systems of the brain is itself an indication of something amiss, and would fit the basic definition of an intrinsic error. It's also possible that the scope of the reorganizing sys-

tem has evolved along with the structure of the brain that permits us to develop higher levels of control systems. So I don't object too much to your concept of the DME, which apparently operates in terms of criteria considerably more advanced than physiological states ("appropriateness," for example). Perhaps your DME is simply a more evolved version of the primitive "Negentropy System" with which we began almost four decades ago.

I do have one argument with your DME, which is that it seems to have many capabilities that I would rather see as aspects of the learned hierarchy. In my development of ideas about levels in the hierarchy, I tried to isolate types of perceptions that at least in principle could be controlled by learned control systems. Anything of that nature clearly doesn't belong in the system responsible for shaping organization, because what is learned is not present at first, yet the process of reorganization has to work from the beginning. I see too much that is systematic and algorithmic in your descriptions of the DME and what it does. If those were stripped away and assigned to the learned hierarchy instead, I think our concepts would come much closer together.

*Bob Clark:* Bill, I think we are, in fact, very close indeed. Dividing ideas into their components—and naming them—can be very helpful. Your remarks relating the old "Negentropy System" to your evolving concept of the "reorganizing system" suggest a need for some form of "intermediate system." Such a concept can be placed on a continuum, with a "pure intrinsic error-driven system" at one end and a "random, arbitrary curiosity system" at the other, leaving your evolving reorganizing system to combine with a "structured memory-using" system—the DME—in between.

The "pure intrinsic error-driven system" operates at a level of desperation, having been driven beyond organized efforts, no longer able to access existing memories. At the same time, the Recording Function continues to produce records that become available for later access.

The "curiosity system," on the other hand, operates when the individual is awake, alert, and without any immediate actions called for. Perhaps this is close to a state of "boredom," or perhaps is a "standby" condition, waiting for something to happen. The Recording Function would also (of course) continue to produce records that become available for later access.

The intermediate system (DME) would be characterized by its use of memories as the source of ways to achieve the goals (provided by higher levels), that are currently dissatisfied. As previously described, it would use memories as a guide for the selection of promising actions in seeking the goals in question. This would include anticipation (via imagination) and application of learned problem-solving programs



where they seem useful. Memory would also be a source, perhaps resulting from application of problem-solving programs, of reference levels for application throughout the hierarchy.

Of course, this entire process could be no better than the assortment of memories available to the individual at the time they are reviewed. Since this entire process is recorded together with continuing current perceptions, the result can be considered a form of "reorganization," at least of the learned systems.

You comment, Bill: "I see too much that is systematic and algorithmic in your descriptions of the DME and what it does. If those were stripped away and assigned to the learned hierarchy instead, I think our concepts would come much closer together." I sympathize with your view here. These "systematic and algorithmic" aspects are partly due to my difficulty in describing my concept of the operation of the DME without using language and concepts typical of the learned hierarchy. I have tried to distinguish between the "pure" DME and a description of the logical requirements for it to perform as defined. The suggestion of a "continuum" might be helpful, with "purely learned" reorganizing systems supplemented on occasion by action of the DME. This results in the role of the DME being a bit "mixed," in the extremes, with those of the "pure reorganizing system" and the "curiosity system." Perhaps we can devise better ways to describe and distinguish among these concepts.

After all, these verbal systems, as well as theories in general, exist only in our memories (and memory supplements called "books," "periodicals," etc.)!

I hope we can move ahead with this, Bill, because there are several more areas for discussion.

You might be interested in the developments as I become more involved with the local city, Forest Park. By selecting suitable time scales, all aspects of Hierarchical Perceptual Control Systems become apparent! This includes intrinsic error, learned systems, reorganizing systems/DME, and curiosity! Fascinating!

Forest Park, Ohio: Population about 20,000, about 30 miles north of downtown Cincinnati. About 600 businesses, about 75 of which are members of the Forest Park Business Association. A few years ago, I helped revise the by-laws of the FPBA—I was a member of the FPBA Board at the time. Forest Park's government uses a City Council-Mayor with a City Manager. I have a copy of their Charter, which impresses me very favorably. (At one time or another, I have been involved in writing/revising various by-laws as well as working with the results, so I have some basis for evaluation.)

It didn't take long to identify each level of an HPCT system as it operates. In addition, the major orientations of several individuals were

observable as they cooperated and interacted in supporting their mutual interests. These observations are also helpful identifying labels for the several levels.

It is fascinating to observe the way the participants think of (read: "perceive") their own actions and interactions. By and large, their thinking is PCT-type thinking—they have goals, personal- and community-, which they are working toward achieving. It is very straightforward, with very little S-R contamination.

I find Control Systems Group members repeatedly concerned with getting some kind of recognition from the "scientific community." This is a losing game—the "scientists" hold the cards. They select the independent variables, the dependent variables, the time scale—and arrange to have any relevant reference levels held constant. Any deviation from these rules guarantees rejection.

Instead, how about working with applications of HPCT? I've been doing it, informally, for about 30 years. This can be done without having to teach anyone the special lingo used in HPCT—most of the key concepts needed in HPCT are already available in everyday language. One only needs to look for them. The applications could be presented (possibly for publication?) in a form that shows how these methods work and how the ordinary language of application can be expressed in generalized abstract theoretical terms. After all, a great many "practical" applications were used in many fields long before "modern" theoretical methods were developed.

*Applications that HPCT Might Explore*

Learning in contrast to teaching
Conflict resolution (internal, interpersonal, intergroup, etc.)
Social systems
Economic systems
Management principles
Government (at all levels)
Argument vs. persuasion
Marketing and sales
Decision making by groups
Motives
Emotions
Cooperation
Personality
Development (of individuals and species)
Genetically determined neural systems
Planning
Character



Anticipation
Memory playback
Freedom
Responsibility
Consciousness

Quite a list—presented here "off the top of my head." Most of these have concerned me at one time or another, and they seem to be to be highly relevant to HPCT treatment.

In several places in *Behavior: The Control of Perception*, Bill notes some uncertainty and expects later additions and revisions. I find the "established" designations of higher levels very logical—but not very useful in attempting to work with "real people." Sometimes the PCTers don't look very "real" to me.

*Bill Powers:* Bob, putting the concepts of PCT into ordinary language as you suggest is a fine idea, and I endorse it. There are sticky spots in doing this, however: those where PCT and common sense part company. Many people speak of emotion, for example, as if it's something that the outside world does to them, and with which they must then try to cope. It's not easy to present a compelling case in ordinary language for the idea that emotion is part of voluntary action and is the product of the person's own attempts to seek goals.

The higher-level definitions of behavior in HPCT aren't meaningful until you translate the terms into real experiences. For example, in your interactions with government types, you have probably seen that many of them state "facts" about human nature—what "people" are like, what to expect of them, and so on. These are system concepts, as I think of them. You probably also hear many people stating generalizations; not specific programs for actions, but *principles* of action. In government, they are often called policies, where the program-level stuff consists of rules, regulations, or laws stated in if-then terms, designed to suit an overall policy at the principle level such as equal treatment, fair pay for adequate work, loyalty, and so forth.

The concept of PCT itself is a system concept. It is composed of principles like control of input and resistance to disturbance, which describe no particular control system but are meant to apply to all control systems however they are designed. At the program level, control becomes a mathematical-logical model containing specific quantitative relationships, no one operation being a control system or accomplishing control of input in itself. The "emergence" of control from the quantitative relationships among parts of control systems is evident only to a higher level of perception, the principle level at which we perceive the principles of control. And from these emergent principles,

once we can perceive enough of them, there emerges the concept—the yet-higher-level perception—of an autonomous self-organizing hierarchy that constitutes human nature itself: a system concept.

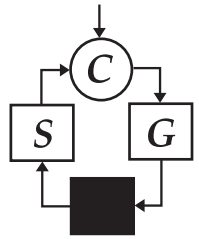
Once you start translating from the too-formal terms of HPCT, you can begin to see the phenomena to which these terms were intended to point. Everyone has principles and system concepts. All you have to do to believe this is to sit in a blue-collar lunchroom day after day and listen in on the conversations. Listen to the people talking about union problems, about work rules, about unfair treatment given to one person or another. Ask their advice on how to get along in the company, and you will be drenched in principles. Ask how they think the company should be organized, and you'll get clear statements of system concepts, not to mention lots of descriptions of errors at that level. (All of which, I must admit, makes me wonder about the relationship of language to these levels—how can such things be described? Some aspects of language must surely operate at the system-concept level, too or higher.)

Behind the simple terms in my proposed levels, there are phenomena that I think are quite real and observable, at all of the levels.

*Bob Clark:* Bill, my suggestion regarding "ordinary language" was for PCTers to select from and use that language. Listening to others can be very useful, revealing much about the concepts, ideas, theories, observations, etc. that are, in fact, in use by "real people." To me, your "simple terms" are far from simple, and I agree that there are such "real and observable" "phenomena." I find it much more useful to work with these phenomena, rather than your abstract (and reasonable) classifications. To do this, I look for words/concepts with more immediate relations to the levels of the hierarchy.

*Bill Powers:* Bob, your recommendations about ordinary language are very much to the point for communicating control theory under everyday circumstances. This is really the "end-around play" that Dag Forssell proposes—forget about the Establishment of psychology and go directly to the people. Control theory, however, contains concepts which are not already in the vocabularies of many audiences, and the existing words usually mean something that has to be overcome before the wanted meaning can be communicated. By trying to make PCT concepts seem *too* familiar, in the hope of getting a friendly reaction from the audience, one can end up convincing them only that there's nothing new in it.






The Control Systems Group is a membership organization which supports the understanding of cybernetic control systems in organisms and their environments: *living control systems.* Academicians, clinicians, and other professionals in several disciplines, including biology, psychology, social work, economics, education, engineering, and philosophy, are members of the Group. Annual meetings have been held since 1985. CSG publications include a newsletter and a series of books, as well as this journal. The CSG Business Office is located at 73 Ridge Pl., CR 510, Durango, CO 81301; the phone number is (303)247-7986.

The CSG logo shows the generic structure of cybernetic control systems. A Comparator (C) computes the difference between a reference signal (represented by the arrow coming from above) and the output signal from Sensory (S) computation. The resulting difference signal is the input to the Gain generator (G). Disturbances (represented by the black box) alter the Gain generator output on the way to Sensory computation, where the negative-feedback loop is closed.