Perceptual and Motor Skills, 1960, 11, 309-323.
Monograph Supplement 3-V11

A GENERAL FEEDBACK THEORY OF HUMAN BEHAVIOR: PART II

W. T. POWERS, R. K. CLARK, AND R. L. MCFARLAND

Veterans Administration Research Hospital, Chicago
Northwestern University Medical School

INTRODUCTION

The model described in Part I is only a part of our general theory—the part which organizes our more general ideas about human behavior and human nature. To conceive of human organization as following that of our hierarchical array of FBCS (externally fed-back Feedback Control Systems) implies a certain attitude toward behavior, different in some important respects from traditional psychological viewpoints. Some of these differences we began with, but most of them took form only as we went back and forth between modifying our organizational model and observing people behaving.

One of the most puzzling, and in our opinion critical, aspects of human behavior is that behavior appears multiordinal. The same behavior can be described in a number of apparently equally-valid ways, from the particular to the general. Usually this representation of human behavior at varying levels of abstraction is put aside during a scientific study, and one particular level is chosen as the most interesting, or sometimes as the only "proper" one. But for us this multiordinality raised a critical question: is it due to the way in which behavior is observed, or is it somehow a significant property of the behaving system?

The answer we have arrived at is, *"Both."* One must never forget that the person observing human behavior is a system like the one he is observing. If we accept that our model represents behavioral organization, particularly in the FBCS aspects, then it is *perception which gives form to behavior.* Behavior will make sense to *E* only if *E* knows *what perceptual variables the behavior is maintaining at some reference-level.* If an organism is producing behavior as a means of controlling a several-times-abstracted variable, then *E* has no hope of seeing order in this behavior unless he is capable of learning to select out of his experiences the relevant elementary sense-impressions and then can combine them in the same way that *S* is combining them to make a perceptual variable. If *S* and *E* are both FBCS, then even in a varying environment requiring widely-varying physical action, *S* will be able to maintain abstract variables at reference-levels, and *E,* if he resembles *S,* will be able to perceive that *S* is doing so.

THE HUMAN HIERARCHY

We have developed definitions of six orders of control systems, giving the corresponding orders of perceptual variables names which represent classes of perception. These classes appear to human beings to be self-evident aspects of directly-perceived sensory fields which we call the "external world." Once one learns to perceive in these ways, the resulting impressions appear to be objective, and one has the feeling of having "discovered" them, in an insightful way. Why it is that through learning one should develop just the six orders we postulate we cannot answer—perhaps the unseen external reality is so structured that we *must* learn to perceive in these ways in order to control our environments, perhaps our brains are so constructed that development of certain types of perceptual transformations is favored, or perhaps these orders of perception are peculiar to our culture, or even to the authors' microcosm! Leaving this problem for the future, we will propose our definitions of the six orders of perception and FBCS which we have been able to work out, and assume for the time being that all people are organized this way. Of course future experimentation will be specifically directed toward testing that idea.

The classes of perceptual variables we will define bear the same relationship to each other as do the feedback signals in the model of Part I. The higher are derived from sets of the lower, and at the same time contribute to still higher-order perceptual variables. Each order consists of a great many individual FBCS each of which controls its individual one-dimensional feedback signal toward a reference-signal set by a higher-order system. The highest order of reference-signal is set by noise or by random action of the N-system. (See Part I.)

In more common terms, the *purpose* for controlling a given perceptual variable toward its reference-level is that of maintaining a higher-order variable at its reference-level. Higher-order perceptions are kept in their goal-states by *specifying* lower-order goal-perceptions; the higher-order system decides (no quotes) on a goal-perception for the lower-order system, but does not actually do anything to achieve it. Thus each goal-seeking system is autonomous to the extent that it must contain the circuitry for making its own feedback signal approach its given reference-level and for recording its own store of potential reference-signals for later use: but each goal-seeking system is controlled to the extent that it does not choose which of its past experiences are to serve as goal-perceptions.

Complexity is not a factor in determining relative order, and neither is number of perceptual elements contributing to a given perception. An nth order variable can be exemplified by a set of lower-order variables (provided the observer has nth order systems) but it belongs to a self-evidently different class of perception from the lower-order variables themselves. In order to perceive and control nth order variables, one must simultaneously perceive and control lower-order variables (except for $n = 1$), but the reverse is not true. Eliminating higher-order perceptions leaves the lower; blocking the lower partially or totally eliminates the higher.

The preceding paragraphs indicate the kind of rules by which one can find a higher-order variable given a set of lower-order variables, or by which one can analyze a higher-order variable into lower-order variables which contribute to it. *All* these criteria must be met, and to understand our definitions properly, the reader must check his understanding against these "rules," hazy as they may at first appear.

In the following, S_n = a typical FBCS of order n; f_n = feedback signal in S_n; r_n = reference signal for S_n; F = feedback function of S_n (see Part I).

We have found a very simple demonstration which is probably the best way of clarifying the first four orders, and perhaps the fifth order as well. The equipment is cheap—two people, *S* and *E*.

First Order

First-order systems we identify almost exclusively with the spinal reflex loops, which are FBCS. These FBCS maintain proprioceptive feedback signals from very limited portions of the environment (tissue, tendons, etc.) at levels specified by the excitatory reference-signals descending the spine. Similar loops involve some cranial nerves. Many signals arising from sensory endings are not involved in S_1 (first order control systems), but for convenience we generally refer to all primary sense signals as f_1, first-order feedback signals.

Demonstration of First Order

S extends his arm in front of himself, with instructions to hold it steady, and *E* places his hand lightly on top of *S*'s. *E* gives a sudden sharp downward push, and *S*'s arm appears to rebound as if on a spring. An electromyograph verifies that this is an active innervated correction and not simply muscle elasticity. The initial position of *S*'s arm makes no difference, and the initial muscle-tensions involved (as long as they are not zero) therefore make no difference to this response, thus showing that the reference-levels for the many systems can be adjusted and that the systems will correct their inputs toward any given reference-setting.

Second Order

Second-order systems S_2 derive their f_2 from sets of f_1. We call the class of all f_2 "elementary sensations," since they represent the initial grouping of the undifferentiated f_1 into elements with characteristic sensory patterns. In the kinesthetic modality, these would be made of signals representing muscle stretch, joint angle, tendon tension, and internal tissue pressure, which add up to the elementary sensation of effort and a kind of absolute sense of position (not relative limb position), like the pattern of signals one gets from clenching his fists. These elementary sensations, f_2, have recognizable patterns by which we identify them; for this reason we sometimes refer to f_2 as identity signals.

DEMONSTRATION OF SECOND ORDER

E now instructs *S* to extend his hand as before, and *E* places his hand on top of *S*'s. Now *E* tells *S* to swing his arm downward as rapidly as he can, as soon as he feels *E* push down. *E*'s hand must begin in contact with *S*'s to make the push as sharp and unexpected as possible.

Immediately after the push, the S_1 return the arm to its initial position, because they act *within the latent period* of S_2. Then, after the return swing is nearly completed, the S_2 react by resetting the r_1. The S_1 are then abruptly given new reference-signals and accelerate the arm downward as requested. *S* cannot eliminate the return swing at the beginning of the response—if he could, he might be subject to instability.

THIRD ORDER

S_3 combine f_2 and/or f_1 to produce f_3, which we call "configuration" or "arrangement" signals. These represent any static combinations of sensations. At third order, many different arrangements give different signals in a given system, although a single S_3 will sense the same arrangement (the same magnitude of the signal f_3) for a number of different sets of f_2. Each third-order system can thus sense a limited range of arrangements of these f_2 which it senses, and ignores or fails to differentiate between arangements of f_2 which do not yield different f_3 (the mechanism of "equipotentiality").

Hand-eye coordination involves, quite often, controlling an arrangement of visual objects toward some static reference-arrangement. In our Portable Demonstrator, the arrangement to be adjusted is the relative position of the *S*'s index finger-tip and *E*'s.

DEMONSTRATION OF THIRD ORDER

E instructs *S* as in the second-order demonstration, but requesting that the movement be made sideways, and again making the initial press in the direction of motion. Now, however, *E* extends his other hand, holding out his index finger, so that *S* will have to move his arm about a foot to eighteen inches to touch *E*'s index finger. *S* is instructed to extend his own index finger, and to swing his arm as quickly as possible after the push and align his finger with *E*'s as *rapidly* and *accurately* as possible, so that the fingertips just touch. At the instant of the push, *E shifts his target finger 4 or 5 inches,* lowering, raising or retracting it.

The first two orders of reaction remain visible, and at the end of *S*'s rapid swing a third phase shows itself; *S*'s finger comes nearly to a stop *near where E's finger initially was,* and then begins a much slower corrective movement quite different in nature from the first two actions. This third phase is the third-order reaction, showing a still-longer latent period. The second-order systems achieve their goal-states much more quickly than third-order systems;

so quickly that under proper circumstances they actually have to wait for the next reference-level to be set by the controlling third-order system.

FOURTH ORDER

S_4 convert sets of f_3 into f_4, which we postulate to represent *sequence.* That is, a given sequence of appearance of the f_3 (or f_2 or f_1) will yield a characteristic magnitude of f_4 in the S_4, and a different sequence may yield a different magnitude. This relationship holds, of course, only for the limited set of f_3 to which a given S_4 is sensitive. Fourth-order feedback functions F_4 must necessarily be rather complex devices, having short-term memory capabilities (as distinguished from the recording properties common to all systems); also they must be considerably slower than the F_3 for stability of control.

It is important to remember that a static feedback signal at fourth order represents a *continuing* sequence, a constant shift of reference-levels r_3. (If the sequence ceases, has any of its lower order elements modified, has its tempo changed, etc., the f_4 must change.)

DEMONSTRATION OF FOURTH ORDER

E instructs *S* to extend his index finger and track *E*'s index finger as accurately as he can. *E* then moves his own finger in a circle 8 to 12 inches in diameter, gradually speeding it up until *S* is tracking smoothly (about one cycle per second). Without warning, *E* stops his finger dead still at some point in the circle. *S* continues to "track" for nearly half a second before being able to stop the independent sequence he has set up. His reaction time does not shorten significantly with practice. Since we know *S* is physically capable of arresting a motion much more quickly than this, the lag is due to the slowness of the fourth-order systems. Unfortunately we have not been able to think of an experiment in which the reactions of the first three orders are visible along with the fourth order reaction. In most *S*s, third-order responses can be observed just as *S* begins tracking; one sees a succession of jerky corrections, as the third-order systems attempt to correct one error in static configuration after another. This is soon supplanted by a more refined fourth-order response as *S* learns the appropriate sequence of movements.

If *E,* instead of merely stopping his hand, jerks it suddenly away, *S* will show a much faster reaction; this is possible because *E* has provided information of lower order, and *S,* if he is not already prepared to use it, will quickly learn to do so. See the later discussion of "reduction of order."

DEMONSTRATION OF FIFTH ORDER

We reverse the sequence of our presentation (definition, demonstration) at this point in order to show experimentally the need to carry our analysis beyond fourth order. In postulating fifth-order control-systems, we are only saying that we think we see orderliness in the selection of fourth-order behavior patterns, and that this orderliness cannot be ascribed to the *N*-system or follow from our definitions of that system. Let us demonstrate fifth order behavior, and then discuss its position in our model.

E requests *S* to track his finger again as before, but now *E* alternates between two different sequences. For example, one sequence might consist of tracing a circle clockwise, the other might consist of tracing another circle counter-clockwise. Let the two circles join to form a figure eight: one circle above the other. The upper may be designated U; the lower, L. If *E* produces any fixed combination of U and L (e.g., U,L,U,L,L,U,L,U,L,L, etc.), *S* will eventually learn it as a single long sequence, and demonstrate fourth-order reaction-time. If, however, *E* establishes a general relationship in his own mind which will produce an ever-changing sequence, then no fourth-order system could learn it (because it never repeats). Under these circumstances, the highest order of system which could track at all would be S_3, and *S* would demonstrate the jerky tracking characteristic of third order, just as though he were following a random target pattern. *E* can check this either by producing a random alternation of U and L sequences, or by setting up a random or very complex spatial pattern.

If *E* uses some fixed relationship, however, to determine whether the next sequence shall be U or L, *S* will eventually perceive what that relationship is, and will be able to track smoothly and change sequences at just the right time. Let us say the relationship can be perceived in this example: U,L,U,L,L,U,L,L,L,-U,L,L,L,L, ... There is no one word for this relationship among sequences, but it can be described as "increasing the number of L sequences by one after every U sequence." A person with fifth-order systems can perceive this relationship directly, whether or not he verbalizes it.

The relationship described has a reverse: one can *decrease* the number of L sequences each time instead of increasing it, provided that one starts with more than one L sequence. Thus at some point in the fifth-order tracking process, *E* can switch to the reverse relationship. Naturally, the first time he does this *S*'s smooth tracking behavior will degenerate to third-order or just go to pieces altogether. After some practice, however, *S* will have learned both relationships, and can switch from one to the other as soon as he sees that the change has occurred. Now fifth-order reaction-time will be observed, and it will prove to be considerably slower than *S*'s fourth-order reaction-time. The reader may like to test our assertion that complexity is no determinant of order; try this elementary fifth-order switch: U,L,U,L,U,L,U,L,L,U,L,U,L . . . . Check *S*'s reaction time both to the double L and also to a sudden stop in the complex sequence, U,L,L,U,U,L,U,L,L,U,U,L . . . . Remember to give sufficient practice so that *S* is reacting as fast as he can.

Incidentally, in the string of symbols U,L,U,L,U,L, one tends to perceive pairs U,L; if a double letter occurs, one switches to perceiving it as L,U. In reading a long alternating string, one can switch back and forth intentionally, and the effort required to do so is quite apparent: U,L,U,L,U,L,U,L,U,L,U,L,U,L,U,L,-U,L,U,L,U,L,U,L,U,L,U,L,U. This is probably as primitive a fifth-order phenomenon as is possible to perceive. Of course the two sequences, U,L and L,U, are fourth-order perceptions as written (at the most); it is the act of changing interpretations that reveals the presence of a fifth-order system.

Fifth Order

Fifth-order systems perceive lower-order information in terms of *relationship.* This word is almost as explicit as the term "sequence," because most of its meanings actually apply at fifth order. In an arrangement (f_3) of dots, one can perceive many relationships: separation of any two dots, a triangle, relative size of the arrangement, distance (imagined) from the viewer, and so forth. In the pair of f_4's "man running" and "another man running" one can perceive "chasing," "racing," "fleeing," "greeting" and so forth.

It is important to grasp the fact that relationship and arrangement are perceived at *different orders.* At third order, every different arrangement of three dots yields a different f_3; at fifth order, a system evolved to perceive in terms of triangles might see the *same* triangle-relationship in those same sets of dots. Likewise, although one might call a sequence a "temporal relationship," we do not use this sense of the term, because a sequence-sensing system responds only to a specific range of sequences among a specific set of lower-order signals. While a sequence-signal may represent *one instance* of a temporal relationship, it does not represent the relationship itself. To a given fourth-order system, the occurrence of the double L in the above strings of symbols would be only a momentary disturbance of the sequence, and it would quickly see that the "proper" alternating sequence was still occurring, provided no control action was required. The fourth-order feedback function recognizes only that an L should be followed by a U, and a U should be followed by an L. It does not "group" these elements.

Fifth-order perceptions relate to areas of wide psychological interest; a man's relationships with other men can be seen as his role, his occupation, his status, and so forth; man-machine relationships can be seen (operator of a machine, victim of buzz-saw, inventor of a device), and the relationships among one's own subsystems can be described (self-respect, conflict, coordination). Interpersonal relationships and group dynamics are fifth-order subjects of study. Communication is conceived by us as essentially a fifth-order activity.

Sixth Order

Our present concept of the nature of sixth-order systems is still rather vague. As previously, we see orderliness in the choice of goals for the highest order described, fifth, and we therefore suspect the presence of higher-order systems and higher-order goals.

Our best guess to date about the nature of sixth-order perception is that f_6s represent variables pertaining to organization or orderliness, which are aspects of *systems.* Thus we say that S_6 perceive and control the nature of *systems* the elements of which are specific relationships and lower-order entities. The thing we call "personality" may be a sixth-order perception; other examples might be a symphony, a government, a self-concept, a scientific discipline, and a mathematical proof.

A "fact" may be partially defined as a perception which does not cause an error in a sixth-order system; certainly any perception which creates a sixth-order error is treated as non-factual at first. A magical trick, a reformed criminal, electron diffraction, and a host of other phenomena have caused more than one person to doubt that he has perceived correctly. This does not mean that one doubts *having perceived* such a phenomenon; it means only that because the perception makes him see a system different from his reference-system, he looks for added information which will give a different fifth-order or lower perception, thus correcting the sixth-order error. He looks for the black thread holding up the magic wand, the secret vice which will mar the perfect behavior, the error in technique which produced the seeming diffraction rings. Sometimes the required information is found, sometimes not. The nature of one's sixth-order systems and the activity of one's *N*-system will then determine whether the required shift in sixth-order perception and reference-level will occur.

So far we have not found any clear demonstration of sixth-order reaction time to go into our Portable Demonstrator.

N-System

The *N*-system, it will be recalled (Part I), senses the discrepancy between a set of intrinsic reference-signals and a set of perceived intrinsic signals representing critical organismic variables. Some of these variables are probably the signals associated with drives, while others may represent more subtle conditions, such as average stimulus input rate, or mean error signal in the hierarchy. We do not know how specific we have to make the reorganizing activity which is the output of the *N*-system. It may be a random effect randomly distributed in the hierarchy, it may be localized in regions where error-signals exist, it may operate according to some rule more efficient than a random shuffling of thresholds (as suggested by modern learning-machine experiments on computers). We are confident that we can learn more about these properties of the *N*-system, but we do not know much yet.

The *N*-system's activity has a very characteristic effect on behavior. When a reorganization is taking place, *a formerly skilled behavior deteriorates.* However, because not all systems are undergoing complete transformation all the time, behavior as a whole during reorganization still has some organization. If one is changing his concept of a skill, the overall coordination may go to pieces, but he will still show the ability to carry out specific sequences and to control configurations, and so forth. What is called "trial-and-error" behavior may often be not an organized search for a new pattern, but the automatic result of changes in high-order organization, necessarily resulting in alterations of reference levels in lower-order systems.

In a complex-learning experiment by the authors (still in process) we have established a task in which the *S* must learn five orders of skill successively in order to meet the requirements outlined in the instructions. Achievement of each new order is soon marked by a plateau in the graph of reaction-time against response number. We regularly observe that just before reaction-time drops to a new plateau, it begins to vary and becomes longer; the graph shows a great deal of "noise" just before a drop. We take this to be evidence of *N*-system activity.

Subjectively, the *N*-system is responsible for the phenomenon called "insight," the "aha" reaction when one suddenly perceives a pattern in lower-order information which he has never seen before, or has never connected with the particular circumstances. This sort of insight is not necessarily helpful or harmful; it is merely a new organization of perception. With the ability to perceive a new pattern, one may experience extensive changes in equilibrium in many subsystems, for the better or for the worse. In the usual case, insights which are not useful are quickly discarded because they create conflict or tend to increase intrinsic errors. For example, it might occur suddenly to a golfer that he might use his putter like a billiard cue and have a better chance at a difficult putt, but a moment spent imagining doing so would reveal the fifth-order and sixth-order ("That's not golf!") conflicts which he could expect. Therefore this behavior pattern is not selected as a reference-level on the golf course.

Notice that the *N*-system never adds new information to the system in the sense of providing a specific answer to a problem. *It merely alters the properties of a system, thus changing the transformations applied to existing information.* It is possible for the learned hierarchy to ignore a new transformation, if higher-order systems perceive that use of it would not achieve the required higher-order perceptual fields. Furthermore, a new perceptual transformation may be such that it is of no use in present circumstances, but may be useful later, so that it appears to "lie dormant" for a time. In solving a mathematical problem, it is common to perceive the final steps which will lead to the required solution long before one has found out how to lead up to them.

Before we leave the subject of N-system, we wish to propose a definition. We have some fairly good reasons for this proposition, but for now we prefer merely to state it and explain what we mean: this is a definition of consciousness.

Consciousness, we propose, is the state of the feedback function in a subsystem in the hierarchy which is being affected by the output of the N-system. Thus the same subsystem can perceive and control a variable either consciously or unconsciously, depending on whether the N-system is actively connected to it. The objects of consciousness are interpreted by the feedback function of the conscious learned system; the subjective experience is that of seeing these interpretations *in the objective perceptual field.* A conscious S_4 perceives that sequences are going on in its environment. A conscious third-order system sees an environment composed of arrangements. A conscious fifth-order system sees a set of relationships.

Consciousness is not differentiated from order to order. One can be conscious simultaneously of a number of different orders of perception. Our language reflects this property by compressing several orders of percept into single sentences: "The little square is inside the big square" stands for perception of several relationships (little, big, inside) and several configurations (the squares). Furthermore, the sequence in which the words are placed identifies how the elements are to be arranged in the "inside" relationship.

The properties of the N-system give consciousness some interesting properties, as we define it. The reader may find it intriguing to consider the effect on a skill normally carried out unconsciously when the system that controls it goes into the state we call consciousness. The reader may also wish to give a detailed verbal description of how he ties his shoelaces while he is doing it.

Reduction of Order

We have invariably found that human *S*s and perhaps animals as well will attempt to use the lowest order of information available that will suffice for doing a task. In design of a sequential task for measuring S_4 properties, one must be careful that there is no element in the sequence which by itself provides enough information for successful completion of the task. We have asked *S*s to make differentiating responses to two sequences of spot deflection, "left, left," and "right, left." Nearly all *S*s showed third-order reaction times (0.3 sec., approximately) instead of fourth (0.4-0.45 sec., approximately), because they learned to see the initial spot as an element in the total *arrangement* of cues on an oscilloscope. If the initial jump filled the blank space to the left, they gave one response, and if it filled the space to the right, they gave the other. No attention had to be paid to sequence at all. It is very difficult to avoid giving such lower-order information. This order-reduction effect may account for what is termed "stereotypy" in learning situations, where an *S* will continue to give a response even though changed circumstances make it in-appropriate. Since *S* is attending to the problem at a lower order than *E* intended, he fails to notice that the higher-order situation has changed.

Order reduction is carried out by human beings in another interesting way, through use of symbols. The reader will remember the lower circle, L, and the upper circle, U, employed in the fifth-order Portable Demonstrator. We represented these two sequences by letters, and then proceeded, later on, to use these letters simply as third-order objects. The letters were actually order-reduced representations of sequences, but could be used any other way we pleased. What makes the difference is the set of rules one uses for manipulating the third-order objects. If they are treated as algebraic variables, then they are manipulated according to the (fourth-order) rules of algebra. If they stand for sequences, then they are manipulated according to a different set of rules. This procedure is very common in mathematics; letters often stand for *operators* which are actually sequences of manipulations, and there is a set of rules for the algebraic manipulation of operator-symbols, different (but nevertheless still fourth-order) from the ordinary rules of algebra.

By such use of symbols as order-reduced representations of higher-order perceptions, one can build verbal or logical structures with many more levels than there are orders of perceptions. Of course the rules relating one level to another will still be of six or fewer types, corresponding to the transformations among human orders of perception. By such order-reducing techniques, human beings can construct symbolic variables representing combinations of events in the second-order perceptual field which they cannot perceive directly—they cannot build feedback functions of sufficient complexity or sufficient accuracy to respond directly to these combinations as abstract variables. We have employed this technique constantly in building our behavioral model. We cannot, however, take credit for discovering the technique—most language is an order-reduced representation of experience.

Conflict Theory

Consider two systems of order n, both controlling the reference-level of a system or order $n - 1$. Generally, each nth-order system will also control other sets of systems of order $n - 1$. Often, the nth-order systems can achieve their respective reference-levels independently of one another, even though they share some systems at order $n - 1$, because other systems can be adjusted to compensate for potential conflicts. But in the case where the two reference-levels at order n demand mutually contradictory settings of r at r_{n-1}, and the common subsystem is essential to both higher-order systems, conflict occurs. Likewise, two higher-order systems can often be simultaneously satisfied by finding a suitable lower-order system; one can satisfy the desire to ride a bicycle and the desire to go downtown by employing the same skill. But, if no common system with this property exists, then both higher-order systems remain unsatisfied, and any attempt to set appropriate reference-levels at lower order will result in conflict.

Conflicted FBCS are in a condition in which correcting the error in one system increases the error, and hence the corrective efforts, of the other system. If both systems were good control systems in the first place, they will react strongly to even moderate errors, and hence when in conflict will tend to send out extreme output signals. This does not necessarily mean *energetic* outputs, but only that if the opposition were suddenly removed, behavior would follow some extreme pattern.

The common subsystem will behave as though its reference-level were set at a compromise value which we term the "virtual reference level," and will act like any other control system. But because the controlling systems are near or at their limits of output, the controlled system will appear to have a fixed reference-level which does not change with circumstances. For all practical purposes, the two controlling systems have been removed from the organism's set of environment-controlling systems, and are serving only to generate a constant reference-signal in the controlled system.

If conflict is severe enough to drive the conflicted systems to their limits of operation, another effect may occur. Feedback systems lose their resistance to disturbance when driven to their limits, but they also enter a very non-linear region of operation, in which all their important characteristics change. A common result is instability, which shows up as oscillation. Thus the system might oscillate, and behavior would show what is called "vacillation."

A pseudo-threshold effect can be seen when a system limits; the error it has been holding near zero suddenly begins to increase when the system reaches maximum output. If an older system exists, which operates to keep a similar error-signal near zero but which is much cruder, requiring a greater error to produce output, the older system will come into action as the error increases, and behavior will be typical of the older system. This is in part our explanation of "regression" and its connection with conflict and extreme stress.

Conflicts can be removed by altering the properties of one or the other controlling system, by altering the reference-levels of either system, by switching one system entirely to the imagination-connection [the mechanism (See Part I) of fantasy, wish-fulfillment, and closure], by introducing a third system to conflict with the unwanted system (suppression), and a few others. In general the removal of the crippling effects of conflict by means *other than* a change in reference-level by a still higher-order system or a realistic change in properties via N-system action, is the mechanism of what is known as the "defense of the ego." All of the classical psychoanalytic defenses can be seen easily as solutions to the general conflict situation outlined above.

It should be remembered that conflict only removes the higher-order systems from action: the commonly-controlled lower-order system remains in action, and actively maintains behavior at the virtual reference level created by the different control-signals. This is one form of "resistance" and is what makes it seem that the system is resisting all change, at least in the conflicted area.

If one arbitrarily forces behavior toward one or the other of the contradictory higher-order goals, the output of the corresponding system will decrease toward neutral as its error-signal decreases. But the other system will still be producing maximum output, therefore it will appear that *S* has suddenly begun to take higher-order action against the disturbance. If the conflict is mild, so that neither system has quite reached maximum output, this effect will be more pronounced. An external agency forcing behavior in the "right" direction will find that *S*'s own motivation in that direction relaxes and his efforts in the opposite direction increase, just as though he were seeking to maintain exactly his present state. This is why the "will power" and "authoritarian" approaches seldom have any lasting effects, and why it appears often that people are actively keeping themselves in unpleasant conditions.

In general, it is plain that the system which is actively maintaining behavior constant is one order lower than the conflicted systems. This is a useful rule to keep in mind if one is a therapist. A person who is in the grip of a compulsive sequential behavior-pattern at fourth order is conflicted at fifth order, not fourth—a fourth-order conflict results in actively maintained stasis, not action. Likewise, a person who shows rigid behavior toward other people is actively and efficiently maintaining his fifth-order interpersonal relationships at a frozen reference-level, and the conflict is at sixth order, not fifth. He has problems concerning his concept of systems; his own, society's, or other people's. It does no good to alter a person's behavior at an order lower than the level of origin of the conflict, except for purposes of safety or survival. The conflict remains and will be expressed differently at the lower order. The paralyzed leg turns into a paralyzed arm; the hatred for father becomes a hatred of money; the compulsive handwashing becomes compulsive bead-telling. Only a change in the systems which are fighting each other through the lower-order systems will have a permanent effect.

Finally, by our postulated definition of consciousness, putting both or all the conflicted systems into the state of consciousness is the only way to start the *N*-system to work changing them.

Demonstration of Conflict

The Portable Demonstrator can readily exhibit some rather striking examples of conflict, along with the various possible results. If *E* joins his hands, aligning the two forefingers to provide a single indicator to be tracked, *S* can readily acquire the fourth-order system needed to track some repetitive movement with his *single* forefinger. After continuing until *S* has clearly established his fourth-order system, *E separates* his two hands, moving each in a different manner. Thus *E* now provides *two,* incompatible, fourth-order reference signals. The movement should be simple, such as a simple circular sequence, or moving the two fingers in opposite vertical or horizontal directions, and *S* can be practiced in both sequences. Indeed, as with all the Portable Demonstrator presentations, it works at least as well when *S* knows just what to expect. In this last demonstration, however, we cannot predict *which* of the various possible responses to the conflict situation will be selected. Commonly *S* will demonstrate the virtual reference level, especially if the conflicting signals are equal and opposite. However, it may be possible for *S* to select one of the two and ignore the other—this is difficult. There are many variations of this demonstration, and the analysis of several of them should be quite instructive for the reader.

A Statement of Values

Perhaps it is fitting to close this section of our paper by a brief statement of how we view the properly-operating FBCS hierarchy.

In the optimum system, no significant conflict exists, so that all systems important to behavior are free to operate over their full range without internal opposition. Likewise, the concept which the system has of itself must include knowledge of the properties of the *N*-system and the signs of its action, so that the *N*-system remains free to keep intrinsic errors minimized, and so that the results of *N*-system action can institute change anywhere in the hierarchy without undue self-preservative action on the part of existing systems. Thus it is capable of modifying its systems as rapidly as changes in its environment may require.

If the organism is in this state, it is performing properly; there is nothing wrong with it. The person perfectly organized in this respect can still fall into conflict with himself, but the *N*-system is capable of finding solutions if they exist. The person is still subject to the limitations of his environment, to the distortions of false information and the illusions inherent in the geometry of perception. The person may be a saint or a sinner, but he will not be mentally incapacitated.

There is no morality inherent in our theoretical structure, although the phenomenon of moralizing can be easily described in its framework. The definition of an optimum FBCS hierarchy reflects our personal preferences—we prefer to see people performing "up to specs," regardless of what they choose to do, and it is toward this end that we choose to work. We also choose to try to persuade other people to accept this goal to see how it works out.

Our value choice implies many detailed attitudes toward human personality and interaction. The optimum system, for example, can be controlled (in a basic sense) only from within; its ultimate determinant of action is satisfaction of its intrinsic reference-levels, whatever they may be. To the extent that a person can be controlled by outside agencies, to the frustration of what he originally wanted, he has something wrong with his internal organization. Of course a good deal of what is termed "control" of behavior is not control at all, but the normal action of independent systems in the process of satisfying their own intrinsic states or learned goals. With respect to the natural organism, the only way to control it is to get control of the means for satisfying its intrinsic state. (This is exactly what is done in much animal experimentation.) This is very dangerous when tried on human beings, because the putative controller is likely to find himself being treated as a disturbing variable in process of being removed.

We believe that all human behavior is essentially based on the individual's experimentation. He would have to try moral values, facts, methods, and so forth to test them for their effectiveness in the ultimate task, that of maintaining his intrinsic state. He would even have to learn, if he could, just what constitutes his own intrinsic state, because this information is not built into his learned systems. His naturally acquired concepts of the details of human behavior are the *content* of his hierarchical system and are all learned. His concepts of social interaction, personality, and all the rest of his attitudes and behaviors were invented by someone, and reinvented, and taught. If the human lot is to be improved, a better picture of "the good" and of "right and wrong" must be invented, and people must also explicitly recognize these ideas as inventions up for critical test. A person must beware of setting up any ideal in his mind as sacred and untouchable, for by so doing, he sets up an automatic mechanism to counter the effects of his N-system, and guarantees a halt in his development.

Summary

A two-part theory of human behavior has been presented; Part I deals with a general conceptual model based on a hierarchical arrangement of negative feedback control systems, of the type in which the control loop includes portions of the environment. Each level of system controls the level below by specifying reference-levels for the controlled systems. Part II outlines applications of the feedback principles to behavior, and introduces six hypothesized levels of perceptual variables associated with human feedback control systems. These levels range from spinal reflexes (First Order Systems) to systems which perceive and maintain orderliness and system concepts (Sixth Order). An organizing system is described.

Accepted November 5, 1960.