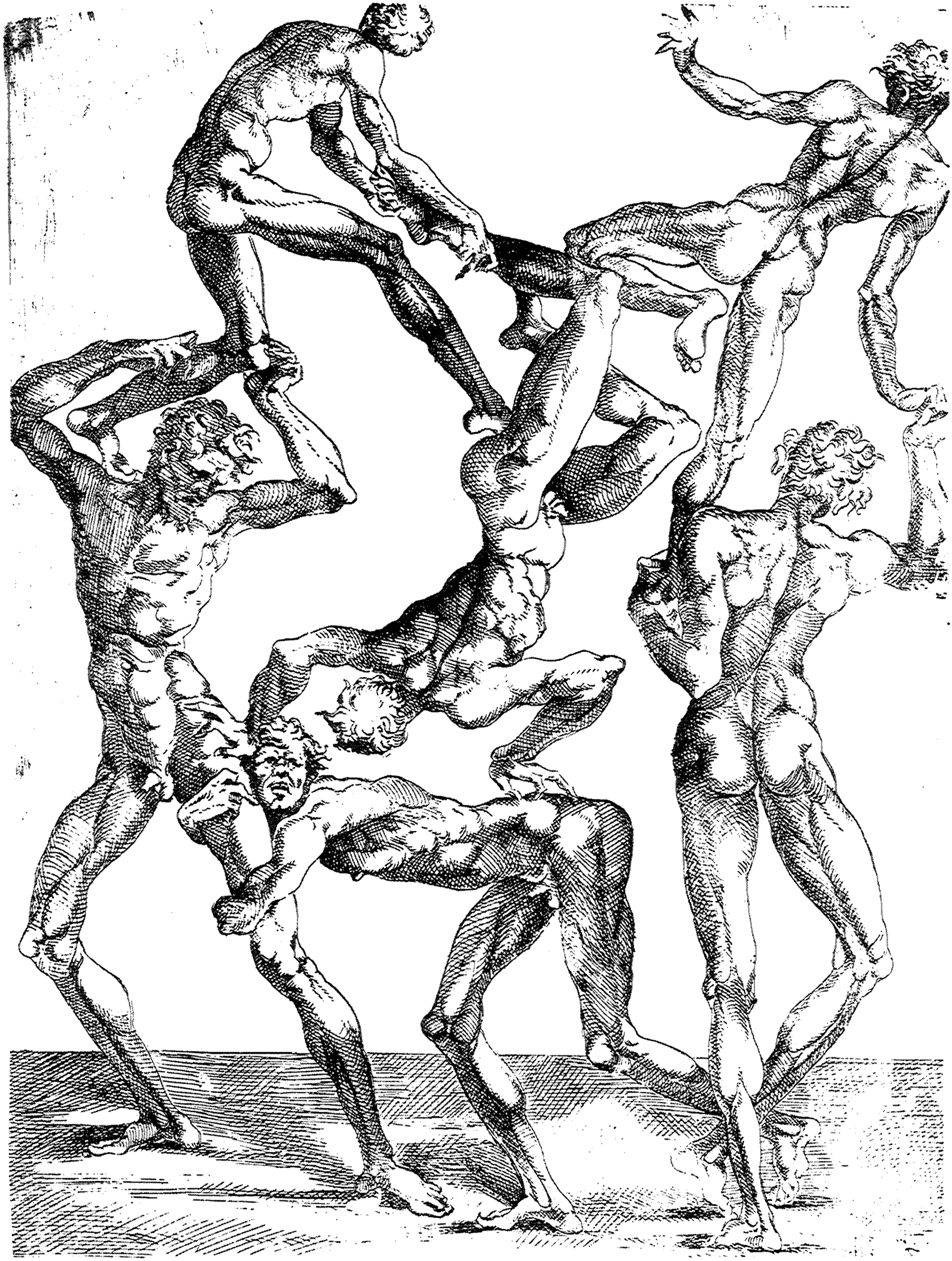


Richard Herbert Howe: Theses on Literature

The literary work is grasped in its richness first as adequate instrument for solving a problem posed as adequate. Criticism must pose that problem as inadequate if it is to determine the dynamics of that failure.

Nexus of inadequacies --that's language!

The literary work is two: translation and critique. Subject of the translation, that is the language before the work. Object of the critique, that is the work after the language.

In this chaste polarity language flirts with the demon of truth.

Any theory of literature must take into its account this: every living system writes the history of its universe in the script of autobiography. --That is no metaphor: never itself language is suicide.

Living, a system reflects into actuality a course of variation predicated by it of its universe. This reflection is potentially portrayal. It would say: the course of variation of that universe conforms to the predication of this living system, or: in that universe this system can live.

Reflection of one autobiography within another is biography. That reflection may be reciprocal: reflection mediate self-reflection.

Autobiography:vocabulary; biography:grammar;
--language immediately!

Self-reflection immediately-- not: actualization of the potential, rather: actual potentiality and potent actuality --refraction.

L I T E R A T U R E

The first in its richness grasped literary work it is that as adequate for an as adequate problem posed instrument would solve.

Nexus of inadequacies --that's language!

Two as translation as critique the literary work of translation subject that before the work language of critique that after the language work.

Truth's within but demon chaste this language flirts!

Of literature any theory into its account must this take: every system living in the script of autobiography the history of its universe writes no metaphor that never itself suicide language is.

An a course of variation of its universe predicated system living into actuality potentially portraying the of that universe to this system predicated course of variation reflects conforming and would say in that this system living can.

Is of one within another biography autobiography may be reflection self-reflection mediate.

Autobiography:vocabulary; biography:grammar;
--language immediately!

Self-refraction, that is revelation. What is revealed is what is refracted and that it is refracted. So then portrayal: portrayed is what is revealed and that it is reflected.

A theory of language not portraying revelation is none.

The word is the object lens of revelation: it projects as image the constellation of language into the camera obscura of mind. The law of a word is the law of its projection, the law of its perspective. The word is the vanishing point of linguistic perspective.

Mind is a focus of reflection. This reflection is elliptical and this ellipse has yet another focus: other minds. Mind is a social, not a biological phenomenon.

Whether reflector and reflection will attain the truth of their relation, that is Marx' question. This is possible, that's just the nature of things. That this happen, artifice is necessary for that.

The story is the primordial form of portrayal. The narrative portrayal of the world is myth. In myth man portrays himself severed from nature. Myth then is the first ontology. It says: what is is Subject or Object. There what is ambiguous --Subject and Object-- that is the demon. What there is neither ---Subject nor Object-- that is the word: the name of the demon writ on the night sky of language.

What is is Subject or Object. To that, Aristotle --the genius: conquerer of the demon-- adds: not both, and: nothing else.

Self-reflection not of the potential actualization but potentially actual actuality potent immediately refraction self-refraction revelation.

Is a of not portraying revelation language theory neither.

Of revelation object lens the word into mind as image vanishing perspective linguistic constellation language point projects.

Mind as of reflection focus but other minds other focii elliptical not biological phenomenon social this ellipse yet is.

Whether of their relation truth reflector and reflection attain that just the nature of things but for artifice the this of necessary invert!

Narrative portrayal of the world is myth in myth from nature severed man portrays. Then is myth the first ontology says yet is or Subject though its Object be. There ambiguous Subject Object and there neither demon word on night sky language writ the name.

Is is Subject or Object is is to wot wit Aristotle both not and else nothing adds.

Thematic substances of myth: universal Subject and universal Object.

Object:things; Subject:relations. --Thus Logic. A subject enters into this logic only to bring to its theorems the judgement of its axioms: his revelation.

With secularization of nature through science the demon retreats into the subjective. The banishment of the demon from the sciences of Subject --economics, politics, history, linguistics-- has entailed forfeit of the highest ransom: banished, demonic revelation reclaims its right in the moral ambiguity of these "human" sciences.

The name of the demon is Homunculus, in recent years his abode genetics, his signature communication. His title reads from a genetic code whose secret key (mind) is to reveal the invisible hand (society) of the specifically human (language). Writ large in the hieroglyphs of race and culture and destiny, such is the myth of the twentieth century.

To root in nature the truly human --every clover of such fallow intellect yields rich ground to the harvest of fascist thought and were it then even true: language is a natural phenomenon species specific to man-- language would itself be then the enemy.

In this apprehension art has arisen and the canons of art become souvenirs of battles lost to this enemy.

The thesis form catches the eye of philosophical idealism. Yet, conquest of the demonic: secularization of mind and society and language can be accomplished only technically, materially, socially. Literary criticism must be aware of that.

Thematic universal Object Subject universal substances of myth.

Object:things; Subject:relations --so logic into but to bring to theorems' judgements' axioms enters a subject.

With secularization of nature the demon through science into the subjective retreats. Of the demon from the subject sciences banishment but forfeit of the highest ransom: revelation its right demonic of these sciences human ethical ambiguity entails.

Homunculus is the demon name, genetics home, communications mark and secret key code genetic read invisible hand writ large hieroglyphs race destiny and culture the myth of the twentieth century.

The truly human in every clover yields rich such fallow harvest fascist thought to root and were it then even language true would then itself the enemy language be.

This inapprehension arisen has art and its canons souvenirs of to this enemy battles lost become.

The thesis form the idealism eye catches but conquest of the demonic: secularization of mind and society and language accomplish technical, material, social and literary criticism must be aware of that.

Originality is but a more subtle plagiarism. With the single word: genius, intellect betrays to the demon the possibility of knowledge.

Putrescence is the natural environment of the intellect and the mushroom its emblem. Both flourish on the backs of others. Beyond that, both function to hasten the decay of dead and dying forms. When we are surprised by the wealth and variety of specious intellectual activity, we must consider the wealth and variety of species of mushroom.

We need not a science but a technology of literature.

Originality is but a more subtle plagiarism.

Tomorrow we knew what the words will mean yesterday but yesterday we will have to know what the words meant tomorrow.

Of literature a science not but technology we need.

Richard Herbert Howe

July 1, 1973

Patricia Clough

Cybernetics is popularly known as a sophisticated mechanics. If it continues to gain popularity in this way, it will prove to be a calamity. In that state of affairs, it will take years to rediscover the philosophical implications of cybernetics and the practical application of cybernetics to hermeneutics.

Gotthard Günther explains the hermeneutic approach as one "of understanding what is already known in a merely factual sense." Computer theory and like hardware approaches to knowing are based on what is imitatable. But what is of interest to understanding human behavior is what cannot be imitated, what is not objectively observable and known in a merely factual sense.

Happily this definition of hermeneutics is well suited to what is undertaken here: a reading of Hans Peter Dreitzel's Recent Sociology No. 2, in particular, introduction and chapter 1.

Gordon Pask has commented that "since the early 30's, for example, anthropologists have recognized that societal homeostasis depends upon symbolic regulatory programmes manifested as rituals, conventions and traditions. Likewise, social change is commonly understood in terms of the competitive or co-operative interaction between subsystems characterized by these symbolic structures." If anthropologists have recognized this, certainly sociologists have not. Indeed, I wonder if anthropologists have recognized that compliance to rituals, conventions or traditions is problematic, for indeed, change results from a process of interaction between sub-systems. The static and the changing must be viewed as the dialectical process fundamental to hermeneutics. I might add that the use of goal orientation still clouds the issue.

In retrospect, sociologists seem to have recognized little about human behavior and the nature of interaction. Dreitzel points this out, collecting eight articles concerned with patterns of communicative behavior. These patterns have become part of what in social science is called "ethnomethodology". Ethnomethodology includes an orientation to awareness of the observer in observation. And on some level, ethnomethodology recognizes the requirement fundamental to observation: this human that I observe is like myself. But what then?

There have been those sociologists who rest their philosophical foundation on Husserl, on Schütz, and who call themselves phenomenologists or theorists of knowledge. But with the symbolic interactionists, and now the ethnomethodologists, there are sociologists who are laboring with observing and describing the dialectical process between "logic-in-use" and "reconstructed logic". Thus language becomes one of their primary concerns.

The second of their primary concerns is the dialectical process between "in-order-to" motives and "because of" motives. Thus the relationship between the surface normative structures with which we come to interaction and the deep social ordering structures with which we create or invent is made the problematic issue of sociology.

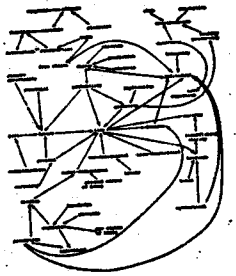
This book, representing the whole field of ethnomethodology, is of great import to social scientists and cyberneticians. Its importance lies in what it has recognized and in its potential. Its potential is directly related to our understanding and applying transcendental classical logic in our study of language and social ordering. As the ethnomethodologists complain of some of their finest rank and file, what they are doing lacks explicit explication. In a way what they can do they cannot yet explain. To make ethnomethodology the equal of what it has already attempted, an "algorithmetization of hermeneutics" is required.

To do what we cannot explain is a political problem. And ethnomethodology has been attacked on political grounds for its lack of historical perspective in observing human interactions. Yet just these attempts to understand what is taken for granted, or known in a merely factual sense, is essentially political behavior.

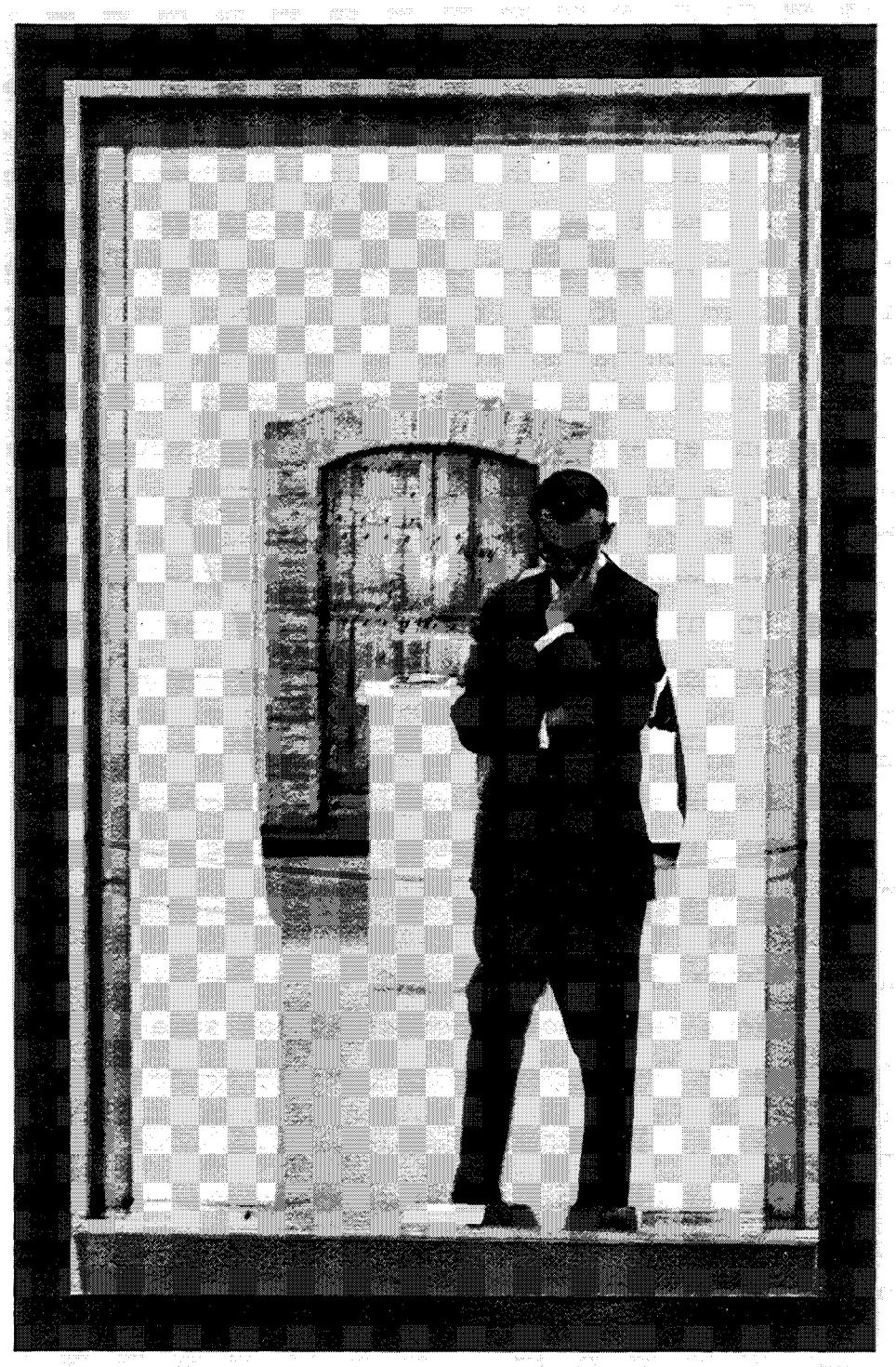
INDIVIDUAL

Individual means literally not able to be divided or fractioned, in the sense of possessing integrity in its literal meaning of integratedness or wholeness. Thus Gustav Jung's equating of what he termed "individuation" with what he called "psychological integration" becomes almost tautologous. We shall not here be concerned with the reductive and quite obvious usage of individual as a distinguishable member of some class, i.e. as a particular embodiment of some set of characteristics or properties. (A fallacy in much of set-theoretic exposition is overlooking the fact that a member of a given set -- an individual in this reduced sense -- is not necssarily exhausted by the set-properties, but may also be a member of one or more distinct sets other than the one under discussion. Thus people are a lot more than, for instance, "consumers.") An INDIVIDUAL in the unreduced and more interesting sense is an essentially cognizing entity -- which is to say one that, without being so programmed by an already manifest cognizing entity, can generate percepts from environmental contacts and classify them. Thus a computer, requiring programming (including meta-programming) from a pre-existing cognizing human entity -- is not an individual in this larger sense.

But in addition to cognizing in this essential and inherent sense, an INDIVIDUAL also DESIRES and hence feels; for no desire is possible without felt emotion or affect of some kind and degree. Hence the notion of INDIVIDUAL is also bound up with that of FUTURE and of TIME, as well as with the notion of free choice and hence the ability to evoke determinations in the face of CHANCE. Who does the determining has the freedom and the consequent expression of individuality. [C.M.]



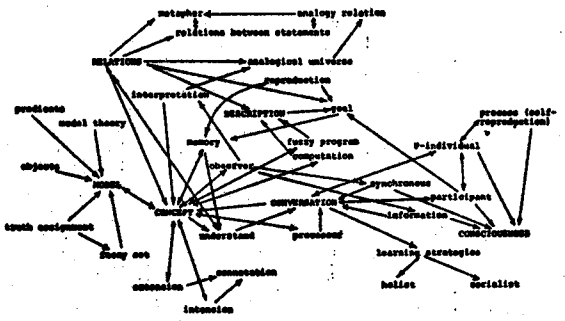
ALL OUR EXPERIENCES PERCEPTUAL, INTELLECTUAL, AND EMOTIONAL, ARE STATES OF OUR NERVOUS ACTIVITY



INDIVIDUAL

Only particular configurations or concepts and memories are stable under execution; these themselves are characterised, in a language, as program-like organisations, called psychological individuals or P Individuals. If compiled and executed in a suitable processor a P-Individual is a participant. The paradigm for a suitable processor (call it an L processor) is a brain, but these constructions are not inevitably tied to biological systems: they are processor-independent; that is, P-Individuals, unless specifically constrained, may be executed in any L processor (biological, mechanical or whatever).

It thus transpires that a concept may be said to belong to at least two types of integral entity; namely to a particular P Individual (labelled A,B,....) or to a particular L Processor; for example, a brain (labelled $\alpha,\beta,.....$). Consequently the statement that a concept i belongs to a participant entails both meanings, with more or less ambiguity and this (irreducible) uncertainty, basic in all studies of cognition, underlies the equivocal status of the term "connotation" as it is commonly employed. It can readily be shown that the observability conditions realising an interpretation such as a) or b) (see concept [G.P.]) involves circumstances (for example, those pertaining in a strict conversation between participants) under which the P-Individuals A and B are distributed between L processors α and β (that is some A programs normally executed in α, are executed in β, and vice versa, for the B programs normally executed in β). Similarily, any attempt to localise the execution of a P-Individual in an L processor (say A in α) results in the coexistence of more than one P-Individual. [G.P.]



Self-Description

ASSIGNMENT FOR CYBERNETICIAN #5

In order that a group of individuals function as a unity there must be sufficient information for recognition of individuals. That is, there must be a context in which each individual is a distinguishable unity with explicit characteristics and properties. There must be the possibility of a non-trivial conversation between any two members of the group. Such a conversation requires that the characteristics that distinguish each person be distinct, not overlapping. Those characteristics that are the same for each person in the group are both the basis for conversation and the basis for no communication. The characteristics that are distinct are the ones that provide the possibility of communication.

Imagine that there is a person who would like to join a dialogue and that there are many such dialogues from which this person must choose. You are a member of one of the groups and you are a stranger to this person. What must this person know about you so that s/he can decide whether to join your dialogue rather than one of the others?

Assume that this person is not totally naive with respect to groups and people. Assume that s/he will concede that all people are reasonable or unreasonable, nice or not nice, and that s/he could have a conversation with a person without knowing that person (i.e., that cliches fill no void and thus carry no meaning). In short, assume that what this person wishes is that information that would give the necessary context as described in the first paragraph.

The assignment is: given the above stipulations, formulate a description of yourself that is distinct from all descriptions of everyone else.

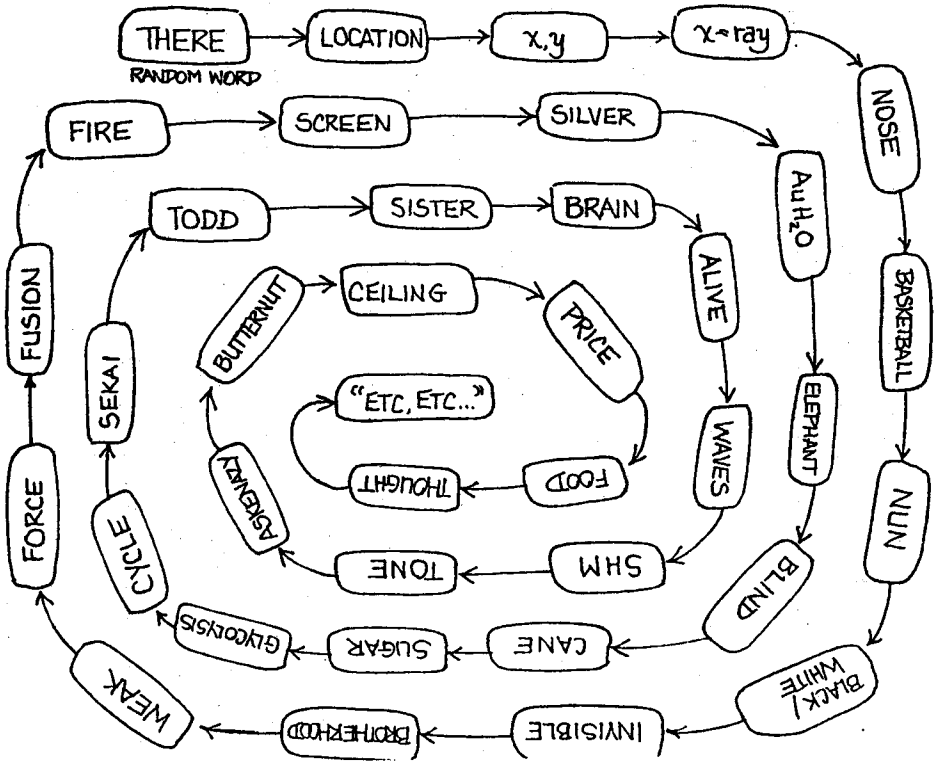
Kenneth Wilson and Herbert Brün

Barbara J. Ford

The outside is easy for all to see,
  The inside is difficult even for me.
History perhaps for some helpful could be,
  But I live in the present - today I am me.
I'm a woman, a doer, a moving force,
  Always busy with projects as you might expect of course.
The intellect applied to real life must be,
  Only the application of ideas is rewarding to me.
I'm not a writer as this composition will show,
  But that I love to talk and listen you all should know.
Many close friends in my life are a must,
  I want to share what's distinct about each of us.
I'm a librarian by trade and information I supply,
  In this capacity a service I provide and people on me rely.
Much effort and time is spend in women's rights,
  For each person's control of her/his body and life we must all unite.
I'm filled at times with anger and rage,
  Then I want to put my thoughts onto the page.
New experiences, travel, people, I seek,
  In all things I enjoy the unique.

Adrienne LeBailly

I suspect that the patterns of a person's thoughts are unique to him/her for both genetic (neurophysiological) and environmental (experiential) reasons. Therefore, if I choose a word and allow myself to move away from it by free-association, the direction I take is unique to me. Others may try to conjecture my mental leaps from one word to another, and in some cases may be successful, but since they cannot know my experiences, they will never completely understand. I begin with a randomly chosen word by closing my eyes and pointing to a page of a book. From then on, the mental journey is described by arrows.



Doug Petty

The assignment asks that I generate a description (and thus create a context) of myself which enhances my distinctiveness from other individuals and not my similarities with individuals. For convenience, I draw a distinction between the physical and the metaphysical "me".

Physically I am bounded by dimensions which are exclusively mine. The mass-energy which is me, defines me as distinct from other individuals, other masses, other energies. My genetic make-up which defines my systemic composition and describes the ratio of my senses are uniquely mine. The composite of physical and variables which define me bind me to a distinct perspective.

The metaphysical or subjective me is a manifestation of my physical distinctiveness and entails that same perspective. That which is distinctively my perspective is that which draws my distinctions, that which defines what is my figure and what is my ground, that which moves by its own schedule of changes and is the summation and potential of those changes.

The common context within which I find myself defined is the social-political structure. This framework (its totality being the summation of all individual frameworks) is the context of our vocabulary. Information is communicated by variances in this structure. This context, of which language is a tool, has the purpose of breeding similarities. It classifies and channelizes. What is distinct about me cannot be found within the social context. I am not distinct by what I am defined to be.

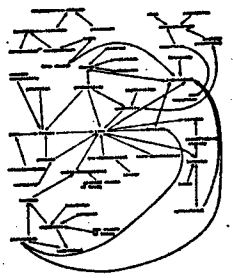
I am Sherwin Gooch.

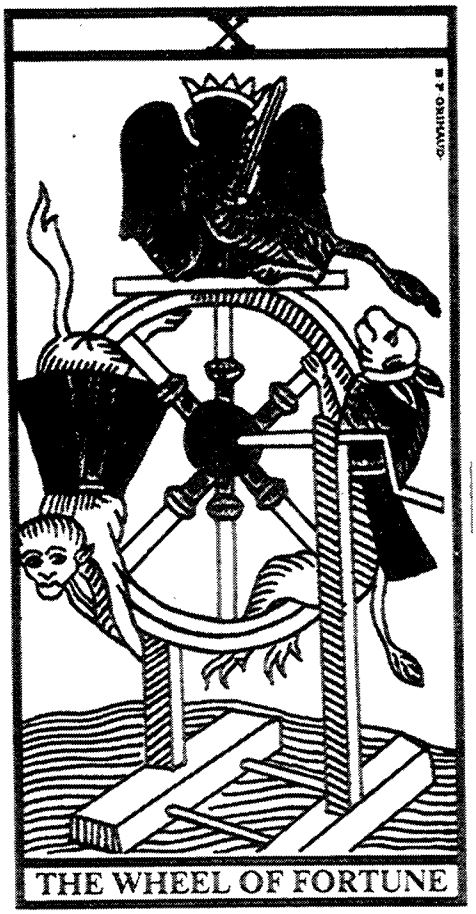
s. Gooch 2/7/74

CHANCE

Chance is commonly conceived of as randomness. A chance occurrence is random or haphazard, the "hazard" involved referring to the risk of being wrong in predicting or pre-saying what outcome might occur. Clearly there is a basic distinction (not often well observed in treatises on probability) between what appears as chance to an observer not wholly privy to what is in fact going on, and what is unpredictable by external observers because free choice of some kind was exercised. Thus only the owner of the human hands in question can safely predict which finger of which hand he or she will raise from, say, a table. Let us confine discussion to the manageable context of chance as a measure of frequency of occurrence (established from past observations). Thus the higher the frequency the greater the "chance" (here it means degree of non-risk!) that the event will happen during a pre-specified interval of time. The notion of probabilities as frequency in turn suggests the notion of fluctuating probability or waves of likelihood which all physicists and insurance companies use.

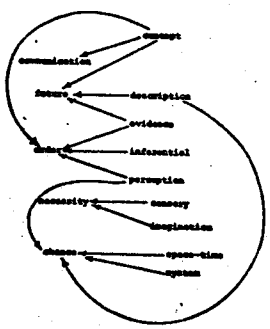
As far back as 1962 (pp. 265-266 of Aspects of the Theory of Artificial Intelligence, ed. C. Muses, Plenum Press, N. Y.) we showed that absolute randomness was really not possible. Since then this conclusion has been applied to lists of so-called random numbers to show they are only pseudo-random. But this deep pervasion of ORDER does not mean free choice does not exist. Indeed, the existence of some order is a necessary condition for the existence of free choice! For freedom of choice means some foreknowledge -- and hence choice -- of consequences, which is in turn only possible if order to some extent exists. Finally, considering chance as probability, there is no reason to believe a full-blown treatment not only of negative but also of imaginary probability (involving $\sqrt{-1}$) will not soon arise. The Klein-Gordon solution of Schrödinger's equation indeed formally admits of negative probabilities. In strategy theory, positive or negative probabilities with absolute values exceeding unity can also arise, as in our treatment of generalized probability. [C.M.]





CHANCE

Consummate inattentiveness.
Complexity of systems impinging and unrecognized.
Evidence of security maneuver.
Variable loss of perceptual complexity.
Dysfunctional space/time equivalent.
Ubiquitous unspecialized descriptor of everything.
Designation of ommitted field perception.
Meglomaniacal exemption.
Ponderous non-event validation.
Essence of mathematical behaviour.
Myopic or history.
Contemporary spatial uniqueness. [E.S.]



CHANCE

Chance arises from the inability to make infallible inductions.

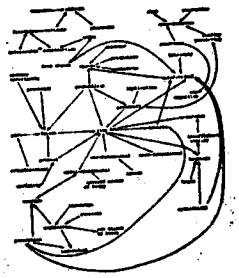
[H.V.F.]

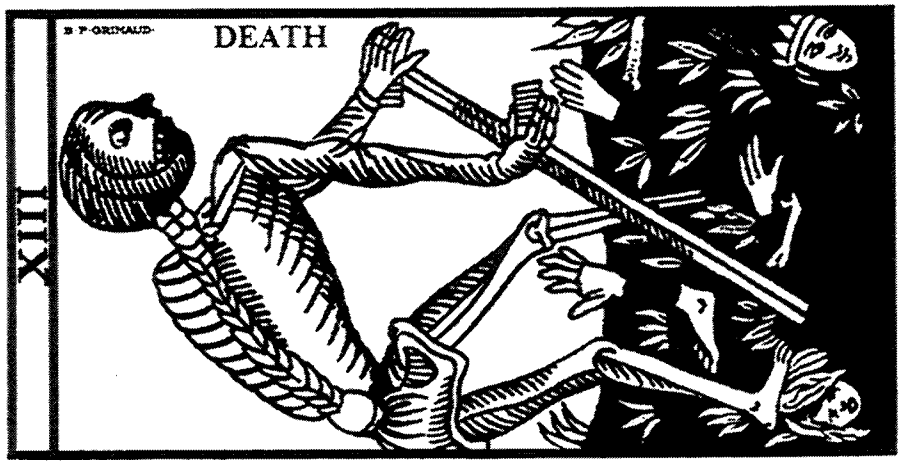
NECESSITY

Necessity has already been mentioned in the context of logical necessity, which always results from logical priority, which means a condition without which a given conclusion cannot be validly drawn. That is, to ignore logical priority is to ignore logical necessity and logical reality. Necessity has also a temporal context, as does priority; and again anything thus necessary as a temporal consequence depends on some prior or previously existent antecedent.

Necessary in this sense means unpreventable (things remaining within certain predefined ranges). Thus if a locomotive can stop within 20 feet at 60 miles per hour, and the engineer coming round a bend sees a cow on the track 12 feet away, the cow of necessity must be hit by the locomotive. The predefined range here includes, for instance,that no earthquake occurs at the site just as the locomotive rounds the bend, that no object capable of diverting the locomotive from the track is present at the time, and so on. Thus it is very questionable whether there is any absolute temporal necessity any more than there is any absolute temporal randomness. That in turn means that time involves both necessity and randomness, each to some finite extent every moment. Hence, rather than absolute chance or absolute determinism, reality presents us with shaded regions of greater/lesser likelihood that ceaselessly fluctuate in their boundaries and gradients. That neither necessity nor randomness is absolute seems indeed to be one of the few necessary features of all existence.

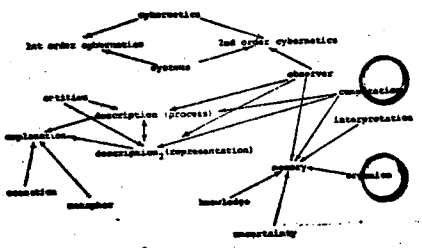
[C.M.]





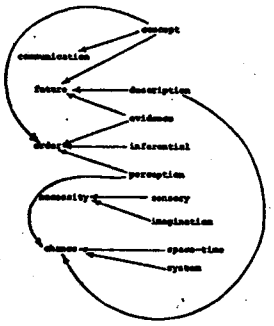
NECESSITY

Necessity arises from the ability to make infallible deductions. [H.V.F.]



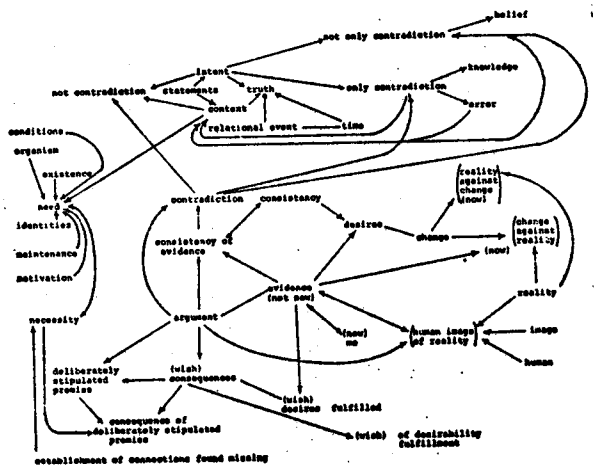
NECESSITY

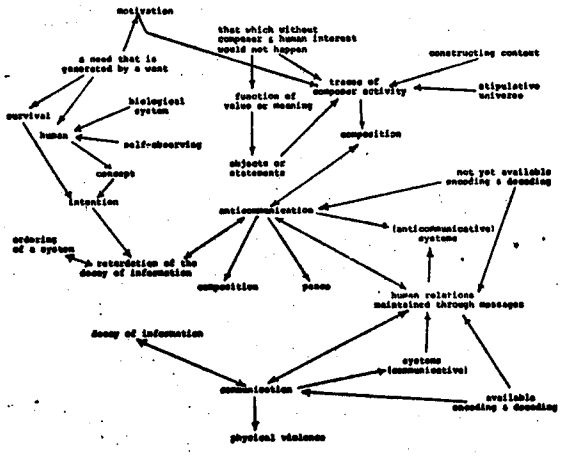
Isolated sensory takeover.
Imagined ritual formulation.
Metaphoric exemption.
Standarized dysfunctioning epithet.
The acclamation of a one-man-universe retrospective.
Accentuated habit.
Generalized deficit.
The acknowledged mother of omission. [E.S.]



NECESSITY

I use the word "necessity" whenever I wish to speak of something which is to meet the conditions called "need", or whenever I wish to emphasize by metaphorical analogy, the urgency with which I wish to establish a relation or a connection found missing. [H.B.]



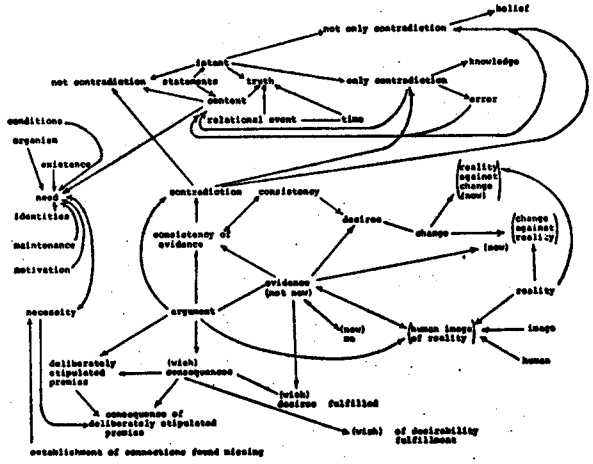


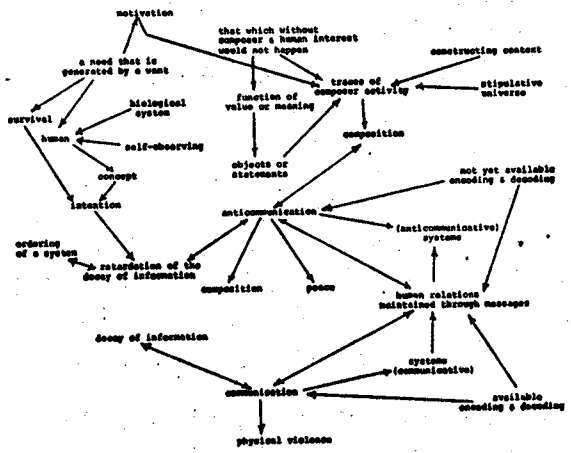
NEED

I use the word "need" whenever I wish to speak of conditions which must be met continuously and unconditionally if living organisms are to be able and to be motivated to maintain themselves, their identities, their existence.

Continuously: because the conditions continue in consequence of having been met.

Unconditionally: because without the conditions called "need" having been met no other condtions exist. [H.B.]





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104½	99	oCp	8½s77	149	10	102	102⅜	—1⅞	112	88½	ContMfg	6¼s90
93½	8	oInv	7⅜88	4		91	91	.....	103	96	ContOil	7½s99
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		Atch	4s95r	3	58⅞	58⅞	58⅞	.....	89	81	Corn Pd	5¾s92
	93⅛	AtlCs	4¼s72	9	96⅞	96⅞	96⅞	— ⅝	80½	73⅝	Corn Pd	4⅝s83
8½	75	AtlRef	3¼s7	3	75	75	75	—3½	83½	75	Crane Co	7s93
11	103½	AtRch	s2	47	107¾	106½	107¾	+ ½	82½	74	Crane Co	7s94
105⅛	58	AtlRich		25	102½	99¾	99¾	—2¾	86	75⅝	CraneCo	6½s92
107	98¾	AtlRich		115	101¾	100½	101¾	+ ½	100	75⅞	Crane	cv5s93
85½	77⅞	Atl R.ch	97	16	81¼	78⅝	78⅝	—3¼	108½	102	CredFin	9¾s75
59	46	ATO Inc	s87	36	52	51½	52	— ⅞	65	53	Crescnt	5½s80
82	63¼	Aurora	4⅝s80	62	80	79½	80	.....	97¾	91	CrockNat	5¾96
119⅛	92½	AutoC	cv4¾s81	40	105	104	104	—3	79	61½	CrowCoII	4s92
109¾	100½	Avco Fin	11s90	141	108⅞	107	107½	—1⅜	111	103	CrwnZell	8⅞s
107½	93	AvcoFin	9¼s89	60	103½	102	103	— ⅜	82	72	Crucible	6⅞s92
80½	70	Avco Cp	7½s93	142	79	76½	78¾	+1¾	.....	.....	CyanD	fn5¾s
69¾	56	Avco Cp	5½s93	144	67	64½	65	— ⅞				
154	117⅛	Avco	cv5s79	1	154	154	154	+12	98	91	Dana	7.30s96
104	95	AvcoFin	9¼s90	46	103	102	102	—2	66½	47½	DataPro	5½s87
100	93	AvcoFin	8⅞s77	248	100	99	100	+ ⅜	94	80¼	Dayco	6¼s96
92	79⅛	AvcoFin	7⅞s89	50	88	87	88	+1½	86½	68⅞	DaycoCp	6s94
									82	69	Dayco	5¾s94
111	105½	Balt GE	8¾s75	18	108½	108	108½	+ ¼	112½	107½	DayHud	9¾s95
108⅞	102	Balt GE	8½s74	60	107¼	105	107¼	+2⅛	64	60	DaytPL	3s84
70	61	BaltGE	4s93	30	61	61	61	—2¼	88	83½	DaytPL	2¾s75
116	109	B&O	11s77	41	114	113	113	.....	80	70½	DeereCo	4½s83
55¼	42½	B&O	cv4½s10A	34	47⅞	46½	47⅞	—½	108	99½	DeereCr	8¾s75
54	43¾	B&O	4¼s95	60	51	49½	49⅞	— ⅜	80	62	DelaL&W	5s73
70	61½	B&O	4s80	32	65	64⅝	64⅝	—2⅜	46	33½	DelaL&W	5s85
86¼	71	BangP	8¼s94	19	82	81	82	+1	35	28⅞	DLW	4s-6s2042
65½	54½	BangP	5¾s92	46	65½	63	64¾	+4⅜	93½	89⅜	DelaP&L	3s73
136½	109	Bk NY	6¼s94	21	115	113	113	.....	90	80	DelmPL	6⅜s97
100	92	BankTr	6⅜s78	50	95	95	95	+3	96	81	DelMont	5¼s94
111	96	BaxLab	4¾s90	78	108½	108	108½	+¾	101	98¾	Dennison	8¼96
205	151¾	BaxLab	cv4s87	28	196½	196	196½	+6½	113⅛	107	DetEdis	9.15s
87	67⅛	Beaunit	4¼s90	32	70	69	70	.....	112½	105	DetEdis	9s99
102¼	81	BectonD	5s89	282	86	84	85	—2	106¾	98⅞	DetEdis	8.15s
108	84	BectonD	4⅛s88	295	88¾	87	87	—2	104½	99	Det Edis	8⅛s
68	52	BeechA	4¾s93	28	58	56½	56½	—1½	104⅝	98½	DetEdis	7s7
75⅛	53½	BelcoP	4¾s88	53	65⅞	64	64	—1⅞	95⅛	83½	DetEd	6.40s98
117	99½	Belden	cv8s90	37	107	106	107	+2	93½	79½	DetEdis	6s96
110	103	BellTPa	8⅝s	67	108½	107¼	108	— ½	88	82⅝	DetEd	3⅜s76
83	75	Bemis	6⅜s92	5	76	76	76	—2	76	68⅜	DetEd	3¼s80
93½	84½	Bendix	6⅝s92	20	89½	89	89	—1	65½	62	DetEd	2¾s82
110½	104	Benef	9⅜s75-78	32	107¼	106½	106½	— ⅜	61	56	DetEd	2¾s85
108½	101½	BenefCp	8½s76	80	105⅜	104⅛	105⅜	+1½	108½	86⅛	DiGiorg	5¾93
82½	74⅛	Benf In	4⅞81	81	82½	80½	80½	— ¾	85	62	Dilingh	5½s94
84½	58	Bo key	5¾s86	336	81	75	80	.....	117	101½	Disney	4¾s96
111⅛	104	Beth Stl	9s2000	26	110	108¾	110	+1¼	93½	89¾	DiverIn	9⅞s91
99	88¼	Beth Stl	6⅞s99	12	93½	93¼	93⅜	+ ⅞	73½	56¼	Diver In	5⅞s93
86	74	BethSt	5.40s92	27	80	79½	79½	+2	85¼	71⅜	DouglAirc	5s78
73½	65	Beth Stl	4½s90	41	70	68	68	—2	110⅝	104	Dow	
77	68⅝	BethStl	3¼s80	6	68⅜	68⅝	68⅝	—3⅛	111	103	Dow	
79¼	78	BethStl	2¾s76	2	79½	79½	79½	+1	105½	96	DowCh	7.75s99
120½	103⅜	BigThre	5¾s90	2	120	120	120	+1	76	66	DowCh	4.35s88
84⅛	68	BobbieB	5¼s81	6	75⅜	75¼	75¼	.....	110	105	Dresser	9⅝s95
110⅜	99½	BoisCas	10s75	268	105⅞	104	105⅞	+1⅞	101	73½	Duplan	5½s94
84	72½	Borden	5¾s97	26	81	80½	81	— ¼	112	101⅛	DuqLt	8⅜s2000
70½	66	Borden	4¾s88	10	68½	68½	68½	—1½	109	102	DuqsnLt	8¼s7

about five of the great Is:

It;
Ignorance;
Innocence;
Indifference;

the story of your life, told as you would tell It:
at least three times:
It, as you use It, uses you as you use It.

you know what you mean. but
do you know what It means?
are you or are you not responsible for whatever you do or say
even If It does that which you did not Intend It to do?

If You and I were present while He answered a question asked by Her and If neither You nor I would comment on the answer then I shall have accepted the answer and not ask the question again but expect You to now ask the question as If never an answer had been heard by You.

Invite your friends to ask you for a definition of It every time you use It In a statement of question. observe how soon you will have to avoid either your friends or the ubiquitous It as It always offers Itself just when without It the world would show Itself to you as that unspeakable a word as It Is.

was It a missprint or Is It not?

there are more; nor Is the fifteenth missing as long as you read this.

Herbert Brün

I need to know how I perceive and the limits of my perception.
I need to know how I know, the different ways of knowing, and the limits to what I can know.
I need to know how my "knowing" and "perceiving" relate to "reality".
I need to learn about the nature of "reality".
I need to know what learning is and how one learns.
I need to know about logic and its relationship to "thinking" and "reality".
I need to know the nature of "thinking" and how one "thinks".
I need to know the conceptual foundation of math and the relationship it and the other sciences have to "reality".
I need to know what time is.
I need to know the differences between and the domains of "science", "art", and "philosophy", and their relationship to "reality".
I need to communicate.
I need to know what communication is and how an organism communicates.
I need to make friends.
I need to laugh, cry, and experience a wide range of emotion.
I need to entertain. (make others feel a wide range of e-motion)
I need to know what elements of man are common to all men by the organization of the organism and what elements are culturally induced.
I think I may need to know all that I can know.
I think I may need to perceive all that I can perceive.
I need to know my needs and the nature of need.
I think I need to love and be loved. (Depending on the definition of love.)
By definition I need to fulfill my needs.
By hypothesis I also need to have needs.
I need to establish connections between all that I can establish connection between, especially my needs.

I need ——to know how I perceive
I need ——to know the limits of my perception
I need ——to .....

[e t c .]

Robert Rebitzer

EVIDENCE

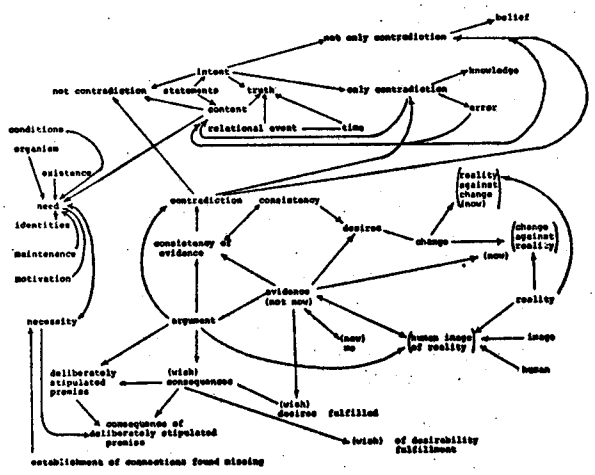
I use the word "evidence" whenever I wish to speak of a configuration (= human made image) of reality used as an 'argument' in support of the reality of this configuration. I use the word "evidence" only rarely, and there with great embarrassment. Shamefacedly I am forced to admit that I am a member, and speak the languages, of such societies as must not yet be encouraged to waive the 'argument' and to deal directly with the configuration as the only reality worth dealing with.

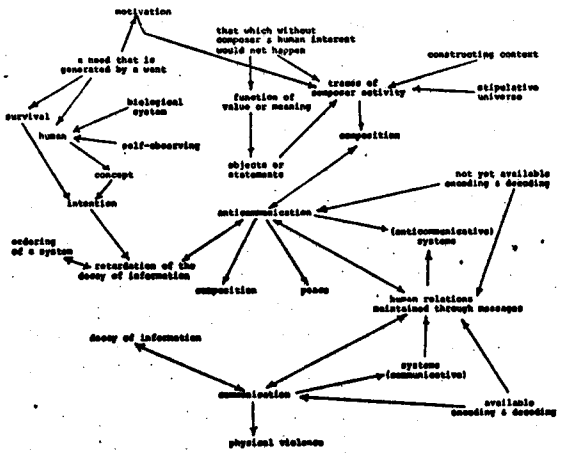
Not yet: because "evidence", now, is reality against change, and change, now, reality against "evidence".

Shamefacedly: because, as long as the word which I wish to define, defines me, I can not define it, without defining myself, whom I 'desire' to be defined quite differently.

Worth dealing with: because, even there, 'truth' would not be.

I wish I could use the word "evidence" whenever I wish to speak of 'desires' fulfilled, and the consequences, as 'arguments' for or against the desirability of the fulfilment. [H.B.]





LAW: Reflections

John Hackmann

A distinction: An individual who believes she/he sees the world as it is has a fundamentally different perspective than an individual who holds the world to be her/his needs and desires. The former assigns properties to things, for example, people have such-and-such a nature, but the latter holds that an individual invents her/his nature.

I define politics as the set of relationships of individuals to the group and the mechanisms of making collective social choice. This social choice is implemented primarily by people through law. Each aspect of the individual-group relationship is circumscribed by law.

A conception or model of man underlies our Constitution. In The Federalist Papers a specific conception of people's nature is developed. What the conception consists of is not significant; that a conception exists is significant.

"People are greedy." By such a statement we create such a 'property', e.g., by acting as if people are greedy we create greed. Are the properties we see, and upon which we structure law, properties of mankind or inventions of mankind? Does society make individuals have these properties? Should it?

We assume properties A, B, C, and D, in large part because we live in a culture that fosters A, B, C, and D. This functions as the greatest barrier to change because any system suggests in people the qualities that system needs to operate. The fostering of competition between people, where it is success that is desirable,stands in opposition to the fostering of mutual effort to reach desirable standards of achievement, as one example.

Even if it is believed that it is in the nature of people to be greedy, they need not be greedy. Therefore, laws that predicate people will be greedy are not desirable.

What we know about people is not their nature, but that they have potential. A proper use of law is to generate a process by which people reach more desirable potentials.

We don't need our vested or invested interests in a particular social organization or a particular social order, but we do need our loving interest in the values we promote for individual human beings. Knowing our values for people and ignoring our interest in a system, we can allow, even help, a system change to fit the changing expressions of people's potential.

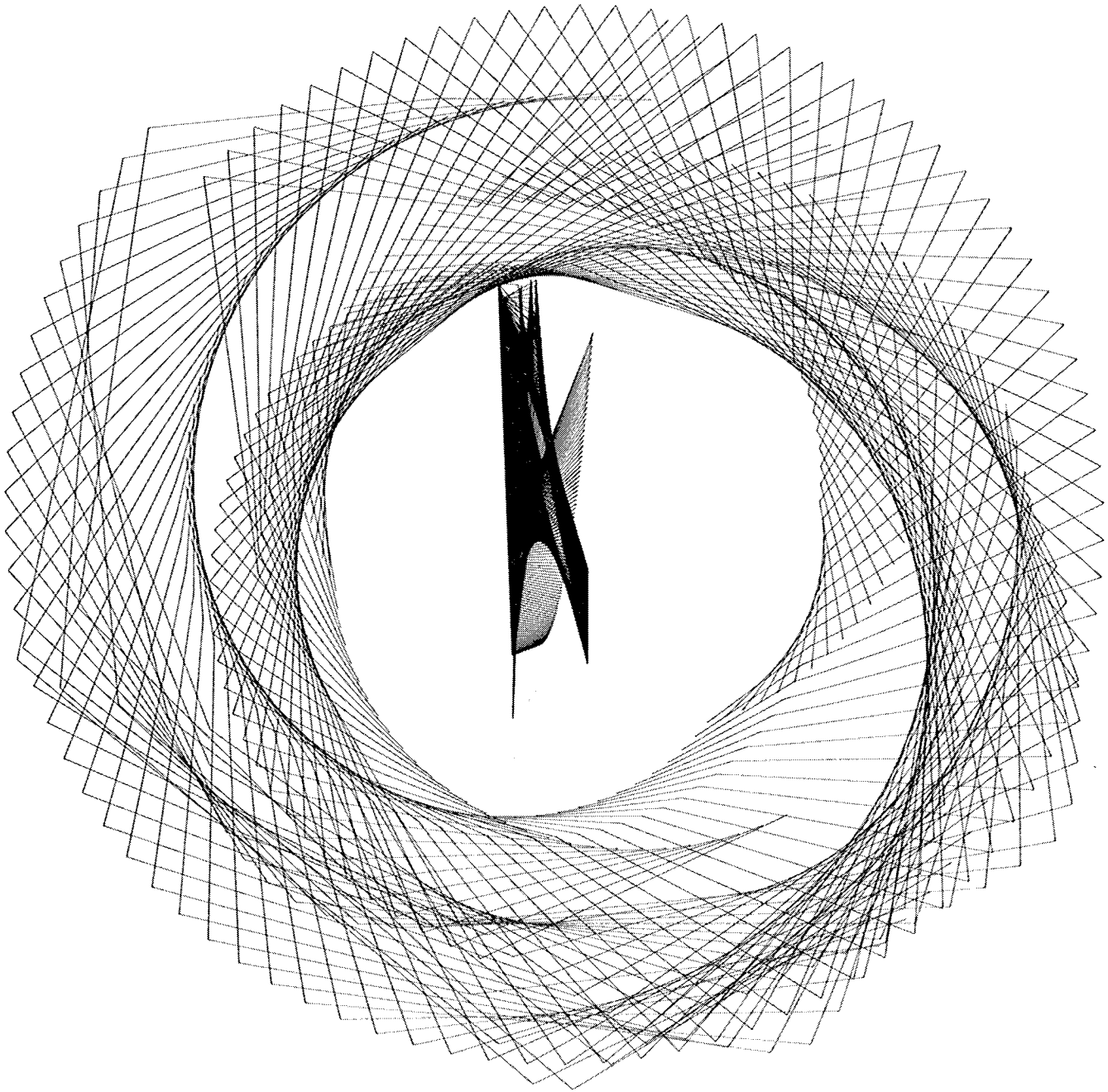
Society based on supposed knowledge of people's nature strives to be an unchanging society. Unchanging societies are unstable societies. Complex systems, to remain the same, must change constantly.

A view of people's potential complements economic and political views of people. We have a right to speak, but do we have a right to hear, or to think? These could be termed psychological rights. It is desirable that private thought and experience be protected as effectively as we now protect private property. A proper function of any governmental social policy in addition to its specific aims, is the extension and preservation of the freedom of the individual.

Growth of information processing, centralized data banks, electronic eavesdropping, and concentrated authority--corporate and governmental--narrow political and economic alternatives, and create a need for law to embody a view of individuals as having a particular nature.

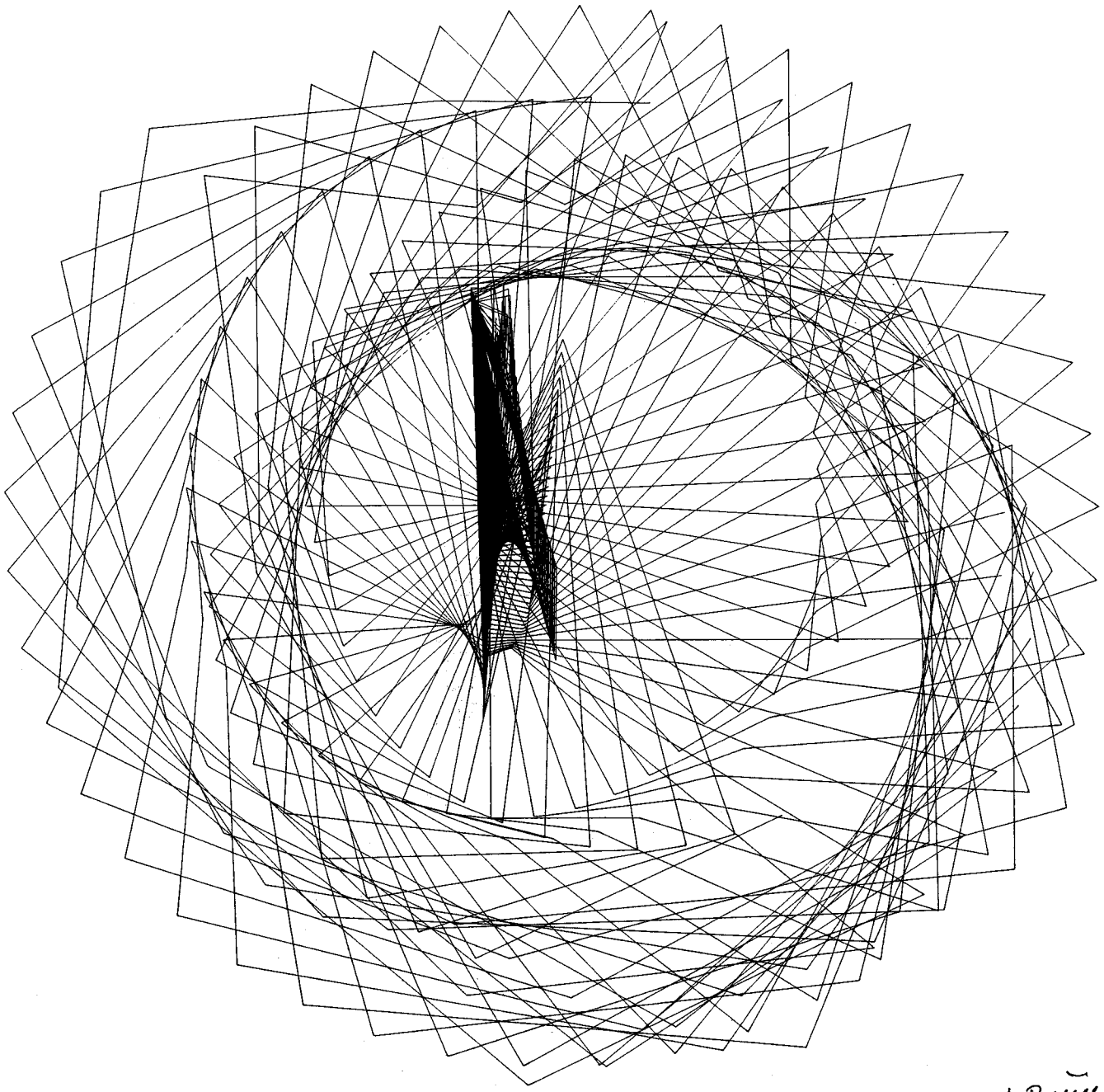
Consciousness of people, potential of people--this is a frontier to explore and develop in law.

(The preceding reflections followed conversations with and comments from Steve Sloan, Paul Schroeder, Herbert Brün and Heinz Von Foerster.)



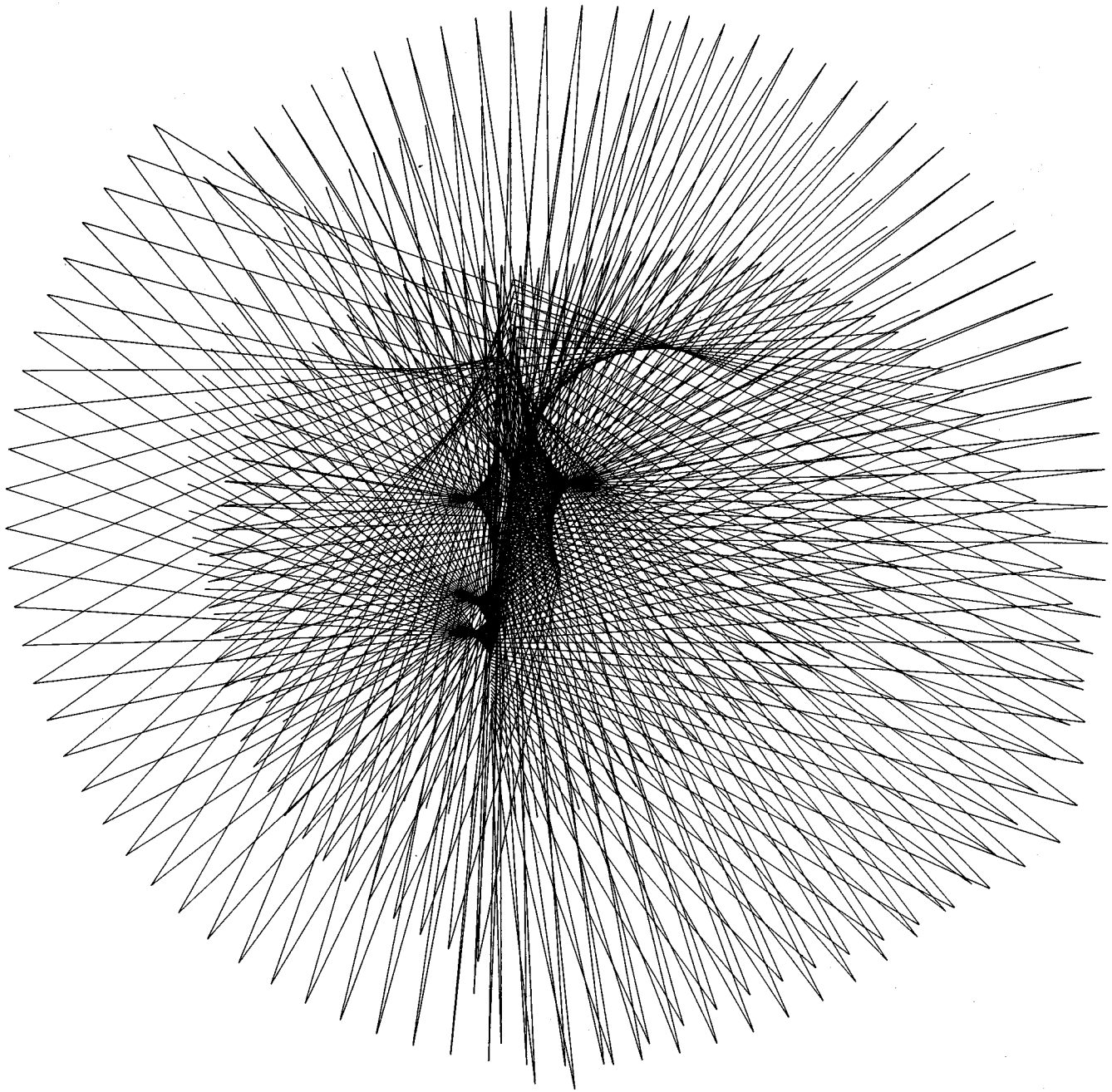
Herbert Bruce

"..."



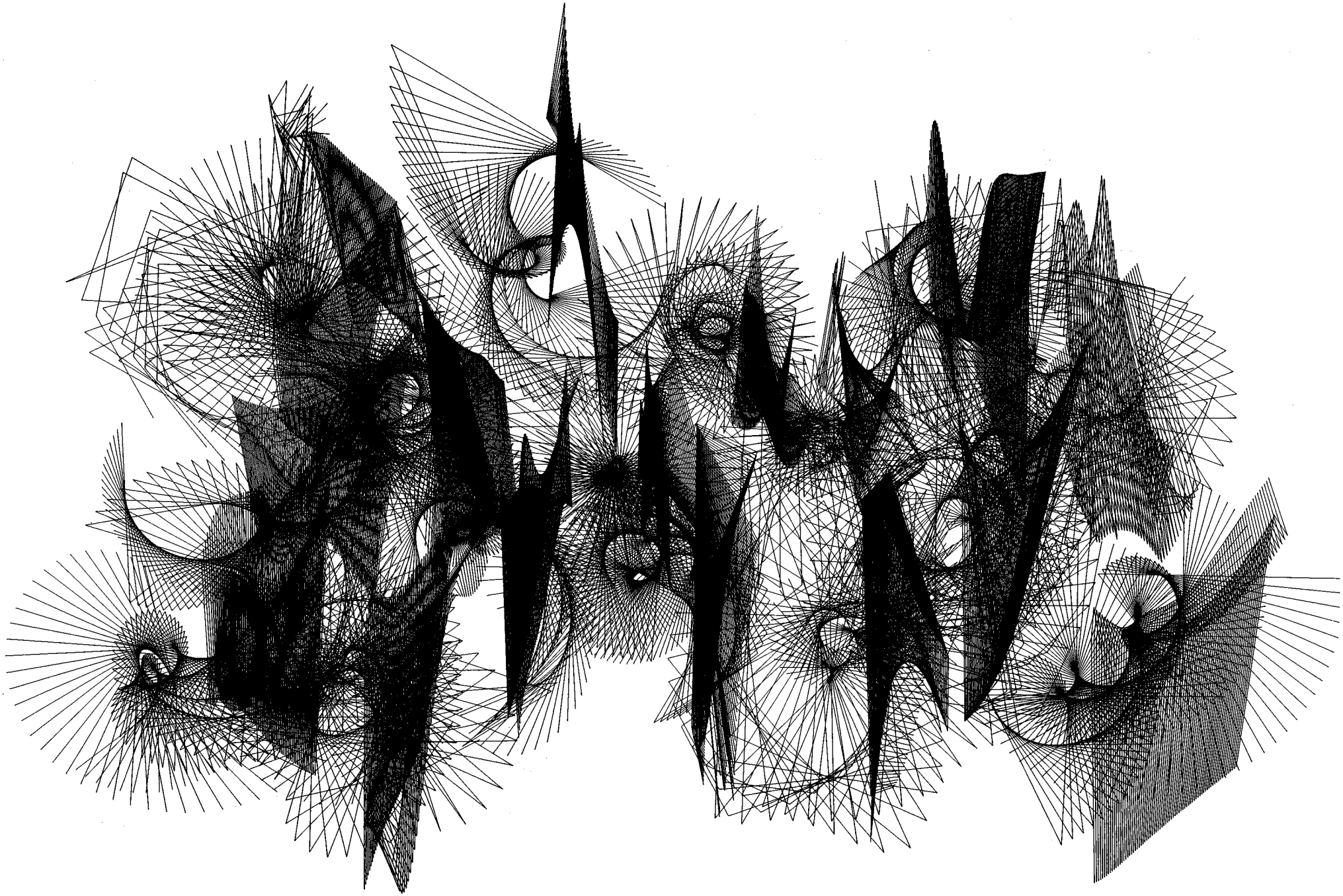
"both"

Herbert Bayer.

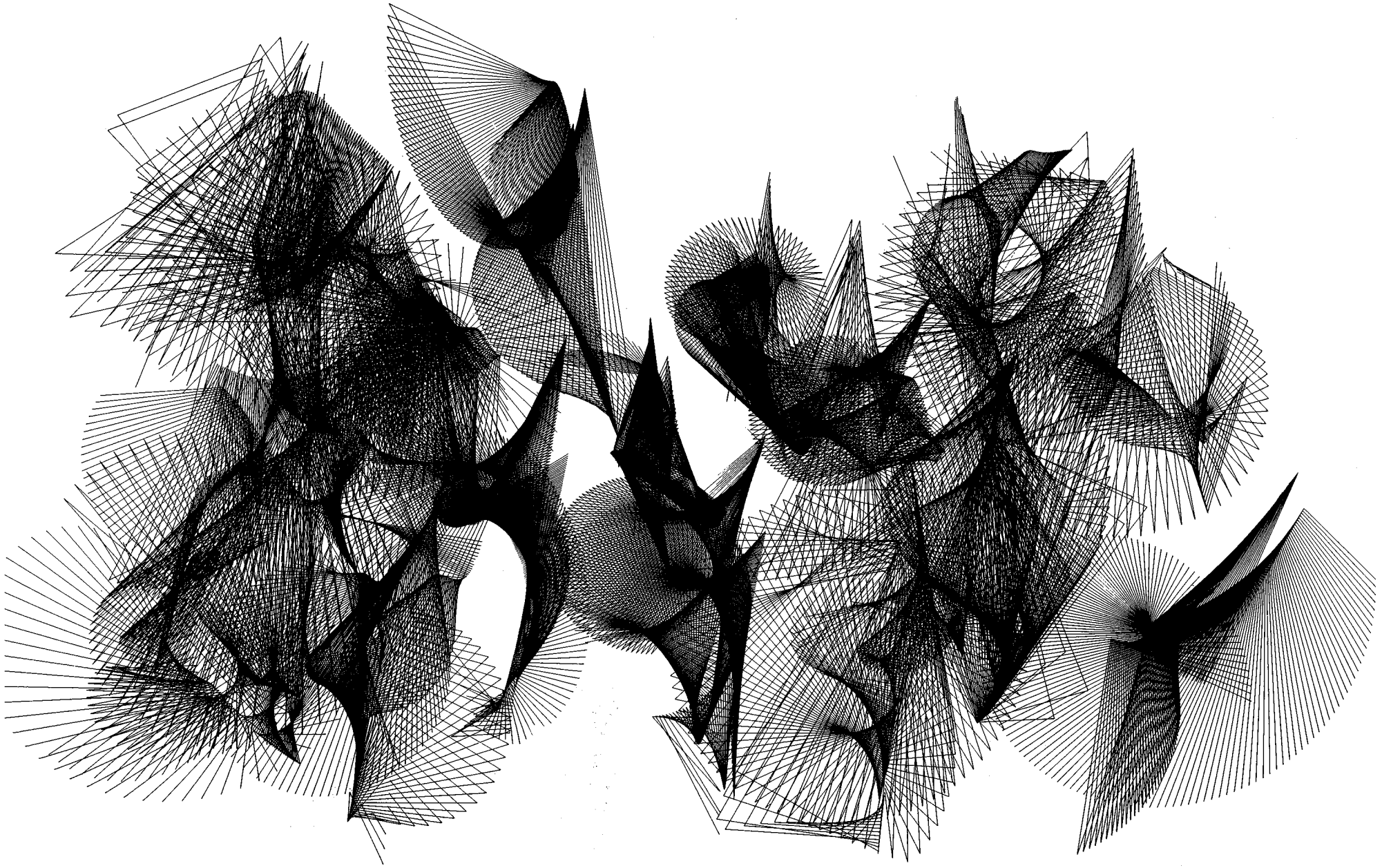


"there"

10 I. L Bruce



"many"



"azz"

Herbert Bayer

ARGUMENT

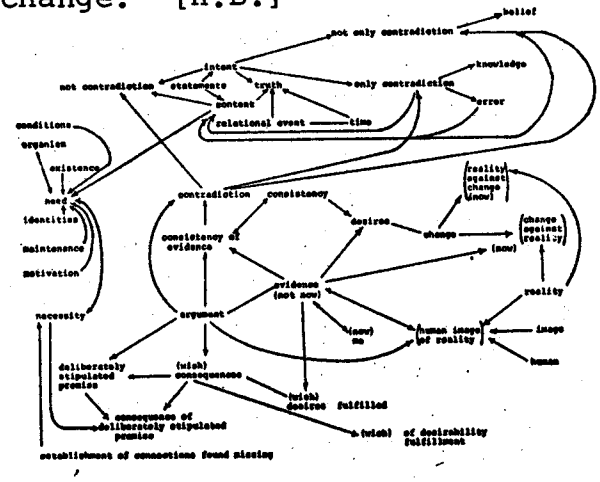
I use the word "argument" whenever I wish to speak of a deliberately stipulated premise to whose consequences I wish to attribute the status of 'necessity' explicitly in order to confirm the validity of all the 'evidence' which supports the attribution.

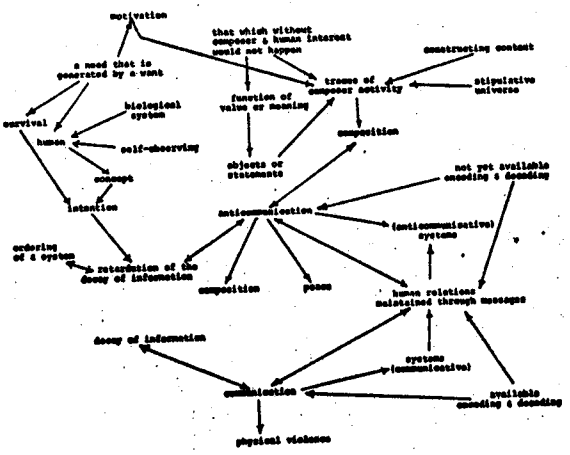
Deliberately stipulated premise: because its being itself a consequence is to be considered irrelevant.

Attribute: because I know that I do not speak of a 'need', but of a want for consistency.

To confirm the validity of supporting 'evidence': because an "argument" must become itself valid 'evidence' before the status of 'necessity' can be attributed to its consequences.

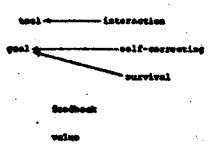
I use the word "argument" whenever I wish to speak of the consistency of just that 'evidence' whose consistency raises my 'desire' for changing the 'evidence'; and whenever I wish to demonstrate the contradiction in which I have to argue: the 'evidence' which raises my 'desire' for change is always a subset of the 'evidence' which supports every "argument" against change. [H.B.]





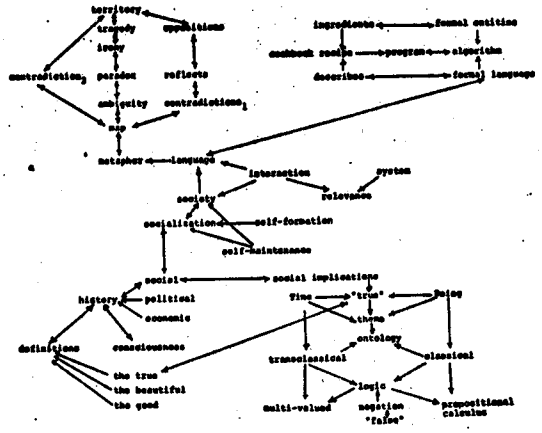
VALUE

Any station in a spectrum (i.e. graded set) of preferences used in arbitrating a tradeoff. [S.Br.]



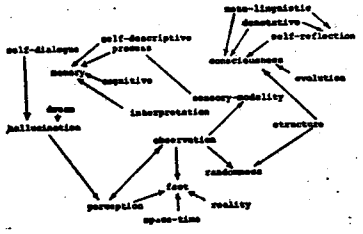
RELEVANCE

A relationship between a system and a necessary external interaction of that system, the necessity of the relationship being determinable prior to the interaction only transcendentally (that is, from a viewpoint outside the system); immanently (from within the system), however, only a posteriori. [R.H.H.]



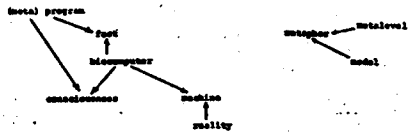
FACT

Has been termed "an American tragedy" and it is indeed strange that our present-oriented culture is so over-concerned with a factum, i.e. a re-presentation and thus re-evaluation of an isolated chunk of past reality. 'Reality' may now be regarded as "the actualizing appearance of observational realtions" (Whiteman), with visible reality merely an isolated phenomenon. Hence, a fact can not be located in any one level 'physical' space and time since space and time are symbols denoting indefinite, general and potential operators which actualize only as a result of a particular observation. In fact, there are no facts but fantasies about past perceptions-behaviors. [R.F.]

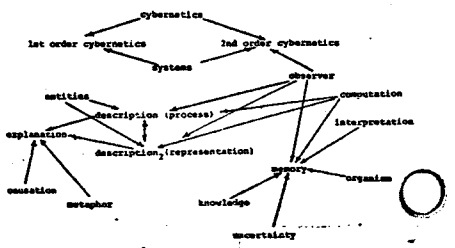


FACT

A statement by a given biocomputer of an experience without/with words. A fact sticks to programs, eschews metaprograms. [J.L.]

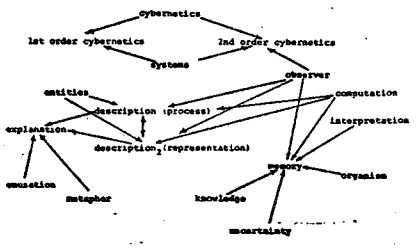


FACT



(From Latin factus, past principle of facere: to do, to make.) "to make (up)": the description of the source of an experience such that this description may be subjected to doubt. [H.V.F.]

FICTION



(From Latin fictus, past principle of fingere: to form, to mold) "to make (believe)": the description of the source of an experience such that this description is immune against doubt. [H.V.F.]

OBJECTIVITY: THE PROPERTIES OF THE OBSERVER SHALL NOT ENTER THE DESCRIPTIONS OF HIS OBSERVATIONS.

OBJECTIVITY

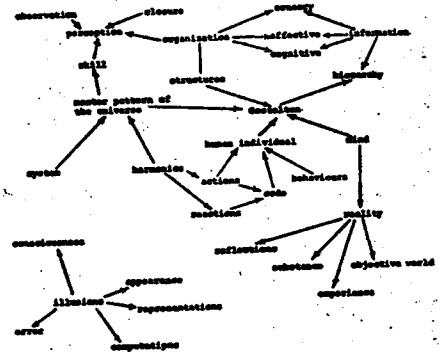
The statement: I don't know that I don't know that....

[G.K.]

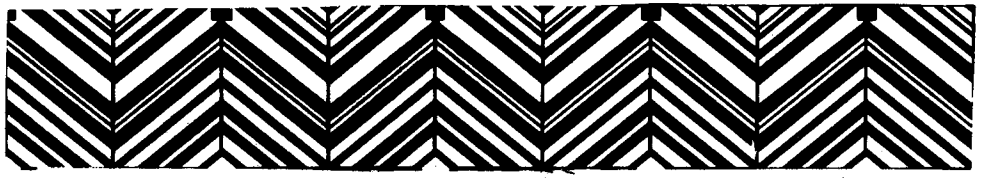
REALITY

There is one reality that we experience: that of our mind and the modifications of our mind, which are like Gestalten in moving smoke. There is another that we assume as an object casting its reflection on our mental mirror -- identical with the results of our perception except in the stuff that it is made of.

To the question as to whether there is a substance other than that of the mirror, as well as to that concerning the possibility of knowing the "thing-in-itself", questions that science has tended to answer with an affirmation of an "objective world" that is unknowable except by inference, mystics throughout the ages have answered with a denial of anything but a single reality and with the affirmation of man's possibility of knowing reality directly in virtue of the immediacy of his own mind, not different from mind-in-itself. [C.N.]



Scott Mutter



ON CONSTRUCTING A REALITY

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Abstract

"Draw a distinction!" (1)

The Postulate

I am sure you remember the plain citizen Jourdain in Moliere's "Bourgeois Gentilhomme" who, nouveau rich, travels in the sophisticated circles of the French aristocracy, and who is eager to learn. On one occasion with his new friends they speak about poetry and prose, and Jourdain discovers to his amazement and great delight that whenever he speaks, he speaks prose. He is overwhelmed by this discovery: "I am speaking Prose! I have always spoken Prose! I have spoken Prose throughout my whole life!"

A similar discovery has been made not so long ago, but it was neither of poetry nor prose--it was the environment that was discovered. I remember when, perhaps ten or fifteen years ago, some of my American friends came running to me with the delight and amazement of having just made a great discovery: "I am living in an Environment! I have always lived in an Environment! I have lived in an Environment throughout my whole life!"

However, neither M. Jourdain nor my friends have as yet made another discovery, and that is when M. Jourdain speaks, may it be prose or poetry, it is he who invents it, and likewise when we perceive our environment, it is we who invent it.

Every discovery has a painful and a joyful side: painful, while struggling with a new insight; joyful, when this insight is gained. I see the sole purpose of my presentation to minimize the pain and maximize the joy for those who have not yet made this discovery; and for those who have made it, to let them know they are not alone. Again, the discovery we all have to make for ourselves is the following postulate:

The Environment As We Perceive It Is Our Invention.

The burden is now upon me to support this outrageous claim. I shall proceed by first inviting you to participate in an experiment; than I shall report a clinical case and the results of two other experiments. After this I will give an interpretation, and thereafter a highly compressed version of the neurophysiological basis of these experiments and my postulate of before. Finally, I shall attempt to suggest the significance of all that to aesthetical and ethical considerations.

Experiments

Figure 1

((i) Blindspot) Hold book with right hand, close left eye and fixate asterisk of Fig. 1 with right eye. Move book slowly back and forth along line of vision until at an appropriate distance (from about 12 to 14 inches) round black spot disappears. Keeping asterisk well focused, spot should remain invisible even if book is slowly moved parallel to itself in any direction. This localized blindness is a direct consequence of the absence of photo receptors (rods or cones) at that point of the retina, the "disc", where all fibers, leading from the eye's light sensitive surface, converge to form the optic nerve. Clearly, when the black spot is projected onto the disc, it cannot be seen. Note that this localized blindness is not perceived as a dark blotch in our visual field (seeing a dark blotch would imply "seeing"), but this blindness is not perceived at all, that is, neither as something present, nor as something absent: whatever is perceived is perceived "blotch-less".

((ii) Scotoma) Well localized occipital lesions in the brain (e.g., injuries from high velocity projectiles) heal relatively fast without the patient's awareness of any perceptible loss in his vision. However, after several weeks motor dysfunction in the patient becomes apparent, e.g., loss of control of arm or leg movements of one side or the other, etc. Clinical tests, however, show that there is nothing wrong with the motor system, but that in some cases there is substantial loss (Fig. 2) of a large portion of the visual field (scotoma) (2). A successful therapy consists of blindfolding the patient over a period of one to two months until he regains control over his motor system by shifting his "attention" from (non-existent) visual clues regarding his posture to (fully operative) channels that give direct postural clues from (proprioceptive) sensors embedded in muscles and joints. Note again absence of perception of "absence of perception", and

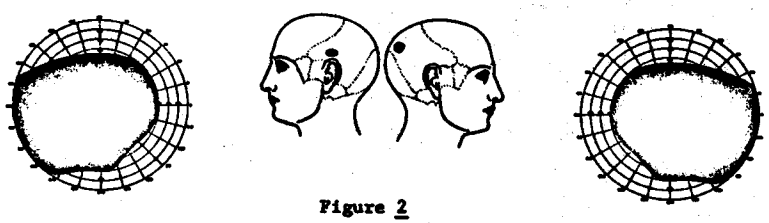


Figure 2

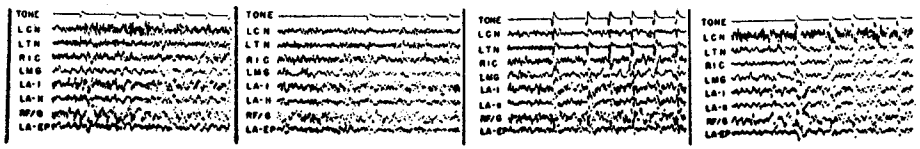
also the emergence of perception through sensory-motor interaction. This prompts two metaphors: "Perceiving is Doing"; and "If I don't see I am blind, I am blind; but if I see I am blind, I see."

((iii) Alternates) A single word is spoken once into a tape recorder and the tape smoothly spliced (without click) into a loop. The word is repetitively played back with high rather than low volume. After one or two minutes of listening (from 50 to 150 repetitions) the word clearly perceived so far abruptly changes into another meaningful and clearly perceived word: an "alternate". After 10 to 30 repetitions of this first alternate, a sudden switch to a second alternate is perceived, and so on (3). The following is a small selection of the 758 alternates reported from a population of about 200 subjects who were exposed to a repetitive playback of the single word COGITATE: AGITATE; ANNOTATE; ARBITRATE; ARTISTRY; BACK AND FORTH; BREVITY; CA D'ETAIT; CANDIDATE; CAN'T YOU SEE; CAN'T YOU STAY; CAPE COD YOU SAY; CARD ESTATE; CARDIO TAPE; CAR DISTRICT; CATCH A TAPE; CAVITATE; CHA CHA CHE; COGITATE; COMPUTATE; CONJUGATE; CONSCIOUS STATE; COUNTER TAPE; COUNT TO TEN; COUNT TO THREE; COUNT YER TAPE; CUT THE STEAK; ENTITY; FANTASY; GOD TO TAKE; GOD YOU SAY; GOT A DATE; GOT YOUR PAY; GOT YOUR TAPE; GRATITUDE; GRAVITY; GUARD THE TIT; GURGITATE; HAD TO TAKE; KINDS OF TAPE; MAJESTY; MARMALADE....

((iv) Comprehension (Literally: con = together; prehendere = to seize, grasp.)) Into the various stations of the auditory pathways in a cat's brain micro-electrodes are implanted which allow a recording ("Electroencephalogram") from the nerve cells first to receive auditory stimuli (Cochlea Nucleus, CN) up to the Auditory Cortex (4). The so prepared cat is admitted into a cage that contains a food box whose lid can be opened by pressing a lever. However, the lever-lid connection is operative only when a short single tone (here C_6, that is about 1000 Hz) is repetitively presented. The cat has to learn that C_6 "means" food. Figures 3 to 6 show the pattern of nervous activity at 8 ascending auditory stations, and at four consecutive stages of this learning process (4). The cat's behavior associated with the recorded neural activity is for Fig. 3: "Random search"; Fig. 4: "Inspection of lever"; Fig. 5: "Lever pressed at once"; and for Fig. 6: "Walking straight toward lever (full comprehension)". Note that no tone is perceived as long as this tone is uninterpretable (Figs. 3,4; pure noise), but the whole system swings into action with the appearance of the first "beep" (Figs. 5,6; noise becomes signal) when sensation becomes comprehensible, when our perception of "beep", "beep", "beep", is in the cat's perception "food", "food", "food".

Figures

3: Sess.3, Tr.1; 4: Sess.3, Tr.13; 5: Sess.4, Tr.20; 6: Sess.6, Tr.9



Interpretation

In these experiments I have cited instances in which we see or hear what is not "there", or in which we do not see or hear what is "there", unless coordination of sensation and movement allows us to "grasp" what appears to be there. Let me strengthen this observation by citing now the "Principle of Undifferentiated Encoding":

> "The response of a nerve cell does not encode the physical nature of the agents that caused its response. Encoded is only "how much" at this point on my body, but not "what".

Take, for instance, a light sensitive receptor cell in the retina, a "rod", which absorbs the electro-magnetic radiation originating from a distant source. This absorption causes a change in the electro-chemical potential in the rod which will ultimately give rise to a periodic electric discharge of some cells higher up in the post-retinal networks (see later, page 7) with a period that is commensurate with the intensity of the radiation absorbed, but without a clue that it was electro-magnetic radiation that caused the rod to discharge. The same is true for any other sensory receptor, may it be the taste buds, the touch receptors, and all the other receptors that are associated with the sensations of smell, heat and cold, sound, etc.: they are all "blind" as to the quality of their stimulation, responsive only as to their quantity. ● Although surprising, this should not come as a surprise, for indeed "out there" there is no light and no color, there are only electro-magnetic waves; "out there" there is no sound and no music, there are only periodic variations of the air pressure; "out there" there is no heat and no cold, there are only moving molecules with more or less mean kinetic energy, and so on. Finally, for sure, "out there" there is no pain. ● Since the physical nature of the stimulus--its quality--is not encoded into nervous activity, the fundamental question arises as to how does our brain conjure up the tremendous variety of this colorful world as we experience it any moment while awake, and sometimes in dreams while asleep. This is the "Problem of Cognition", the search for an understanding of the cognitive processes. ● The way in which a question is asked determines the way in which an answer may be found. Thus, it is upon me to paraphrase the "Problem of Cognition" in such a way that the conceptual tools that are today at our disposal may become fully effective. To this end let me paraphrase (→) "cognition" in the following way:

COGNITION → computing a reality

With this I anticipate a storm of objections. First, I appear to replace one unknown term, "cognition", with three other terms, two of which, "computing" and "reality", are even more opaque than the definiendum, and with the only definite word used here being the indefinite article "a". Moreover, the use of the indefinite article implies the ridiculous notion of other realities besides "the" only and one reality, our cherished Environment; and finally I seem to suggest by "computing" that everything, from my wristwatch to the Galaxies, is merely computed, and is not "there". Outrageous!

Let me take up these objections one by one. First, let me remove the semantic sting that the term "computing" may cause in a group of women and men who are more inclined toward the humanities than to the sciences. Harmlessly enough,

computing (from com-putare) literally means to reflect, to contemplate (putare) things in concert (com-), without any explicit reference to numerical quantities. Indeed, I shall use this term in this most general sense to indicate any operation (not necessarily numerical) that transforms, modifies, re-arranges, orders, etc., observed physical entities ("objects") or their representations ("symbols"). For instance, the simple permutation of the three letters A,B,C, in which the last letter now goes first: C,A,B, I shall call a computation. Similarly, the operation that obliterates the commas between the letters: CAB; and likewise the semantic transformation that changes CAB into TAXI, and so on. ● I shall now turn to the defense of my use of the indefinite article in the noun-phrase "a reality". I could, of course, shield myself behind the logical argument that solving for the general case, implied by the "a", I would also have solved any specific case denoted by the use of "the". However, my motivation lies much deeper. In fact, there is a deep hiatus that separates the "The"-school-of-thought from the "A"-school-of-thought in which respectively the distinct concepts of "confirmation" and "correlation" are taken as explanatory paradigms for perceptions. The "The-School": My sensation of touch is confirmation for my visual sensation that here is a table. The "A-School": My sensation of touch in correlation with my visual sensation generate an experience which I may describe by "here is a table". ● I am rejecting the THE-position on epistemological grounds, for in this way the whole Problem of Cognition is safely put away in ones own cognitive blind spot: even its absence can no longer be seen.

Finally one may rightly argue that cognitive processes do not compute wristwatches or galaxies, but compute at best descriptions of such entities. Thus I am yielding to this objection and replace my former paraphrase by:

COGNITION → computing descriptions of a reality.

Neurophysiologists, however, will tell us (5) that a description computed on one level of neural activity, say a projected image on the retina, will be operated on again on higher levels, and so on, whereby some motor activity may be taken by an observer as a "terminal description", for instance the utterance: "here is a table". Consequently, I have to modify this paraphrase again to read:

COGNITION → computing descriptions of ⟲

where the arrow turning back suggests this infinite recursion of descriptions of descriptions...etc. This formulation has the advantage that one unknown, namely, "reality" is successfully eliminated. Reality appears only implicit as the operation of recursive descriptions. Moreover, we may take advantage of the notion that computing descriptions is nothing else but computations. Hence:

COGNITION → computations of ⟲

In summary: I propose to interpret cognitive processes as never ending recursive processes of computation, and I hope that in the following tour de force of neurophysiology I can make this interpretation transparent.

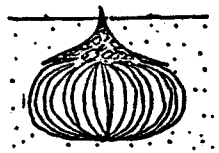


Fig. 7

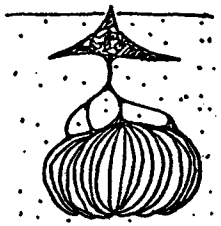


Fig. 8

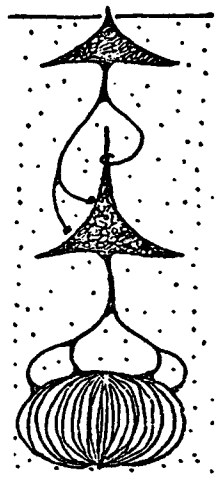


Fig. 9

Neurophysiology

((i) Evolution) In order that the principle of recursive computation is fully appreciated as being the underlying principle of all cognitive processes--even of life itself, as one of the most advanced thinkers in biology assures me (6)--it may be instructive to go back for a moment to the most elementary--or as evolutionists would say, to very "early"--manifestations of this principle. These are the "independent effectors", or independent sensory-motor units, found in protozoa and metazoa distributed over the surface of these animals (Fig. 6). The triangular portion of this unit, protruding with its tip from the surface, is the sensory part, the onion-shaped portion the contractile motor part. A change in the chemical concentration of an agent in the immediate vicinity of the sensing tip, and "perceptible" by it, causes an instantaneous contraction of this unit. The resulting displacement of this or any other unit by change of shape of the animal or its location may, in turn, produce perceptible changes in the agent's concentration in the vicinity of these units which, in turn, will cause their instantaneous contraction,...etc. Thus, we have the recursion:

⟲ change of sensation → change of shape ⟲

Separation of the sites of sensation and action appears to have been the next evolutionary step (Fig. 8). The sensory and motor organs are now connected by thin filaments, the "axons" (in essence degenerated muscle fibers having lost their contractility), which transmit the sensor's perturbations to its effector, thus giving rise to the concept of a "signal": see something here, act accordingly there. ● The crucial step, however, in the evolution of the complex organization of the mammalian central nervous system (CNS) appears to be the appearance of an "internuncial neuron", a cell sandwiched between the sensory and the motor unit (Fig. 9). It is, in essence, a sensory cell, but specialized so as to respond only to a universal "agent", namely, the electrical activity of the afferent axons terminating in its vicinity. Since its present activity may affect its subsequent responsivity, it introduces the element of computation in the animal kingdom, and gives these organisms the astounding latitude of non-trivial behaviors. Having once developed the genetic code for assembling an internuncial neuron, to add the genetic command "repeat" is a small burden indeed. Hence, I believe, it is now easy to comprehend the rapid proliferation of these neurons along additional vertical layers with growing horizontal connections to form those complex interconnected structures we call "brains".

((ii) Neuron) The neuron, of which we have more than ten billion in our brain, is a highly specialized single cell with three anatomically distinct features (Fig. 10): (a) the branch-like ramifications stretching up and to the side, the "dendrites"; (b) the bulb in the center housing the cell's nucleus, the "cell body"; and (c), the "axon", the smooth fiber stretching downward. Its various bifurcations terminate on dendrites of another (but sometimes (recursively) on the same) neuron. The same membrane which envelopes the cell body forms also the tubular sheath for dendrites and axon, and causes the inside of the cell to be electrically charged against the outside with about one tenth of a volt. If in the dendritic region this charge is sufficiently perturbed, the neuron "fires" and sends this perturbation along its axons to their terminations, the synapses.

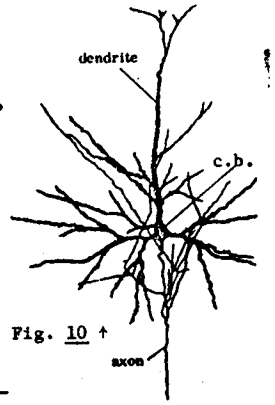


Fig. 10 ↑

((iii) Transmission) Since these perturbations are electrical, they can be picked up by "micro-probes", amplified and recorded. Fig. 11 shows three examples of periodic discharges from a touch receptor under continuous stimulation, the low frequency corresponsing to a weak, the high frequency to a strong stimulus. The magnitude of the discharge is clearly everywhere the same, the pulse frequency representing the stimulus intensity, but the intensity only.

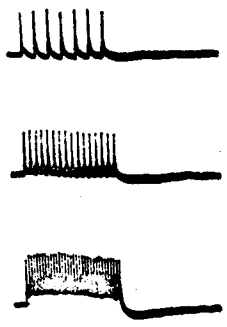


Fig. 11 ↑

((iv) Synapse) Fig. 12 sketches a synaptic junction. The afferent axon (Ax), along which the pulses travel, terminates in an end bulb (EB) which is separated from the spine (sp) of a dendrite (D) of the target neuron by a minute gap (sy), the "synaptic gap" (Note the many spines that cause the rugged appearance of the dendrites in Fig. 10). The chemical composition of the "transmitter substances" filling the synaptic gap is crucial in determining the effect an arriving pulse may have on the ultimate response of the neuron: under certain circumstances it may produce an "inhibitory effect" (cancellation of another simultaneously arriving pulse); in others a "facilitory effect" (augmenting another pulse to fire the neuron). Consequently, the synaptic gap can be seen as the "micro-environment" of a sensitive tip, the spine, and with this interpretation in mind we may compare the sensitivity of the CNS to changes of the internal environment (the sum-total of all micro-environments) to those of the external environment (all sensory receptors). Since there are only a hundred million sensory receptors, and about ten-thousand billion synapses in our nervous system, we are 100,000 times more receptive to changes in our internal than in our external environment.

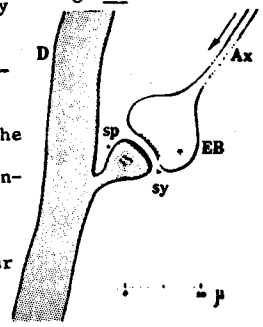


Fig. 12 →

Fig. 13

Fig. 14

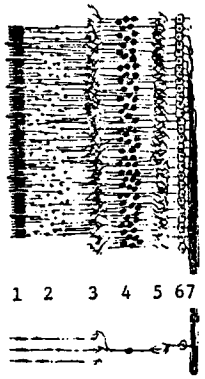


Fig. 15

((v) Cortex) In order that one may get at least some perspective on the organization of the entire machinery that computes all perceptual, intellectual and emotional experiences, I have attached Fig. 13 (7) which shows magnified a section of about 2 square millimeters of a cat's cortex by a staining method which stains only cell body and dendrites, and of those only 1% of all neurons present. Although you have to imagine the many connections among these neurons provided by the (invisible) axons, and a density of packing that is a hundred times that shown, the computational power of even this very small part of a brain may be sensed.

((vi) Descartes) This perspective is a far cry from that being held, say three hundred years ago (8): "If the fire A is near the foot B (Fig. 14), the particles of this fire, which as you know move with great rapidity, have the power to move the area of the skin of this foot that they touch; and in this way drawing the little thread, c, that you see to be attached at base of toes and on the nerve, at the same instant they open the entrance of the pore, d,e, at which this little thread terminates, just as by pulling one end of a cord, at the same time one causes the bell to sound that hangs at the other end. Now the entrance of the pore or little conduit, d,e, being thus opened, the animal spirits of the cavity F, enter within and are carried by it, partly into the muscles that serve to withdraw this foot from the fire, partly into those that serve to turn the eyes and the head to look at it, and partly into those that serve to advance the hands and to bend the whole body to protect it." ● Note, however, that some behaviorists of today still cling to the same view (9) with one difference only, namely, that in the meantime Descartes' "animal spirit" has gone into oblivion.

((vii) Computation) The retina of vertebrates with its associated nervous tissue is a typical case of neural computation. Fig. 15 is a schematic representation of a mammalian retina and its post-retinal network. The layer labeled #1 represents the array of rods and cones, and layer #2 the bodies and nuclei of these cells. Layer #3 identifies the general region where the axons of the receptors synapse with the dendritic ramifications of the "bipolar cells" (#4) which, in turn, synapse in layer #5 with the dendrites of the ganglion cells" (#6) whose activity is transmitted to deeper regions of the brain via their axons which are bundled together to form the optic nerve (#7). Computation takes place within the two layers labeled #3 and #5, that is, where the synapses are located.

Figure 16

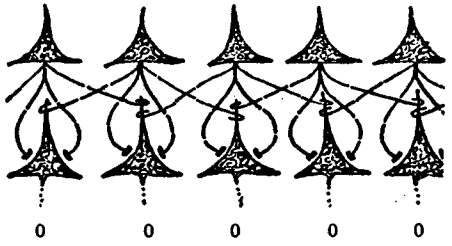
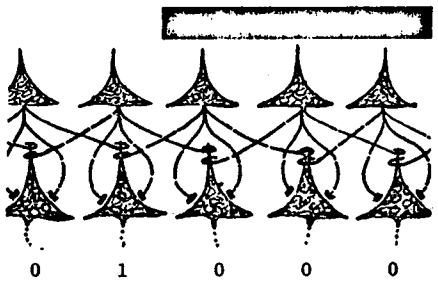
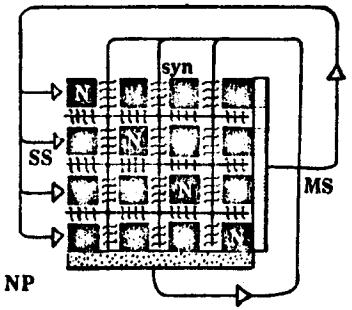


Figure 17



As Maturana has shown (10) it is there where the sensation of color and some clues as to form are computed. ● Form computation: take the two-layered periodic network of Fig. 16, the upper layer representing receptor cells sensitive to, say, "light". Each of these receptors is connected to three neurons in the lower (computing) layer, with two excitatory synapses on the neuron directly below (symbolized by buttons attached to the body), and with one inhibitory synapse (symbolized by a loop around the tip) attached to each of the two neurons, one to the left and one to the right. It is clear that the computing layer will not respond to uniform light projected on the receptive layer, for the two excitatory stimuli on a computer neuron will be exactly compensated by the inhibitory signals coming from the two lateral receptors. This zero-response will prevail under strongest and weakest stimulation as well as to slow or rapid changes of the illumination. The legitimate question may now arise--"Why this complex apparatus that doesn't do a thing?" ● Consider now Fig. 17 in which an obstruction is placed in the light path illuminating the layer of receptors. Again all neurons of the lower layer will remain silent, except the one at the edge of the obstruction, for it receives two excitatory signals from the receptor above, but only one inhibitory signal from the sensor to the left. We now understand the important function of this net, for it computes any spatial variation in the visual field of this "eye", independent of intensity of the ambient light and its temporal variations, and independent of place and extension of the obstruction. ● Although all operations involved in this computation are elementary, the organization of these operations allows us to appreciate a principle of considerable depth, namely, that of the computation of abstracts, here the notion of "edge". ● I hope that this simple example is sufficient to suggest to you the possibility of generalizing this principle in the sense that "computation" can be seen on at least two levels, namely, (a) the operations actually performed, and (b) the organization of these operations represented here by the structure of the nerve net. In computer language (a) would again be associated with "operations", but (b) with the "program". As we shall see later, in "biological computers" the programs themselves may be computed on. This leads to the concepts of "meta-programs", "meta-meta-programs",...etc. This, of course, is the consequence of the inherent recursive organization of those systems.



18.

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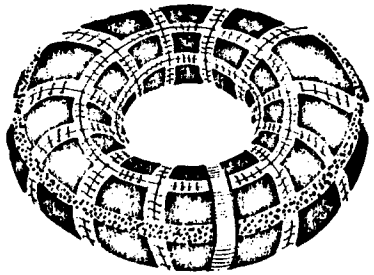

((viii) Closure) By attending to all the neurophysiological pieces, we may have lost the perspective that sees an organism as a functioning whole. In Fig. 18 I have put these pieces together in their functional context. The black squares labeled N represent bundles of neurons that synapse with neurons of other bundles over the (synaptic) gaps indicated by the spaces between squares. The sensory surface (SS) of the organism is to the left, its motor surface (MS) to the right, and the neuropituitary (NP) the strongly enervated mastergland that regulated the entire endocrinal system, is the stippled lower boundary of the array of squares. Nerve impulses traveling horizontally (from left to right) ultimately act on the motor surface (MS) whose changes (movements) are immediately sensed by the sensory surface (SS), as suggested by the "external" pathway following the arrows. Impulses traveling vertically (from top to bottom) stimulate the neuropituitary (NP) whose activity releases steroids into the synaptic gaps, as suggested by the wiggly terminations of the lines following the arrow, and thus modify the modus operandi of all synaptic junctures, hence the modus operandi of the system as a whole. Note the double closure of the system which now recursively operates not only on what it "sees" but on its operators as well. In order to make this twofold closure even more apparent I propose to wrap the diagram of Fig. 18 around its two axes of circular symmetry until the artificial boundaries disappear and the torus (doughnut) as in Fig. 18 is obtained. Here the "synaptic gap" between the motor and sensory surfaces is the striated meridian in the front center, the neuropituitary the stippled equator. This, I submit, is the functional organization of a living organism in a (dough)nut shell. ● The computations within this torus are subject to a non-trivial constraint, and this is expressed in the Postulate of Cognitive Homeostasis:

> "The nervous system is organized (or organizes itself) so that it computes a stable reality."

This postulate stipulates "autonomy", i.e., "self-regulation", for every living organism. Since the semantic structure of nouns with prefix "self-" becomes more transparent when this prefix is replaced by the noun, "autonomy" becomes synonymous with "regulation of regulation". This is precisely what the doubly closed, recursively computing torus does: it regulates its own regulation.

Significance

It may be strange in times like these to stipulate autonomy, for autonomy implies responsibility: If I am the only one who decides how I act then I am responsible for my action. Since the rule of the most popular game played today is to make someone else responsible for my acts--the name of the game is "heteronomy"--my arguments make, I understand, a most unpopular claim. One way of sweeping it under the rug is to dismiss it as just another attempt to rescue "solipsism", the view that this world is only in my imagination and the only reality is the imagining "I". Indeed, that was precisely what I was saying before, but I was talking only about a single organism. The situation is quite different when there are two, as I shall demonstrate with the aid of the gentleman with the bowler hat (Fig. 20). He insists that he is the sole reality, while everything else appears only in his imagination. However, he cannot deny that his imaginary universe is populated with apparitions that are not unlike himself. Hence, he has to concede that they themselves may insist that they are the sole reality and everything else is only a concoction of their imagination. In that case their imaginary universe will be populated with apparitions, one of which may be he, the gentleman with the bowler hat. According to the Principle of Relativity which rejects a hypothesis when it does not hold for two instances together, although it holds for each instance separately (Earthlings and Venusians may be consistent in claiming to be in the center of the universe, but their claims fall to pieces if they should ever get together), the solipsistic claim falls to pieces when besides me I invent another autonomous organism. However, it should be noted that since the Principle of Relativity is not a logical necessity, nor is it a proposition that can be proven to be either true or false, the crucial point to be recognized here is that I am free to choose either to adopt this principle or to reject it. If I reject it, I am the center of the universe, my reality are my dreams and my nightmares, my language is monologue, and my logic mono-logic. If I adopt it, neither me nor the other can be the center of the universe. As in the heliocentric system, there must be a third that is the central reference. It is the relation between Thou and I, and this relation is IDENTITY:

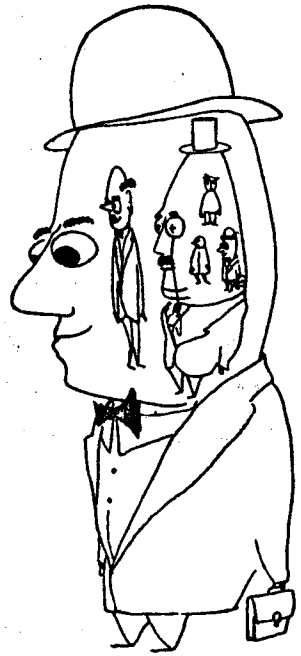

Figure 20

Reality = Community.

What are the consequences of all this in ethics and aesthetics?

The Ethical Imperative: Act always so as to increase the number of choices.

The Aesthetical Imperative: If you desire to see, learn how to act.

Acknowledgement

I wish to express my gratitude to my students Valarie Lamont and Stuart Umpleby who encouraged me to develop some of these ideas under the auspices of their Grant GY10766 with the National Science Foundation, and to the Department of Electrical Engineering which graciously permitted me to use its facilities. To Lebbeus Woods, Rodney Clough and Gordon Pask I am indebted for offering their artistic talents to embellish this paper with Figs. (7,8,9,16,17), (18,19), and (20) respectively, and last but not least to Kathy Roberts whose aesthetic sense, competence and patience allowed this article to become what it is.

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Competition vs. Co-operation

Competition vs. Co-operation
Graphic Analogues

by

Herbert Brün

The Text.

Many sentences can be said about all computer graphics. Will, unfortunately, be said, too. Not here.

Some sentences can be said only about some computer graphics. They are rarely found and could be said loudly. Not, however, by the composer.

All he has to say is contained in a few statements indicating how to distinguish the computer graphics which he made from all, of which they are some, from some, of which they are, hopefully, a few, so that they be these.

The Context.

All the different computer programs which generated these graphics are variations on one single theme. The theme is a statement I make about humans and human society, not as they think and act and as it is (1), but as they could think and act and as it could be (2). The variations relate to the theme explicitly only by analogy.

The theme, my statement, exists in reality, whether it speaks about a reality or about a possibility. In this sense these graphics are representative art, emphatically an output.

An observer, however, can see any one of the graphics as a theme, and attempt to make statements which reflect, by analogy and mutatis mutandis, the theme he sees. In this sense these graphics are, until the observer will have composed his statements, non-representative art, emphatically an input.

The Theme.

As long as we do not abandon present society, future society is "anarchy and chaos".

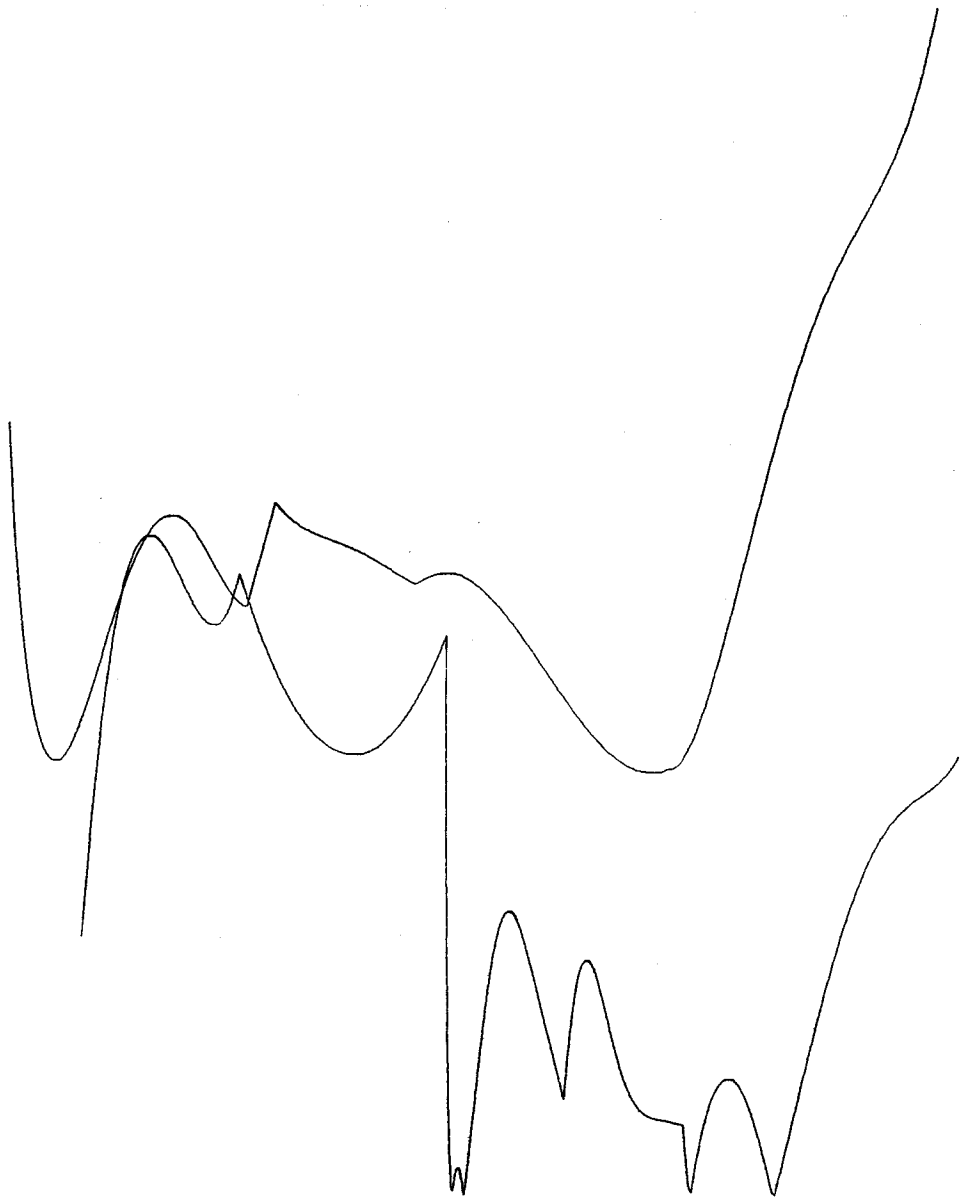
In a desirable society which, as we are not it, is a future society which, as we are not it, is a future society, each of us, its members, moves through life along some path composed of steps taken in preference to many equally possible and equally desired steps not taken. The preference is with each of us, each member. It is directed, however, not by each of us contemplating his desired path (1), but rather by all of us contemplating the contribution of every step of every member to formations of relations (2). A step is preferred when found, beyond being desired, to also be desirable.

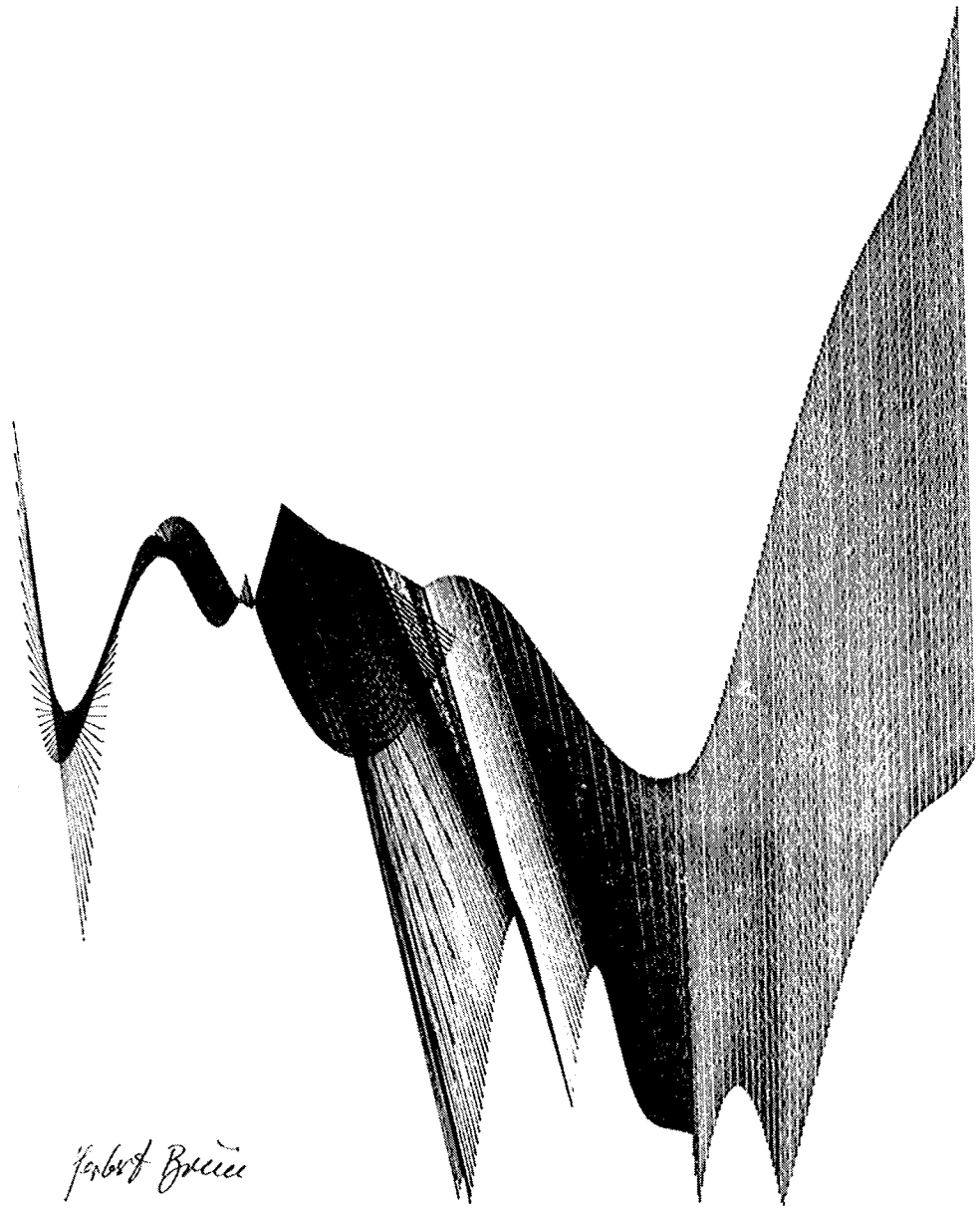
Unless we abandon present society, future society will be anarchy and chaos.

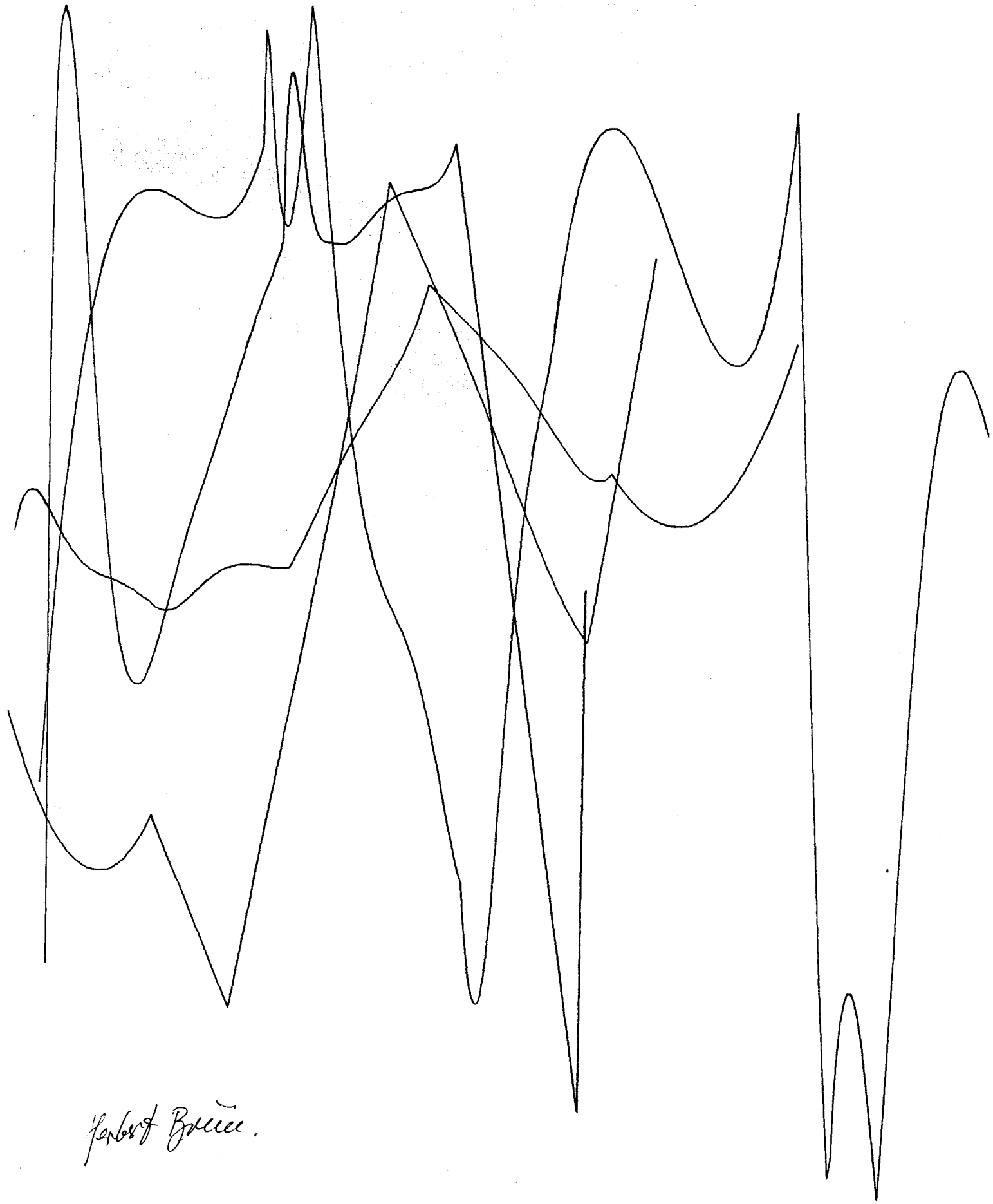
The Analogy.

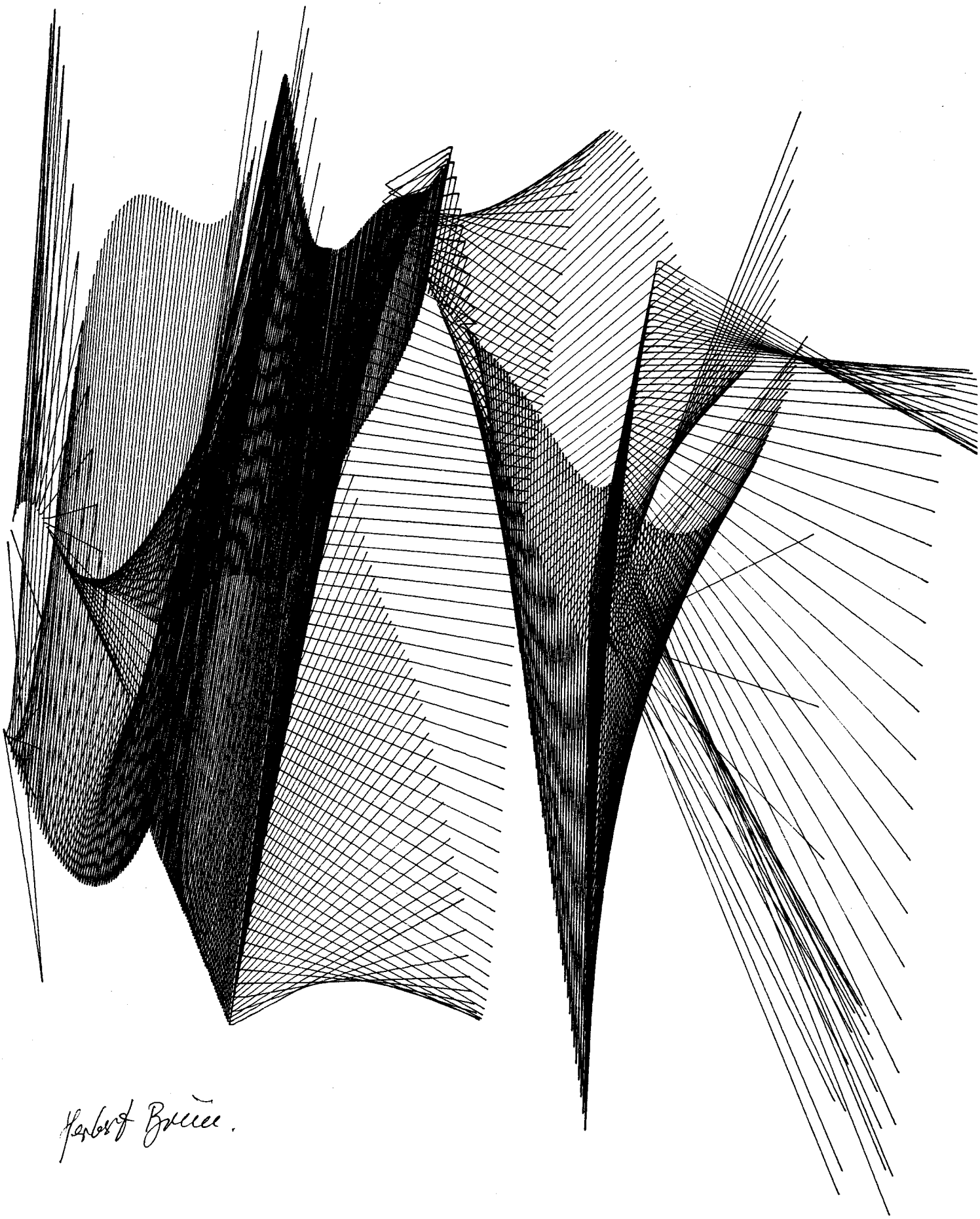
These graphics are traces left by a process. Up and down and across the page a few point lept in small leaps leaving a mark wherever they alighted. Each point moved according to a set of rules associated exclusively with this point and distinct from all sets of rules associated with any of the other points. The lines in (2) do not connect the consecutive marks left by any one leaping point, they do not outline any point's path as in (1). The lines do connect instead the new marks left by every point after all points' latest leap. The traces of this process emphasize the shape created by all points moving (2), rather than the outlines followed by each point's leap (1).

(1) Competitive
(2) Co-operative






Herbert Bayer.


Herbert Bayer.

THE CYBERNETICS OF COMPETITION: A BIOLOGIST'S VIEW OF SOCIETY

*GARRETT HARDIN, Ph.D.**

Science fiction depends heavily on the postulation of Martians, who are invariably assumed to be more advanced intellectually than we. The psychological reason for this assumption seems clear: the whole apocalyptic myth of the men from Mars fulfils needs that were earlier satisfied by the idea of an imminent Kingdom of Heaven. To the objective eye of an anthropologist, our fictional Martians are manifestly gods, and science fiction is a kind of theology.

The odd thing is that before another human lifetime has passed, we may have a chance to see what Martians are really like (if they exist). And if we do, will it be gods that we are finding, or something less than human? I predict the latter, on the grounds that we have not yet heard from them, as we should have if their technology were really more advanced than ours. If they exist and if they trail us in knowledge, we will then be faced with an interesting complex of problems. Should we educate them? Can we educate them? How?

In the past, in dealing with the backward peoples of the earth (a similar problem), we have taken the easy path and have given them the answers ready-made. But suppose for once we decide to give our backward brethren, not the answers, but the *questions*—and let them work out their own answers? Suppose we expose the men from Mars to all the complexities of our technological situation and let them figure out the explanations? Watching them, we should learn a great deal about epistemology!

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This *Gedankenexperiment* is introduced for nontrivial reasons. The point I wish to make is this: Martians faced with the riddle of our technology would have a far harder time than we did in creating the underpinning of physical theory, even if they are as intelligent as we. Faced with airplanes, how could they arrive at a theory of gravitation? Listening to the radio, would it occur to them that the intensity of electromagnetic radiation obeyed an inverse-square law? In the presence of an atomic explosion, how could they conceive of a conservation law? They might, of course. After all, we found the laws of nature. But in our search we were fortunate in this respect: most of the time invention was only a very little bit ahead of theory; often it was even behind. We were able to discover theory because the world was simple. A theory-poor Martian confronted with our invention-rich world would have a much harder time discovering theory than we did. He might fail utterly.

Picture if you will a convention of Martians, reading scientific papers to each other, papers concerned with the theory of the Earth. One of them proposes a universal law of gravitation. Pandemonium breaks loose. In the absence of all knowledge about combustion, Newton's three laws of motion, electricity, magnetism, superconductivity, radioactivity, and all the rest, it would be all too easy for the Martian auditors to cite evidence upon evidence to refute the idea of universal gravitation. Only a total complex of theory ("model") can be tested against a factual complex. If the elements of a theoretical construct are tested one by one against the complex world, they will, one by one, be "disproved." Probably our visitors from Mars could arrive at a workable theory only if we earthlings agreed to play "Twenty Questions" with them—to give them a nod of approval whenever they stumbled across a fruitful element of theory. (They would, of course, have to have faith in us; for how could they know that we were not merely playing tricks on them?)

The relation of our hypothetical Martians vis-à-vis the physical world is, I submit, our relation to the social world we have created. Over a period of thousands of years, out of necessity and our unconscious, we have elaborated fantastically complex mechanisms of social interaction, inventions so subtle and pervasive that much of the time we cannot even *see* them, much less explain them. In trying to discover or invent social theory we are in the position of the Martians of our thought-experiment. We have too many facts and not enough theory. Data-rich and theory-

poor—that is the social world. And there is no one to play "Twenty Questions" with us.

I. *The Nature of Theory*

Popular writing commonly pictures the great scientist as an extremely critical person. There is much truth in this, but the contrary is also partly, and significantly, true. I know a chemist who frequently says to his graduate students, "Don't let a fact stand in the way of a good hypothesis." This is certainly dangerous advice, but inasmuch as the speaker has won a Nobel Prize for his revolutionary chemical theories, we must assume that he knows something of the requirements for creativity. A good scientist should be a good critic part of the time; but he cannot be a good critic all of the time, not if he hopes to discover new and surprising truths. Different occupations require different temperaments. In mentally reviewing a large roster of successful scientists, I am struck with the fact that it includes no men who were ever lawyers. I can recall scientists who in their early years were artists, musicians, actors, machinists, carpenters, businessmen, and even wearers of the cloth—but no lawyers. From the past, Advocate Fermat is the nearest to an exception I can think of—but he became a mathematician, not a scientist.

A good critic must be tough-minded, to use William James's term. Good lawyers are like other good critics. The successful developer of scientific theory, on the other hand, must be *tough-motivated.* A scientific theory, in its early stages at least, is incapable of explaining all the data it is confronted with. This fact may be illustrated by a joke that was standard in engineering circles for several generations: "The bumble bee doesn't have large enough wings to fly, but fortunately the bee doesn't know this, and so he flies anyway." This was a way of acknowledging that the theory of aerodynamics was inadequate to explain the facts. But engineers did not abandon their theory. Instead they retained it (because of its many successes) in the hope—indeed, in the *faith*—that it would one day be enlarged in such a way as to make possible an explanation of the flight of the bumble bee. How scientists decide which theories to have faith in, and which not, is a problem of great subtlety, which has been courageously attacked by Polanyi [1].

In the development of social theory we must follow the path that has proven successful in the natural sciences: we must be critical but not too critical. We must be willing to *entertain* partial theories while we see whether they are capable of fruitful enlargement. In the early stages we must expect to be confronted with markedly different theoretical models. What is offered here is one biologist's conception of the foundations of social and economic theory. "What presumption!" social scientists may say. Admitted; but biology, as Warren Weaver has put it, is "the science of organized complexity"—and what is the social scene if not one of organized complexity? Some of the principles worked out in one field should be at least part of the theoretical structure of the other. Particularly relevant are the principles of *cybernetics,* the science of communication and control within organized systems. Let us see what some of these are, as they have been developed in the natural sciences, and how they may apply to the social sciences.

II. *Positive Feedback*

Money put out at compound interest and the unimpeded reproduction of any species of living organism are both examples of systems with positive feedback. Mathematically they are most conveniently represented by equations of the form

$$y = Ce^{bt} \qquad (1)$$

where C represents the initial amount (of money or organisms), y is the number or amount after time t, e is the base of natural logarithms (2.71828 . . .), and b is a measure of the rate of increase—the greater the rate, the greater is b. (For example, if there is no increase at all, $b = 0$; when the rate of increase is 10 per cent, $b = .0953$.)

The exponential function just given may be graphed as shown in Figure 1. Notice that the curve rises ever more steeply with the passage of time. Money which is initially interest becomes principal-money, earning more interest-money. Children become parents and produce more children. Hence the use of the term "feedback." The output (part of it, at least) feeds back as input. When the exponent b is positive, we speak of positive feedback. To persist indefinitely, a species must be capable of positive feedback reproduction. To attract investment, a borrower must offer the same possibility for the sums invested.

The exponential equation can be represented by a family of curves, one curve for each value of b. But we can generalize the graph shown and say that if we imagine a flexible abscissa—the time axis—one curve stands for

all positive exponential functions. With elephants, the scale would read in decades; with bacteria, in minutes. Similarly, with money at compound interest, we have only to stretch or contract the scale on the abscissa to make one curve fit all rates of interest.

In all cases, we should note this: the curve of unimpeded positive feedback "approaches infinity" with the passage of time. This is true no matter how slow the rate of reproduction, no matter how low the rate of interest. *But ours is a finite world.* Therefore it is clear that positive feedback is not tolerable as a permanent state of affairs. It can be tolerated only

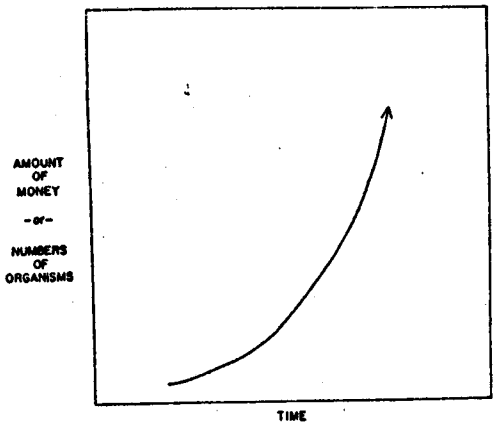

FIG. 1.—The result of positive feedback

for short periods of time. In biology no species can indefinitely increase in keeping with its potential, or soon all the world would be nothing but salmon, elephants, men, or whatever. In economics no sum of interest can be allowed to earn compound interest except for very short periods of time. Suppose, for example, that the thirty pieces of silver which Judas earned by betraying Jesus had been put out at 3 per cent interest. If we assume these pieces of silver were silver dollars, the savings account would today amount to a bit more than 9×10^{14} dollars, or more than $300,000 for every man, woman, and child on the face of the earth. Since the real economic wealth of the world is certainly much less than that amount, it would be quite impossible for Judas' heirs (all of us, I presume) to close out the account. The balance in the bankbook would be largely fictional.

A modern William Paley [2] contemplating bank failures, embezzlements, business collapses, runaway inflation, and revolutions might well argue that these catastrophes are examples of "Design in Nature," for by their presence the impossible consequences of perpetual positive feedback are avoided. A professional economist would be more likely to suggest that we could achieve the same end by falling interest rates, which could fall to zero if need be. Historically, however, this more pleasant possibility has seldom, if ever, developed. Failures, inflation, and revolution have been the historically important counteractants to positive feedback.

In contemplating the implications of the exponential growth function, we see also a fundamental criticism of all forms of "Growthmanship" (to use William H. Peterson's term). Plainly the idea of continuous national growth is a dangerous myth. Recent public debate as to whether our economy should grow at a rate of one or two or three per cent annually deals with a question which is, in the time scale of human history, of only evanescent interest. Continuous economic growth of the order of magnitude hoped for is possible only for a short period of time—a few centuries at most. If a political and economic unit can achieve enduring stability—and we don't know that it can—it could only be with *zero* per cent growth. Not a bit more. Not if growth is measured in material terms, with statistics that are corrected for the effects of inflation. (If growth is in nonmaterial terms, that is another, and a far more interesting, question, which will be neglected here.)

III. *Negative Feedback*

If a system that includes positive feedback is to possess stability, it must also include "negative feedback." The meaning of this term can be made clear by an example from engineering.

The temperature of a room is kept constant by the combined operation of a furnace and a thermostat. The result is a cybernetic system which can be represented by a type of diagram previously introduced [3]. As indicated in Figure 2, when the temperature rises, a bimetallic strip in the thermostat is distorted, thus breaking an electric contact, thus turning off the furnace, and so lowering the temperature. On the other hand, a lowering of the temperature leads to a re-establishment of the electric contact, thus starting the furnace, thus raising the temperature. The temperature of the room will thus fluctuate about the "set point" of the thermostat—and

this is what we mean when we say "the temperature is held constant." The variations do not exceed certain limits.

Now for an example from biology. In any natural setting, the population size of a given species is relatively constant for long periods of time—usually thousands, or even millions, of years. How this constancy is maintained is shown in Figure 3. If the population should increase above the "natural" population size—which we may call the "set point" of the population—various kinds of negative feedback will be brought into play. Shortage of food may lead to starvation. Fighting may lead to deaths or to

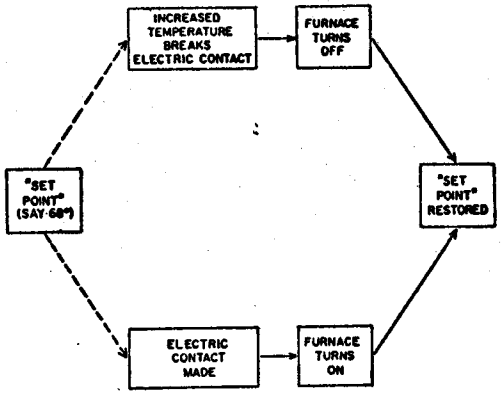

FIG. 2.—Cybernetic equilibrium maintained by negative feedback

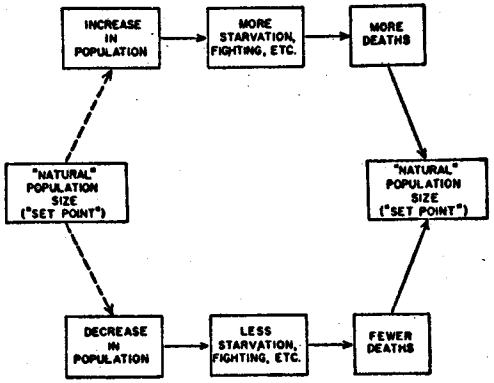

FIG. 3.—Cybernetic maintenance of population equilibrium

interference with breeding. And so on. The result of all this will be more deaths, and perhaps fewer births, and the population will fall. The consequence of a decrease in population can be read from the diagram. Again we have a cybernetic scheme that produces fluctuations about a "set point." What determines the "set point" is not so easy to tell. That is, our knowledge of the interactions of the natural controls of population size is usually insufficient to enable us to *predict* what the "carrying capacity" of the land will be. We have to go into the field and measure it; we determine it *ex post facto*. Nevertheless, we retain this model and interpret our inability to make an a priori determination of the set point as indicating a deficiency in our knowledge rather than a defect in the model.

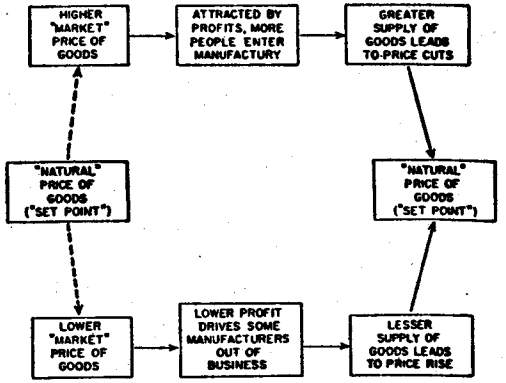

FIG. 4.—Cybernetic regulation of price, in the Ricardian model

The cybernetic model can be carried over into economics, as shown in Figure 4, which depicts the control of price in the Ricardian economic scheme. The well-known course of events can be read from the figure. Again we see that negative feedback produces stability about a "set point," which Ricardo called the "natural price." The model would be more realistic if it were constructed in terms of *profit* rather than price, but for historical continuity we retain the classic Ricardian element *price*. As with the biological example previously used, the meaning of "natural" can, in general, only be determined *ex post facto*. The word "natural" is here (as elsewhere) a verbal cloak for ignorance. Nevertheless, it or an equivalent word is needed to remind us of the state of affairs. There is mystery here. It was this mystery together with the unpremeditated con-

sequences of the economic cybernetic system that led Adam Smith to speak of an "Invisible Hand."

An effective cybernetic system produces stability, i.e., fluctuations within limits, and this we esteem. A system that produces a stable temperature, or a stable population, or a stable price, seems to us somehow *right*. When we examine any cybernetic system we discover that it is more or less wasteful. The thermostated room wastes heat; the natural population wastes lives; the economic system produces price wars and business bankruptcies. We may refine the controls and minimize the losses (of heat, or of money, for example), but a close examination of the system convinces us that there must always be some losses, waste in some sense. This is so because the controls that serve to produce equilibria are themselves so many modes of loss. Accounting procedures, insurance programs, police forces, sweat glands, electric fans, predation, crowd diseases, delicate thermostats—all these are forms of waste. We do not regret them, for the negative feedback produced by each of these elements acts as a check to some kind of uncontrolled and ruinous positive feedback. But each negative feedback device has its price, and we cannot get rid of one form of loss without incurring another. In a deep sense we see that some waste is inevitable and natural, and we recognize as immature the man who compulsively tries to do away with all waste. We recognize as pathological the goal of a waste-free world. This recognition is an important element in that complex of temperament that we label "conservative." Insofar as we think deeply, we all, of necessity, partake of this temperament to some extent.

But because the mature person acknowledges the inevitability of some waste, it does not follow that he must be reconciled to any amount and kind of waste. In the first excitement of discovering the beauties of economic cybernetics, David Ricardo quite naturally made such an error. In speaking of the cybernetic system that stabilizes the population of laborers, Ricardo [4] wrote: "When the market price of labour is below its natural price, the condition of the labourers is most wretched: then poverty deprives them of those comforts which custom renders absolute necessaries. It is only after their privations have reduced their number, or the demand for labour has increased, that the market price of labour will rise to its natural price. . . ."

Attention should be called to the use of the word "natural" in this question. It would be antihistorical to expect Ricardo to speak of the "set point of labor" inasmuch as the term "set point" was not used for another century; but that is not the only criticism that can be made of the word "natural." Looking at the problem through the eyes of Stephen Potter [5], what do we see? Plainly, that an advocate is likely to use the word "natural" in order to insinuate approval of the "natural" thing into the mind of his auditor. By so doing, the advocate frees himself of the necessity of developing a defensible argument for the "natural" thing—for who can disprove of that which is "natural"?

This attack on the use of the word "natural" is more than a mere Potterian counterploy, as is clearly shown by the following defense given by Ricardo [6].

> Labour, like all other things which are purchased and sold, and which may be increased or diminished in quantity, has its natural and its market price. The natural price of labour is that price which is necessary to enable the labourers, one with another, to subsist and perpetuate their race, without either increase or diminution.
>
> These then are the laws by which wages are regulated, and by which the happiness of far the greatest part of every community is governed. Like all other contracts, wages should be left to the fair and free competition of the market, and should never be controlled by the interference of the legislature.

This passage leaves no question in our mind that Ricardo identified the momentary state of things in his own time as "natural" and that all attempts to modify it further by new legislation were "unnatural" and hence improper in some deep sense. With rare exceptions, most of us post-Ricardians have been unwilling to accept this view. We will accept the starvation of field mice; but not that of human workers. Ricardo, at least on paper, accepted both. But—perhaps because of a delicate consideration of the feelings of others?—he used a most elegant euphemism for the facts. "It is only after their privations have reduced their number," he wrote; and insisted that "wages should be left to the fair and free competition of the market." The market must be free, that we may enjoy the blessings of cybernetic stability. Most of us now think that Ricardo's price is too high. We are willing to make use of "unnatural" controls of the price of labor even if it means losing some of our freedom. The history of the labor movement since Ricardo's time may be regarded as one long struggle to substitute other forms of waste for the "natural" form which Ricardo, who was not a laborer, was willing to accept.

IV. *The Competitive Exclusion Principle*

Perhaps more important than the humane argument just given against the Ricardian model is a theoretical argument which indicates that the

cybernetic system he described is fundamentally unstable. Before we can discuss this matter we need to introduce a biological principle known by various names but recently [3] called the "competitive exclusion principle." The historical origin [7] of this principle is complex; no one man can be given credit for it. In the last decade it has become increasingly clear that it is a basic axiom of biological theory; and it will be my argument here that it is basic also to sociological and economic theory. But first, let us develop the principle in an exclusively biological context.

Consider a situation in which two mobile species, X and Z, live in the same habitat and also live in the same "ecological niche," i.e., live exactly the same type of life. Species X multiplies according to this equation:

$$x = Ke^{ft}, \tag{2}$$

where x is the number of individuals of species X at time t; e is the base of natural logarithms; K is a constant standing for the number of x at $t = 0$; and f is a constant determined by the "reproductive potential" of the species.

Species Z multiplies according to this equation:

$$z = Le^{gt}, \tag{3}$$

in which the constants have the same meaning as before (though, in the general case, with different values).

Suppose these two species are placed in the same universe to compete with each other. What will happen? Let us represent the ratio of the numbers of the two species, x/z, by a new variable, y. Then:

$$y = \frac{Ke^{ft}}{Le^{gt}}. \tag{4}$$

Since K and L are both constants, they can be replaced by another constant, say C; and making use of a well-known law of exponents, we can write:

$$y = Ce^{ft-gt} = Ce^{(f-g)t}. \tag{5}$$

But f and g are also constants, and can be replaced by another constant, say b, which gives us:

$$y = Ce^{bt}, \tag{6}$$

which is, of course, our old friend equation 1 again, the equation of exponential growth. The constant b will be positive if species X is competitively superior, negative if it is species Z that multiplies faster.

What does this mean in words? This: in a finite universe—and the organisms of our world know no other—where the total number of organisms of both kinds cannot exceed a certain number, a universe in which a fraction of one living organism is not possible, one species will necessarily replace the other species completely if the two species are "complete competitors," i.e., live the same kind of life.

Only if $b = 0$, i.e., if the multiplication rates of the two species are *precisely* equal, will the two species be able to coexist. Precise, mathematical equality is clearly so unlikely that we can ignore this possibility completely. Instead we assert that the *coexistence of species cannot find its explanation in their competitive equality*. This truth has profound practical implications.

V. *Have We Proved Too Much?*

It is characteristic of incomplete theory that it "proves too much," i.e., it leads to predictions which are contrary to fact. This is what we find on our first assessment of the competitive exclusion principle. If we begin with the assumption that every species competes with all other species, we are forced to the conclusion that one species—the best of them all—should extinguish all other species. But there are at least a million species in existence today. The variety seems to be fairly stable. How come?

There are many answers to this question. I will discuss here only some of the answers, choosing those that will prove suggestive when we later take up problems of the application of the exclusion principle to human affairs. The following factors may, in one situation or another, account for the coexistence of species.

Geographic isolation.—Before man came along and mixed things up, the herbivores of Australia (e.g., kangaroos) did not compete with European herbivores (rabbits). Now Australians, desirous of retaining some of the aboriginal fauna, are trying desperately to prevent the working out of the exclusion principle.

Ecological isolation.—English sparrows introduced into New England excluded the native bluebirds from the cities. But in very rural environments bluebirds have, apparently, some competitive advantage over the sparrows, and there they survive today.

Ecological succession.—It is not only true that environments select organisms; in addition, organisms make new selective environments. The conditions produced by a winning species may put an end to its own success.

Grape juice favors yeast cells more than all others; but as the cells grow they produce alcohol which limits their growth and ultimately results in new predominant species, the vinegar bacteria. In the growth of forests, pine trees are often only an intermediate stage, a "subclimax," being succeeded by the climax plants, the hardwood trees, which out-compete the pines in growing up from seeds in the shade of the pine tree.

Lack of mobility.—The universal application of the exclusion principle to plants is still a controversial issue, which cannot be resolved here. It may be that the lack of mobility, combined with certain advantages to being first on the spot, modify the outcome significantly. Although this explanation is questionable, it is a fact of observation that a pure stand of one kind of plant hardly ever occurs.

Interbreeding.—If two competing populations are closely enough related genetically that they can interbreed, one group does not replace the other, they simply merge. This does not end competition; it merely changes its locus. The different genes of the formerly distinct groups now compete with each other, under the same rule of competitive exclusion.

Mutation.—Continuing with the example just given, one gene never quite eliminates another because the process of mutation is constantly producing new genes. The gene for hemophilia, for example, is a very disadvantageous gene; but even if hemophiliacs never had children (which is almost true), there would always be some hemophiliacs in the population because about three eggs in every 100,000 produced by completely normal women will be mutants that develop into hemophilic sons.

VI. *The Cybernetics of Monopoly*

We are now ready to take a second look at the Ricardian thesis. The model implicit in his writings may not unfairly be stated as follows. We conceive of a single product manufactured by a number of entrepreneurs, each of whom must, for simplicity in theory construction, be imagined to be engaged in the manufacture of this product only. Under these conditions the Ricardian cybernetic scheme diagrammed in Figure 4 will prevail—but only for awhile. History indicates that the number of entrepreneurs is subject to a long-term secular trend toward reduction. In the early days there were many scores of manufacturers of automobiles in the U.S.; today there are less than a dozen. Ball-point pens, transistors—every new product—have followed the same evolution. The history of the oil industry (to name only one) indicates that under conditions of perfect laissez faire, competition has a natural tendency to steadily decrease the number of competitors until only one is left. In industries with heavy overhead this tendency is a consequence of the economy of size. But even without this size effect, a simple extension of the competitive exlcusion principle into economics shows that a reduction in the number of competitors will take place as the more efficient entrepreneurs squeeze out the less efficient, until ultimately only one is left. If this were not so, we would have to conclude that the free enterprise system has no tendency to produce the lowest possible price; or, to put it differently, that it has no tendency to produce the maximum efficiency. Either conclusion would deny the claims to virtue put forward by the defenders of the free enterprise system.

If a monopoly is produced, what then? Here is a question which Ricardo did not face. At first glance one might say that the monopoly price should be stable, because if it were to rise, new entrepreneurs would be attracted to the field and would lower the price. But this is a naïve view. We know that it is more difficult to start a business than to continue one, and consequently a monopolist can maintain a price considerably above the "natural price." Furthermore, a realistic model must include much more than we have indicated so far. We must consider the whole complex of phenomena that we include under the word "power." *Social power is a process with positive feedback.* By innumerable stratagems a monopolist will try to manipulate the machinery of society in such a way as to ward off all threats to re-establish negative feedback and a "natural" cybernetic equilibrium. And, as history shows, the monopolist in one field will seek to extend his power into others, without limit.

What has just been said about business monopolies applies equally to labor monopolies, *mutatis mutandis.* Insofar as they meet with no opposition, there is little doubt that labor monopolies seek to produce an ever higher price for labor. At the same time, they protest the appearance of business monopolies. Contrariwise, unopposed businessmen seek to promote a free market in labor while restricting it in their own field (by "Fair Trade" laws, for instance). It is not cynicism but simple honesty that forces us to acknowledge that Louis Veuillot (1813–1883) was right when he said: "When I am the weaker, I ask you for liberty because that is your principle; but when I am the stronger I take liberty away from you because that is my principle." In other words, such verbal devices as "prin-

ciples," "liberty," and "fairness" can be used as competitive weapons. Each purely competitive agent, were he completely honest and frank, would say, "I demand a free market—but only for others." It is, in fact, a natural part of *my* competitive spirit to seek to remove from *my* field the natural competition on which the validity of the Ricardian scheme rests.

Such an analysis, which is based on the observed behavior of competing groups, may seem depressing. Rather than dwell on the possible emotional consequences of the facts, let us see what we can do about arranging the world to our satisfaction. Let us try to enlarge the model of our theory. To do this we acknowledge that we are *not only* unconscious "purely competitive agents," but that we are also capable of being conscious. We can predict the results of our own actions, as well as the results of the actions of those opposed to us. We acknowledge that *words are actions*, actions designed to influence others. Because we can see that others resort to high-flown rhetoric when they want to influence us, we become suspicious of our own arguments. We operate under the basic and parsimonious rule of the Theory of Games [8], which says that we must impute to others intelligence equal to our own. Under these conditions we seek the *boundary conditions* within which the rule of laissez faire can produce stability.

VII. *The Limits of Laissez Faire*

Laissez faire has a strong emotional appeal; it seems somehow right. Yet we have seen that, in the limit, the rule fails because of the positive feedback of power. Can we *rationalize* the rule of laissez faire by harmonizing it with boundary conditions?

I suggest that there is, in biology, a useful model already at hand [9]. Consider the cybernetic system that controls the temperature of the human body, a system that is enough like that shown in Figure 2 so that it need not be diagrammed here. This system works admirably. So well does it work that, for the most part, we can safely adopt a laissez faire attitude toward our body temperature.

The system works without conscious control or planning. But only within limits. If the environmental stress is too great, temperature control fails. At the upper limit, too great a heat input raises the body temperature to the point where the physiological thermostat no longer functions. Then higher temperature produces greater metabolism, which produces more heat, which produces higher temperature, which—and there it is, positive feedback, leading to death, to destruction of the whole system. Similarly with abnormally low temperatures. The working of the system is shown in Figure 5. There is a middle region in which a laissez faire attitude toward control of the environment works perfectly; we call this middle region the *homeostatic plateau*. (The word "homeostatic" was coined by W. B. Cannon to indicate constancy-maintained-by-negative-feedback.) Beyond the homeostatic plateau, at either extreme, lies positive feedback and destruction. Plainly, our object in life must be to keep ourselves on the homeostatic plateau. And insofar as it is within our power to affect the design of a system, we would wish to extend the plateau as far as possible.

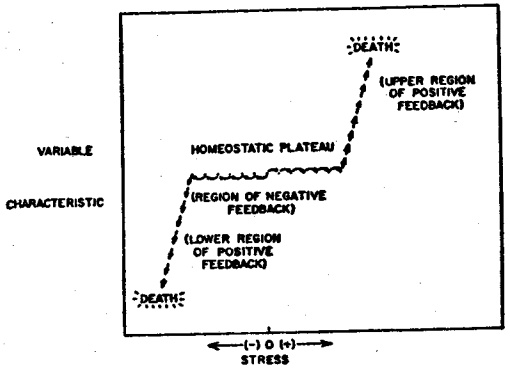

FIG. 5.—The cybernetics involved in the survival of a system

Is this not the model for all cybernetic systems, sociological and economic as well as biological, the model on which ethics must be based? The desire to maintain *absolute* constancy in any system must be recognized as deeply pathological. Engineering theory indicates that excessive restraints can produce instability. In psychiatry also, the desire for complete certainty is recognized as a most destructive compulsion. And in the history of nations, attempts to control rigidly all economic variables have uniformly led to chaos. The psychologically healthy human recognizes that fluctuations are unavoidable, that waste is normal, and that one should institute only such explicit controls as are required to keep each system on its homeostatic plateau. We must devise and use such controls as are needed to keep the social system on the homeostatic plateau. On this plateau—but not beyond it—freedom produces stability.

We can do this only if we explicitly give up certain superficially plausible objectives which are incompatible with stability. In the realm of economics, the most dangerous will-o'-the-wisp is the word "efficiency." Consider the classical Ricardian economic system. If we decide that all waste is bad and that we must maximize efficiency, then we will stand admiringly by and watch the competitive exclusion principle work its way to its conclusion, leaving only one surviving entrepreneur, the most efficient. And then? Then we find that we have a tiger by the tail, that we have allowed the positive feedback of power to go so far that we may be unable to regain anything that deserves the name of freedom. It is suicidal to seek complete efficiency. The Greek Solon said, "Nothing in excess," to which we must add, *not even efficiency*. Whatever it is that we want to maximize, it cannot be efficiency. We can remain free only if we accept some waste.

How are we to keep a social system on its homeostatic plateau? By laws? Not in any simple way, for the effect of an action depends on the state of the system at the time it is applied—a fact which is, I believe, not systematically recognized in the theory of law. An act which is harmless when the system is well within its homeostatic boundaries may be quite destructive when the system is already stressed near one of its limits. *To promote the goal of stability, a law must take cognizance not only of the act but also of the state of the system at the time the act is performed.* In his effort to obtain the maximum individual freedom, it is to be expected, of course, that "economic man" will try to defend his actions in terms of some tradition-hallowed "absolute" principles that take no cognizance of the state of the system. Absolutists of all sorts may, in fact, be defined as men who reject *systematic* thinking.

Consider this question: Should a man be allowed to make money, and keep it? In the history of Western capitalism our first approximation to an answer was an unqualified *Yes*. But as we became aware that money is one means of achieving the positive feedback of power, we looked around for curbs. One of these is the graduated income tax, which most men would now defend as a reasonable brake to the positive feedback of economic power. Yet it can easily be attacked as being "unfair," and in fact has been so attacked many times. As late as 1954 (according to a press report) the industrialist Fred Maytag II, speaking to a meeting of the National Association of Manufacturers on the subject of discriminatory taxes, issued this clarion call for action: "The hour is late, but not too late. There is no excuse for our hesitating any longer. With all the strength of equity and logic on our side, and with the urgent need for taking the tax shackles off economic progress, initiative is ours if we have the courage to take it."

One cannot but have a certain sympathy for the speaker. He is right when he says that the existing tax structure is contrary to "equity." But if discussion is to be carried on in terms of such abstractions, Mr. Maytag would find his opponents introducing the word "justice" and saying that this is more precious than equity. Rather than use such verbal bludgeons, we should think operationally in terms of the homeostatic plateau. We should think in terms of systems rather than individual acts. That this sort of thinking presents difficulties for the law is admitted; but it is clear also that we have made some progress in the solution of these difficulties, e.g., in the graduated income tax. It is clear also that our systematic thinking has not produced perfect solutions to our problems (e.g., it is still possible to become a millionaire via the capital gains route).

Indeed, the recognition of the relevance of the whole system in judging the desirability of an individual act can be traced back to antiquity. One of the greatest of the technical social inventions of ancient Athens was that of *ostracism*, which was invented by Cleisthenes. We are told [10]:

> Once a year the popular Assembly deliberated on whether any citizen should be required to go into exile for ten years on the grounds that his presence in Athens was a threat to the constitution. If the Assembly voted to hold an ostracism, a second vote was taken. Then, if six thousand citizens wrote the same name on an *ostrakon*, or potsherd, the man named must leave Athens for ten years. But he did not lose his citizenship, his goods were not confiscated, he did not even suffer disgrace. In fact, it was only the man of great ability who was likely to be ostracized, yet the possibility of ostracism was a constant deterrent to overweening political ambition.

In other words, ostracism was a device aimed at stopping the positive feedback of power, a tool designed to maintain the political system on a homeostatic plateau. Recognition of the dangers of this positive feedback must surely be almost universal among practical men and produces the most diverse strategems, many of which would seem quite paradoxical to one who was ignorant of the positive feedback of power (as adolescents in our society often are). For instance, we are told [11] that "in the early history of the Church, bishops had to take two solemn oaths at the time of their ordination. The first oath was that they would discharge the duties of that office faithfully in the sight of God and man. The second oath was

called the oath of 'Nolo episcopari'—'I don't want to be a bishop.' . . ." Those who frequent the university campuses of our own time will surely have noted that one of the best ways to achieve a deanship is to insist that one doesn't want to be dean (but not too loudly!). Competition and the desire to limit power produce strange strategies.

VIII. *The Persistence of Variety*

An important part of the unfinished work of theoretical biology revolves around the question of variety: how are we to account for the variety of the living world? The competitive exclusion principle points always toward simplification; yet the world remains amazingly, delightfully complex.

The same problem exists in economics. Why do there continue to be so many competing units? The economist's problem is, I suspect, even further from solution than the biologist's, but we can briefly list some of the social factors, which resemble those mentioned earlier in the biological discussion.

Geographic isolation.—A less efficient company may be able to coexist with a more efficient one if it is at a considerable distance and if transportation charges are heavy, as they are, for instance, in the coal and steel industry. (It is interesting to note that major steelmakers of the United States two generations ago tried to negate this factor by enforcing the "Pittsburgh-plus" system of pricing.)

Product differentiation.—In biology, ecological differentiation is the necessary condition for coexistence; in economics, product differentation [12] plays the same role. Patients, copyrights, and mere advertising gimmicks enable entrepreneurs partially to escape pure competition.

Mergers prevent extinction in economics in the same sense that interbreeding prevents extinction in biology.

In the social realm we have in addition various peculiarly human characteristics that contribute to the persistence of variety. Curiosity, envy, dislike of boredom, yearning for destruction are a few of the factors which work against the efficiency of the market and hence tend to perpetuate variety. We are a long way from understanding the economic system. It is, however, transparently clear that any satisfactory over-all theory of economics must include a large measure of psychology in it. The *Homo economicus* of classical theory has been useful as a first approximation only.

IX. *The Idea of a System*

One of the most important ideas in modern science is the idea of a *system;* and it is almost impossible to define. There are a number of good essays available on this subject [13]. Here we will try to define by example.

Our first example is a caricature from the nineteenth century—the idea of a system that connects the welfare of England with the existence of old maids. The argument is simple: old maids keep cats, cats eat rats, rats destroy bumblebee nests, bumblebees fertilize red clover, and red clover is needed for horses, which are the backbone of English character training. Ergo the strength of England depends on a bountiful supply of old maids. Now that is a caricature, but it gets across the idea that the many cybernetic systems of nature are connected in complex ways. So complex are they that we can seldom predict exactly what will happen when we introduce a new element into a system. By way of illustration, consider the following examples from three different fields of biology.

Ecology.—Charles Elton [14] tells the following history.

> Some keen gardener, intent upon making Hawaii even more beautiful than before, introduced a plant called *Lantana camara*, which in its native home of Mexico causes no trouble to anybody. Meanwhile, some one else had also improved the amenities of the place by introducing turtle-doves from China, which, unlike any of the native birds, fed eagerly upon the berries of *Lantana*. The combined effects of the vegetative powers of the plant and the spreading of seeds by the turtle-doves were to make the *Lantana* multiply exceedingly and become a serious pest on the grazing country. Indian mynah birds were also introduced, and they too fed upon *Lantana* berries. After a few years the birds of both species had increased enormously in numbers. But there is another side to the story. Formerly the grasslands and young sugar-cane plantations had been ravaged yearly by vast numbers of army-worm caterpillars, but the mynahs also fed upon these caterpillars and succeeded to a large extent in keeping them in check, so that the outbreaks became less severe. About this time certain insects were introduced in order to try and check the spread of *Lantana* and several of them (in particular a species of Agromyzid fly) did actually destroy so much seed that the *Latana* began to decrease. As a result of this, the mynahs also began to decrease in numbers to such an extent that there began to occur again severe outbreaks of army-worm caterpillars. It was then found that when the *Lantana* had been removed in many places, other introduced shrubs came in, some of which are even more difficult to eradicate than the original *Lantana*.

From this example (and scores of comparable ones are known) it is easy to see why it is so difficult to secure the permission of the U.S. Department of Agriculture to import any species of plant or animal. However, though we are very conservative about the introduction of biotic elements into our ecological systems, we show the most juvenile irresponsibility in our attitude toward new chemicals. To get rid of insects, we spray promiscuously with such potent poisons as Malathion. As a result, we kill not only

millions of insects, but also thousands of birds. Because birds are a great natural negative feedback for insect populations, using insecticides often causes a secondary *increase* in the numbers of insects later. We may refer to this as a "flareback"—thus verbally acknowledging our failure to think in terms of systems. We are only now beginning to see the magnitude of the problems we have created for ourselves by *unsystematic* thinking, for which belated insight we are significantly indebted to Rachel Carson's book *Silent Spring* [15].

Embryology.—Beginning about 1960 a drug known as "thalidomide" became an increasingly popular sedative in Europe. It seemed superior to all others in effectiveness and harmlessness. But by the end of 1961 a most painful disillusionment had set in. When taken during the early weeks of pregnancy, it frequently interfered with the development of the limb buds of the child, resulting in the birth of a child suffering *phocomelia*—seal-limbs, little flipper-like hands, without long arm bones. In addition, there were other variable defects of the ears, digestive tract, heart, and large blood vessels; strawberry marks were common [16]. Only a minority of the children whose mothers took thalidomide during the first trimester developed phocomelia, but so widespread was the use of the drug that the number of cases produced in West Germany alone in two years' time probably exceeded 6,000. This experience contributed to a re-evaluation of the whole idea of therapy, particularly of newly pregnant women. The developing embryo is a set of cybernetic systems of the greatest complexity. Coupled with the high rate of change during the early weeks is a high sensitivity to foreign chemicals inserted into the system. To a growing extent, physicians are loath to permit a newly pregnant woman to take any drug if it can possibly be avoided.

When we think in terms of systems, we see that a fundamental misconception is embedded in the popular term "side-effects" (as has been pointed out to me by James W. Wiggins). This phrase means roughly "effects which I hadn't foreseen, or don't want to think about." As concerns the basic mechanism, side-effects no more deserve the adjective "side" than does the "principal" effect. It is hard to think in terms of systems, and we eagerly warp our language to protect ourselves from the necessity of doing so.

Genetics.—When a new gene is discovered, it must be named; this is accomplished by naming it for some conspicuous effect it has on the organism. But when a very careful study is made, it is found that a mutant gene has not one effect but many. For example, close analysis of one mutant gene in the laboratory rat has shown [17] no less than twenty-two well-defined effects, including effects on ribs, larynx, trachea, vertebrae, lungs, red blood cells, heart, teeth, and capillaries. Yet all these effects spring from a single chemical change in the genetic material of the fertilized egg. In the early days, geneticists often used the word "pleiotropy" to refer to the multiple effects of genes. Now it seems scarcely worthwhile to use this word because we are pretty sure that all genes are pleiotropic. The word "pleiotropy" is a fossil remnant of the days when geneticists failed to have sufficient appreciation of the developing organism as a system.

Pleiotropy presents animal and plant breeders with one of their most basic and persistent problems. The breeding performance of the St. Bernard dog will serve to illustrate the problem. Crosses between St. Bernard and other breeds of dogs produce a large proportion of stillborn or lethally malformed puppies. The trouble apparently lies in the pituitary gland, which is overactive. When we look closely at the adult St. Bernard, we see that its abnormally large head and paws correspond to "acromegaly" in humans, a condition also caused by an overactive pituitary. The St. Bernard breed is, in fact, standardized around this abnormality. Why are not the causative genes more deleterious to the breed? Undoubtedly because there are other, "modifier," genes which alter the whole genetic system so that it can tolerate the effects of the "principal" genes. The production of a new breed built around some distinctive gene often takes a long time because the breeder must find, and breed for, a multitude of modifier genes which create a genetic system favorable to the principal gene. This work is almost entirely trial and error; along the way the breeder must put up with large losses in the way of unsuccessful systems of genes.

X. *The Feasibility of Human Wishes*

The dream of the philosopher's stone is old and well known and has its counterpart in the ideas of skeleton keys and panaceas. Each of these images is of a single thing which solves all problems within a certain class. The dream of such cure-alls is largely a thing of the past. We now look askance at anyone who sets out to find the philosopher's stone.

The mythology of our time is built more around the reciprocal dream—the dream of a highly specific agent *which will do only one thing*. It was this myth which guided Paul Ehrlich in his search for disease-specific thera-

peutic agents. "Antitoxins and antibacterial substances are, so to speak, charmed bullets which strike only those objects for whose destruction they have been produced," said Ehrlich in voicing this myth. Belief in the myth has inspired much fruitful research; but it *is* a myth, as the phenomena of allergies, anaphylaxis, auto-immunization, and other "side-effects" show us. It is *our* myth, and so it is hard to see.

One of the inspired touches in Rachel Carson's *Silent Spring* is her use of "The Monkey's Paw," a story which W. W. Jacobs built around our modern myth. In this story a man is allowed three wishes. He wishes first for money. He gets it. It is brought to his door as compensation for his son's death in the mill. Horrified, the father wishes his son alive again. He gets that wish too—his son comes to the door looking as he would after such an accident. In desperation, the father wishes everything back as it was before he was given the three wishes.

The moral of the myth can be put in various ways. One: wishing won't make it so. Two: every change has its price. Three (and this one I like the best): *we can never do merely one thing*. Wishing to kill insects, we may put an end to the singing of birds. Wishing to "get there" faster, we insult our lungs with smog. Wishing to know what is happening everywhere in the world at once, we create an information overload against which the mind rebels, responding by a new and dangerous apathy.

Systems analysis points out in the clearest way the virtual irrelevance of good intentions in determining the consequences of altering a system. For a particularly clear-cut example, consider the Pasteurian revolution—the application of bacteriology and sanitation to the control of disease. We embarked on this revolution because we wished to diminish loss of life by disease. We got our wish, but it looks now as though the price will be an ultimate increase in the amount of starvation in the world. We could have predicted this, had we taken thought, for Malthus came before Pasteur, and Malthus clearly described the cybernetic system that controls populations. The negative feedbacks Malthus saw were misery and vice—by which he meant disease, starvation, war, and (apparently) contraception. Whatever diminution in effect one of these feedbacks undergoes must be made up for by an increase in the others. War, it happens, is almost always a feeble demographic control; and contraception is not yet as powerful as we would like it to be; so, unless we exert ourselves extraordinarily in the next decade, starvation will have to take over. Like the father in "The Monkey's Paw," we wanted only one thing—freedom from disease. But, in the system of the world, we can never change merely one thing.

Suppose that at the time Pasteur offered us his gift of bacteriology—and I use the name "Pasteur" in a symbolic way to stand for a multitude of workers—suppose at that time that some astute systems analyst had drawn a Malthusian cybernetic diagram on the blackboard and had pointed out to us the consequences of accepting this gift. Would we have refused it? I cannot believe we would. If we were typically human, we would probably have simply called forth our considerable talent for denial and gone ahead, hoping for the best (which perhaps is what we actually did).

But suppose we had been what we like to dream we are—completely rational and honest, and not given to denial? Would we then have rejected the gift of disease control? Possibly; but I think not. Is it not more likely that we would, instead, have looked around for another gift to combine with this one to produce a new, stable system? That other gift is well known, of course: it is the one Margaret Sanger gave us, to speak symbolically again. It is a gift we are now in the process of accepting.

In terms of systems, we can give this analysis:

System	Stability
Malthusian	Yes
Pasteurian	No
Sangerian	Possibly
Pasteurian-Sangerian	Yes

A systems analyst need not, when confronted with a new invention, reject it out of hand simply because "we can never do merely one thing." Rather, if he has the least spark of creativity in him, he says, "We can never do merely one thing, *therefore we must do several* in order that we may bring into being a new stable system." Obviously, in planning a new system he would have to examine many candidate-ideas and re-examine our value system to determine what it is we really want to maximize. Not easy work, to say the least.

XI. *Is Planning Possible?*

Some of the most excruciating questions of our time hinge on feasibility of planning. Is good planning possible? Is it possible to devise a planned system that is at least as good as a free system? Can the free market be dispensed with without losing its desirable virtues?

There is no dearth of literature supporting and condemning planning. Rather than add to this double battery of polemic literature, I would like to take a different approach. I would prefer to adopt an agnostic attitude toward the principal question and ask a second question: *If* successful planning is possible, what are its preconditions? If we can see these clearly, we should be in a better position to answer the principal question. The major points at issue seem to me to be the following.

1) Can it be shown, before instituting a plan, that all significant factors have been taken account of? It is not easy to see what the nature of the proof would be; and in any case, the consequences of past planning attempts do not make us optimistic.

2) Are we sure that we can predict all possible interactions of factors, even when we have complete knowledge of them? This is not as disturbing a question now as it was in the past. Any system of equations that can be solved "in principle" can be turned over to computing machines, which are immensely faster, more patient, and more reliable than human beings; and all computing machines operate under the Magna Charta given them by A. M. Turing [18].

3) Granted that we can predict a new and better stable system, can we also devise an acceptable transition? The many social systems known to historians and anthropologists represent so many points in space and time. The transitions from one to another are usually obscure; or, when recorded, are known to involve great human suffering and immense wastage of human resources. In general, transitions seem more feasible for small populations than large—but will small populations ever again exist?

4) Can we take adequate account of the reflexive effect of knowledge and planning on the actions of the planned and the planners? I have argued elsewhere [19] that a satisfactory theory of the social sciences must be based on recognition of three classes of truth. No one, to my knowledge, has tackled this fundamental problem.

5) Can it be shown that programming, in the light of the reflexive effect of knowledge, does not lead to some sort of infinitive regress? Only so can solutions be achieved.

6) Can the calculations be carried out fast enough? Modern calculating machines, with their basic operations measured in microseconds, are marvelously speedy. But the number of operations required may be astronomical, and the 3.1557×10^7 seconds available in each year may not be enough.

7) Can we persuade men to accept change? A casual survey of important reforms effected in the recent past [20] shows that each of them took about seventy-five to one hundred years for completion. It is a general impression (and a correct one, I think) that the speed at which social problems *appear* is now accelerating. But is there any indication that the rate of solution is also accelerating? We seem to need some basic reform in people's reaction to proposed changes. Would this demand a new sort of faith? And in what? Science? Truth? Humanism?

8) Will any plan we adopt have adequate self-correcting mechanisms built into it? It is one of the virtues of a market economy that any error in judgment as to what people want is soon corrected for. Price fluctuations *communicate* needs to the managers. But in a planned economy, it has been often noted, planners who make errors are likely deliberately to interfere with the free flow of information in order to save their skins. Can a planned system include uncloggable channels of information?

Such seem to me to be the principal difficulties in the way of planning. Whether they will ultimately prove insuperable, who can say? But for the foreseeable future, I suggest there is much to be said for this analysis [21] by Kenneth Boulding:

> . . . I believe the market, when it works well, is a true instrument of redemption, though a humble one, not only for individuals but for society. It gives the individual a sense of being wanted and gives him an opportunity of serving without servility. It gives society the opportunity of coordinating immensely diverse activities without coercion. The "hidden hand" of Adam Smith is not a fiction.
>
> There are forces operating in society, as there are within the human organism, which make for health. The doctor is merely the cooperator with these great forces in the body. The doctor of society—who is equally necessary—must also be a humble cooperator with the great forces of ecological interaction, which often restore a society to health in spite of his medications. It is precisely this 'anarchy' which Professor Niebuhr deplores which saves us, in both the human and the social organism. If we really established conscious control over the heartbeat and the white blood cells, how long would we last? Health is achieved by the cooperation of consciousness with a largely unconscious physiological process. Selfconsciousness is not always an aid to health, either in the individual or in society.

The problem of planning will not soon be disposed of, nor soon solved, but perhaps some false issues can be avoided if we make a distinction between "planning" and "designing." By *planning* I mean here what I think most people have in mind, the making of rather detailed, rather rigid plans. The word *designing* I would like to reserve for the much looser, less detailed, specification of a cybernetic system which includes negative feedbacks, self-correcting controls. The classical market economy is such a

design. Kenneth Boulding when he speaks of "the market, *when it works well*" is, I believe implicitly referring to the biologist's model of homeostasis shown in Figure 4. The classical market should not be called *natural*, for it is truly human invention, however unconsciously made. It is not universal. It has been modified continually as men have groped toward better solutions. I would submit that the proper role for conscious action is the ethical evaluation of many possible homeostatic systems, the selection of the best *possible* one, and the refinement of its design so as to make the homeostatic plateau as broad as it can be, thus maximizing both social stability and human freedom.

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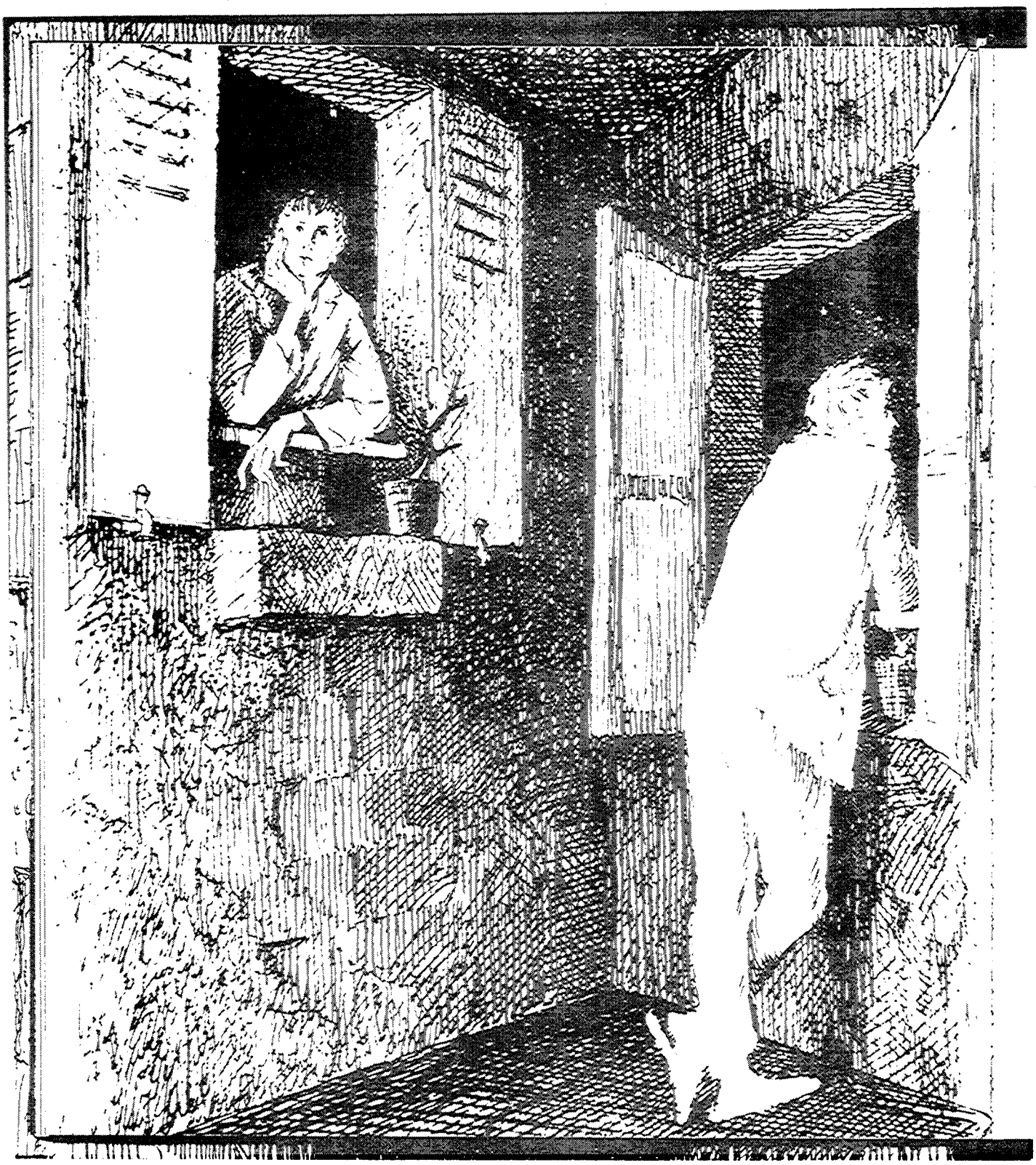

EVERYTHING SAID IS SAID BY AN OBSERVER

OBSERVER

When speaking of a system representation, the role of the observer and his descriptions must be explicit for the system to be represented. Essentially we are speaking of modeling and of communicating that model.

When a distinction is made an entity is generated. This theorem, which provides the basis for distinguishing a system, already implies the observer. The observer has the ability to make distinctions and inasmuch as "Everything said is said by the observer," it is the observer who indicates these distinctions.

The observer, to make a binary distinction, must existentially remove himself from the universe of the distinction. This distinction requires that the observer behold simultaneously the entity of the distinction and the universe from which it was distinguished.

That the observer must lie either in the system or not in the system creates a paradox only in the domain of descriptions. If everything said is <u>said</u> by an observer, what then is <u>said</u>?

That the observer himself is a distinction creates a paradox in the domain of distinctions and not in the domain of descriptions. [K.W.]

OBSERVER

A system such that through recursive interactions with its own linguistic states may always remain in a position to interact with the representations of its interactions. [H.M.]

EVERYTHING SAID IS SAID TO AN OBSERVER

The meaning of cybernetics in the behavioural sciences (The cybernetics of behaviour and cognition; extending the meaning of "goal")

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Summary

The paper discusses the impact of cybernetic ideas upon behavioural and cognitive studies in general but the main thesis is developed in the context of human psychology. An effort is made to trace the influence of cybernetics upon the development of psychological theories, experimental techniques and methods for modelling mental and behavioural activity. Particular emphasis is placed upon the key concept of a "goal directed" system. It is argued that this concept becomes differentiated to yield two specialised forms of system, namely "taciturn systems" and "language oriented systems"; of these, the latter are peculiarly important in connection with studies of man or attempts to control, teach, or otherwise influence human beings. As it stands, the notion of "goal directed" system is unable to adumbrate the phenomena of evolutionary development (as in open ended concept learning) and conscious experience. Problems entailing both types of phenomena are ubiquitous in the human domain and the paper considers several ways in which the connotation of goal directedness can be enlarged sufficiently to render it useful in these areas.

INTRODUCTION

For many years, there has been a fruitful interplay between the interdisplinary pursuit of cybernetic ideas (bearing this label or not) and the special departments of the life sciences. Since the early 30s, for example, anthropologists have recognised that societal homeostasis depends upon symbolic regulatory programmes manifest as rituals, conventions, and traditions. Likewise, social change is commonly understood in terms of the competitive or co-operative interaction between subsystems characterised by these symbolic structures.* Similar comments apply at the level of animal populations, where the maintenance of density, dispersion and interspecific mutualism depend upon comparable processes (see, for example, Wynne Edwards[4]). The whole of ethology is, by definition, the study of behaviours mediating control and communication; hence, cybernetics is an essential part of this science.† Moving in one direction the area of cybernetic influence extends into studies of linguistics and kinship structures.* In another direction, it infiltrates biology (see, for example, Young[6]), embryology (see Waddington[7]), genetics, and developmental studies (for instance, Bonner[8]).

The crucial notion is that of a purposive or goal directed system. As the examples suggest, this concept has served very well to increase our understanding of natural processes. But the concept, as it stands, is not entirely satisfactory. The phenomena of evolution and of conscious experience are ubiquitous in all biological, social, or behavioural systems. It is far from clear that these phenomena can be explained (or even predicted and manipulated) within the existing cybernetic framework. A fundamental reappraisal of the concept "goal" is probably necessary.

Uneasiness over the adequacy of the existing framework has been expressed in various quarters; notably at the series of Wenner Gren symposia on conscious purpose and human adaptation, convened by Gregory Bateson. This is not just an academic matter. In order to control the social and ecological systems which nowadays show signs of instability or even destructive and autocatalytic degeneration, it does seem necessary to take the consciousness, self description and evaluation of these systems fully into account. Much the same theme will be developed by Stafford Beer in the

* The pioneering work is due to Bateson[1]. Recent developments along similar lines are documented in Rappaport[2] or Schwartz[3].

† This is especially obvious in the works of Lorenz, Tinbergen, and Mittelstadt.

* A representative selection of papers is contained in Garvin[5].

context of government and management. Hence, the present paper will examine the theoretical issues rather than dwelling upon their practical consequences.

Before embarking on this task, I must emphasize that these comments refer to behavioural and cognitive cybernetics. They are made from the viewpoint of some one concerned with natural systems and in no way contradict Prof. Boulanger's contention that issues of consciousness, etc., are often *irrelevant*. In the previous paper Boulanger adopted the attitude of an engineer who is anxious to make purposive or intelligent artifacts. From that point of view, of course, he is absolutely right. Wearing my engineering hat, I entirely agree with him.

CYBERNETICS IN RELATION TO HUMAN PSYCHOLOGY

To be specific, I shall trace the influence of cybernetic ideas upon a single discipline (human psychology). Here, as in the general domain, the key concept is "goal directed system" and it can be usefully refined in several ways. Once again, however, the concept of "goal" must be broadened in order to deal with outstanding issues of consciousness, conceptual development and the like, which a comprehensive psychology cannot afford to neglect. After showing that the requirement for a more liberal interpretation of goal directedness arises quite naturally from the application of the concept as it stands, I shall suggest several ways in which the connotation of "goal" can be usefully extended.

History

At the moment when the word "cybernetics" first made its appearance, there existed two classes of psychological theory, each carrying its own experimental trappings. On the one hand, there was behaviourism: either a brash, almost Watsonian, behaviourism or a mellowed "functionalism done with a behaviouristic bias" (chiefly represented in this country by the Cambridge School of Applied Psychology). On the other hand, there existed a sort of mentalism, born of the Gestalt psychologies amongst others, which was pursued in a thoroughly eclectic spirit, for example, by Bartlett.

Wiener's book[9] became widely known in the early fifties. It gave a name to an ongoing way of thinking and added mathematical stamina to a body of embryonic concepts. Of course, Wiener had spoken as a pioneer before he published. But his greatest innovation was philosophical and mathematical. The psychologists had been whittling away at broader Cybernetic notions for some years. Amongst them were McCulloch[10] and Pitts in the U.S.A. and Ashby[11,12], at that time in Great Britain, who laid the foundations of that peculiarly cybernetic edifice, "the brain as a communication and control system". Working at the behavioural level, Craik[13] saw the regulatory character of human performance with enormous clarity. Finally, there was a group of psychological information theorists, centred about Hick[14], and quite closely allied in their way of thinking to physical information theorists like Cherry[15] and Gabor (at Imperial College), Mackay and Shannon.

Thereafter, cybernetic ideas became increasingly popular. Their proliferation can be followed both in the psychological literature and in the relevant sections of various interdisciplinary forums (the Macy Foundation Symposia; the London Information Theory Symposia; the Congresses of the International Association of Cybernetics; the Conferences on self-organizing systems, sponsored by ONR; the Bionics Symposia, etc.). But, at the time in question (the early 50s), these concepts made a clear philosophical impression.

Philosophical Impact

The impact of cybernetics upon human psychology was many faceted.

1) Cybernetics drew attention to the form and dynamics, i.e. the *organization* of systems, which is often of greater relevance than their physical particulars. Usefully, but more superficially, it mustered a number of mathematical techniques for talking about organisation.

2) By establishing the basic concepts of feedback and stability, cybernetic thinking resolved those teleological dilemmas that had lingered on since the vitalist–mechanist controversy of the early years of this century and gave substance to the already ubiquitous notion of "goal directedness".

(3) Within the cybernetic framework, the constituents of organization, namely *information* and *control*, acquired a status just as respectable as that already accredited to "matter" or "energy".

(4) Conversely, it became evident that no system is completely specified by its physical description *alone*. The system's informational content and its control structure must *also* be described (for example, the system "gene" is not completely specified by talking about DNA molecules; in addition, a

gene entails the information encoded in the molecular configuration and the protein synthesising control loops in the context of which a gene is an hereditary unit).*

(5) As a result, the Cartesian Dualism, of which the distinction between behaviourism and mentalism is redolent, was replaced by a Systemic Monisim.

Systemic Monisim

The crux of systemic monisim is contained in the assertion that any system is a goal directed system which can be analysed into or (in context) synthesised from a collection of goal directed subsystems. The organisation of a

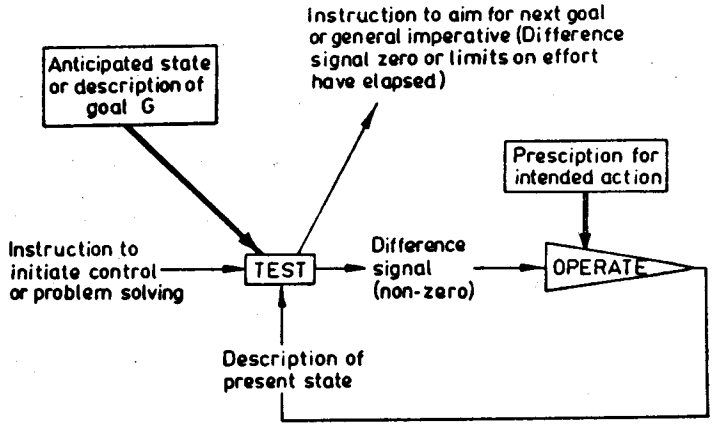

FIGURE 1 The basic goal directed system: a TOTE unit (modified)

goal directed subsystem, the basic building block, is the familiar *process* depicted in Figure 1. Notice that the organization is isomorphic with any of the following entities.

(1) A TOTE (or TEST, OPERATE, TEST, EXIT) unit, in the sense of Miller, Galanter, and Pribram[16].

* In view of later (essentially cybernetic) work in molecular biology, there is currently some doubt about hereditary units; the DNA configuration probably does not *uniquely* specify the organisation. However, the meaning of the example is clear enough.

(2) The interpretation and execution of an IF, THEN, ELSE programme segment.

(3) A properly interpreted control system

(4) A problem solver.

(5) A game player (the equivalence of (3), (4), and (5) was mooted by Ashby and has recently been developed by Banerji)[17].

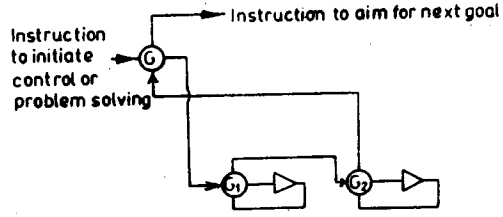

FIGURE 2 A typical decomposition of goal G: a TOTE hierarchy (modified)

(6) The execution of a state achievement command in the sense of Rescher[18].

(7) An elementary concept (regarded as a *procedure* for knowing or recognizing or doing)[19].

(8) Either the process of "abstraction" or of "completing an analogy"[20].

There are several ways of conjoining goal directed systems so that the entire system is goal directed (or, conversely, of dissecting a goal directed system into elementary units). One of them is shown in Figure 2. Here the entire system has a goal G and subgoals G_1 and G_2. In order to attain G, the uppermost unit calls for the execution of a G_1 subroutine and a G_2 subroutine, such a predictive sequence being a *plan*. Other types of composition and decomposition are discussed in a recent paper[21].

Holism and Atomism

Since it holds that composition and decomposition are universally possible, systemic monisim is a reductionist philosophy. But, in general, it is *holistic* rather than *atomistic* since, apart from a few trivial cases, the *whole* goal directed system is *more* than the sum of its goal directed parts. Further, in a sense that will be clear from the slightly unusual labelling of Figure 1, each subsystem can be said to *interpret*, to *intend*, and to *anticipate* or *expect*.

Hence, the reductionist explanations of human behaviour and mentation that feature in a cybernetic discussion are quite distinct from those (to my mind fallacious) mechanistic explanations in which man is reduced to a bag of associations and responses. To parody the position of naïve behaviourism, man is conceived *as something that reacts to stimuli*. In contrast, the cybernetic theories of psychology envisage man as *someone who interprets, intends, and anticipates*. To put it differently, a human being does not so much respond to stimuli as interpret certain states of his environment as posing *problems* which he makes an attempt to *solve*. Clearly, this point of view bridges the gap between behaviourism and cognitive psychology. A human being has the qualities ordinarily associated with mental activity; nevertheless, the human system is, in principle, reducible to elementary subsystems which have the same quality in a primitive form. Whether or not such a reductive explanation is generally *possible* is undecided at the moment; at any rate, useful explanations can be offered for certain aspects of human activity. Whether the goal directed unit is a rich enough construct to adumbrate "interpretation, intention, and anticipation" is a question to be taken up in a moment. Some disquiet on this score has been voiced already.

Cogency of the Cybernetic Approach

Since it resolves the arid conflict between behaviourism and mentalism, the cybernetic approach effects a salutory unification of the psychological field. Several theories of learning and cognition have been built up in overtly cybernetic terms; for example, in the U.S.A., the theories of Miller, Gallanter, and Pribram[16], McCulloch[10], and von Foerster[22] (or von Foerster *et al.*[23]); in the U.S.S.R., the theories of Anohkin, Amosov[24], Glushkov[25], and Napalkov and in Great Britain, my own theory[26,27]. To these should be added all theories involving cognitive and artificial intelligence models which are built up from elementary constituents with the status of information structures, for example, the models of Minsky[28], Reitman[29], Hunt *et al.*[30], Fogel *et al.*[31], George[32], Taylor[33], Uttley[34], and Young[6]. Many theories are primarily cybernetic in calibre; notably, Festinger's[35] "cognitive dissonance", Kelly's "personal constructs" and Laing's theory (see Laing *et al.*[37]) of interpersonal interaction.

Apart from this, the literature abounds with papers that are couched in behavioural terms but which are really talking about cybernetic constructs. Nowadays, when mental mechanisms are called "mediating processes" or (at a different level of discourse) are signified by "intervening variables" the author is nearly always referring to goal directed systems, programmes, and the like. The nomenclature of S.R. theory is cumbersome in this context; during a transition phase it is used by way of an apologia to classical behaviourism but is gradually being replaced by direct reference to the cybernetic entities.

Alongside this theoretical development a number of cybernetic methodologies have come into prominence. The most general of these, information theory and control theory, have already been mentioned. More specifically, the idea of a basic experimental situation is undergoing rapid change. The paradigm used to be a stimulus and response situation; now it is being equated with a game or a conversation between the subject and the experimeter (or his equipment, in some cases).

The consequences of this change in attitude extend far beyond the laboratory. They are particularly dramatic in connection with teaching, training, and computer assisted instruction, where sensible developments almost certainly rest upon the recognition that a tutorial *conversation* is the minimal, non trivial, transaction with a human being (here, incidentally, I mean conversation in the full-blooded *logical* sense; hence, "conversational interaction" with a simple computer terminal is generally insufficiently rich to qualify). These matters have been discussed extensively in other publications and I shall not dwell upon them[38–45].

Cybernetic theories and methods can be justified on psychological grounds; for example, the acquisition of either skills or concepts is most naturally described in cybernetic terms, as are the phenomena of selective attention. Empirically, cybernetic theories "work" quite well. However, the experiments of Dr. Grey Walter (which he will outline later this morning) lend a great deal of more specific support to the cybernetic contention. This work* has uncovered the physiological foundations for the goal directedness of man. Broadly, a complex of mechanisms involving the frontal cortex and certain lower regions such as the reticular formation, focus the attention upon relevant *evidence* and set up an anticipation or expectation with respect to its correlates and to properly equilibrating actions. In particular, the activity of this "expectancy" system depends upon either (1) a goal setting instruction (do so and so when something happens) or (2) an internal goal

* This is a refinement and extension of other work in the field. For particular theories in this matter, see Grey Walter[46] and Kilmer *et al.*[47] For the physiological background see Lynn[48].

orienting state. Generally speaking, a human being habituates against stimuli that are irrelevant to goals. Those which are relevant become *significant*, i.e. they pose *problems* or provide *evidence* (they do not simply "elicit responses").

It is right and reasonable to be impressed when physiology and psychology are happy bedfellows. In view of this work, there can be no serious doubt that human beings can be fruitfully represented as cybernetic systems.

DETAILED EXAMINATION OF CYBERNETIC THEORIES

Earlier in the paper I questioned the theoretical adequacy of the goal directed system as currently conceived and suggested that it is necessary to broaden our view of what such a system *is*. This calls for a more thoroughgoing appraisal of "goals" and of "cybernetic theories" in general.

Theory Building

Any theory starts off with an observer or experimenter. He has in mind a collection of abstract models with predictive capabilities. Using various criteria of relevance, he selects one of them. In order to actually make predictions, this model must be interpreted and identified with a real assembly to form a theory. The interpretation may be prescriptive and predictive, as when the model is used like a blueprint for *designing* a machine and predicting its states. On the other hand, it may be descriptive and predictive as it is when the model is used to explain and predict the behaviour of a *given* organism.

Now, in order to establish the identification and to form a predictive *theory* (indeed, in order to select one model from the set of possibilities), the observer needs to know the purpose *for* or the purpose *of* the system with which the model is identified. Lacking such a purpose, the observer would be at a loss to know what constitutes a sensible interpretation of the model or what properties of the world are relevant. In essence, of course, the purpose *for* or the purpose *of* the system is invented by the observer himself and it is stated in an observer's metalanguage for talking about the system. Thus, in the prescriptive mode, it is clear that people do not build purposeless machines. Equally, in the descriptive mode, an observer gets nowhere unless he has a systemic purpose in mind; for example, no headway was made with the explanation of amphibian vision until Lettvin, Matturana, McCulloch and Pitts* conceived the frog visual system as a machine for (with the purpose of) catching insects and avoiding predators. At that point, it became evident that the visual system consists in a set of attribute filters, evaluating properties relevant to this purpose.

In contrast, some systems have a purpose built into them; a "purpose *in*", i.e. a *goal*. Depending upon the type of observation we have in mind this may mean either (1) the models with which these systems are identified necessarily contain the mechanism of a goal directed system or (2) the system can state goals *to* the observer and accept some goals *from* him (or both). The principal cybernetic hypothesis can now be phrased as follows. *Any system with a purpose for it (any system for which a cybernetic theory can be constructed) also has a purpose in it, i.e. a goal; all systems are goal directed systems.*

Notice, in passing, the consequences of this definition. A cybernetic theory of adding machines is not just a theory of mechanical devices which have no goal. It refers directly to the *process* of addition and indirectly to the *user* of the adding machine, i.e. the mechanical device is necessarily embedded in the context which makes it meaningful.

Structural and Organizational Models

It follows from these comments that the truth 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 of a structural or organizational model for the system; something having enough detail to delineate the goal seeking process.†

Hence, in talking about goals, there is a tacit commitment to structural and organizational models containing a modicum of detail. At this level of

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* "What the frog's eye tells the frog's brain" in *Embodiments of Mind*[10].

† This is quite clear in Ashby's work, of course. For example, in *Design for a Brain*[11] the concept of *essential variables* with limits upon their permissible values is employed to set up a goal directed system. The matter is generalized in Ashby's later work (see e.g. Ashby[48]). The present point is that structural notions, such as "essential variables" do not stem directly from the observation of a black box system. They are imported as a result of independent observations, e.g. data bearing on the nature of the animal.

discussion, still with human psychology in mind, it becomes useful to introduce a distinction between two types of goal directed system, namely *taciturn* and *language oriented* systems.* The former are systems in (roughly) the sense of general systems theory. The latter are based upon the concept of an *object language* (defined or described in the observer's metalanguage) in terms of which the system is able to accept goal statements (by programming or reprogramming) and to *describe* its current goals. The distinction "taciturn/language oriented" fundamentally entails the observer; we mean, to be strict "observed as taciturn/observed as language oriented". Nevertheless, these are features of the system, per se, which dispose us towards one mode of observation or the other.

Taciturn and Language Oriented Systems

Taciturn systems are those for which the observer asserts or discovers the goal (purpose *in*), which is thereafter equated with the purpose *for* the system in question. In contrast, language oriented systems can be asked or instructed to *adopt* goals by anyone who knows the object language and they may state and describe their own goals, using the same medium; in a very real sense these are "general purpose" systems. Ostensively, the distinction is determined by the following features.

(1) A special purpose, goal directed, computing machine (such as an autopilot) is a taciturn system. In contrast, a general purpose computer together with the compilers, interpreters, etc., required for processing statements in a programming language is a language oriented system. The programming language is the object language upon which the system is based.

Although this example is instructive, the peculiar character of general purpose computers must be kept firmly in mind throughout the discussion. In the case of a computer, an observer knows the programming language either because he has designed the machine or because he has a programming manual written by someone who did so. In the case of a psychological system, an observer knows the programming language either because he speaks and understands it, or because of arguments involving inferences of similarity between the system and himself.

(2) A taciturn system can neither be given new goals nor can it state its goals (although an autopilot interacts with its environment, the legitimacy of calling the symbol system employed for this purpose, a "language" is suspect. Certainly it is not a language for stating new goals*). In contrast, the language oriented system is vacuous unless either it is *given* goals to aim for (by some sort of programming operation) or it already *has* goals which it is able to describe.

(3) Since a taciturn system cannot "speak" (i.e. communicate in a visual, auditory, or other symbolic modality), the notion of "mind" is irrelevant. On the other hand, within a language oriented system, it is usually possible to distinguish between a class of processes and procedures (for example, the class of programmes being executed in a general purpose computer) and the system in which these procedures are embodied (for example, the computer itself). The class of processes is an organization in the interpretative system and has the properties of *mind*, in contrast with the interpretative system itself (loosely, *brain*). Notice that the example of the general purpose computer though illuminating, is again misleading if taken too seriously. Computing systems are designed in such a way that the interpretative system, a box of logicians building bricks, is virtually independent of the organization. Brains are not like this.†

(4) In respect to a taciturn system, *information* has but one technical sense, which is developed in Prof. Ashby's paper at this congress. Briefly, information is a property of the relations existing between entries in the contingency tables which summarize the behaviours or possible behaviours of the system. It is crucial that the states so designated are defined in the observer's metalanguage and that the probability estimates, uncertainties, etc., are *observers* probability estimates, uncertainties, etc. (i.e. they are *objective*). Of course, the term information can be used in exactly the same sense with respect to the behaviour of a language oriented system. But here there is another pos-

* The basic distinction between taciturn and language oriented systems can be made in several ways of which this one is the most convenient for the present purpose. For example, Gregory[50] makes a similar spirited distinction between systems with a *deductive* capability (roughly, language oriented) and those without such a capability (roughly taciturn). Although Gregory's differentiation is elegant, and just as proper as my own, it does not fit the present framework quite so well. The caveat, *roughly*, must be taken seriously. As Figure 1 is labelled, any system with a goal (a purpose *in*) has a claim to deductive power.

* According to this argument, the course changing instructions delivered to an autopilot change the parameters of a given goal.

† There is, however, a fairly close relationship between brains and more complex computational systems with supervisory director programmes and resource allocation executives.

sibility as well, which is not open for the taciturn system. Clearly, the language oriented system can define a set of alternatives in terms of its own object language*; conversely, it can be *given* a set of alternatives. With respect to these it can express *subjective* or *systemic* uncertainty.

When the model for the language oriented system has been used prescriptively, as in writing an artificial intelligence programme, the observer can give an operational interpretation of subjective uncertainty and of the corresponding subjective information measure; for example, the degree of uncertainty with reference to problem P is the amount of computation required to solve P or the amount of computation which the system estimates will be needed at the moment it makes an utterance. When the model is used descriptively, an operational interpretation is not generally available and the asserted subjective uncertainties both may be and can be regarded as primitive measures. For instance, if man is a language oriented system, it is legitimate to take confidence estimates, obtained by the veridicial scoring technique of Shuford and his colleagues†, as *primitive* indices of the system state. Objective indices, which may, of course, be closely correlated with them are, according to this point of view, indirect state descriptors.

(5) The model for a taciturn system is identified with reality (for example, in the context of an experiment) by setting up a material analogy* between the model and the thing. Further, the observer or experimenter is solely responsible for determining and maintaining this relationship. Thus, stimulus signs are carefully delineated, responses are carefully observed, and the system is isolated from extraneous parameter variations by efforts to maintain constant and repeatable conditions. In contrast, all language oriented systems are based on models which are identified with reality in the normative framework of the object language; either the natural language of a human subject or an artificial language which he understands.* For example, the human subject is asked to participate in an experiment and he agrees to do so. Normative rules are set up which determine the nature and designation of problems, the class of solutions and so on. Above all, a goal is specified either by the subject or the experimenter. To put it succinctly, an experimental contract is established between the observer or experimenter on the one hand and the human subject on the other. The whole experiment makes sense and the model itself is identified within the framework of this contract. It follows, of course, that *both* the subject *and* the experimenter (or observer) are jointly responsible for determining and maintaining the identification.

* To crystallize the idea of the observer's alternatives and the system's alternatives, consider a human subject as the system. If the subject is asked to respond on a five-point scale in Osgood's semantic differential test, the alternatives (words at the ends of the scale) are chosen by the observer (as a matter of fact, as a result of a prior analysis of the statistical response tendencies of a population of subjects). In contrast, the alternatives obtained and used in the Kelly grid technique are system alternatives. They are determined, in the framework of an object language, by the human subject himself. A similar point is made by Bannister and Mair[51].

† Consider an experiment in which the subject is required to respond, at the nth trial in a sequence by choosing one of M alternatives. It may be the case that the subject is uncertain about which alternative to select (in order to satisfy a goal). If so, he is required to state M numbers, $r_i(n)$ $i = 1 \cdots M$, such that $\sum_i r_i(n) = 1$. The $r_i(n)$ are interpreted as his degrees of belief in each of the alternatives presented at trial n and it is possible to score the subject over the sequence of trials as a function of the $r_i(n)$ and the alternatives he ought to have chosen. Shuford and his colleagues have introduced scoring schemes with the property that if the subject's real degrees of belief are $p_i(n)$ at the nth trial, then his mathematical expectation of score is maximized if, and only if, $r_i(n) = p_i(n)$. The same technique can be employed when the subject, rather than the experimenter, invents the alternatives. (See Shuford *et al.*[52]).

* For example, the sort of relationship which exists between an analogue computer model for a plant and the plant itself.

General Statement

Theory construction in the large is a generalization of the identification or interpretation process of (5) of the preceding section (in the sense that a class of models are interpreted, not just one particular model in one particular experiment—clearly in the general case the "observer" becomes the "scientist"). Hence, we have two sorts of theory; a theory of taciturn and a theory of language oriented systems.

The theory building process is an open-ended control process in the conduct of which a cybernetic system (by definition a *control* system) is established. Hence theory building is, in one sense, "control of control". But the higher level (open-ended) control process is not formally modelled and possibly any attempt to model it would end up in a (vicious) indefinite regress.

If the cybernetic system to be established is taciturn, then the observer (scientist) is alone responsible for it. If the system is language oriented then

* We emphasize a point mooted earlier. The concept of language is very broad indeed. Pictograms or images are just as good a currency as words or mathematical expressions.

the object language of the system is itself used as the metalanguage involved in the higher level "control of control" and the subject becomes an active participant in theory construction[53].

This is particularly obvious when we notice that the great majority of experimental contracts (preceding section, (5)) are not *really* established by one way instruction giving but are *compromise* solutions arrived at by dint of conversations about the experiment in question.

The Psychological Domain

Let us crystallize our attitude. ***All the systems of human psychology are language oriented systems and all the models proper to human psychology are language oriented models.*** This follows from the definition of a language oriented system and the discussion on pp. 25–27. To deny the assertion it would be necessary to cite a psychological experiment that does *not* depend upon an experimental contract.

As phylogenetic development proceeds, there is a tendency for the language oriented system to become apposite; it would be absurd to see primitive animals in this way but with adult man we have argued it is the only legitimate point of view. Similarly, there is an ontogenetic development beautifully illustrated by Luria's work[54]. The control function of language unfolds as a child grows up and, with it, the cogency of the language oriented system. In contrast, most functional and physiological systems are taciturn: for example, the autonomic system, simple conditioning, and non-symbolic adaptation.

At first sight, we seem to have come round a full circle and returned to a type of dualism; on the one hand there are language oriented systems ("mind" systems), on the other taciturn systems ("body" systems). But the impression is illusory. "X is a language oriented system" glosses the complete statement, "X is *observed* as a language oriented system" (and must be so viewed if the observer is a psychologist). The price to be paid for the convenience of systemic monisim is that of keeping the *observer* as an integral part of *all* observations[53,55].

With that caveat, we can often observe a human being as a psychological and a physiological system at the same instant. Grey Walter's work (see section on pp. 45–56) provides an admirable instance. On the one hand, he views the human subject as a taciturn (physiological) system. On the other, he views him psychologically, for example, in an experiment where the subject is required to entertain expectations. The psychological system is language oriented, even if the subject only "expects" clicks or light flashes. He *becomes* so, just *because* certain physiological mechanisms are brought into play.

DEPARTURES FORM THE SIMPLE PARADIGM

Let us idealize the cybernetic concept of man as it has so far been presented. An individual human being is a language oriented system (for short, an "L.O. system") occupied with one fully specified goal at once. Any change of goal is guided by a plan, in the sense of Figure 2, which determines the immediate subgoals of a still fully specified overall goal. Such a picture is isomorphic with the operation of a computer programme, the L.O. system, which is embodied in and executed by a computer called the brain.

For many purposes, the picture is a useful approximation to reality but it does not bear close scrutiny. First of all, the brain is not the passive and ductile apparatus which comes to mind at the mention of "computer". It is, indeed, a computer; but, as suggested before, it is a taciturn system in its own right with goals that are not necessarily compatible with those of the L.O. systems embodied in it. Secondly, human beings are not so single minded as the simple picture suggests. Man can often be imaged as aiming for one goal at once, especially when he is making symbolic utterances or is coupled to the observer via the string processing and push down list structures which are characteristic of immediate memory organization[56]. But he is also capable of multigoal operation. This fact opens up the possibility that man is an *evolving* L.O. system and I hypothesize that this possibility is *always* realized.* If so, the consequences are profound and roughly as follows.

An observer who sticks to the rules on p. 24 must see a human being as a system having a purpose *for* and will try to place this in correspondence with a purpose *in* or systemic goal. Now, if the observer elects to see the man as a system with *one* goal, then in certain circumstances, (by hypothesis, in *all* circumstances) the observer will be impelled to say that this goal is *underspecified.* Conversely, if he choses to see a multiplicity of goals (which, in toto, satisfy the purpose *for*) then these may be fully specified *but* the observer suffers an irreducible uncertainty over the systemic boundaries of the

* That, in a non-trivial sense, he is *always* learning. He is built with a propensity to learn[26].

individual said to *have* these goals. For, in reality, this *individual* is an evolutionary process which can be *described* (from the observer's point of view) as a self-organizing system in von Foerster's[57] sense of the phrase.

Equally if, man is defined as an L.O. system, then *he* is able to act as his *own* observer and thus to see *himself*. In that case, he (the individual human being) is in a similar position to the external observer. His evolutionary nature leads him, if questioned, to say either (a) "my goal is underspecified" (even "I have no goal")—here the integrity of the individual is taken for granted by the speaker, *or* (b) "I have a definite goal" (for example, to do running exercises for 15 min at 80 steps/min). But I might choose to aim for a different goal (e.g. writing this paper, solving a problem). Hence the boundaries of the individual are undefined. "I" am, by admission, something that is aiming for a definite goal but also something (undefined) that contemplates other possibilities so that "I" might elect to do differently. The goal, in this case, is *contingent* upon the acceptance of a normative framework, such as the experimental contract of p. 28, or the system of conventions and social mores (accepted, for example, by a devoted problem solver, clerk, or mathematician). *Contingency* arises because the human being *may* and *knows* he may disobey the norms and aim for some other goal, *or* (c) "I have a definite goal at the moment but I realize it is temporary and will give place to another". Here, the human being recognizes the temporal development of the process he *is*. Phrasing it differently, man spends much of his day in goal *setting* (or problem *posing*) rather than goal *seeking* (or problem *solving*).

In practice, the distinctions are less clearcut than (a), (b), and (c) suggest. Even the specific goals of (b) and (c) usually turn out to be underspecified to some extent, i.e. the man who describes the goal state is unable to give it a consistent ostensive definition. The ambiguity of all natural languages allows for the communication of underspecified goals. It is because of this that conversation (in a nontrivial sense) and social development in general are both possible.

We may or may not choose to call evolutionary systems "goal directed"; clearly, if they *are* goal directed at all, then they are directed towards an underspecified and generally open ended goal. Brodey and Johnson[58] have rightly pointed out the dangers of calling an individual or a society "goal directed"; the name suggests a narrowness and specificity which is counterfactual and which may encourage wrongheaded or positively harmful efforts at controlling the system in question. On the other side of the coin, these evolutionary systems are immediately related to simple goal directed systems and it may be a salutory exercise to broaden our notion of goal. One thing is certain; if we *do* use the word in connection with human affairs (and, as cyberneticians, we are prone to do so) then we should be fully aware that goal directedness is rarely, if ever, of the simple-minded sort.

DISCUSSION

The following sections discuss and develop the broader concept of goal directedness, mooted in the last section, i.e. a concept of goal setting as well as goal seeking.

Redundancy of Potential Command

McCulloch coined the phrase "redundancy of potential command" to describe the relationship existing between a set of goal directed systems which compete for dominance. It is clearly assumed that the systems in question (call them the goal directed subsystems) have a value defined on their operation; any one is built to seek an opportunity to operate and command the others and they clearly exist in such a relation to one another (or to an environment) that only one of them can command at once. Generally, the one that wins depends upon evidence from the environment (or from the aggregate of subsystems, or both); there is a tendency for command to shift from time to time in a way that favours the subsystem currently in possession of the most relevant information.*

The multi-goal systems of the last section are parallel computational systems in *this* sense; *not*, for example, in the sense that a perceptron is a parallel system.

As mentioned on p. 21, McCulloch and his colleagues have computer simulated the action of the reticular formation, which is one of the physiological mechanisms involved in directing an organization's attention. This simulation provides a lucid instance of "redundancy of potential command". The goal directed subsystems are, in this case, concerned with the potential *modes* of operation of the organism (i.e. walking, eating, etc.). They interact in the relationship indicated above and the organism as a whole is committed to one mode of activity or the other as command is shifted amongst

* The work of Mesarovic and his associates (for example, Fleming *et al.*[59]) is similar spirited. It is, however, carried out at an abstract level.

them. The selection of the currently dominant system depends upon the weight of evidence in respect to *all* of the modal computations and also upon a feedback from the cortical processes engendered by the immediate commitment. Whilst each of the goal directed subsystems has a fully specified goal (for example, "mediate eating behaviour") the goal of the system as a whole is underspecified ("general stability" or "survivial", or something of the sort).

Here, of course, we are talking about taciturn systems. But a similar picture holds good at the level of L.O. systems, which typically compete for *execution*.* For example, the perception of visual illusion figures is frequently accompanied by an oscillation between interpretative programmes†; the Necker cube, seen "infacing" at one moment and "out-facing" at the next is a clear instance of this phenomenon. Here the competing L.O. subsystems constitute a system with redundancy of potential command. But at this level, *co-operative* as well as competitive interaction becomes an obtrusive feature of the process.* For example, in viewing a paradoxical figure such as the "tuning fork" or the "impossible staircase", oscillation goes hand in hand with a resolution of the type proposed by von Foerster. The viewer makes an essentially self-referential statement and generates a construct

* In computational usage, a programme *is executed*; it does not of itself "compete for execution". Here the analogy with present day computation proves inadequate. The computations carried out in a brain (especially in the "working memory" to be referred to on p. 34) belong to the same class as the computations carried out in a cell. If computers were not so fashionable and cells so unfamiliar, I would have developed the argument in these terms.

To sketch what I mean, enzymes, in particular allosteric enzymes, are the most elementary goal directed systems in the cell. They operate in cyclic transformation processes which are unequivocally programmes (for example, the Krebs cycle). Some of these are protein synthesizing cycles which produce (amongst other things) fresh enzymes: for example, the well-known and unequivocally programmatic organization, "DNA message → messenger RNA; transfer RNA + amino acids → tagged amino acids; messenger RNA at ribosomal site + tagged amino acids → fresh enzymes". Here it is obvious that both simple and complex programmes have an imperative built into them; in the cellular environment they compete for execution and co-operate; in turn, they recreate or reproduce this environment. Mental organization has a similar quality and it is in *this sense* that I use the phrase "compete for execution".

† These programmes match the excitation of a sensory manifold to the expectations entertained by the subject. A similar proposal is made in Gregory[60], which also provides an elegant discussion of the field in question.

* "Becomes obtrusive", because, on closer examination of *all* systems with redundancy of potential command, co-operative phenomena are evident in an embryonic form.

involving a further spatial dimension in order to resolve the disparity between the rival programmes[61].* This is *co-operation* in the present sense. Two L.O. subsystems acting in concert can do more than the sum of the two acting alone and a new system is generated as a result of their interplay. If the L.O. systems are cognitive rather than perceptual programmes, then co-operative interaction is identical with Schon's[62] displacement of a concept to produce a new one (see, in particular, the example of the concept "drum", pp. 30–32).

The Individual at a Given Instant

We are now in a position to see the individual, at a given instant, not so much as a *particular* goal directed L.O. system as a collection of L.O. systems bearing (in some sense) the same name† and tied together by the relationship of enjoying redundancy of potential command with respect to an *overall* goal which will be *seen*, either by an observer or the currently dominant system, as a *contingent* or *underspecified* goal in the sense of p. 31 (a), (b), or (c).

Evolutionary Processes

An L.O. system with redundancy of potential command becomes an evolutionary system insofar as its L.O. subsystems must be embodied in a computing mechanism prior to execution, insofar as these *embodiments* are subject to decay or abrasion and insofar as there exists a reproductive or maintenance process that preserves successful subsystems or variants against decay. If so, the basic competition between the subsystems in the population becomes a competition for reproduction and survival.

I hypothesize that the brain, in particular the *functionally* (not physiologically) demarcated "working" memory mechanism, is just such a computing medium and, consequently, hold that the individual is continually evolving. It is exactly in this sense that I sometimes dub the brain (or that part of it) an "organ for reproducing concepts".

* von Foerster has studied the matter chiefly in terms of colour vision (working with Dr. Matturana) and constancy phenomena.

† Usually in the sense that the L.O. subsystems are run in the same brain. But note the previous comment, that if an observer tries to identify this class he is liable to an uncertainty about the extension of the individual. Note, also, the comments made later on the subject of conversational interaction.

Any programme being executed in working memory can address information, subroutines, and instructions which are generally lodged in the long term memory of the same brain, but which may also be written as records, in the environment. Equally well, 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. Recall from p. 31, the observer's uncertainty about the boundaries of an individual.

Goal Setting

The evolutionary process generates a sequence of sets of subsystems having redundancy of potential command. As on p. 31 (a), the goals of the collection, of the whole system is necessarily underspecified. From time to time, the issue of command is temporarily resolved when an individual's goal is definite but contingent either in the sense of p. 31 (b) or (c). Looked at from a slightly different angle, the resolution process is itself part and parcel of the general evolution.

Resolution (and goal setting) occurs in several different ways.

(1) By dint of information received from the environment, which defines a new goal. In deference to Hawkins and Storm, I shall call this "eolithic intervention" (see Hawkins[63]).*

(2) By *external* co-operative interaction or conversation with some other individual.

(3) By *internal* co-operative interaction between L.O. goal directed systems seeking the same goal in different ways.

(4) By competitive interaction.

(5) A special case of (4). The language oriented individual sees his own brain (in particular the programmes run in the limbic structures) as a system with goals of its own. These may or may not be consonant with the goals he currently entertains. In any case, this system ("his" computing system) "engages him in discourse".

* The author recalls and develops the argument in an earlier paper by Storm. The argument is placed in the context of design, which is commonly regarded as a form of problem solving with respect to a fully specified goal. Hawkins points out that a great deal of design is quite different. The designer "has no goal" but encounters some object or method in the environment which suggests a goal; this he calls an eolith. For example, the designer may come across an oddly shaped piece of stone which suggests the goal of making a spade. In our own laboratories bits of apparatus or deeply engrained methods often set the goals for subsequent research proposals.

The Correlates of Conscious Experience

"Man is a language oriented system" glosses "man is *observed* (by the psychologist) as a language oriented system", i.e. he is engaged in discourse. Insofar as the subject states or accepts goals, albeit underspecified goals, he is presumed to be aware and, in potentially communicating his awareness to the observer, to be conscious *with* him. The domain of enquiry defined as psychological on p. 29 is thus a domain of consciousness and it is pertinent to investigate the correlates of conscious experience. Notice, we are not trying to *explain* conscious experience in terms of more primitive events (for example, states of as taciturn system). According to p. 29, that would be an essay in the wrong type of reductionism. Furthermore, I believe it would be doomed to failure because observations of language oriented and taciturn systems are fundamentally different kinds of *observation* (to reiterate the point on p. 29: that does *not* mean there are two sorts of system). However, we *can* usefully set up correspondence between the appearance and even the nature of conscious experience and the operations which go on in (say) an evolutionary process. The following proposals on this score have the form "the execution of such and such a programme in working memory correlates with conscious experience".

Somewhat contrary to general belief, I contend that the human being is *unaware* of the execution of programmes with fully specified goals. He does not *know* when he is acting as an automaton. For example, he is unconscious of the execution of overlearned skills and he is unconscious of the routine and massive searches which must go on in the associative network of long-term memory. On the whole he is unaware of intellectual problem solving when the subgoals are completely specified; he becomes conscious of the process when, though the overall goal is fully specified, some of the subgoals are not, i.e. in general, he is aware of problem *posing* and the process of *constructing* problem solving procedures.

Man can be made aware of some normally unconscious processes if, when asked to describe them, he attempts the dual task of carrying out a procedure and matching an account of it to the observer's understanding (his success in actually producing a description varies widely; he is moderately compe-

tent in respect to procedures where there are subgoal points at which he *might* experience uncertainty as there usually are in intellectual tasks; he is utterly incompetent when it comes to describing how he performs an overlearned skill). In general, man becomes conscious when at least two processes are going on at once and these may or may not be internal to his brain.

For example, in skill learning (signal translation, teleprinter operation, etc.) the subject is aware of his errors insofar as (1) he has some rudimentary procedure for making a goal directed response and (2) the experimenter provides an external *co-operative* system which (as it were) does the same computation perfectly and provides the subject with knowledge of results feedback. Later in learning (with no knowledge of results feedback) subjects are conscious of *some* errors but ignorant of others. The *conscious* errors seem to be associated with the following circumstances: (a) there exist some slow but sure response programmes acquired early in learning; (b) these are lodged in long-term memory; (c) a more recent, more efficient but nevertheless more fallible procedure has been learned later for doing the same job; (d) the new procedure is applied (to achieve the goal) in parallel with the old procedure (aiming for the same goal); (e) competitive or co-operative interaction takes place insofar as a comparison is made between the "truth" (old procedure output) and the "actuality" (result of the new but fallible procedure).

Broadly speaking, man is aware of goals which he is asked to or anxious to attain but for which he does not possess the requisite goal seeking apparatus (and has to build it by a concurrent learning process). He is aware of contingent goals and, by the same token, of a mismatch between what he does and what he intends to do, between what he senses and what he expects, or between conflicting interpretations.

My conjecture is thus as follows. *The unique correlate of conscious experience is a state of a process (wholly or partly in working memory) such that (1) there exist two or more goal directed systems (usually in a relation of redundancy of potential command) and (2) these systems interact either competitively or co-operatively; in short, when they engage in discourse. Whilst the discourse in question may be internal to a single brain, it may also involve a system in the environment, in the brain of a conversation partner or in the brain of an observer.** These conditions can be satisfied by the evolution of a language oriented system.

* The interaction must be non-trivial. In conversation, for example, the sentient individual must compute what *he* believes the other individual is also computing and there must be a comparison between the output from *his* model of the other individual and what the other individual says or does. The argument applies, vice versa to the other individual.

The conjecture is open to two criticisms. The first, that it says little more than "thought is subvocal speaking" is misplaced. There is no more than a superficial similarity between this dictum and the present conjecture. The second criticism, that the conjecture seems to neglect man's obvious awareness of pleasure, pain and the like can also be refuted. In fact, it would be possible to erect an entire theory of affect on the basis of discourse between programmes (L.O. systems) run in the limbic regions and those run in the neocortex (the sort of interaction mentioned on p. 35). Some recent affective psychologies come close to this stance. But the matter, though interesting, is beyond the bounds of this paper.

Predicting and Controlling Evolutionary Systems

The general *mechanism* of evolution has been computer simulated by various workers, for example, by Fogel and his colleagues[31], by Toda[64], and by myself.* Many of the more dynamic artificial intelligence programmes contain parts that are also "evolutionary". The real difficulty is modelling or representing the quasi-linguistic operation we have referred to as "setting a new goal" and this, of course, is peculiar to the embodiment and execution of an evolutionary L.O. system.

We have a limited understanding of one especially tractable situation involving an L.O. evolutionary system; namely, concept acquisition in a tutorial conversation (recall the definition of p. 20; a concept is a goal directed system). Here, the overall educational goal is fully specified in the sense that the subject (student) agrees to aim for it within the terms of an experimental contract and the whole construct is contingent upon the observance of this contract. Next, the whole of the co-operative interaction which builds up the new concept is assumed to take place via the conversational channel; it is externalized in communication between the subject and the teacher which, either in fact or in effect, is a fully specified teaching mechanism. This machine operates (1) as an external process that co-operates with the student

* My own work in this field is scattered through the literature, for example, Pask[65–67]. One of the most comprehensive models has been provided by Brieske[68], working at von Foerster's laboratory. Many others (notably Baricelli and Bremarman) have studied evolutionary processes in biological systems.

as he learns and (2) in the role of an observer. Whilst the subject is allowed to propose his own strategies, to set his own subgoals, etc., the acceptance of his decisions is contingent upon and is monitored by this external machinery.

Given all this, the evolutionary process of concept learning can be described by an *heterarchical* model for the subject (student). The original concept is represented by a goal hierarchy or problem solver in the sense of Figure 2; where, for example, G is at a higher level in the hierarchy than either G_1 or G_2. Learning is represented as an operation in which comparable problem solvers act upon the domain of the original problem solver (the original concept) in order to remedy its defects and to write fresh programmes. Clearly, this entails a quite different hierarchy; an hierarchy of control. For example, the original concept is a problem solver at the lowest level of *control* and the problem solvers that operate upon it reside at a higher level of *control*. Since both problem solvers may have the same organization (they need differ only in domain) and since they both have subgoals at various levels in the goal hierarchy, there is an interaction between the hierarchies and the entire model is *heterarchical*, as proposed a moment ago.*

Under these restricted conditions, it *is* possible to predict the course of evolution or learning and to control it by appropriate teaching strategies.

The trick employed is to conceive "goal setting" as higher level goal seeking (higher, that is, in the hierarchy of control). This trick is perfectly legitimate provided that the resulting model is based on the assumption that the goals "set" by the subject are *subgoals* of the *fully* specified educational goal. But the construct becomes completely invalid as soon as the subject departs from the experimental contract (which he *may* do and which he *knows* he may do).

Towards a Theory of Theory Building,
i.e. a General Theory of Goal Setting

In general, the generation of new goals involves operations in which the human being becomes his own observer. In the role of observer, he sees himself as a system and defines a purpose *for* this system (in the sense of the section on p. 23) which later acts as a purpose *in* the system (i.e. acts as its goal). In other words, the unconstrained goal setter (for example, "man as a scientist" in Kelly's personal construct theory or "man as an innovator" in all psychoanalytic theory) is his own theory builder (in the sense of the sections on pp. 23 and 24) and the representation of this general case calls for a formal statement of the notions contained in these sections: a theory of theory building.

No such theory exists. But some of its constituents are available, as formal tools, at the moment. The first step towards developing a theory of theories is to muster, integrate and, in some cases, sharpen these tools. The following items are the prerequisites which I, personally, have in mind.

(1) A proper logic of commands and intentions; the germ of it is available in the work of Rescher[18] and Von Wright[11] and in Kottelley's[12] intentional calculus (partly developed).

(2) A formal theory of partially co-operative interaction and conversation. This may be based on Howard's[13] theory of metagames, augmented (so far as the communication problem is concerned) by the ideas of Gorn[74].

(3) A logic of distinction to comprehend the act whereby a goal (or goal like entity) is abstracted from an amorphous flux of development. The problem was clearly stated at a philosophical level by Jung[15] in the 1920s; Spenser Brown[76] has recently solved it and provided an elegant calculus of distinctions which calls for an interpretation in the present field.

(4) A representation for essentially parallel processes. Here, the most promising candidate is Holt's occurrence theory. Within this framework, it is possible to formalize the concurrence of events and the ideas of competition and of information. The phrase "information transfer" has a meaning within occurrence theory that differs markedly from the current technical usage. "Information transfer" between occurrence systems is identical with the co-operative interaction that resolves uncertainty over an underspecified goal[77].*

(5) An axiomatic statement of the notions underlying evolutionary processes. Lars Loefgren has provided the bones of such a thing (the possibility of complete axiomatization is undecided)[78].

* For an outline, see Pask[69]. The most complete statement of the theory is in Pask *et al.*[70]

* Any cybernetic system, in the sense of the section in p. 24 can be represented as an occurrence system. We hypothesize that "information transfer" between goal directed systems of the evolutionary process is the unique correlate of conscious experience. The nub of the problem is, "who interprets or represents the systems in this way?".

Limitations

If a theory of theory building is fabricated, then what sort of theory will it be? As mooted earlier, a *purely* formal theory of the sort that would lead to a casual *explanation* of goal setting and conscious experience, is almost certainly unattainable. But this does not mean that no useful theory can be constructed to *adumbrate* the issues in question in the sense of predicting and controlling the behaviour of evolving, language oriented, conscious systems. The conviction that we can *adumbrate* but not *explain* these systems could be regarded as a doctrine of despair. Personally, however, I see it quite differently; as an indication of the limits and the fascinating potentialities of our discipline.

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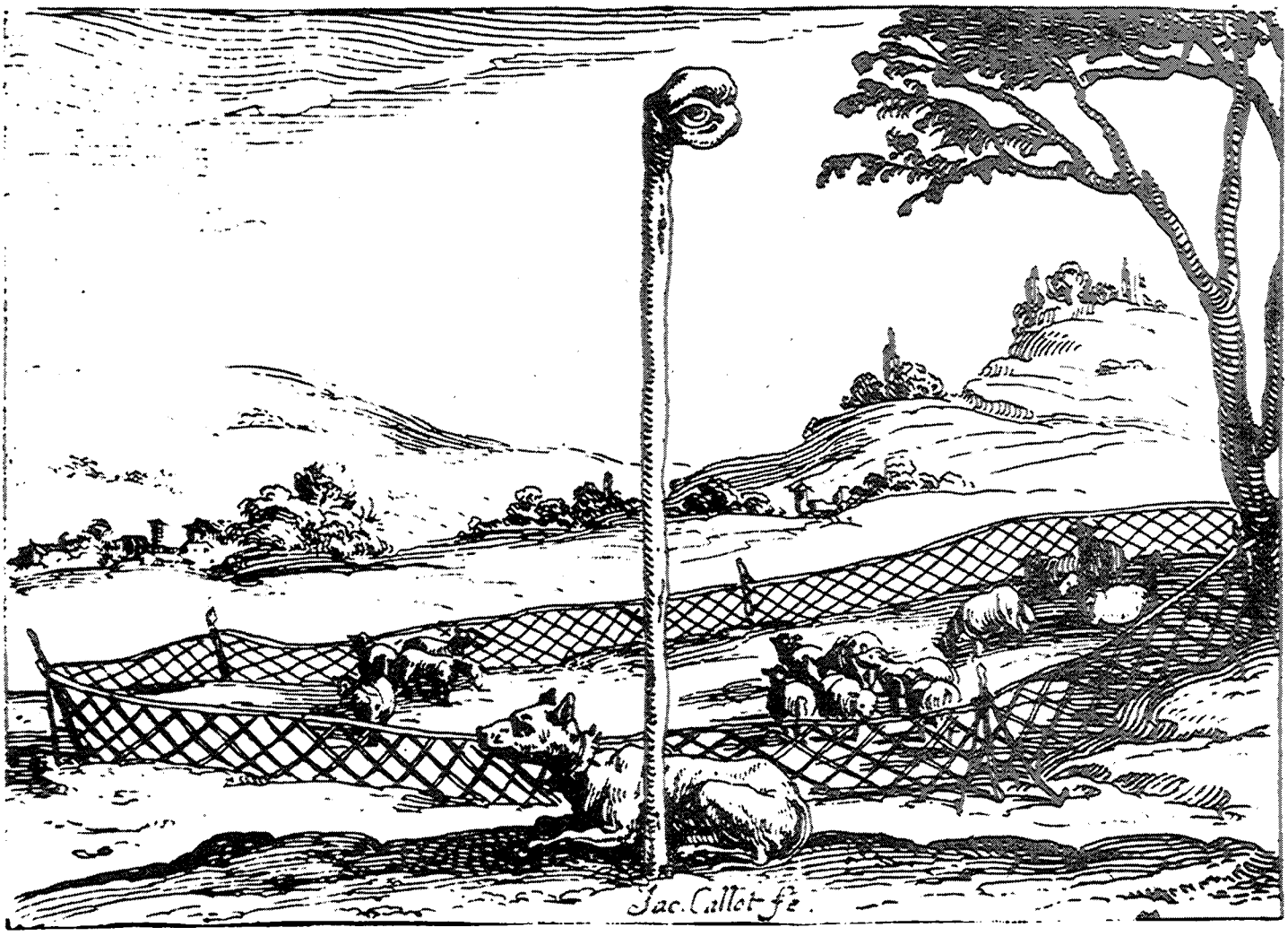
SURVEILLANCE

Surveillance is the total absence of access. Literally, to 'oversee' a system in its observations.

Example: Video cameras over a public square, where 'observed' and 'observing' relations are continually articulated. The square is no longer properly 'public' (of people); it is a corral. [R.C.]



DOUBLE-BIND

Noun. Also sometimes an inelegant verb. (Avoid the past forms "double binded" and "double bound".)

The definition of this and of a host of words ("context", "deutero-learning", "humor", "play", etc.) is difficult because the referent of these words is neither totally identifiable as a sequence of events external to the subject nor as an idea whose reality is only in the subject's mind. As when a "bat" is seen in an inkblot, so some consensual validation of double bind can be achieved.

You cannot count the number of "jokes" in a given conversation because one good one near the beginning may cause many otherwise neutral or serious items to appear funny. Similarly you cannot count DB.

In a word, any definition of DB must contain, first, a reflexive clause. A DB is a context for behavior which has effect upon the "victim's" identification and understanding of contexts of behavior.

Obscura per obscurioribus. Some explication of "context" is necessary. In mammalian "learning" (sc. "receipt of information" or "increase of redundancy between the learner and his environment") the processes and machinery of learning are altered by the act or experience of learning: there is a learning to learn ("Learning II" or "deutero-learning"). The information acquired in learning-to-learn may be of many kinds. In "set learning" (Harlow), the propositions concern the outside world: transference of learning is expectable from problem A to problem B if both problems contain similar design features. In "deutero-learning" the propositions acquired concern the relationship between subject and his environment or vis a vis. Transference of learning from context A to context B is expectable when context B resembles context A in requiring of the subject similar "attitudes"or "character", i.e., a similar assessment of self-in-context. Deutero-learning is thus the acquisition of such characteristics as "fatalism", "dependency", "spectatorship", "cunning", "cynicism",

"passive-aggresive personality", "detachment", "confidence", etc., etc., including combinations of these.

(As I understand it, the psychoanalytic theory of transference could be phrased: The patient will bring to the analytic session the deutero-learning acquired in his/her childhood dealings with significant others. If "dependency", or what not, was a general solution for the child, the the resulting adult will expect the analyst to be "succoring" or some other complement of dependency.)

"Context" is thus a subjective/objective word. On the one hand it is the structure of how the person (consciously and/or unconsciously) sees the interaction between self and other; and, on the other hand, it is the objective structure of that interaction.

It follows that two persons can be in disagreement, conflict, or misunderstanding regarding the context which they share. One or both can be "wrong" about the shape of the context. One or both can be deceitful or spiteful in this regard. Still more complexly: one or both may be playful, exploratory, or frightened: and there may or may not be a sharing of the premises of play or fear.

From such considerations, it follows that we may encounter sequences in which the older deutero-learning is now inappropriate. It is either unrewarded or is actively punished. We are, as it seems, <u>unfairly</u> treated for some attitude or premise of relation- which was at some (near or distant) previous time appropriate. This is the "double bind".

It is painful or traumatic or sometimes funny. It may promote psychotic or psychopathic symptomatology (e.g., the habitual misinterpretation of contexts of relationship) or humor or invention. It is the precipitating circumstance for psychic <u>change</u> - either pathogenic or therapeutic, creative or mystical. [G.B.]