



Ricardo Hoffmann ct.

FEEDBACK: BEYOND BEHAVIORISM

William T. Powers

Summary

Consistent behavior patterns are created by variable acts, and generally repeat only because detailed acts change. The accepted explanation of this paradox, that "cues" cause the changes, is irrelevant; it is unsupported by evidence, and incapable of dealing with novel situations.

The apparent purposefulness of variations of behavioral acts can be accepted as fact in the framework of a control-system model of behavior. A control system, properly organized for its environment, will produce whatever output is required in order to achieve

a constant sensed result, even in the presence of unpredictable disturbances. A control-system model of the brain provides a physical explanation for the existence of goals or purposes, and shows that behavior is the control of input, not output.

A systematic investigation of controlled quantities can reveal an organism's structure of control systems. The structure is hierarchical, in that some quantities are controlled as the means for controlling higher-order quantities. The output of a higher-order system is not a muscle force, but a reference level (variable) for a lower-order controlled quantity. The

highest-order reference levels are inherited and are associated with the meta-behavior termed reorganization.

When controlled quantities are discovered, the related stimulus-response laws become trivially predictable. Variability of behavior all but disappears once controlled quantities are known. Behavior itself is seen in terms of this model to be self-determined in a specific and highly significant sense that calls into serious doubt the ultimate feasibility of operant conditioning of human beings by other human beings.

BAUM

Although there is much of value in the article "Feedback: Beyond behaviorism" by W. T. Powers (26 Jan., p. 351), it is based on an outdated and misconceived idea of behaviorism.

Behaviorism consists in the view that a scientific psychology must deal with the observable. From this proposition, it follows that psychology should be a science of behavior, and that explanations of observed phenomena should be couched in the same terms as the observations themselves, rather than invoking imagined autonomous entities ("explanatory fictions") as causes. Many, perhaps most, psychologists today are behaviorists.

Since its points are mainly methodological, behaviorism never has been wedded to any particular conception of behavior. Early behaviorists perhaps held views similar to the one Powers criticizes, but the inadequacy of describing behavior in terms of responses to stimuli was recognized over 30 years ago. With the recognition that behavior is affected by its consequences (the Law of Effect), open-loop descriptions began to pass away. Few behaviorists today would disagree with Powers's statement, "there can be no nontrivial description of responses to stimuli that leaves out purposes." Emphasis on purpose, in fact, has been the hallmark of modern behaviorists' thinking (1). The behaviorists' solution to the problem of purpose has been exactly the one

suggested by Powers—selection by consequences. That behavior and consequences constitute a feedback system is taken as a basic premise (2). It is presented this way in at least one elementary text (3).

Powers covers familiar ground in two other points. In his discussion of acts and results, he actually reinvents Skinner's concept of the operant (4). One of Skinner's most important innovations was this conception of a unit of behavior consisting of the class of responses (Powers's "acts") defined by its environmental effect (Powers's "result"). As Herrnstein has pointed out (1), Skinner's approach to the problem of purpose was to define behavior in terms of its consequences.

Also familiar is the notion of the hierarchical organization of behavior. Lashley (5) made the earliest clear statement of this view. He argued, as does Powers, for a hierarchy of goals and subgoals in behavior. It seemed the only way to account for organized sequences.

Although Powers's attack on behaviorism is misguided, and many of his ideas have been set down before, nevertheless the constructive aspects of the article deserve praise. The very lack of novelty itself shows that Powers, albeit unwittingly, is square in the mainstream of modern behaviorists' thinking about instrumental behavior. His discussion of feedback, therefore, is most welcome, because it helps define the direction in which we are moving.

References and Notes

1. R. J. Herrnstein, introduction to J. B. Watson, *Behavior* (Holt, Rinehart, and Winston, New York, 1967).
2. The opening sentence of *Schedules of Reinforcement* by C. B. Ferster and B. F. Skinner (Appleton-Century-Crofts, New York, 1957) reads, "When an organism acts upon the environment in which it lives, it changes that environment in ways which often affect the organism itself."
3. H. Rachlin, *Introduction to Modern Behaviorism* (Freeman, San Francisco, 1970). See also D. J. McFarland, *Feedback Mechanisms in Animal Behaviour* (Academic Press, London, 1971) and P. van Sommers, *The Biology of Behaviour* (Wiley, Sydney, 1972).
4. B. F. Skinner, *The Behavior of Organisms* (Appleton-Century-Crofts, New York, 1938). See J. R. Millenson, *Principles of Behavioral Analysis* (Macmillan, New York, 1967) for a treatment in terms of set theory.
5. K. S. Lashley, in *Cerebral Mechanisms in Behavior*, L. A. Jeffress, Ed. (Wiley, New York, 1951), p. 112.

REESE

Powers briefly describes a closed-loop feedback model of behavior, with special reference to purposive behavior. The model is of interest and deserves serious consideration as an alternative to other behavioral models, but there are some points about the presentation that warrant critical comment.

First, as a model, the system can do no more than represent the phenomena in the domain encompassed. A model (of the type under consideration here) provides no explanations, except in the sense of intuition or analogy. Powers does not describe the theory to be associated with the model, and therefore no real explanations are provided.

Second, Powers asserts that no be-

havioristic model has been able to account for purpose; but in fact purpose has been adequately derived from such behavioristic constructs as the conditioned goal response (the fractional anticipatory goal response, r_g) and other mediational response. In Powers's system, "purpose" is like a template; its effect is not goal-seeking behavior but goal-maintaining behavior, and it is concurrently represented in the system. Powers does not provide adequate, empirically based definitions of the key concepts, such as "reference signal," and in this sense his model is nonbehavioristic. Nevertheless, as far as one can determine, the model is mechanistic, in that the components of the feedback loop are analyzed as a unidirectional, linear causal chain. The very fact that the components can be analyzed in this way indicates that there is no dialectic interpenetration, or reciprocal interaction, because in such interactions the components are inseparable from the whole or structure that comprises them (1).

Powers concludes that "Behavior itself is seen in terms of this model to be self-determined in a specific and highly significant sense that calls into serious doubt the ultimate feasibility of operant conditioning of human beings." Were it not for the ambiguity of the meaning of "ultimate feasibility," one could reject the statement on empirical grounds. The research literature is replete with studies demonstrating operant conditioning in human subjects

by human experimenters, in some cases without the subjects' being aware even that they were subjects (2). One can also, in any case, question the statement on theoretical grounds, because "self-determined" has, as Powers says, a specific meaning in the model, and this meaning has no implication of free will. In the model, "organisms are self-determined in terms of inner control of what they sense, at every level of organization except the highest level." Inner control refers to feedback ("error signal") regarding the discrepancy between the "reference signal," or goal, and the "sensor signal," or input. As the model is mechanistic, the error signal will inexorably produce specific "effector functions," or responses. That is, the responses are completely determined by the error signal (and, perhaps, by the state of the system), and the error signal is completely determined by the reference signal and sensor signal. As the sensor signal is determined by the environment, any variability in self-determination must come from variability in reference signals. Their source is not specified in the model (except at the highest level, at which they are assumed to be biogenetically determined). The model does not demand a reference signal that prohibits operant conditioning; this reference signal was introduced ex hypothesi and is not entailed by the model.

In summary, the model (i) is not explanatory, (ii) is not the only mechanistic model that provides a derivation of purpose, and (iii) does not intrinsically preclude human operant conditioning.

that truly reflects the system's output. From that point outward, the results of that output become more and more mixed with properties of any events in the external physical environment, so that even such elementary behavior as a "movement" no longer is a unique indicator of a particular activity in the nervous system. Thus, while Baum's pronouncement seems reasonable on the surface, it ignores one of the deepest conceptual dilemmas of behaviorism.

The control-system model shows that behavior at any level, as well as its relationship to "stimulus events," makes sense as soon as one recognizes the concept of the controlled quantity. To find the proper definition of the controlled quantity, the observer must recognize that his own point of view determines the behavior he will observe, and he must find an objective way to discover the *right* point of view—namely, that of the behaving system. The observer must try to find out which of the infinity of potential controlled quantities is the one that the behaving system is actually sensing and controlling. Only when the controlled quantity has been correctly identified can the observer see that the system's outputs are always such as to counter the effects which environmental disturbances would otherwise have on the controlled quantity. In my article I presented an experimental paradigm, new to psychology, for testing hypotheses concerning the controlled quantity and its reference level.

In the section on controlled quantities in my article, there appears an approximation, $g(d) \approx -h(o)$, which

says that the cause-effect relationships that can be observed between stimulus events and consequences of nervous system outputs—responses—are expressible wholly in terms of the physics of the local environment, containing almost no information about the behaving system at all. I see no way in which behaviorism can survive a full understanding of the derivation and significance of this harmless expression. If control-system theory does indeed describe correctly the relationship between organisms and their environments, behaviorism has been in the grip of a powerful illusion since its conceptual bases were laid.

It is therefore not possible that behaviorism already contains an adequate treatment of feedback phenomena; if it did, a behaviorist would have discovered this illusion already. Many behaviorists have observed feedback phenomena, but they have tried to deal with them by translating the terminology of control-system theory in such a way that well-accepted behavioristic principles would remain undisturbed. That is why "purpose" has lost its original meaning of inner purpose or intentionality, and has been redefined as *consequences*. That redefinition was necessitated by the fact that early behaviorists knew of no physical system that could contain inner purposes—their telephone-switchboard model had no place for them, and control-system theory then lay far in the foreseeable future.

In control-system terms, a purpose is not a consequence of behavior, but a model inside the organism for what it wants the perceptual consequences

References

1. H. W. Reese and W. F. Overton, in *Life-Span Developmental Psychology: Research and Theory*, L. R. Goulet and P. B. Baltes, Eds. (Academic Press, New York, 1970), pp. 115-145; W. F. Overton and H. W. Reese, in *Life-Span Developmental Psychology: Methodological Issues*, J. R. Nesselroade and H. W. Reese, Eds. (Academic Press, New York, 1973), pp. 65-86; W. F. Overton, *Hum. Develop.*, in press; L. von Bertalanffy, *General System Theory* (Braziller, New York, 1968). H. M. Rosenfeld and D. M. Baer, *Psychol. Rev.* 76, 425 (1969).

POWERS

The comments by Baum and Reese on my control-system approach to understanding behavior are the most balanced I have received from behaviorists. I thank them for trying to find a place for my work within behaviorism, an attempt that reflects generosity, but not understanding, of what I said (or tried to say). The conceptual basis of control-system theory is so alien to behavioristic thought that there can be no such easy reconciliation. The best we can hope for is a constructive confrontation.

Baum says that a scientific psychology must deal with the observable, which to him means behavior. Behavior, however, is not something self-evident that anyone can see just by looking. What is the behavior of a man walking? Is he really tensing his leg muscles, moving his legs, walking, going to buy a paper, on his way to work, making a living for his family, or maintaining his self-respect? The point of view of the observer defines the behavior he sees. The *actual* behavior of the nervous system consists solely of sending neural signals to muscles and glands; that is the last event

of its outputs (modified by environmental disturbances or not) to be. When I bow, my inner purpose is to perceive all the pins falling on the first ball. What I perceive is generally something different. I am still doing my best to alter my outputs in such a way as to reduce the error between what I generally perceive and what I intend to perceive. Another observer can discover that intended perception by manipulating my environment until he finds the state where I cease to alter my outputs in opposition to the changes he causes. There is nothing metaphysical or conjectural about this process. But it does not make any sense in behavioristic terms, because it is designed around rigorous laws of feedback, not around the imprecise usages of the term feedback that are found in behaviorism.

There seems to be a general impression that feedback is analyzable (in Reese's terms) by following a "unidirectional, linear causal chain" around and around a closed circle (I trust that Reese noticed that the circle is closed). That approach to feedback, often expressed as taking into account the effects of a response on subsequent stimuli, is the natural one, but, as every beginning control-system engineer soon discovers, it leads to totally incorrect predictions of the behavior of the system being modeled. The qualitative chain-of-events approach leaves out the crucial factor of system dynamics; when that is properly taken into account, through use of a physical analysis of the system and its environment and application of differential equations or transform methods, a very different

and surprising picture emerges. If the control system one wants to model is free of spontaneous, self-sustained oscillations (as normal behavioral systems are), time lags in the system can safely be ignored, and the behavior of the whole system can be seen quite correctly as occurring *simultaneously* with disturbances. The output changes *along with* the disturbance (a normal, slowly varying disturbance), and the input variable being monitored continually tracks the inner reference signal, if a variable inner reference signal exists. There are no loopholes in this analysis; if organisms are in the negative feedback relationship with their environments, this is how they behave. To arrive at a different conclusion, one would have to show that the bases of control-system theory are wrong, and he would have a lot of engineers who use it every day to convince.

Thus, the attempts by behaviorists to bring feedback phenomena into the scope of their conceptual scheme have involved only a superficial adoption of certain terms and loose qualitative observations, the true beauty and power of control-system concepts having been left behind. The distortions of feedback theory that occurred in the adoption of the terminology were precisely those which would prevent change in the basic conceptual scheme of behaviorism (this should not surprise control-theory fans, since all organisms manipulate their own perceptions to keep them in the desired state).

There is no "reference signal that prohibits operant conditioning," as Reese puts it while guessing wrong about what I meant. Operant condition-

ing is a fact; in my model, it is a portion of a control process whereby organisms modify their own inner structure of control systems as a means of keeping certain critical variables (W. R. Ashby's term, as I noted), at genetically established reference levels. I was talking about the *feasibility* of people deliberately trying to control the behavior of other people through deliberate application of operant conditioning.

In order to control another person, one must establish contingencies or schedules of reinforcement. Whatever one chooses to use as a reward, he must make sure (i) that the subject needs or wants the reward and (ii) that the *only* way the subject can obtain the reward is by doing what the experimenter wants to perceive him doing. The experimenter, of course, is trying to control his own perceptions relative to his own inner purposes, using the subject as his means.

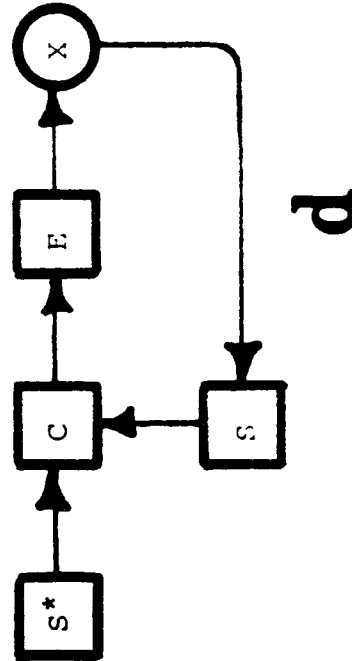
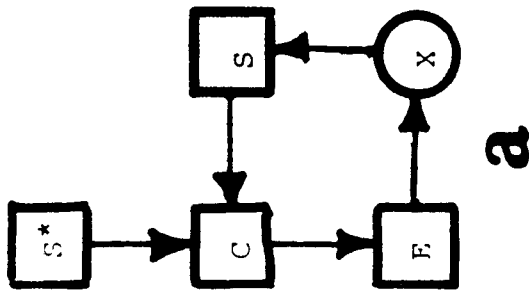
The establishment of contingencies, therefore, requires that the experimenter already be the sole source of something the subject wants, and establishing that situation is where operant conditioning will fail as a way of controlling behavior—as it has failed throughout recorded history. An experimenter trying to control people rather than laboratory animals cannot conceal the fact that he has what the subject wants, and is withholding it until the subject does what the experimenter demands. If one person can establish a contingency, another person can see that he has done so, and can decide to "unestablish" it. If the act

that the experimenter wants to see performed in any way inconveniences the subject, the subject will be forced by his own nature to find a way to circumvent the contingency. He can operate properly only on the basis of his own inner purposes, not on the basis of the experimenter's. Only a god capable of seeing a person's entire structure of inner goals could establish contingencies for that person without creating conflicts that would lead to a direct and violent confrontation. Even then, the god would be constrained to controlling the person in ways that created no uncorrectable errors in that person's control hierarchy.

Operant conditioning is only a modern term for what people have been trying to do to each other since civilization started. Everyone knows that people seek rewards and will change their behavior, within limits and as necessary, to get those rewards. But rewarding always implies withholding, and withholding what people need is a sure way to create violent and bloody conflict. An excellent case can be made for the statement that the present state of the world is the direct result of people trying to set up contingencies of reward for each other. It is time we realized that this principle of social interaction is the cause of, not the solution to, our most serious human problems.

Finally, I want to acknowledge the justice of some of the criticisms of my work. I know that I have overgeneralized in speaking of "behaviorists" when I really should have said, "some behaviorists." My aim is to find ways to effect a transition from what I believe is an outmoded view

of the nature of human nature—and animal nature—to what seems a vastly more productive and humane point of view. My attitude toward what I see as the basic errors of behaviorism is not one of irritation or superiority. My model is only a feeble step in the right general direction. It is instead that there is an enormously difficult task ahead—but, considering what I see as the possible results of success, worth all the effort. I hope that Baum and Reese and other behaviorists will come to see it this way after careful consideration. I know their task is harder than mine, and it would be even harder if this clash of ideas were set up so that someone had to win, and someone had to lose.



P. CLOUGH

Noam Chomsky introduced his critique of Skinner's Beyond Freedom and Dignity by likening the responses to Skinner's book to responses to a Rorschach test. The overwhelming acceptance of Skinner's proclamations in science and in their social milieu led Chomsky to wonder "What kind of a world is this?"

The dialogue that fails to take place between W. Powers, and Reese and Baum (the first representing the principles of feedback control, the second and third, the principles of behaviorism) is a failure that itself describes the effects of behaviorism on our way of thinking. As behaviorism does not ask "why this behaviour", or even "how this behaviour", so Reese and Baum fail to address the purposive context in which Powers makes his observations. Within a behavioristic mode, their answers or "responses" to Powers cannot be explained. But in a mode beyond behaviorism, a mode in this case constituting nothing more than common sense, Reese and Baum make an understandable response.

They do not explain the discrepancy between their goal, entailed in behaviorism, and the goal that is entailed in Powers' presentation. Rather, their remarks can be explained as nothing more than manipulations of their own perceptions made to keep them in their desired state, as Powers points out. Sadly, their behaviour is the example that necessitates an explanation that is beyond behaviorism that describes behaviour as purposeless.

The simple physical explanation of stimulus/response as disturbance/output provided by Powers seems satisfactory in putting behaviorism into place. But there is dissatisfaction for those who accept goal-directed behaviour on the part of living organisms, in that so fundamental a principle is rejected by behaviorists, thus placing obstacles in the way of understanding goal-directed systems such as learning, social change, conversation, formal languages, and science itself. Fortunately, the organism continues to oppose disturbances, making adjustments at every level in the hierarchy of control. Let us hope that such opposition need not be bloody.

Mr. Powers has constructed an alternative framework for analyzing behaviour, employing a closed feedback loop rather than the open loop system that, he feels, the behaviourists utilize. His system is this: a disturbance in the environment acts as an input quantity that is sensed and then compared to a reference signal. This comparison leads to the generation of an error signal that activates the system's effector functions, leading to an output. This output is again sensed, compared, and a new error signal is generated --thus resulting in a closed loop system where responses (outputs) become stimuli (inputs) through environmental feedback, in an attempt to maintain homeostasis.

How does Powers' system differ from the behaviouristic one? In his view, the difference arises from the behaviouristic construct that denies the existence of purposive goal directed behaviour. I believe (as does William Baum) that Powers has misinterpreted the behaviourist viewpoint. Most of today's behaviourists do not deny that purpose and goals are valuable heuristics for understanding behaviour; they only object to employing them in empirical studies of behaviour, because thus far no one has been able to isolate and quantify these variables. Powers states that "given knowledge of the controlled quantity one can deduce the form of stimulus-response relationships from physical, not behavioural laws." However, to isolate and quantify the concepts of goals and purpose, one must first identify the reference level (goal) and quantity being controlled (purpose) before these physical laws can be "deduced", a task that has not been effectively tackled thus far.

Powers is, therefore, in the same boat that the early non-behaviourist psychologists found themselves in: he knows that purpose and goals are there, but he has not discovered a means to make them quantifiable, and they are not, therefore, empirically verifiable. At present the only alternative is to measure those quantities that are observable and quantifiable, and these are stimuli and overt behaviour.

As for Powers' implication that it is improper for human beings to consciously establish contingencies that will affect other human beings, I feel that he is being extremely naive. We are constantly being affected by environmental contingencies and reinforcements; therefore, the issue is not whether we should be controlled by the environment (which necessarily includes our fellow men), but whether this control is to be harnessed and utilized in a purposive fashion rather than being allowed to exert its influence uncontrolledly.

R. CLOUGH

"BOOBY"

In Chin's Bar one evening, a friend of mine in Psych dropped by and gave me the following paper, labeled "Transcript of Remarks, Third Annual Symposium on 'Operant Conditioning', Before Slavery and Indignity Prize":

Mr. Reese and Mr. Baum, it gives me great pleasure to award you the Third Annual Before Slavery and Indignity Prize for challenging the assertions of Mr. William T. Powers that when a control system is operating effectively (no pun intended), the sum of the effects of the disturbance and the system's active output will be nearly zero.

By intervening on the side of human intransigence, a quality, I repeat, of humans and not of telephone "on-off" circuits, you have brought us closer to the day when we need no longer speak of control systems as operating to reduce disturbances. For you have created the ultimate disturbance: FREE WILL. This is a bonafide meliorum for our committee and has made our job of selecting this year's prize winners a pleasure.

Without any further applause, we would like to present the citations:

To William M. Baum, Department of Psychology, Harvard University --

In your letter to Mr. Powers, you begin by re-stating the Behavioral Creed: "A scientific psychology must deal with the observable. Psychology is a science of behavior; explanation (why questions) of observed phenomena should be couched in the same terms as the observations (what questions) themselves." You have challenged Powers on the question of purpose by invoking Skinner, saying, "Skinner's approach to the problem of purpose was to define behavior in terms of its consequences." This is a weakness in Powers' argument for all he poses is the alternative "to conclude that acts vary in order to create a constant behavioral result. That implies purpose: the purpose of acts is to produce the result that is in fact observed."

Rodney Clough

In place of Skinner, Powers invokes "purpose"! He puts the cart before the horse in addressing predictability, the effects of which we are all aware. You, Mr. Baum, have restored our awareness that we are all predictable. You have demonstrated that once again we can resist imagining ourselves as "autonomous entities". Downwards and backwards, Mr. Baum, as our Cambridge behaviorists say!

To Mr. Reese, Department of Psychology, West Virginia University --

To you, Mr. Reese, goes our gratitude for confronting Mr. Powers on his charge that operant conditioning is not "ultimately feasible". Well, we know we haven't solved that problem, yet, and that's because there are people like Powers around. Why, did not Powers incriminate himself by saying "Human beings are more prone to learn how to circumvent arbitrary deprivation than they are to knuckle under and do what someone else demands in order to correct intrinsic error"?

Well, we're working on that one too, Mr. Powers! As far as "intrinsic error", we're trying right now to reduce human infallibility to the point where the environment is perceived as being infallible--not the human being. That should clear up some questions as to purpose, eh, Mr. Powers?

(Pause. There is a shuffle of papers at this point and some muted scratchings on the podium.)

Oh, excuse me, Mr. Reese; we were talking to you. Yes... ah, yes, MR. REESE. Here we are, yes. Free will. You supported your challenge, Mr. Reese, not by invoking Skinner, but by invoking FREE WILL. And in a genuinely dialectical way which places us within easy reach of Marx and Freud. Powers says, "When controlled quantities are discovered, the related stimulus-response laws become trivially predictable."

(Aside to the master of ceremonies, in muted tones, "He hasn't heard about some of those new-fangled drugs we're instituting as part of the prison reform program, just so the cons don't forget that they're cons." Laughter.)

Rodney Clough

Powers goes on. "Variability of behavior all but disappears once controlled quantities are known. Behavior itself is seen in terms of this model to be self-determined in a specific and highly significant sense..."

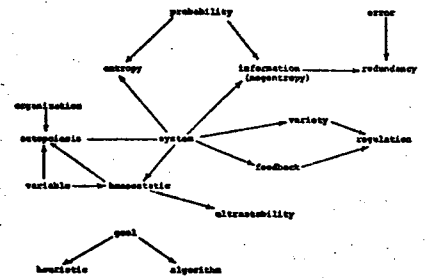
Mr. Reese, you smelled perfidy out by challenging that Powers' notion of self-determination is opposed to the notion of free will. Aren't we free? And what does that mean? That we are free to act predictably and to explain what we are going to do by the measured, concrete redundancies of...need I go on? Isn't it clear? Mr. Powers is introducing ambiguity, not predictability, into the human condition. Do we appear to have questions in our heads? DO WE?

That's right; we don't. WHY? I will tell you why, because we are cleaning up all the ambiguity; the nasty, little ambiguities which forever torment us. For centuries we tried. We looked at the human being...straight in the face and we saw there were many ambiguities. And we couldn't understand why there were so many. So we're reducing them. And there's no better place to begin, than by controlling what the human being does. Because only by controlling what the human being does will we know that deep down inside in that little ticker they call the soul, there is...that's right; just a little space for FREE WILL.

We are going to protect that little space and it's men like Reese and Baum with me tonight who will be doing the work. Not since we awarded the clean-up prize to the men who white-washed the Paris posters depicting human beings like sheep--those political ones put up by the hostile art students in '68--have I felt such a thrill as tonight. Miss Flossabee, would you present the awards. (To the gasps of the audience, a smartly dressed, white-coated female lab assistant comes out on stage, dragging a wagon with two large food pellets standing up. The pellets are wrapped in saran wrap with a large pink bow tied around and a sign on each which reads, "BOOTY".)

ULTRASTABILITY

In cybernetics, the capacity of a system in homeostasis to return to an equilibril state after perturbation by unknown or un-analysed forces (against the intervention of which the system was therefore not explicitly designed). [S.B.]



ULTRASTABILITY

The ability to modify internal relationships and/or influence environmental conditions in the interests of neutralizing actual or potential obstacles to the maintenance of stability. [S.U.]

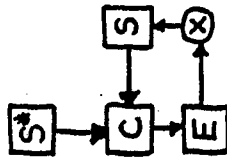




Jim Rebitzer:

PLAYING WITH FEEDBACK CONTROL SYSTEMS:
THOUGHTS ON SELF-CONSCIOUSNESS

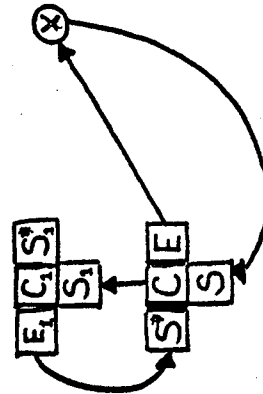
A feedback control system can be diagrammed like this:



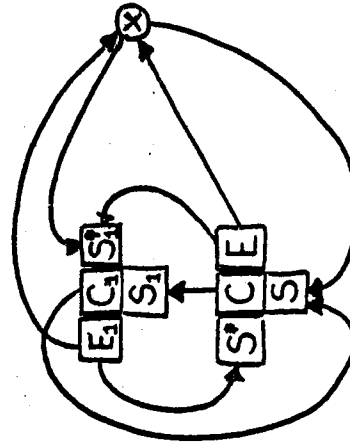
- S : What is (appears to be) the case
- S*: Desired state
- A : Discrepancy or comparison between S and S*
- R : What to do with A
- E : Effector
- C : Comparator
- X : State of affairs represented by S

This seems like a reasonable model until Herbert Brün brings up the following point: If what appears to be the case (S) is all that exists for the system, then A does not exist for the system, because it is not incorporated in S.

This problem can be restated like this: A can be evaluated only in C, the comparator. Thus for A for C, C must be aware of its own existence. Two ways for doing this suggest themselves: a) either C can be expressed through S, or b) another system can monitor C. In the latter case, C feeds information into the other system that is keeping track of and may influence the comparison process of C. Two diagrams of these inter-system relations are:



METASYSTEM A



METASYSTEM B

A can be classified as hierarchical while B is heterarchical. In both A and B the A of C exists for the metasytem because C's output is incorporated in the S₁ of C₁. In B, C₁ and C are aware of each other (and therefore themselves) because they are each part of each others S. In other words, C is connected to S₁ and C₁ is connected to S. Model A, however, makes no provision for the recognition of the existence of A in C₁. The hierarchical model just pushes the original paradox up one level. This brings us back to the first answer to the problem. There must be some way in which C (or C₁) can express itself in its own S and thereby perceive itself. It appears that C can transmit information about itself to itself by the actions of its effector E on X. The actions of E transmit through X onto S. Thus C can become aware of its own goals and goal comparison processes by observing its own reactions under certain states of X.

MECHANISM MAYBE

Patricia Clough

The model referred to by the relation of state: S, goal: S*, discrepancy: A, what to do with A: R is a model that I came to regard critically. That it illustrates a "person reaching for a ball", for example, was never important to me. It seemed clear to me that it did do that, but that the importance of the model would lie in its application to what might be called "social interaction", semantics, metaphor, conversation, etc.

But now I would say that the importance of the model does lie in the fact that it illustrates "a person reaching for a ball", and not so much its application to "social content". Simply, this "feedback model", as it is, cannot be immediately applied to social content. It can, in fact, narrow our vision, for there are transformational rules that are not yet contained in the model. Presently, something goes on outside the model that needs yet to be explained.

The ball and the person are for the observer both in the same realm of "objective data"--what is; for the actor they are both in the realm of "subjective data"--my ball catching. To apply this model to social context, where subjective and objective data have

intermixed status for both observer-observer and actor-observer, is to describe man as passive.

The model says that in the cultural, social realm man does have possibilities all at once available to him that regulate his choosing. Let us consider rules. To postulate that man's culture consists of common rules that are his goals or by which he asserts his goals is an attack on man's capacity to be a free individual.

Man invents and not just by breaking one of all the shared rules. Man invents by relating to rules to make sense of how he has acted. after he has acted. That is not to say that he is not goal-oriented. At the cultural and social level, what should be the case can be represented by S as well as S*. This is because there is always more than one system present.

Now, I have said that what the model can do (person-ball demonstration) is in fact important. I feel that the biology and neurophysiology of cognition is made non-trivial by this model. And a sociology or an anthropology of cognition is best built on a non-trivial biology of man. This model does this, but if we push the model insensitively we may lose what we have gained.

Let me demonstrate my point.

S: It appears to be the case that there is a social science that cannot yet explain human interaction but, rather, trivializes human behavior.

S*: What should be the case or what should appear to be the case is a social science that at least does not trivialize man.

Δ: My desire is the discrepancy between S and S*.

R: Is what shall satisfy my desire by removing the discrepancy. These distinctions are inaccurate, and might show that 1) I do not understand the model or that 2) the model, so to speak, does not understand me:

Case 1. My S* is in fact my S because I desire it to be. That it should become S for others makes R that which makes Δ consciously shared between me and others. I know what S* is not and if I knew what it is, then it is S.

Case 2. If I do not know what S* is, then it is inconsistent with the model; there is no picture in my head like "ball in hand". I know what S* is not, so it is S, and we're back to case 1.

Makes me queasy.

S, S*, Δ, R

Rodney Clough

The four entities outlined in Von Foerster, "Various Representations of the Same Feedback Control System", can be identified in terms of language-oriented systems. Conversely, these entities, when approached from the level of second order cybernetics, can provide a foundation for the observation and interaction with all language-oriented systems.

The impetus to apply cybernetics to observe feedback control systems comes from Pask, "The Cybernetics of Behavior and Cognition; extending the meaning of 'goal'". Von Foerster's model comes from an observation of goal-directed or purposive behavior. In this example, the purpose being stated as "hand catching ball" (S*); the state of the organism (S); Δ, the discrepancy between desired goal state S*, and the observed state S; R, a rule of transformation to compute Δ, thus bringing S* and S into equivalence relationship.

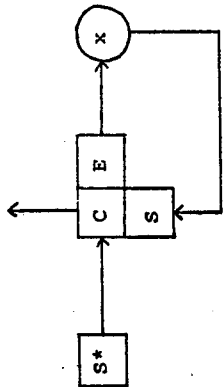
Consider that to separate out these four entities--S*, S, Δ, R--initiates a theory about them and in what ways they function. Restated, these four entities are the proper responses of an organism which is capable of observing itself: S*, "purpose for" the system; S, "purpose of" the system; Δ, discrepancy between what the observer describes as the purpose for the system and what the observer can describe given observable behavior of the system; and R, a rule of transformation or plan.

Recall that this model has been stated in the observer's meta-language; that is, a language for talking about the system, which is distinct from our natural or object language. A meta-language for talking about the system would be the procedure of explaining S*, S, Δ, R--"throwing the ball in air and catching it"---and making certain notations on a black board.

We extend S* to mean "purpose for" the system, whether we are talking about theory-building systems or "ball catching systems". The important point is we identify the model with "forming a theory" or "catching a ball".

This would rule out case f, where S* is interpreted as "placed outside the system", for serious study. By removing S* from an identification of the model, we create teleological questions,

questions such as "what constitutes a sensible interpretation of the model or what properties of the world are relevant".¹ This is a major pit-fall of behaviorist theories, which look to the subject to produce effects, but look elsewhere--to the environment, to the experimenter--to produce relevance.



We extend S to mean "purpose of" the system, i.e. its descriptive states. Here, certain linguistic ambiguities enter in, which were alluded to by Brun during the discussion of Von Foerster's model. Whereas S is the part of another regulatory system, namely language, S*, properly, is not. The formulation and re-formulation of desires is an instinctual move on the part of the organism observed in his observations to be his/her/its "best" regulator of that system.

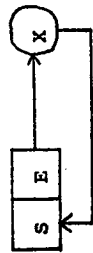
This brings us to the principal cybernetic hypothesis, as Pask calls it: "Any system with a purpose for it (S*) (any system for which a cybernetic theory can be constructed) also has a purpose in it (S); i.e. a goal; all systems are goal-directed systems (S → S*)." ²

Using second order cybernetic principles, S* is the prescriptive mode of theory-building; S is the descriptive mode of theory building. Δ is the discrepancy between "relevance" and "prediction". R is the plan we employ to get from what are the relevant properties to what are the predictable or alternative states of the system.

At this point in the discussion, we can contemplate the placement of the "existential operator" is. The success of a model of

theory-building depends in toto on how we describe S to ourselves. Pask puts it this way: "It follows from these comments that the truth ('is the case-potential') of

the cybernetic hypothesis cannot be decided (in respect to a particular system) at the level of the most fundamental and the simplest type of model: Ashby's 'black box'. However long a system identified with such a model is observed and however many experiments are carried out by varying the 'black box' input, it will only be possible to say that the system behaves as though it is (or is not) a goal directed system. The whole concept of goal directedness depends upon the interpretation (S*) of a structural or organizational model for the system; something having enough detail to delineate the goal-seeking process (S → S*)." ³

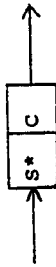


case f': once S* is removed from the system, the system becomes a trivial machine.

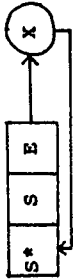
From the perspective of the observer, interacting with his observations, S is not quantifiable. We are talking about internal states (S1, S2, S3...Sn). To approach a meaningful description of S rests on how we specify S*. If we elect to see the system as having one goal, S, then when S* changes to S**, we will be impelled to say that the statement S → S* is underspecified. If we elect to see the system as having a multiplicity of goals (S1, S1', S''), then we will lose sight of the individual (S*) said to have these goals.

Consider, however, that we, acting as observers invent Δ (the discrepancy of S*, S) to identify S* with a "purpose for" and to describe the relevant properties "in" S. By distinguishing S* and S, we can proceed (R). In other words, by the act of distinction (Δ), as observers, we are the existential operator. We can say, what is (appears to be) the case and what should

(appears to be?) the case.
 The alternative approach to distinguishing "goal states" (Δ 's) generates effects, but no relevance. We can identify the system with S^* :



calling the system "a special purpose, goal-directed, computing machine".⁴ Or, we can identify the system with S , by objectifying the model with a thing, according to a prescribed set of describers.



In the first case, the system can neither be given new goals nor can it state its goals. In the second case, the observer having once objectified the model, is responsible for maintaining the given set of describers and "the system is isolated from extraneous parameter variations (originating at C) by efforts to maintain constant and repeatable conditions (x)".⁵

In both cases C , the computer/comparator-entity, does not have two inputs (S^* , S) and one output (E). Hence, it cannot converse with itself nor with any other system. It is what Pask calls a "taciturn system".

However, the system to which we credit the capacity to distinguish "goal states" (Δ 's) is a "language-oriented system". The awareness of a computer or Δ -generator and E , effector, linked to the computer, lends "speech" to the beast and recognition of similar speech faculties in other beasts.

Can a Δ between conversant systems be formulated? The language needs to be built; we need practice and the foundation is second-level cybernetics. Δ is the choice of plans (R) or procedures from S to S^* . Pask concludes, "If the system is language-oriented, then the object language of the system ("ball catching"), is itself used as the meta-language involved in the higher level 'control of control' and the subject becomes an active participant in theory construction."⁶

Presumably, though Pask does not stipulate this in his article, Δ conforms to switching modes of moving through relational networks. Is S^* or S dominant? McCulloch's phrase "redundancy of potential command" needs to be extended into the area of "reproducing concepts". There is the possibility for investigating linguistic interactions on this level: "An evolutionary process in brain A can be coupled linguistically to a process in brain B ; conversational interaction often mediates exactly the same kind of co-operation as the internal process of conceptual displacement. Hence the evolving individual is sometimes distributed rather than localized in a single brain."⁷

Does this mean that S^* or the prescriptive mode predominates?

Notes

All references are to Pask, Gordon, "The Meaning of Cybernetics in the Behavioral Sciences; The Cybernetics of Behavior and Cognition; Extending the Meaning of 'Goal'", from J. Rose (ed.), Progress of Cybernetics, Vol. 1, Gordon and Breach, New York (1969); Publication #237, Biological Computer Laboratory, Department of Electrical Engineering, University of Illinois, Urbana.

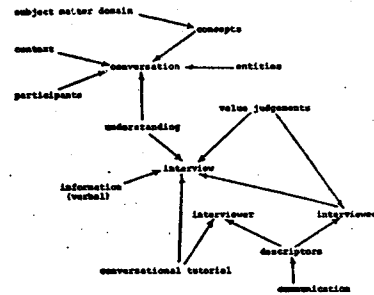
1. p. 23
2. p. 24
3. p. 24
4. See the distinction Pask makes between taciturn and language-oriented systems, pp. 25-28.
5. General Statement, pp. 28-29
6. P. 35, p. 31, paragraph beginning "Equally if, man is defined as an L.O. system..."
7. p. 35

GOAL

GOAL

A goal is a description of the relation computed by a concept. Such descriptions are usually underspecific insofar as the majority of concepts have Fuzzy intensions (programs). Their existence is a prerequisite for the reproductive computations already discussed, (that is, at a microstructural level, a description is computed and a program is constructed to realise this description).

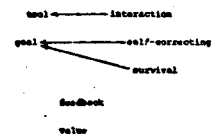
A participant may intend to achieve a goal if there is a concept for it in his repertoire; if not, he may intend to learn to achieve a goal, by building a concept that may achieve it. [G.P.]



GOAL

(1) An image deliberately held in front of an incomplected action to goad and direct its accomplishment. e.g. Orgasm.

(2) The convergent direction of any self-correcting process. e.g. Survival. Deliberation is not required. [S.Br.]



GOAL

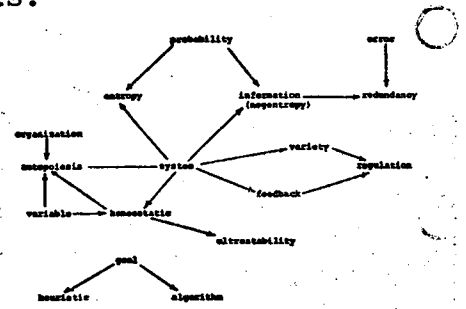
A final condition or series of conditions in which the behaving object reaches a definite correlation in time or in space with respect to another object or event or series of events. [S.U.]



HOMEOSTASIS

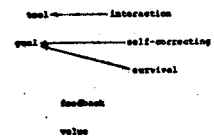
(1) The disposition of biological systems to maintain critical variables within physiological limits.

(2) In cybernetics, this disposition is generalized mathematically to include all (not only biological) systems that maintain critical variables within limits acceptable to their own structure in the face of unexpected disturbance. [S.B.]



HOMEOSTASIS

Another bad word is homeostatic. What is meant is homeodynamic. [S.Br.]



HOMEOSTASIS

Dynamic self-regulation; the ability of a system to maintain its fundamental, internal balances even while undergoing various processes of change. The concept was formulated by Cannon in 1929-32. [S.U.]

THE NERVOUS SYSTEM IS ORGANIZED OR ORGANIZES ITSELF SUCH THAT IT COMPUTES A STABLE REALITY

ANY REALM OF HUMAN ACTIVITY IN WHICH DECISIONS ARE MADE COULD BE A POLITICAL ARENA

The Nature of Purpose

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There are a number of connections between what has been dealt with in this conference and what I want to deal with. The notion of purpose has been taken in the sense in which one talks of purposes that already by implication are well defined, whereas my interest is in looking further into the process of the definition of purpose, or of the active meaning of the verb "to purpose."

In an essay published posthumously in 1952, the American engineer-novelist, Hans Storm,¹ undertakes to contrast two principles of human workmanship. One he calls the principle of design, and the other, by a "slightly bastard etymology," the principle of eolithism. The principle of design he describes from the engineering textbooks of the 1920's, and from his own practical experience as an electrical engineer.

The designer must first know approximately what he wants and how it is to be used. Next is a choice of building material which must be of known and, as far as possible, of uniform properties. This certainty as to what his objective is and this uniformity of the materials are essential to the whole process. They affect not only the geometrical result of good design, but also the mental discipline with which the process of designing takes place. Given a knowledge of the material and the final objective, the one is applied to the other—the design is applied



to the material. The plan begins to emerge, checked and extended by the use of well-known arithmetical rules. This process is continued until the whole becomes realistic in detail, making contact—as Storm says—with the existing world.

At this point a change is made from thought construction to physical construction. The direction of the operation is reversed, starting from contact with the material world and piecing together the structure until it embodies the objective with which the whole process started.

As an illustration of what Storm is talking about, let me describe a hypothetical child building a mobile by the principle of design. He begins with various animal figures which are going to decorate the bottom of the mobile. Being a skilled designer, he knows that what counts for balance is the weight of the figures. Having ascertained their weights, he goes to the drawing board, groups them in pairs or triples, hangs them pictorially on some number of thin sticks, and, using the method of moments, determines for each stick the center of gravity from which it is to be suspended. He now labels each of these drawings with the sum of weights it represents and begins again with the process of grouping and suspending these composite weights, from still other thin sticks. Since at each tier of the mobile the number of weights to be suspended is decreasing by half or more, he soon gets to a last pair or triple of composite weights and draws a suspension of these and, finally, the center of gravity of the whole system. He is finished with the design stage. He now fashions all of his sticks, notching them at the calculated positions. Having designed the mobile from the bottom up, he builds it now from the top down. He lifts it to the ceiling and, lo and behold, the whole thing balances. The result has a quality, as Storm would say, by which it can be universally recognized—a certain internal consistency, a certain finish, an orderly and uniform style, unchildlike to the utmost.

Storm wishes to challenge an assumption that comes with the principle of design in our society, namely, that this principle is basic and universal; an ideal by which we can measure all craftsmanship from its most primitive and blundering begin-

nings; a presupposition to which all craftsmen are committed, whether they know it or not, or whether they like it or not. To challenge this assumption, Storm, a professional designer himself, puts forth an alternative, a wholly different principle of workmanship for which he borrows the term eolithism. To establish the *human* character of this method, Storm first describes the basis of *animal* craftsmanship. In a very amusing and accurate description of nest-building, he describes it as the accidental by-product of a number of specific little programs released by the occasion, such as picking up twigs and dropping them, with no evidence of interest in the final product which happens, as though by a conspiracy of nature, to assemble itself in the end.

Storm finds a few examples of this sort of craftsmanship among humans, among the activities of the collectors of books, stamps, crockery, automobile parts, and such like things, but, generally, it is a rare style among us. Far more frequent, although in our society pushed into a corner of disesteem and lowered social status, is the eolithic pattern.

An eolith is literally a piece of junk remaining from the Stone Age. Storm quotes a definition, “stones picked up and used by man and even fashioned a little for his use.” The important matter in the definition is that eoliths were picked up already accidentally adapted to some end and, more importantly, strongly suggestive of the end. We may imagine the person whom the anthropologists describe so formidably by the name of *man*, strolling along in a stonefield, fed, contented, thinking preferably about nothing at all—for these are the conditions favorable to the art—when his eye lights perchance on a stone just possibly suitable for a spearhead. That instant, the project, the very idea of the spear, originates. The stone is picked up, the spear is in manufacture. Not only do the shaft and the thongs remain in the background as things which will in due time no doubt be thought of and be taken care of, but the very need and usefulness of the spear are in a way subsidiary to that instant’s finding; and if the spearhead during the small amount of fashioning that is its lot goes as a spearhead altogether wrong, then there remains always the quick possibility

of diverting it to some other use which may suggest itself.

Now we come to the serious point of Storm's ironic argument. To sharpen the contrast with the principle of design, he says, let us remember the basic principle of the designing workman. He must know what he wants and, even before the design begins, he must decide on his material. The fashioner of eoliths, on the other hand, must have a continually open mind about materials and he must be very adaptable in the matter of ends of what he wants. If the eolith defies the use it first suggested, then, perhaps, there is another use equally interesting and worthy. The essential limitations of the principle of design lie in the givenness and fixity of goals, and the need to eliminate variety and heterogeneity from the means and materials; they are thereby reduced in any significance or value they may have, *except* in serving those given ends.

A characteristic of eolithic craftsmanship is that it never goes twice the same and, therefore, uniform procedures, theories of design, and so forth, are of very little use. The doorpost picked up on the beach was many times as rugged as design would require, and the structure itself so redundant in the bracing which suggested itself along the way, that the problem of stability simply didn't require advanced planning. Alternative ends further weaken the requirements of design. The unruly ox, an eolith by Storm's analogy, is readapted to usefulness in the stewpot, and the tree that fails to bear fruit becomes firewood. Armed with these distinctions and stories, Storm now turns to the examination of our contemporary society which—and he speaks of the 1930's—has become so dominated by the principle of design that eolithism is all but excluded. All natural eoliths have been long since swept up from urban settings. The only resource for the unsuppressible impulse, where it does emerge, lies in the availability of materials which were once designed for specific use but are now worn out or obsolete. Thus, the great symbol of the eolithic impulse, submerged but not suppressed, is the junkman. Both he and his customers suffer from social' disesteem because they do not bow to the dominant principle of design. The logic of the design principle eats farther into the organization of life when designers go from uni-

formity of materials to uniformity of parts and kits whose mass production eliminates all competing intermediate species. Thus, more and more it happens that a practical man, wanting to satisfy his individual and, by the new standard, eccentric wants, is forced to improvise with materials never intended for these purposes. In the interest of mass production, men's goals themselves are forced into restricted and stereotype patterns.

A good essay is in its own nature a rather eolithic construction. It begins with some story, some item of curious concrete detail picked out of the course of experience. It explores some chain of associations, abstracting patterns of gradually widening significance, until, finally, something generic and universally relevant has been defined—not defined abstractly, but defined around that spearhead. It is likewise in the spirit of such procedures that one man's construction would be picked up by another and put to uses which the first might never have foreseen or intended. Hans Storm's essay lay after his death in an old pile marked, "Returned from Publisher." As a friend of Storm's and of his literary executor, I saw it and, having some dim presentiment of use to put it to, got it published as it certainly deserved.

Perhaps, you may guess what my intended use is, but I must confess that I'm still not really too sure—I'm being quite eolithic. Throughout the history of ethics we see many attempts to systematize that part of the common culture which deals with conduct and decision around what we can now refer to as the principle of design. Just as our immediate actions can be organized and grouped around a variety of specific goals or functions, so these in turn can be judged as serving a single ultimate goal or *summum bonum*. This must be fixed and unalterable, invariant to all choice. But that implies in turn a goal with roots so fixed in human nature that there is no possibility of significantly questioning or altering it.

With respect to the second requirement of design, the material out of which a life is to be fashioned, well-tested rules of design are needed but also the material must be sufficiently homogeneous to make those rules applicable repeatedly; otherwise, there is no point in having them. The hierarchy of design

rules, in this view of accumulated prudential wisdom, is what we call morality.

Now there is a dilemma in this way of thinking, which philosophers usually refer to as teleological or goal-dominated ethical theory, and which has long been noticed by its critics. It appears that the definitions of a supreme goal, a *summum bonum* implicit in human life, whether naturalistic or also supernaturalistic in sanctions, are not specific enough; not of sufficient informational richness to govern choice in the endless variety of concrete situations calling for choice. Such a goal only appears to govern, in the minds of those who claim it as their guide, because they have unwittingly read into it some dominant bias which is, in fact, highly specific—the projection of their own highly specific commitments and engrossments written large. So it is that capitalists and communists will not be outdone in their devotion to the long-run ends of human welfare but claim sometimes to be debating or battling merely over a choice of alternative means. So, a young person debating with himself over a choice of vocation attempts to weigh the alternatives before him as means to his future well-being and satisfaction as he defines those goals at the moment. So, the advocates of civil disobedience and of “Black Power” might debate as to which means is more conducive to the overcoming of racial domination in the United States. In none of these cases, I believe, can we avoid conceding that the purported end, conceived rigorously as invariant to the proposed choice of means, is something somehow ill-defined. To conceive of a Good Society is to be quite essentially vague about the historical development of that society. To conceive a future in America which is no longer vexed by the issues of race is to face the question whether, in that world we seek, “Whitey” will get off very easily or whether he has to suffer and learn a bit more in the process. The inheritance for the future of our society, of the very paths among which we are now attempting to choose, is not at all going to disappear. It is not at all obvious that the futures we are looking at are invariant to this kind of choice in quite essential ways—even, perhaps, in rather grossly visible institutional ways. It is not easy in general to see goals, future goals in human affairs, with sufficient specificity so that they

can, in fact, preside over choices (which we can then call choices of means) and, at the same time, be genuinely invariant to the consequences of those choices. The futures themselves seem to differ, not merely the means. If you represent this graphically, you may draw a choice of means as lines which branch from a choice point and then reconverge. At the point of reconvergence, you could say, from that point on I needn't take into account the consequences of the choice, because from there on they are washed out. But suppose the lines don't reconverge? Then I think you have to speak of the choice of ends as well as of means.

Such examples as these, and many others that I am sure you can recall out of your own personal experience, or out of our national political experience, raise very basic questions as to the degree to which the state of such a being as a human being can be conceived independently of his history, or as to the degree to which ends can be conceived independently of means. If ends cannot be defined in such a way as to render them invariant to a choice of means, then there are simply no pure choices of means. Thus, the moral problem of means and ends simply does not arise, which is one way of solving that problem. Theoretically you can say—you know, the standard moral debate —“Yes, but does the end justify the means?” If the question arises, the answer *must* be, of course, “no.” We must formulate the end so that it *includes* the means.

If we are to define a goal or a purpose as a future state, on the other hand, to be brought about through instrumental control, it must be defined as an equivalence class, invariant to some range of choice among what we can then call alternative means. The choice of means may then and only then be subsumed under the principle of design, as a choice of instrumental scaffolding, not effecting or entering into the nature of the goal as a goal. They are then subject only to criteria of technical reliability and efficiency where optimization means minimum expenditure of resources applicable to the achievement of other ends.

Storm's principle of the homogeneity of means in design reaches its pinnacle in our traditions when all the *de facto* heterogeneity of alternative means is declared irrelevant to

the definition of the dominant purpose and then measured by a common numeraire of economic value. Optimization becomes the sole criterion of choice. The implicit notion of a quantity of means gets generalized, in spite of the enormous heterogeneity of the actual means which we employ through the social mechanism of production and exchange, and we end with the substantive notion of value basic to the classical economists, from Quesnay to Marx.

If there is a goal which is single, ultimate, and well defined, then all choice becomes instrumental and all choice falls under the principle of optimization, the principle of design, no matter how the goal itself is defined. This is why Kant rather shockingly declared that theological ethics—he had in mind the specific formulation of the goal of obtaining the kingdom of heaven—fall under the principle of hedonism, the pleasure principle.

Once you have such a goal, all action becomes instrumental and the question is simply how to get there. Let me come back in this connection to a question of design that Storm does not explicitly touch. Some ends, some versions of the supreme goal, are already matters of more or less. If you think about pleasure-principle formulations of ethics, you want to maximize the pleasure. Others are all or none, like that of being among the elect in the literal Augustinian version of what it is all about. But these latter goals, although they are all or none, are quantifiable, intermediately quantifiable in terms of expectation values. I am sure many of you know Pascal's "great wager," which is a careful calculation of this kind. Goal-seeking in the presence of uncertainty, of noise, requires a matching redundancy of effort. Hence by husbanding our resources rather than wasting them, we are able to increase our expectation of success. We have husbanded them for the supreme purpose. Thus, in Kantian context, we get the Protestant ethic which makes it quite clear that if a rich man can hardly enter heaven, as it says in the Good Book, a poor man has even less chance. So, it is not true that the well-designed life is irredundant by the standard of a noise-free or surefire pathway to salvation. In Storm's symbolism, a properly designed structure will have just that

degree of redundancy which is sufficient to render it functional in the presence of all the uncertainties involved in the calculations of stresses—you know, the redundancy which is known as a safety factor.

When a child builds a tower out of drinking straws and pins, you might, as an exponent of design (this is my never-never child who operates by the principle of design), urge him to get it up to its intended height with a minimum number of straws; but then you might urge that it be proof against any ten scissor cuts, thus posing a problem close to that of the theory of error-correcting codes. The result would still be design, not eolithism. It was not in this connection that Storm mentioned safety factors, however; it was in connection with the counterideal of eolithism to which I now wish to turn.

The starting point, you will remember, was that of a situation in which purposes are not very clear or very firm and where the materials we find around us are qualitatively diverse and heterogeneous—a situation which in some respects rather does resemble the real world. He said that eolithic structures that were built in this way usually did in fact stand and serve the purposes they had helped to suggest because relative to those particular purposes they would be radically overdesigned. And this is where I come to the question of the nature of purpose.

I have argued elsewhere that purposive or teleological description is a proper mode of scientific description in many contexts outside that of human praxis, notably, of course, for some systems in biology and the study of the machine as a quasi-biological system.

What is absent from all such teleology, however, is a certain component of what the philosophers have called intentionality. For most purposes that idea can also just be rendered as intention, but let's use the technical term that has been coined. As long as we restrict ourselves to the description of behavior in living things or machines or people, teleological concepts are appropriate wherever the system described is one for which a particular metastable equilibrium is characteristic of the system, which can be known independently of the particular mechanisms of informational feedback, and so forth, by which the

system attains or maintains that equilibrium. What is missing, and what the older antivitalists were objecting to in the vitalists, is the idea that a system which could be described in teleological language in this sense was, thereby, supposed to be a conscious agent *intending* its goal. So, the question now before us is how we are to conceive that special and crucial component of purpose called intentionality. It is my own position that we human beings *have* the concept of purpose, as distinguished from *being* more or less purposive in our behavior—as are all the other animals—because in a new and emphatic sense of the word, we are purposive *beings*.

What I want to point out is that we alone are able to destablize first, then to modify, and, finally, to invent goals. We are *more* purposive than other animals because we are able to analyze and resynthesize our goals into more comprehensive patterns of a hierarchical nature; we are able to design our goals. That is the positive side. In a correlative sense, we are *less* purposive than the other animals. This is the negative side. We are all too conscious of the tentativeness and potential inadequacies of these designs we make, and thus are subject not only to deviation from steadfastness but also subject to despair. Where there is no *vision*, the people perish. Not only are we subject to despair but also to withdrawal in the face of despair—which is why that naughty fellow, James Thurber, added “And where there is *television*, the people also perish.”

What I am urging is that the root concept of purpose, namely the concept as it functions in the intellectual economy of human praxis, functions because we alone in the animal kingdom are able to set purposes and not just seek them. When our purposes are clear and steadfast, we think least about them and, in the ideal limit, we are not conscious of them at all. They govern but we do not consult them; *we* do not have to. *They* are in charge. They are in use but they are not under scrutiny *as* purposes. Problems that arise then are problems about means, and means are judged in the light of purposes; but, again, the purpose itself does not have to be in focus and you do not have to have a word for it. If men were wholly dominated by fixed and unalterable purposes, biologically built-in and arranged in

some automatic hierarchy of priorities, these purposes would never be noticed or talked about, any more than a child who uses the logical form of contraposition is conscious of it *as* a logical form. It is only because we are committed and able to fabricate the purposes which organize our behavior that we are conscious of purposes or intend them. And intention involves construction, invention. At this point, I believe, we must recognize Storm's second principle of workmanship and see the verb to purpose as denoting a mode of intellectual activity which is inherently eolithic. Since one cannot accept the conceptual framework of a single, unquestionable goal which is informationally rich enough to discriminate and measure all available choices as being choices among means, it follows that goal-setting is not itself a teleological process that fits the pattern of the theory of design. If it is a teleological process, it is one in a somewhat altered and novel sense. The setting of goals is an eolithic process by nature, and the capacity for setting goals is the capacity uniquely associated with intentionality, with self-consciousness as a phase of experience.

Let us start from the position that at any given time a human being can be described and, indeed, *must* be described, in terms of overt involvements or purposes which, as we say, take up his time; but these purposes are not intrinsically stable and are subject to perturbation. That is the first principle of the eolithic mode.

The second is that the eolithic craftsman is responsive to the suggestions of the heterogeneous and varied nature of his materials when the structure to be fashioned is not a bridge or tower but the individual life, or society's life. The materials in question will consist of everything the craftsman can command as his own, which means his property, that which is proper to him in the old meaning of *propriety* which I would like to revive. Propriety includes not only one's physical possessions in the usual sense but also one's self, one's needs, desires, commitments and talents. Peripheral to oneself as center of this sphere are one's possessions and the resources one can command. These resources of property are not merely instrumental. Because they are heterogeneous and variable, they are not subject to uniform

rules of calculation. It is out of this qualitative diversity that purposes get destabilized, just as Storm's eolithic craftsman finds that, if the spear doesn't work this time, he'll find another use for the stone at which he has been working. Purposes get destabilized and in the end reconstructed. Ends may, of course, come into conflict with each other and that is one way of seeing them destabilized, but, if that conflict gets beyond the stage of a mechanical tug-of-war, it leads to a reassessment of resources, a situation which I would define as a tension between established purposes and the collectivity of one's resources. A purer case arises when there are no conflicting well-defined goals. Storm's *man* was just wandering among the stonefields, well-fed and content, and, if you had asked him what he was up to at the moment, he would have said, "Oh, nothing much." But then he saw the odd-shaped stone and it became the very model of what would someday be called the spearhead.

On the eve of such a daring innovation, man has, I think, always a moment of nervousness about the whole enterprise because it occurs to him that it might be successful. Perhaps he has a momentary daydream about impaling the bison with this new device, as the pygmies impale the elephant, and he wonders whether perhaps he isn't getting too big for his boots. In fact, such an invention will not be a mere means because it will affect the whole quality and organization of his life quite irrevocably. Is he quite sure that he wants to go that way? And, if our ancestors who invented the wheel or the smelter had foreseen us, perhaps they would have shied away from the enterprise or at least thought twice about it. That is one side of the tension between existing goals and available resources but, when we home in on the more typically human resources that we command, there is another side. A part of what it means to say that our resources are heterogeneous and varied is that they do not all fit equally well into a given rationalized pattern of goals. Some of them go unused and underdeveloped or undeveloped. The human clay out of which we fashion our lives is sometimes resistant to the particular fashioning and suggests instead a different goal which it might more readily serve. Not only the odd-shaped stone but the odd-shaped impulse may

summon up the customary action for review and suggest its redefinition.

What was the first impulse, the first time, that led to the first act of hospitality? Or the first refusal of the young or perhaps not-so-young priest to make the human sacrifice? When did that first happen? What was it that moved the elderly lady *not* to get up one day on the bus in Montgomery? Where does the novelty come from that now and then intrudes itself into a standard situation and in the end transforms it into the beginning of a new pattern of work or conduct? Sometimes it might be ennui, sometimes it might be the perception of closure in the system of your activities which you have come to realize will not reach beyond a certain domain; you are interested then in something which you perceive as beyond that domain. Symmetry is a potent destabilizer on occasion. It is part of our responsiveness to each other as is the personal authority of those who impress us with skill or assurance or power. Conscience, the internalized voice of authority, may give us pause as may the authority of tradition. Whatever the source, it can be characterized as arising from within the collectivity of our resources, but all of this is only the opening phase. What now comes along is the kind of problem-solving which is different from scientific problem-solving, whether in the theoretical or any other related domain of science. I could call it ethical problem-solving if the word were taken broadly enough to include all redefinition of ends, whether or not they were conspicuously connected with what we would ordinarily call moral issues.

Since alternatives now are not viewed in merely instrumental terms, they are not commensurable with respect to their efficiency in terms of presiding and unquestioned goals, and that means the choice is not made by what we metaphorically call weighing or deliberating, which means in Latin, "from balancing." The balance implies that you have an operational definition of weight. Aristotle said we only deliberate about means, never about ends, and, in this literal sense of the word "deliberate," he is, I think, correct. But, if he means the reconstruction of ends is not a reflective, judgmental, or cognitive process, he is

clearly wrong. It is a mode of problem-solving and the general form of the problem is this: to what end or system of ends will I commit myself?

My previously accepted goals are destabilized and I am for the moment disengaged, not committed to them. The situation I want to deal with is one in which I know very well the best choice but, for some reason, rebelliously, impulsively, perversely, I do not go along. That fact by itself means I am unwilling to follow my standard, my fixed and stable goal, although at the moment I have no other in which to put my trust. So far, my account is purely factual and descriptive; we simply find ourselves in such situations. But, if I now try to go on and say how, in fact, we behave in such situations, I will have to list alternatives and then commit myself to a philosophical value judgment, a tough nut for philosophers.

One way of acting is to suppress the offending and destabilizing impulses, characterizing them as bad, wicked, and naughty, together with a showing of guilty emotion. Complete suppression is not guaranteed, however. The impulses may pop up again in the forms which Freud has taught us to be aware of. Or we may stay in the quandary, confused and inactive. Or we may yield to the invasive impulse and break with the past recklessly, risking later regret. Whatever I do, there is an alternative, qualitatively distinct from the others because it is what I *ought* to do. This is a funny kind of "ought," a philosophical ought, if you wish.

At any rate, let me describe it schematically. It is a process of problem-solving in which I go through several phases which are conceptually distinct; to go through that process is what I ought to do.

In the first phase, I can shift back and forth between the formerly dominant involvement and the habitual standard of evaluation which it carries with it, on the one hand, and the newly suggested alternative, on the other; and at each shift I can both criticize and modify the definition, the description of each alternative, so that I am in effect scanning an increasingly wide range of potential courses of action around each of the original poles. A part of this process is that I look farther than

I have before at various factual questions which now become relevant. The new and deviant interest may be superficial and its virtual abandonment without significance. Or I may find in defending the new interest that it plausibly represents some previously unnoticed capacity of talent which has been excluded or undervalued in the dominant economy of my life. I might seriously think of doing something which, at one time previously and according to my still dominant values, I would regard as cowardly, for example. But in a new light it may appear as courageous. Or the opposite.

I may discover inconsistency in the rationalization of the dominant economy or of the proposed departure from it. I may find inconsistency with other interests not directly involved in the original definition of the issue, and so on. The essential point is that, as each originally conflicting viewpoint reasserts itself, I may have to modify the future course of action it proposes, to meet difficulties and objections that have been raised against it. The process is what the lawyers call an adversary proceeding. If it develops well, it does so because each alternative gets progressively modified until, at some point, they overlap, they coincide. This coincidence now defines a solution to the original problem and constitutes what can properly be called a rational choice of ends. Interests or commitments or desires which initially stood in conflict, old and settled versus new and raw, have now been progressively redefined until as redefined they no longer conflict but are synthesized as a single course of action. And this course of action may resemble the one or the other original course more strongly in initial or overt steps to be taken or it may be quite different from either in outer manifestation. Its sanction is that it has been arrived at by the successive application of relatively impartial, although seldom infallible, tests of consistency, of probable fact, of feasibility, of self-knowledge, of authority, and so on.

A friend of mine once gave what I regard as a nice shorthand formula. When in a dilemma, introduce novelty. This is the real point: successful ventures of ethical problem-solving, in the sense of redefinition of ends, are characterized not by instrumental choice in relation to still more ultimate ends but by a

refinement of discrimination, by the invention of previously improbable and thus inaccessible ways of functioning which bring greater order and confidence or competence into our lives. There is nothing arbitrary or subjective about the pattern of such problem-solving. It begins with a situation in which we are, in fact, estranged or alienated from the full power of previous commitments and ends with a situation in which we will, in fact, commit ourselves to action, newly defined, although never quite without a sense of strangeness, discontinuity, and residual anxiety.

What I am trying to get at is a mode of the human capacity which Dr. Bar-Hillel noted in discussing the superiority of the human being as the theorizer. This superiority makes it extremely plausible that machines in their interaction with us should be used in a way instrumental to theorizing rather than as a substitute for it, although the theory of theorizing may very well lead us to fascinating machine experiments. But I would add to Bar-Hillel's emphasis on man as theorizer another and, I think, related emphasis. Man is also uniquely constituted to be a setter of goals—although we have very old traditions which enable us to evade facing this. The modern form in which this emphasis has been stated most acutely, too acutely to be digestible, is that of contemporary existentialism. According to Mr. Sartre, at any particular moment you are making a choice of being what you are and consciousness is choice. Although one can understand the nature of that communication, as a sober philosophical statement it seems to me quite outrageous.

The process of choice itself is not something which happens as though in the blink of an eye—the way Sartre seems to see it. The process of choice is a rational process, if by rational you refer to something that shows strong, essential analogies with other forms of problem-solving, other forms of intellectual activity, the use of similar schemata. Choice then clearly is a rational activity and we cannot say, "I chose to do this" unless we have, in fact, *constructed* the end which we then say we have chosen. The sense of ownership of a purpose—"It's mine because I built it"—is, I think, one way of getting at the mystery of the "philosophical ought." I have committed myself to a goal

in a very intelligible way: I built it. Just as you commit yourself to a house when you build one for yourself. If we can get away from thinking of choice as choice among antecedently *given* alternatives and think of choice as a constructive process, then I think we will be at the beginning of some wisdom about the whole discussion of purpose and the whole situation in which we find ourselves, in which means are so often the center of our interests, and ends are so fugitive in our discussion as objects of serious consideration. Then we will perhaps be on the way to making the transition which I, for one, think we are deeply committed to: in such a field as cybernetics we should not only be concerned with something called science, but also concerned with the setting of goals and, in particular, the setting of the goals which we need to set here and now.

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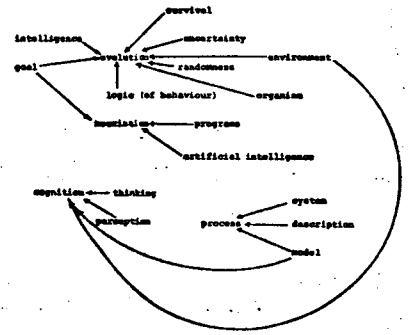
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PROCESS

The changes which take place within the system. Ordinarily the boundaries of the system are defined and its dimensions of description chosen so as to more nearly approximate orthogonal components (degrees of freedom). Changes on these dimensions then describe the process, but such a model is always less than accurate and complete.

[L.F.]



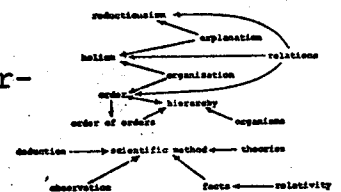
CONTROL

The ability to present inputs to some process/machine such that only desired outputs are observed. [G.K.]

HIERARCHY

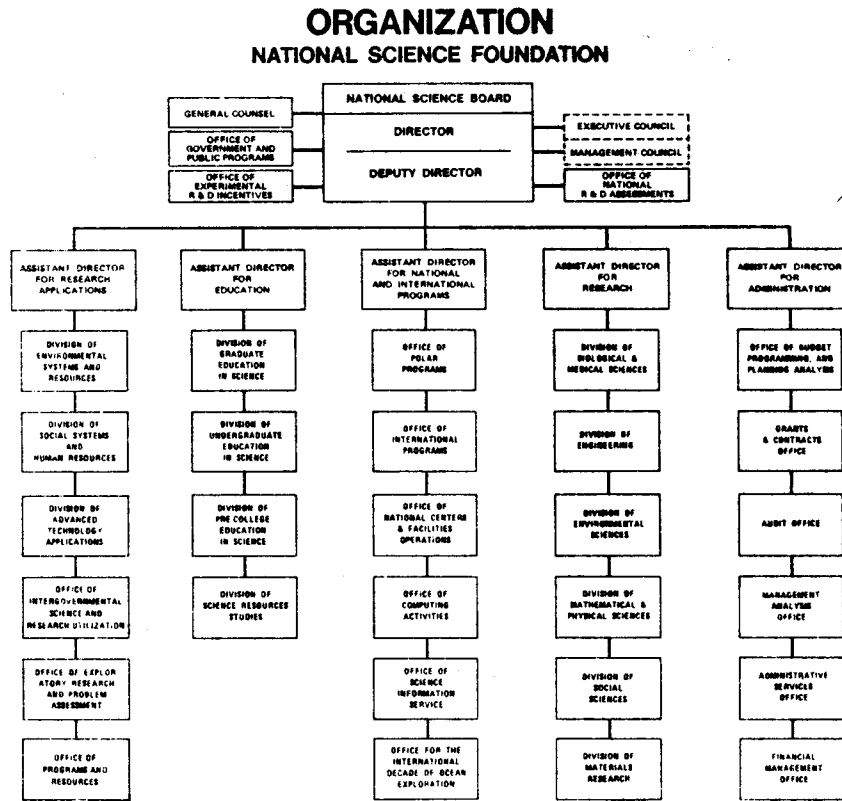
A hierarchy consists of an "order of orders," as it involves a ranking of pre-existing orders into some structure. In nature, hierarchies abound. Cells are organized into organs which in turn constitute organisms, the organization of which forms a population. In the physical world, elementary particles (of which more elementary "elementary particles" are constantly being found), order to form atoms whose organization in turn constitutes molecules, and so on to the galaxies.

The fundamentality of the concept of order, which leads to the formation of hierarchies, may be extremely important in that it underlies both biology and physics, allowing the relations between the fields to be perceived. Cyberneticians may find examination or awareness of hierarchical structure useful in that such consideration encourages one to note the nature of the orderings, the relationships between levels, as well as the orderings within any given level. [S.H.]



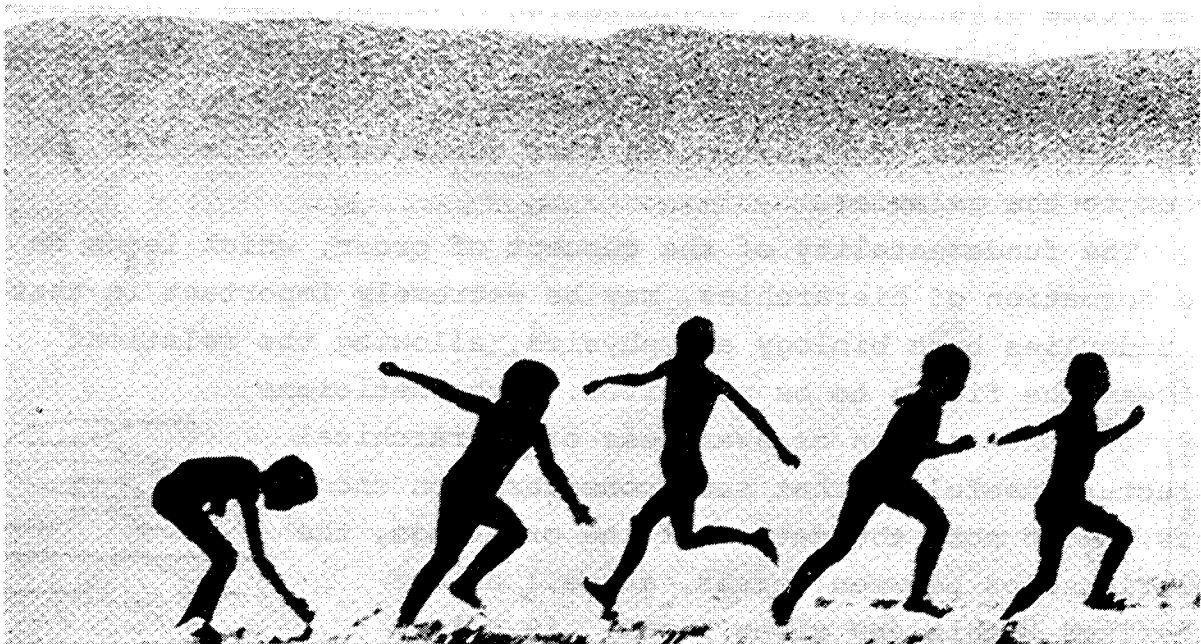
HIERARCHY

A form of organization resembling a pyramid. Each level is subordinate to the one above it. [S.U.]



HETERARCHY

A form of organization resembling a network or fishnet. Authority is determined by knowledge and function. [S.U.]



A HETERARCHY OF VALUES DETERMINED BY THE TOPOLOGY OF NERVOUS NETS

WARREN S. MCCULLOCH

Because of the dromic character of purposive activities, the closed circuits sustaining them and their interaction can be treated topologically. It is found that to the value anomaly, when *A* is preferred to *B*, *B* to *C*, but *C* to *A*, there corresponds a diadrome, or circularity in the net which is not the path of any drome and which cannot be mapped without a diallel on a surface sufficient to map the dromes. Thus the apparent inconsistency of preference is shown to indicate consistency of an order too high to permit construction of a scale of values, but submitting to finite topological analysis based on the finite number of nervous cells and their possible connections.

The term "reflex" originally meant a disturbance which, initiated by an extra-nervous organ, returned by a nervous path to that same organ. The law of Bell-Magendie, that impulses enter the nervous system by dorsal and emerge by ventral roots, specified the direction of conduction of these circular disturbances. Circular propagation in this direction was called dromic, in the opposite, antidromic. With the possible exception of phenomena comparable to that described by Porter, no response of any effector has ever indicated an antidromic reflex although conduction in the reverse direction has been demonstrated in both the dorsal and ventral roots.

The term "reflex" has latterly been used of any activity in which one pylon was extra-neural regardless of whether or not it was somatic. Lack of anatomic continuity about the external pylon let aftercomers ignore the essential circularity. All reflexes are dromes, activities of feed-back mechanisms, and consequently their function includes all purposive activity.

In addition to reflexes, there exist within the central nervous system reverberating circuits which for brevity are called endromes. Endromes are not in general so related to reflexes as to be uniquely syndromic or antidromic. Their temporal importance in determining the formal properties of nervous activity has been previously discussed (McCulloch and Pitts, 1943). Concerning endromes as well as reflexes, it is well to recall that a given feed-back circuit may be regenerative for one temporal combination of excitations and degenerative for another.



Obviously any number of parallel circuits may be utilized by a single drome and these circuits may divide and unite without the disturbance ceasing to be dromic. Anatomically, the nervous components of their paths consist of neurons so related that the disturbance passes from neuron to neuron over a synapse from the axonal terminations of one neuron to the cell body of the next. With questionable propriety, the terms dromic and antidromic have been applied to passage across a synapse in this and the reverse direction respectively. The impropriety arises from the interrelation of two or more dromes. Conduction in each is dromic, in both, syndromic, but from one to the other, whether it facilitates or inhibits, it is properly neither syn- nor anti-, but heterodromic. Without heterodromic activity reflexes would occur independently of one another. It is therefore to these that one must look for sub-, super-, or co-ordination of reflexes; and, therefore, for behavior, including all relevant aspects of purposive activity.

For the following discussion, it is unnecessary to distinguish homeostatic from appetitive activity. One may even ignore the asymmetry of adversion and aversion, but it is essential to remember that the circuit, whether regenerative or degenerative, must be closed for its activity to be purposive. Thus, in its simplest form, any drome maps in a plane as in Figure 1.

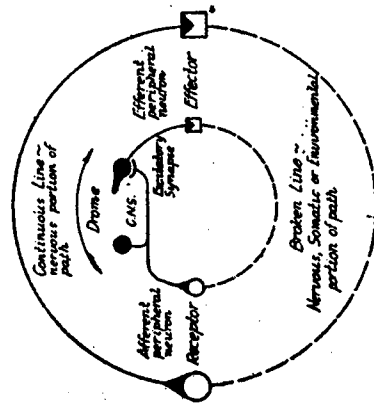


FIGURE 1

For a theory of valuation to be scientific, it must rest on observation and lead to prediction. Empirically, one must observe choice. Choice implies that two or more potential acts are incompatible. The observation requires some overt act with inhibition of incompatibles.

There must then be two complete circuits and an inhibitory, heterodromic influence from the one (for an overt act) to the other (for an incompatible act). The circuit maps as indicated in Figure 2.

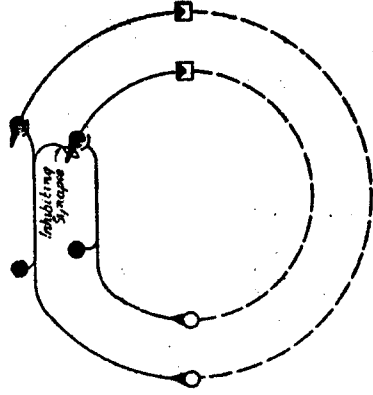


FIGURE 2

This scheme can be elaborated for any number of circuits arranged in order of dominance of dromes of each over all within it as in Figure 3.

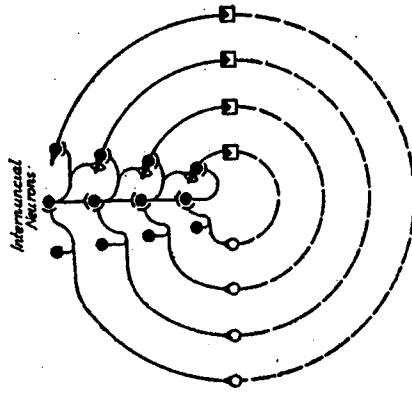


FIGURE 3

This figure in which heterodromic paths between parallel circuits require no diallels, or "crossovers", demonstrates that any hierarchy of values indicated by choice requires only a nervous net that maps on a plane. The term "hierarchy" in this context has two implications; each drome determines some aim, goal or end, and no two dromes determine exactly the same end. Because organisms live for these

ends, they are appreciated by them neither as means to other ends nor as conduct forced upon them, but rather as having that kind of power or importance which culminated in the notion of the sacred or holy—this is the religious implication of "hierarchy" as applied to values. The second implication, arising from the sacerdotal structure of the church, is that the many ends are ordered by the right of each to inhibit all inferiors. The number of ends, although large, is finite. The order is such that there is some end preferred to all others, and another such that all are preferred to it, and that of any three if a first is preferred to a second and a second to a third, then the first is preferred to the third. Logically, therefore, to assert a hierarchy of values is to assert that values are magnitudes of some one kind. Summarily, if values were magnitudes of any one kind, the irreducible nervous net would map (without diallels) on a plane.

Ever since theories of value deserted the inadequate, rational or proportional, Platonic approach, they have been notably inferior to intuition in inferring the outcome of an untried choice. Examination of the theories uncovers that values have been subsumed to be magnitudes of some one kind. Experimental aesthetics, economics, and conditioned reflexology have produced instances in which, under constant condition, preference was circular. One such instance would have been sufficient basis for categorical denial of the subsumption that values were magnitudes of any one kind. Thus, for values there can be no common scale.

Consider the case of three choices, *A* or *B*, *B* or *C*, and *A* or *C* in which *A* is preferred to *B*, *B* to *C*, and *C* to *A*. The irreducible nervous net is shown in Figure 4.

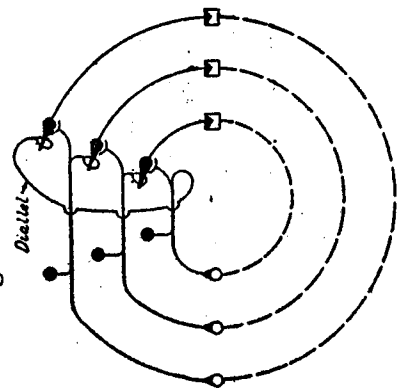


FIGURE 4

It requires one diallel in the plane. Its three heterodromic branches link the dromes so as to form a circle in the net which is distinguished from an endrome in that it is not the circuit of any drome but transverse to all dromes, i.e., diadromic. The simplest surface on which this net maps topologically (without a diallel) is a torus. Circularities in preference instead of indicating inconsistencies, actually demonstrate consistency of a higher order than had been dreamed of in our philosophy. An organism possessed of this nervous system—six neurons—is sufficiently endowed to be unpredictable from any theory founded on a scale of values. It has a heterarchy of values, and is thus interconnectively too rich to submit to a *summum bonum*.

Topological analysis of the intricacies of values implied by interlocking circularities of preference or of the equivalence of diallels in circuits to the surface on which the nets map without diallels are alike beyond the scope of the present article. Yet, it seems pertinent to note that, however complicated, the ultimate solution is finite even in man. The number of neurons in the brain is some 10^{10} and the number of irreducible diallels is presumably smaller. Let us suppose the worst of possible conditions. In the case of a circular preference, for 3 items, 1 diallel mediates 1 diadrome; for 4 items, 3 diallels mediate 4 diadromes; for 5 items, 6 diallels mediate 7 diadromes; for 6 items, 10 diallels mediate 15 diadromes; for 7 items, 15 diallels mediate 31 diadromes; and so on. Thus, from simple topological considerations, it is clear that if d be the number of diallels and D , the number of diadromes, and if the diallels be arranged in such a manner as to produce the maximum possible number of diadromes, then $D = 2 - 1/2^{d-1} + 2^{d-2} - 1$. For an astronomically large number of diallels $D \rightarrow 2^{d-1}$, but d is less than 10^{10} . Therefore, D , is less than 10^{10000} .

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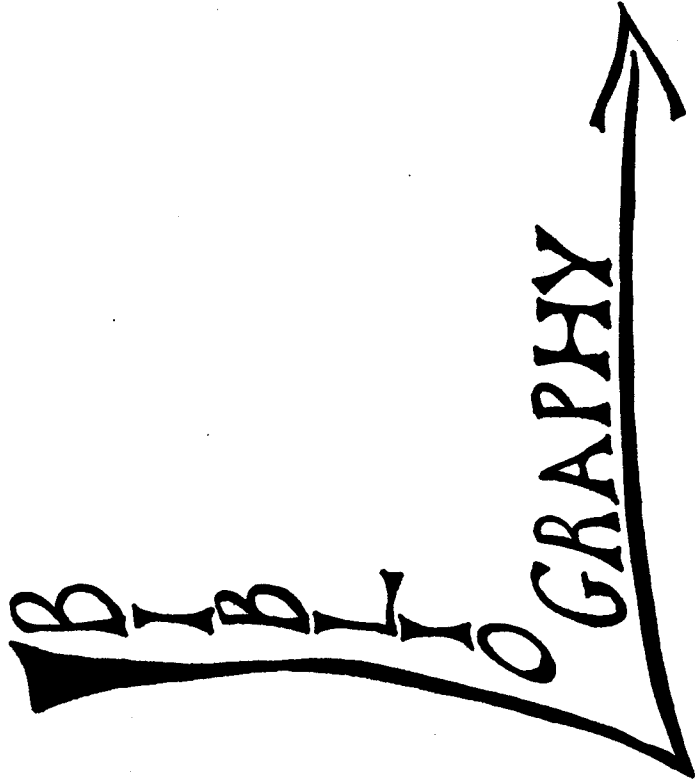
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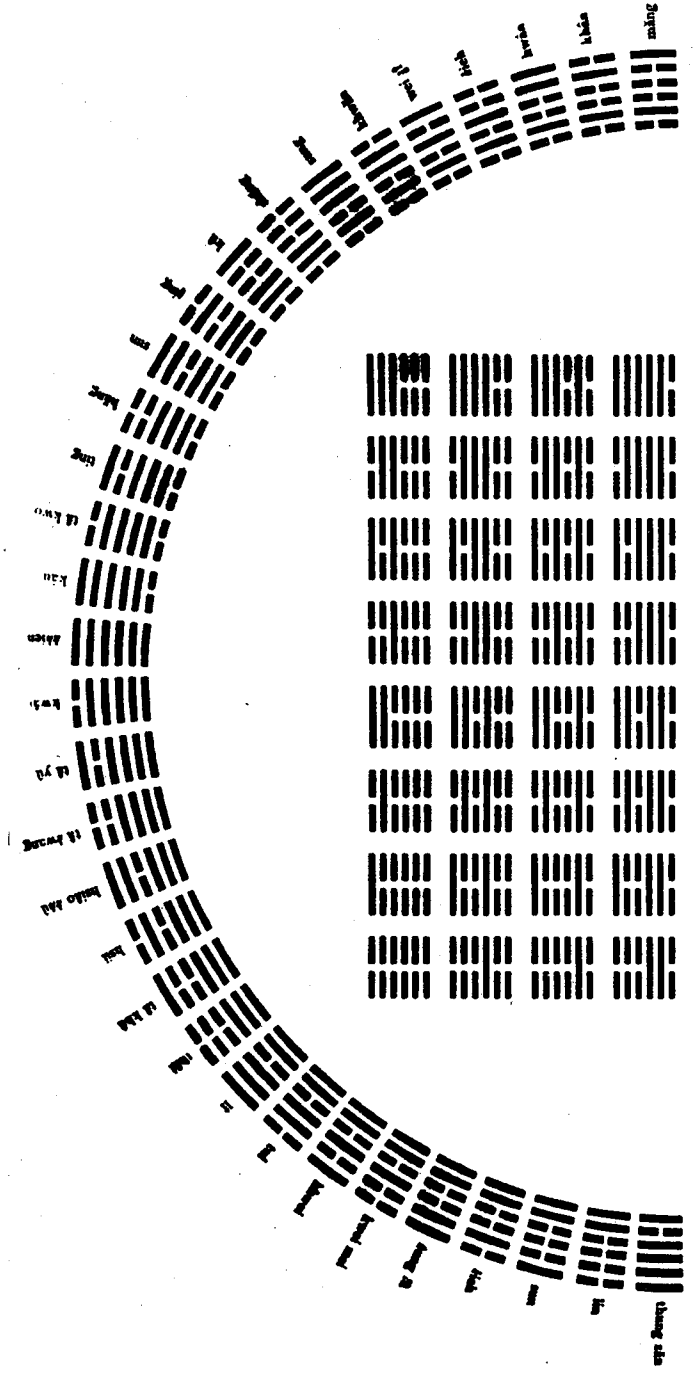
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HOLISM

Sometimes termed "anti-reductionism," holism contends that merely looking at a collection of parts and their interactions is not sufficient; the whole will not be understood if only a part is examined. The whole, in fact, is considered to encompass more than the sum of its parts--an "organizing principle" may sometimes be invoked. Holism seems a more useful attitude in connection with cybernetic thought.

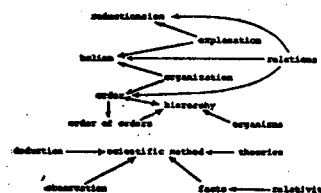
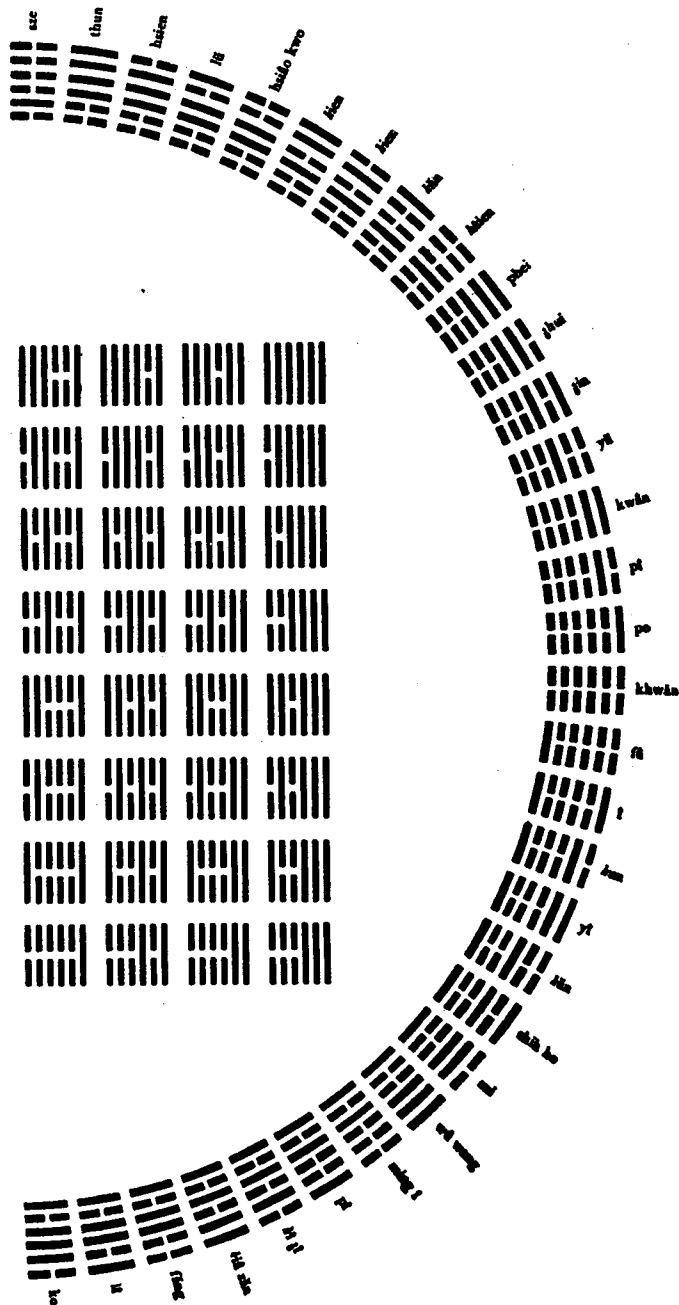
Holism too may have problems, based on its preoccupation with overall structural organization and form, if these are considered to the exclusion of analysis of the parts.

"the perception of the future and the future of perception"

"the politics of learning and the learning of politics"

"the phrasing of profundities and the profundity of phrasing"

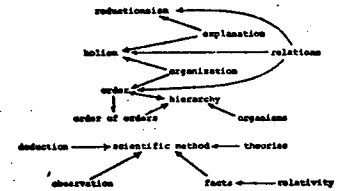
[S.H.]



REDUCTIONISM

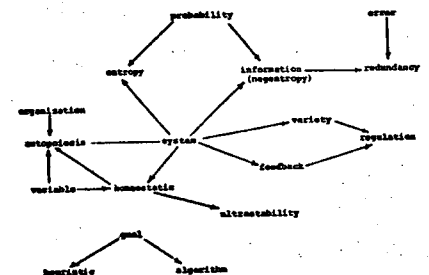
Idea that analysis of a phenomenon is best accomplished by continually breaking it down or "reducing" it to lower levels, apparently under the assumption that once the lower levels are comprehended, resynthesis can occur and the higher levels will fall into place upon a solid foundation. Thus phenomena which appear to be peculiarly biological may be analyzed in chemical terms, which themselves are based upon physical principles, etc.

I see two main problems inherent in such an analytic method. One involves the fact that breakdown may proceed indefinitely since a yet lower level will always exist, so resynthesis of levels may never be attempted, and it is doubtful that explanation of the phenomenon will be achieved (of course, one's definition of "explanation" is important here). Second, I object to the reductionist's assumption that the relationships between levels, relationships often ignored or destroyed by analytic methods, are not significant considerations. From my limited experience with cybernetic theories, I have become aware of the importance of looking at interconnections and relationships as a method of understanding seemingly unrelated or contradictory situations. Reductionistic analysis does not seem useful in such a context. [S.H.]



VARIETY

In cybernetics, the total number of possible states of a system, or of an element of a system. The Law of Requisite Variety (Ashby's Law) expresses the fact that 'only variety can absorb variety': a regulating system must be able to generate as many states as the system regulated. [S.B.]



Pask

8 Industrial Cybernetics

THE chairman said '... our company is not its wealth, nor its factories, gentlemen, the old lot or the new 'uns' (he adjusted his tie), 'these' (he glared at the reading desk) 'are mere trappings. Our company's a living thing, gentlemen. It grows.' He sat down, flushed and wheezing. The executives clapped, excusing the diction of a self-made man. They reckoned him old fashioned, a bit poetic in his dotage. But, in fact, the self-made man had told a revolutionary truth, as he had told it before, badly, and without the faintest idea what to do about it. Had they listened, and understood, it would have shaken them to the bottom of their incentive schemes and order schedules.

Its Impact

Stafford Beer, ⁸⁶, ⁸⁷, ⁸⁸, ⁸⁹, has stressed this essentially cybernetic concept; that industry is an organism; in a usefully expanded, cogent and decisive fashion. He means us to take the statement literally, not as an after-dinner analogy. A particular industry has the same trouble in preserving its identity and surviving amidst the flux of its environment as any animal. It either evolves or decays.

Having discussed the properties of organisms we know what to expect, and it will be more profitable to dwell upon the impact of Stafford Beer's idea. To the accountant, for example, it means that his model of the company, his precious double-entry stuff, is but a tiny facet of the truth. Something like an increase in profit is no measure for the health of an organism (he realized this before, of course, and thought it odd - but did not mention the matter). Nor is there any unique measure of growth, for it is the growth of an organism, and that upsets the assumption that an *optimum* condition can be achieved by some manipulation of sub-optima such as 'maximize turnover', 'maximize productivity' and others. To the operational research people it means that their models need rethinking. True, at a reflex level, simple feedbacks to simple operations, there is little change. But the organism,

industry, has a vast redundancy of mechanism and the structural certainty has gone. To the manager it means that management cannot be efficient as well as authoritarian. It is an issue of persuasion, compromise and catalysis. He always knew that men and machines were cursed. Cybernetics offers a scientific approach to the cussedness of organisms, suggests how their behaviours can be catalysed and the mystique and rule of thumb banished.

What about the engineer? Just now there is plenty of conventional automation, but in a few years he will find this organism disconcerting. After all, engineers are accustomed to computers that sit in large, metal boxes, have sensory elements in a process and effectors that they control. Amongst the next batch of computers there will be some that are chunks of polymer, made to exist inside reaction vessels, and catalyse reactions with which they are in contact. The sensing and computing will not be distinct and maybe the effectors will also form part of the same thing.*

The Structure of Industry

We have argued the virtues of partitioning, hierarchical structure and division of labour sufficiently to take their existence for granted and only discuss how they should be brought about. Now, in an organism an hierarchy will not be described by an organization chart (at any rate, not of the currently drawn, inflexible kind, where *A* is responsible to *B* and *C* refers the matter to *D*, taking action if *E* sends a copy to *F*). From the recent literature it looks as though the men who draw these charts (and, heaven forbid, even put them into practice) would agree. They have reached the nasty-tasting conclusion that not every individual does fit into a niche. Indeed, an organization composed of individuals that do, is formally moribund. It is comforting to realize that the glorified, stratified, feudalized empires of industry work because the chart is disobeyed, that without the grace of local imperfection the whole structure would be unstable as a house of

*A further possibility, amusing in its own way, is an animal computer, which could be valuable for slow speed, essentially parallel data processing. Skinner once used pretrained pigeons⁹⁰ as pattern recognizing automata in a guidance mechanism, and they have also been used in industry. Working along somewhat different lines Beer and I have experimented with responsive unicellulars as basic computing elements which are automatically reproducing and available in quantity.

cards (or a brain without its reticular formation). For stability by design rather than by default, the people who get things done must be allowed to run from niche to niche and communicate with their colleagues in real words, not duplicated advice notes. I will go even further and say, in an efficient biological hierarchy, each member must have the possibility, however small, of inverting the structure without leaving his niche to do so. I do not mean 'the office boy can rise to be manager'. I mean, 'in some unspecified conditions the office boy can take the managerial decisions' - when that would be a fitting adaptation.

Now it is easy to cite some kinds of process where my proposal is sheer nonsense. Mass production and routine data processing, for example, are most efficient when rigidly organized. Very well, then, have automata to do the stupid jobs that are entailed. A robot is more reliable than a man and, by definition of the work schedule, readily constructed. Any process best represented by a production chart can be *completely* automated. There are even robots for assembly jobs which used to be an exception to this rule.

The point was made most elegantly by Norbert Wiener¹¹ in *The Human Use of Human Beings*. Define 'man' functionally (the alternative, as a 'bag of chemicals', I find unacceptable), and he is at least an adaptive decision maker. To use him where neither choice nor adaptation are called for is not a human use. Conversely, automation never put a man (in this functional sense) out of work. If it does stop him playing the robot so much the better, for too much imitation makes us robot like. In particular, it is both distasteful and dangerous to regard man as a cheap substitute for an automaton - dangerous because there is a vicious circle and ultimately man will lose.

There still remains the question; who will pay the men who used to play at robots? Overall, two possibilities occur. First, the added efficiency of the process (demand for its product assumed) makes it possible to sustain these people in more human pursuits (there is some quantitative evidence in favour of this possibility). Otherwise rethink the concept of efficiency, and organize the process so that it is most efficient, *given the maximum utilization of human beings*. This, I agree, does not necessarily entail maximum short-term productivity, but I assume a certain social responsibility on the part of management.

Decision Making

Who or what can take managerial decisions? It is perfectly obvious that *managers* are unable to deal with the problems of modern industry. If you rig up a computer to give a manager all the information he needs about the state of the factory, it is necessary to include about a day's lag - otherwise he decides in a frenzy of misguided zeal that leaves the place in a shambles. He is not stupid. On the contrary, he is a highly trained, intelligent man. His decision capacity is simply overloaded. But, if you cannot tolerate the lag, and, nowadays, we cannot, the manager must be replaced.

An obvious solution lies in 'Two heads are better than one'. But, whilst true in a way, this adage was always defective. You cannot add wisdom by adding heads on a committee. That is the fallacy of team research (you cannot buy a research team. With luck it grows, making its own common language and thriving on personal interplay which has nothing to do with research). I suspect it is also fallacy of managerial groups.

How, then, can we combine the brains in the available heads? First, can we do it? Yes. There are existence proofs. Research teams that *do* work. Often enough husband and wife share a common language and make jointly wise decisions. I have seen the process also in groups of actors at club theatres, amongst jazz musicians and in football teams. These are stable communities that make genuine group decisions. Of course, they play at decision making all day long, and respond concertedly when a familiar situation appears in the real world. The *rapport* between horse and rider is not dissimilar; they decide together about the terrain. But, I have never seen this efficient organization in industry. The atmosphere is too earnest (maybe it must be). There is something that makes us approach the paper mill with a ponderous solemnity alien to a honky tonk. For all that, it may not be impossible to recapture some of the requisite abandon, by having managers play together via an adaptive machine. By analogy, the managers ride the same horse and the terrain is replaced by an image of their factory. At any rate, some serious work is in progress.

A second, closely related solution to the problem occurs when the industry is, in any case, biologically organized. Then there is redundancy of potential command. The whole system is inter-

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- acting very closely indeed with the little microcosm of managers. Now, in this situation, we can never say where a decision is made, or that one bit of the whole melange is a control mechanism. The best we can do is to point out a badly distinguished managerial group and say that decisive activity is probably dense in this region.
- Suppose that for some reason (size, speed, or elaboration) this knot of dense decision making cannot be a group of men but must be an evolutionary network. We have dwelt enough upon its possible form. Now look at the much more important question; given an evolutionary network, what would induce you to trust it as a decision maker? Not its cleverness, for it can be as clever as we can afford. I believe our confidence can only stem from our experience in conversation with it - and I propose two different tests. In the first, acting as a potential employee I should ask 'Can I owe allegiance to this network?', accepting it only if the answer is in the affirmative. Now, for my own part, I cannot owe allegiance to a box of tricks; to a programme - regardless of whether it is embodied in a computer or worked out in stereotype by a human board. This attitude 'allegiance' is a relation between persons, and the object of it must be an individual, or a group of people with its own personality. I think I should credit the network with this quality only in so far as it seemed to understand, even if it rejected, my contribution to the decisions in hand.
- Next, acting as its potential employer, I should interview the network, taking its previous experience and behaviour into account. But, more important than this is the question of whether, in some sense, the network is like my image of myself being a manager (this part of the interview is difficult, for there is no verbal communication - but the essential requirement is that the network be capable of its own kind of discourse beyond the bounds of management). On this test, I shall accept the network if and only if it sometimes laughs outright. Which, in conclusion, is not impossible.
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