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1967 BEHAVIORAL MODEL OF MAN. HIS CHAINS REVEALED *

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1. A CHAIN OF PREMISES. INTRODUCTION TO HOMEOKINESIS

The physiological system in man seems to be founded on the following elements:

1. There are many active system chains organized around cells, which are the atomistic element of the biological organism. (System analysts may prefer to visualize networks. Since the field phenomena are not so absolutely fixed spatially, we prefer to think of them as causal chains.) The genetic encoding from which these biochemical chains develop is not yet adequately known. Thus their description must continue to be macroscopic and phenomenological.

2. What seems to be common among all the internal systems is that their actions are organized into essentially unstable closed chains of a biochemical - mechanical - electrical nature involving the solids, liquids, and gases in the body; e.g., the breathing chain, the heart beat chain, the voiding chain, etc. They usually end as stable non-linear limit cycles (that is rhythmic elements), often passing through transient stages as the organism is affected by changing contingencies in the external milieu.

3. The collection of all of these chains forms an extensive system of such non-linear oscillators whose action is controlled mainly by inhibition. It is this collection of oscillators (of active linearly unstable, but non-linearly stable, ever beating networks) that represents life itself.

4. The scheme of regulation and control by which these oscillator systems are modulated through their non-linear stable operating range is best described by the term 'homeokinesis'. This is proposed as a modification of Cannon's concept of homeostasis, to connote that it is the manipulation of kinetic variables of space and time (such as a changing concentration in a local tissue), by which the processes, predominately regulatory, take place.

5. Study of such operation may be tackled effectively by what is called dynamic systems analysis. This requires, for its most useful pursuit, a technical decision as to what processes limit observation of the system from below at the shortest time and the smallest spatial element of significance in the continuum of processes; and, from above, at the longest time and longest spatial element of interest. Within these limits the analysis of the spatial and temporal spectrum of effects can be attempted.

6. For the macroscopic biological organism - man representing the most significant prototype in our discussion - we must include the molecular biological level. It would provide the same age-old trap that sought to describe macroscopic physics on an atomic level, or that still persists in attempting to describe atomistic physics on the level of phenomenological macroscopic laws. It is necessary, instead, to stick to the hierarchical level that suits the macroscopic system. Similarly the subcellular processes must be excluded. The cell, as the atomistic unit of organization, thus sets our lower limit.

Generally our interest must turn to the higher level of the minimal organized group of cells from which system chain function emerges. The summed-over-space capillary bed in which the near 10 micron free red cell interacts with the near 1 micron capillary system wall, the glomerulus, the summed-over-space-and-time communications unit in the local neural net, etc., illustrate the lower functional levels. The time scale limit is about 0.03 sec. The extensive ex-

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ploratory background of the encephalographer in the macroscopic signals from and within the brain cannot point to any significant organized content below this limit. (Although interaction in the megacycle range with the total organism is well in process of demonstration and a kilocycle range of cellular processes is also becoming known, such time scales are not directly involved in gross behavior. To look at behavior in these terms would be as much beside the point as describing a chair by subatomic physics, electrical events in the 60 cps home system by invoking the velocity of light, or the detailed logic of the individual neuron).

At the upper limit, the isolated animal is our unit. Beyond this lies the province of the social sciences; although behavior begins on the unit-to-unit interaction. Correspondingly, the long time limit is the single 'relaxation' process that is a man's lifetime.

Thus from the most fleeting 'moment' of Stroud (1967), near 1/20th sec, to the lifetime of degradation of the gonads, in 70 years is the play of man's life defined; from the single sperm or ovum and the single streaming red blood cell to the whole brain and body is the case deployed.

7. What is it that a man does? He eats and moves about so that he can continue to eat and move about. At the right enfolding time, he couples and reproduces so that the newly formed unit can eat and move about. By genetic changes through mutation and selection he adapts to the changing milieu, so that the enfolding species can continue the process. In time, his systems fail, and he dies. In time his species may fail and die. A more suited adaptive system continues. Through all of the biological kingdom, the same story is told. In common with many purely physical processes, the failure is often one of two types - either an actual dissolution, or else a non-resilient fixity of brittleness.

From the dynamic systems' point of view, the following two tasks, (a), and (b), must be accepted and a third, (c), must be considered.

(a) How is it that the metabolic process is regulated to continue the movement?

(b) How is it that the movement is regulated to continue the metabolic processes?

(c) How is it that reproduction ensues?

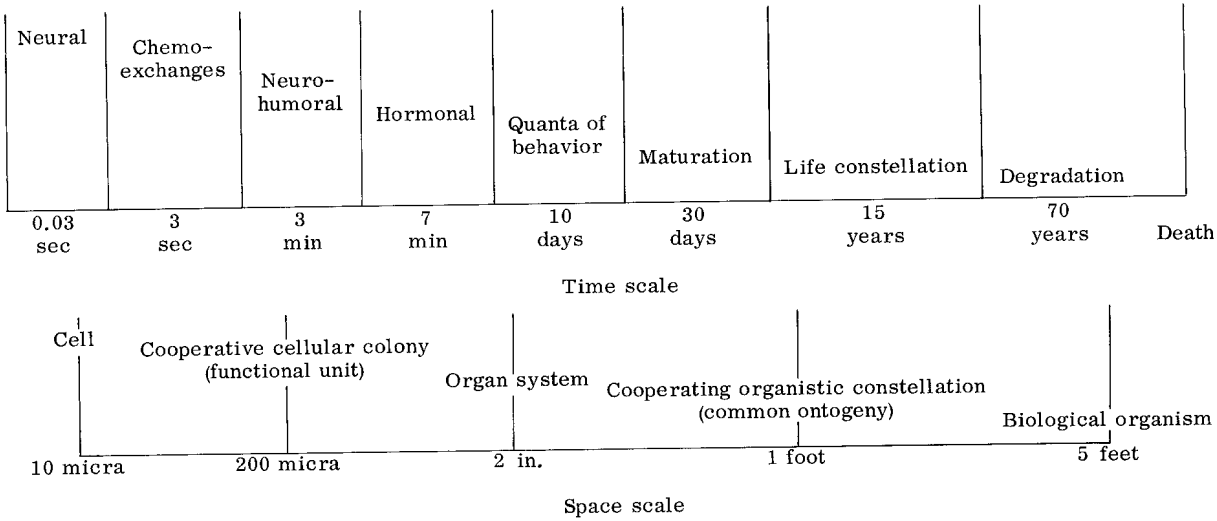
The third task is excluded from our extensive consideration at present. It begins to probe at a longer time scale. However, how and why it starts cannot be neglected.

8. In the time domain, this limitation means that the atomistic unit of behavior (that is, of the gross action of behavior) is much closer to 30 days than to a lifetime; but the 15 years to adolescence must lie within focus, and the 70 years to failure of an endocrine system must also be viewed. However, it will only be necessary to bring the family unit of mother-father-child and the peer group just barely onto the stage.

Graphically, these space-time domains can be characterized by the following approximate scalar metrics. (Without extensive discussion they must be regarded as schematic, fig. 1).

9. What makes the chains run are predominately catalytic reactions (commonly called 'enzyme-hormone' links). However, these are coordinated by fluid mechanical and by electrical streams, and they involve mechanical elements. Transport, conduction, convection, diffusion, bipolar stress, chemical linking - these are some of the unit processes that are involved.

Fig. 1. The dynamic spectrum for man (involving behavioral response).



The distributed factory that makes up the human being would be a chemical engineer's delight.

10. The spectrum of such chains is not continuous, nor even densely populated. Instead, it would appear that there is a rather limited time fracturing (or time locking) through which processes tend to form and be cooperatively involved. There apparently exists nearly a limited finite matrix of regulated elements. Its columns are such elements as the metabolic reaction - fuel, oxygen, water, carbon dioxide, and some other chemical constituent streams, typically electrolytes) and of time scales (as the rows of the matrix), and there seem to be regulating chains that fit many of the temporal intersections. Not all animal species use exactly the same chains, or even time scales, but the density and distribution of number of chains is similar.

11. The nervous system is used to mediate these chains, otherwise their predominantly linearly unstable characteristic would show up. They would go into violent sustained (i.e. schizogenic) oscillations or 'saturate' (i.e. cramp off). The nervous system is thus used as the mediator between information - a measure of contingencies in the surrounding milieu, both internal and external - received as sensory input, and the unstable motor and glandular systems. The resultant is a controlled synchronization in which most systems are 'repressed' or 'inhibited' (i.e., thereby regulated) to a very limited oscillatory range; whereas some are released from inhibition so as to go into orbit. System motion proceeds by the scheduling of these orbits in time; as a series of 'postural' elements of the body as a whole, enfolding its repertoire of behavior 'moment' by 'moment'. The body moves by its responsive velocity schedule of one posture per moment. Each posture represents a linked series of orbits, forming in toto an orbital constellation.

12. The characteristic schedules, enfolding as patterns in response to excitation, make up the behavior of the animal.

2. THE CHAIN CONTINUED. INTRODUCTION TO THE PHYSICAL-CHEMICAL SYSTEMS INVOLVED IN BEHAVIOR

13. The active regulatory chains are biochemical, under hormonal intervention.

14. A very basic biochemical intervention, which may be regarded as a high speed 'alertive' reaction, is furnished by noradrenaline which outlines the active nervous system paths as they conduct information. This 'leakage' flux provides a microchemical change-producing tonus to the system. Its relaxational time scale is of the order of 0.1 sec.

15. A concomitant chemo-electric action is shown in muscle tremor or microvibration always going on in the organism. Its neural involvement is shown by disappearance of the vibration upon a barrage of impulses along the motor nerve. In man, the frequency band is as wide as 6-18 cps. Currently it is considered that this vibration likely has both neuromuscular and cardiovascular connection.

16. Even less well-studied are such oscillations as a micro-oscillation in the cardiovascular system at the levels of capillaries - at 3-4 cps level in some animals; similar high frequency flickering motion on the brain's surface; or flicker in the glomeruli activity in the kidney, etc. Whether such oscillations have similar causality is not known, although we would suspect so.

A characteristic phenomenon observed in the chains that have been investigated, with whatever underlying structural scheme that it suggests, is that the motor system is locally unstable (and this appears to be true for all systems regardless of their size or involvement), and thus exhibits its fundamental linearly unstable limit cycle rhythm. In the first instance, the nervous system is used to 'inhibit' the system (i.e., to provide some marginal stability that keeps the limit cycles bounded); in the second instance, the nervous system is also used to remove the inhibition in such a fashion that a smooth coordinated movement ensues, often likely with a suppression of the limit cycle oscillation (or vibration).

17. While all of the higher frequency rhythms - including the brain 'waves' appearing on the surface of cortex, as found in electroencephalography, as well as the active aperiodic pulses and trains of pulse-like potentials associated with nervous paths - are quite subtle and often neglected in considering the large scale and long time integrative action of the system, they are always present. They are chemo-electric. They utilize mechanical and hydraulic links. Their presence makes it impossible to view the system, at any level, as static. However, conversely, they are not the communications' language of the system. Their buzz is not the information flux, only an indication that the system is dynamically in flux. One can infer that a complex biological 'factory' is running by its mere dissi-

pative noise. However, decoding the internal functional communications and transport fluxes is a more difficult matter.

18. The informational fluxes are: the sensory inputs; *on the surface* - temperature, pressure, force (concentrated pressure), ionic state, humidity; *at fixed portals* - temperature, visual electro-magnetic radiation (light), chemical fluxes (smell, taste), mechanical fluxes (sound), pressure (touch on specialized regions like the lips); *throughout the volume* - gravitational-acceleration gradients.

These are the external ones. In addition, internally, there are many fluxes, generally being received neurally, chemically, or hydraulically through the blood carrier.

19. The net effect is that these signals - the winds of the milieu, both internally and externally - blow through the system, in particular to nervous system portals.

20. The information fluxes always course through the system. (They include the internal signals from the heart, the ventilation center, and some others at all times.) They are certainly 'known' in the nervous system in the cord, the basal ganglia, the cerebellum, the thalamus and the cerebrum; while the fluxes of the internal milieu are certainly known in the hypothalamus. At present it is only possible to surmise, as a premise, that there is a fairly complete body image of the system that is being updated at a high frequency rate (such as near 10 cps) and that this body image is electrical, hydraulic, mechanical, and neurochemical.

21. Motional changes, induced by motor activity, feed back electrical, hydraulic, mechanical information to provide a dual system for detecting changes. In the 'stationary' system, the tremor oscillations furnish positional information. In the 'moving' system, the nervous system provides velocity information and likely inhibits the stationary tremors. As a result, the electrical information system is thus not an intrinsic information system arising as part of the fundamental organ's adaptive development, but as an incidental convenient system that results in finer motional control.

22. To a large degree the hypothalamus is the highest automatic regulator of the potential state variables in internal organs, glands, and the blood vessels. It patterns the response of autonomic systems at a medium cycle time scale (at the minutes level). As yet inadequately proven, this includes hormonal control through the pituitary-portal system. It may be regarded as a switchboard that operates in a ring oscillator mode (that is cycling through its affector variables). It acts as a slow follower on chemical signals produced within those various internal systems.

23. A most central signal is the socially conditioned high speed adrenaline signal (generally viewed as the fear, fight, flight autonomic response from the adrenals - it is worthy of note that the adrenal medulla embryologically is nervous tissue derived). As one component of this adrenergic response, one may regard that the output of the nervous system is its high speed production of adrenaline (noradrenaline) at nerve ends, so as to limn or outline the system. This is used as an 'arousing' signal or 'grouping' signal for what the instantaneous properties or status of the system is, and what may likely be the fact of the external world. As a sustained small signal excitation, it helps keep the internal systems sufficiently regulated to face the likely motor system demands that may be placed by the reticular core (i.e., the command system) and to ready the system for follower action.

24. For some added detail and perspective at this point, we are stressing that nervous output outlines the system with adrenaline at the tenth second level. (It is the reticular core furnishing discrete informative signals to the rest of the nervous system - in the 0.1-0.3 sec range - that furnished the sustained grouping signal.) The adrenals then furnish large scale regularizing signals throughout the blood system at the 2 min level (considering a number of distributed lags makes it effective at the 4 min level, cf. Cannon's spike in blood sugar). The hypothalamus then provides follower action at the 7 min level.

25. It is generally accepted that the reticular formation likely has the large scale arousal system in the brain. As a parallel core system throughout the neuraxis and midbrain it has connections to all levels of the nervous system. Acting as a probabilistic computer based on all internal and sensory inputs, it controls the arousal of the system with regard to the direction and level of attention and of motor activity. Its buzz may be regarded as representing the libido function (if not regarded as purely sexual).

26. The most meaningful hypothesis is that signals from all sources run up and down the reticular core, which contains the potential command system to commit the organism as a whole.

3. THE CHAIN CONTINUED. THE FUNCTIONAL AND ELEMENTARY STRUCTURAL ORGANIZATION OF BEHAVIOR

27. To bring the brain into focus, we must take the view of the interior milieu in which it carries winds of excitation into the nervous system, simultaneously into the reticular core, to the hypothalamus, and into specialized receptive areas. The hypothalamus has a variety of automatic responses (i.e., it operates with a routine algorism). These are routinely energized by reticular excitation. The system that is most commonly involved in response to changing winds is that of the basal ganglia.

28. The basal ganglia often form the highest center for programmed acts. (Certainly in birds and reptiles, and most often in naturally, as opposed to culturally, programmed performance in man. However, in man, there are some acquired skills which remain cortical.) The basal ganglia may be regarded as the storehouse (i.e., memory) for routine actions. One may picture that they store action routines as analogues; i.e., as bits of tape for such action analogues. They are relatively short term, amounting to routines in the fraction of a second to seconds level (though they may be repeated then many times). It is remarkable how rapidly they can be called forth. At a lowest level is the spinal reflex arc, in which an incoming signal from a receptor passes to the spinal cord and a signal returns to a motor effector. This only need take 0.1 sec. A more complex input, which has no direct cordal response, can get up to basal ganglia, which will furnish the open network with a 'tape' routine. How, exactly where, and in what form such analogues are stored is not yet known.

The basal ganglia act as a deductive system. They have the rules (as action analogues). They are presented with a case under a particular rule, and they prescribe the corresponding motor action. The basal ganglia program the actions of the body on the body.

They can only perform these actions very rapidly if the passage to the cord is fast, if the wave passage up and down the reticular core is fast, and if the recall of analogues is fast. There must be a random access to the basal ganglia memory. They show degradation, but not markedly so.

29. These lower systems - basal ganglia, hypothalamus, cord - are competent to deal with the rapid anxiety situation, the fight-flight problem.

30. This represents the beginnings of a high frequency behavioral response system.

How is action determined? Watch a person or a dog or a cat, etc. The state of the system does not remain fixed. It is basically unstable. The system will not stay put. If you put the organism down it will soon start to move. If it exhibits extensive motion, it will stop in time. Whatever the inputs are, whether DC, slowly changing AC, or rapidly changing aperiodic or AC, the system changes. It changes its 'posture'. (By posture will be meant the relation of the body to the body. Thus postural dynamics will refer to the hurling of the external systems of the body into orbits by setting the internal systems of the body into orbits.) Furthermore, it does this routinely at a rate of approximately 10 per min. These dynamic postural changes can occur within very few nervous 'beats' - Stroud's moment - of up to 0.3 sec. Almost by definition, once developed, whether by learning or otherwise, the dynamical postural responses are subcortical (i.e., responses of the body on the body. In the response of the body to the external world, they may retain and require a cortical contribution, as illustrated in speech).

At high speed, the reticular core can act on displacement inputs within 0.1 sec, on velocity inputs within 0.2 sec, and on acceleration inputs within 0.3 sec. It can obtain information and provide the command for about 14-18 kinds of actions. Logically the reticular core operates as an abductive system (in the Aristotelean sense). It commits the system. It questions whether this information state is a case under one rule or another and takes an executive action that actuates the controllers of controllers; i.e., it is a command control system. In doing so, it may or may not consult the cortex.

The reticular formation, phylogenetically old and basic in function, is the longitudinal core of the central nervous system. Most other systems in the brain are an outgrowth of the reticular system, e.g., the thalamus, the cortex, and the cerebellum illustratively. The cerebellum, reporting to the core, is an internal clock or autocorrelator that regularizes motor actions and computes signals up out of noise. The thalamus and cortex, involved in inductive processes in the organization of perceptions into conceptions and in the formation of long-term plans, report the results of their processing to the core. All sensory systems, such as the eye and ear, and probably all motor systems have direct inputs to the reticular core. For example, as soon as a

signal is 'seen', the reticular core has made the decision, and it permits the lateral reticular system to directly signal the motor system.

31. Since these subcortical dynamic postural elements are multivaried within the complex that forms the behavioral pattern, they are best regarded as making up a heterarchy of responses (remembering that the postural elements are hurled into orbit by the removing of an inhibition; i.e., by permitting the system to become unstable). A logical classification - say among endocrine systems involved - of these response elements is essentially out of the question at present. Today is the time for observation; tomorrow, perhaps, for the formation of theory.

32. Illustrative dynamic postural elements (almost as if a return to an older behavioral psychology, but here posed on a dynamical foundation within the physiological systems) are the following:

postural attitudes of parts (of the head, feet, body, ears, hands)
postural dynamics of parts (such as dynamic scanning for movements; dynamic scanning of a system for people's eyes; characteristic movements)
yawn
stretch
rapid eye movement
laugh
insecurity stereotypes (tics, twitches, scratches)
sweat response
saliva response
voice pitch.

33. The subcortical posturing represents setting various systems into orbital paths; i.e., by maintaining or releasing their inhibitions. The two large slower follower systems seem to be:

(a) The adrenaline-blood system. Circulating adrenaline in the blood seems to involve a 1-2 minute cycle time. (Including hurling the entire system into action may drag out the entire adrenaline surge response to 3-4 min). The principle follower element seems to be the oxygen flow available to the tissue (as marked by the red blood cells) through the capillaries. This flux wave, dragging concomitantly the other metabolic elements - sugar, carbon dioxide, water, lactate, heat production - into dynamic cycles likely represents the 'escapement' for the thermodynamic power cycle of the system. (Its significance may escape the biological reader so that the implications in this thought had best be made clear. If the metabolic processes are to remain 'purposeful', that is, to discharge those functions that seem to fit the animal's activity patterns in the ecology, they require organization. The physical view of organization of energy transfer is the task of thermodynamics. In transit, such transfer involves a sustained temporal process and, thus, an escapement, unless it is tied uniquely to cues such as light-dark, seasonal changes, etc. Simpler biological systems that are tied only to cues may exist. The complex human, homeostatically operating or its more complex description, homeokinetically operating, must be freed more from the vicissitudes of the milieu. Thus it must be self-timed.)

(b) The hypothalamus. (At the near minute level, with a connection to the pituitary system as the master regulation endocrine gland.)

34. In lower animals, the reticular core represents the entire executive logic of arousal and shut-down of function. When shut down, the animal enters a discharge phase and burns off waste products. It 'rests' and 'dreams'. When it 'arouses', the animal goes into action.

In the higher animal, particularly the human, the reticular core assigns the (phylogenetically) newly emergent role of induction to the cortex. If the input pattern is not a case that is fitted by the standard analogue patterns immediately available from the basal ganglia, the case is referred quickly (i.e., within 0.1 sec) to the cortex. The cortical memory (whose storage place is as yet unknown) is an analogue memory of many past cases. Presented now with external patterned 'facts', it 'guesses' at a law (i.e., it wires together a network response that excites the motor oscillators into action). The cortex 'takes' (that is, forms) habits. Once these are set up on the motor side, the cortex is often no longer involved and the solution analogue may be transferred or formed within the basal ganglia.

In primates, the cortex is quite busy with optical signals. Much of its peripheral input is loaded up with optic signals. This is the 'price' the biological system pays for such a precise invariant optical field. (Note that other fields - sound, temperature, gravity, chemical fields - are not outlined with such detailed precision and relative consistency.)

It is also quite busy with verbal signals. There are well defined regions associated with speech. A great puzzle is the source of the large active memory and recall.

35. In a very sketchy form, thus, roles have been assigned to:

cortex	cerebellum
reticular core	sensory input nervous system
basal ganglia	motor output nervous system
cord	endocrine system
hypothalamus	

36. We now approach the medium time of be-

havior - the 1-1000 hr time domain. This is the time to go on vacation, to get drunk, to fall in love, to take a job, to get an important idea, to get married, to menstruate, to commit suicide.

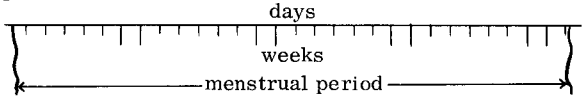
What has been most common in philosophic-psychological-psychiatric-psychoanalytic speculations are various aspects of the mind-body problem such as the distinction between responses that may be closely coupled, nearly 'wired' from input to output by direct mechanistic paths, or those that require a more vitalistic, indeterministic volitional conscious system interposed.

Much of the metaphysical argument can be avoided if it is recognized that our present concern is the result more of changes in the state of the internal inputs to the system - i.e., to the central nervous system - rather than to external inputs.

In this longer time scale the external inputs now only appear as a quasistatic system of much slower 'cues', that is, a slowly changing DC environment. (One day is much like another, and one week like another.)

Thus it is essential to embed a given animal into a fixed milieu. This will have to mean a Darwinian evolved creature, man - say 10 000 BC to the present - with a specific genetic coding, in a given socio-ecological milieu, say 20th century American civilization. More specifically, a stable configuration male-female-*n* children family group in a stable society will be considered. (For completeness, the responses in perhaps a handful of different social - economic - ecological groupings might have to be covered for the present total earth's milieu. However, only our own will be used as illustration.)

The unit of cueing will have a long scale time constant of the order of the female menstrual period.



37. If the 'geographic' differences of human behavior types may involve a dozen regional and economic differences, what are the 'histographic' differences? (Ordinarily history involves specific individuals or groups - John Doe, British entrepreneurs in the 17th century, etc. We propose to ignore this concept for behavior.)

They are drawn as patterns, it seems, from the following state 'syndromes' (syndrome here denotes the concurrent connected internal states of the biological system). They may be identified as dynamic action states of the system, such as 'The system sleeps', etc.

Percent of time	
30	sleeps
5	eats
1	drinks
1	voids
3	sexes
25	works
3	rests (no motor activity, indifferent internal sensory flux)
5	talks
4	attends (indifferent motor activity, involved sensory activity)
4	motor practices (runs, walks, plays, etc.)
1	angers
1	escapes (negligible motor and sensory input)
2	anxiouses
2	euphorics
1	laughs
1	aggresses
1	fears, fights, flights
8	interpersonally attends (body, verbal or sensory contact)
1	envies
1	greeds
100% ± 20%	of the time involvement.

In this complex of behavioral rhythms (± 20% is permitted for uncertainty) is the patterned activity of the nervous system and the internal organ systems involved. It is these internal and external characteristics that make up human behavior.

38. The basic characteristic is the instability of the brain system. Thus it tends to develop an internal oscillatory rhythm. Beyond the changing threshold cues, the actual performance is conducted mostly at basal ganglia level with ritual fill, that is, the social activity, the content of books, intellectual activity, all are ritualistically filled past the minor originating cues.

39. A most significant element in the organization of behavior is the use of cues. (What should be noted is the large number of geographic, social, etc. cues.) In case of a temporally (or spatial) cued input, the animal will develop a ritualized fill of behavior. (We are indebted to Dr. Rioch for the thought. A 'ritual' by definition is a patterned response which is stereotyped.) Its likely construct follows from the system instability. An animal cannot maintain undischarged nervous excitation energy, but must seek to release it by releasing the inhibi-

tion on some motor response system so as to unstabilize it into orbital action.

40. The stereotypes of behavior may be taught by the mother. (In birds, they may arise from genetic unfolding; in fish, from the father; commonly, from the dominant parent.) In rough approximation, they recapitulate the phylogenetic progress up to the particular species (Gesell).

41. What is particularly noteworthy in the biological system is the patterning of behavior that runs it through a repertoire of performances. Psychology of higher animals should be regarded as a 'pattern' psychology. Since the patterns are not rigidly fixed, they are not deterministically preprogrammed, and not rigidly cued; they can only be self-activated, and thus must arise from internal instability (namely, the entire chain from inside to external boundary conditions in the milieu forms a linearly linked unstable chain) so that the system goes into 'motor-sensory-internal organ' motion. However, the orbital synchronous patterns that arise must thread, in an ergodic sense, all of the 'needed' systems responses. Thus these 'needed' responses must be regarded as 'hungers' (i.e., connected with the metabolic hunger of individual survival, or the genetic hunger of species survival). *The pattern of behavior must involve and thread the system's hungers.* This temporal threading must fit the cues (or the cues must have been fashioned or adjusted, or adapted to fit the species). Then it can exist.

42. A species must be 'comfortable' in its pattern fitting into the time space. The first nonlinear rule of behavior (likely for higher cortical species) is that a non-cortical routine of patterns must be arrived at that fits the cue space with small integral cycle numbers. Then things - the hungers, particularly - come off on time and the system is not in sustained stress. (If humans had to perform a task, such as eating with regularity over 23 day periods, it would be most confusing.)

43. For such compatibility to be arrived at, there must be a sustained effort, by orbits, to bring the existing set of body images toward some optimal 'picture'. It is some optimal view of reality that the mother and father (or their surrogates) attempt to develop in the child. It is a view of 'which way is up'!

44. Assuming this to be true, it is possible to roughly describe the known patterning response among the set of 'hungers' listed.

(a) *The system eats.* A limited number of times per day (fitting the socio-ecological boundaries) the system eats. An absorption period of about 4 hr in the stomach empties it, and leads to signals that are recognized as a call to search for food or seek to eat. The exact cues are not known. Blood sugar, etc. have not been proven. However, hypothalamic centers are possibly involved in the excitation. With sufficient delay, stomach contractions become strong enough to certainly furnish cues. More subtle ones are used 'socially'. Trained animals - which, of course, include people - can transfer the burden to an internal fixed timing.

(b) *The system drinks.* There is more rapid absorption through the enteric tubular system and a complex storage system. Signals are recognized as a call to search for or seek to drink. The exact cues are not known. Mouth cues are involved, but hypothalamic centers can also be involved. There is a large 3-day cycle, but this is more likely on the retention and discharge side. The cuing instability to seek water is extremely strong in man (not as rapid in desert animals with greater or more tenacious water storage).

(c) *The system voids.* Specialized kidney and bladder systems are highly involved in water retention. (In ruminants, or in hibernators one may note considerable specialization for food retention.) At shorter term, a few times per day voiding cycle exists. Stretch receptors afford commonly identified signal. The $3\frac{1}{2}$ day water cycle - large in magnitude - suggests a long period hormonal control.

(Note the characteristic of these first three behavioral items. While they are all clearly essential hunger elements, and suggest a dichotomous polar character - of eat - not eat, void - not void, drink - not drink - they are not sharply deterministic but ad lib. The individual needs only to pattern them into a satisfactory cycle. When he does not, or cannot, or has not learned how, or been retrained how, he can break down. Thus the command-control system, the nervous system, is not a rigid system, but a plastically unfolding internally unstable system.)

(d) *The system sexes.* The rhythm is about a few times per week. (A typical pattern might be 2.8 ± 1.0 experiences per week.) In a married couple, the rhythm is strongly influenced by the menstrual cycle (the weekly experience level may fluctuate with a range as large as 1 to 5). With the cessation of menstruation (menopause) or apparently with its artificial interruption by pill, the cycle shortens to closer to 15-20 days; i.e., to a nonautonomous rhythm. It is such shorter 2-3 week rhythms that seem to make up the content of mid-term 'psychological' behavior.

(e) *The system works.* A daily motor pattern emerges in the normal man. Much of it has developed in the search-seek system for food and water. In more elementary terms it can be seen in the gorilla and more primitive in grazing animals. After sleep, 'in the morning' (for night animals, the process is reversed), commonly the stretch 'posture' prepares the system for motor activity. There may or may not be cortical patterns, which in the human must be broadly stored in the basal ganglia. The move to get out of bed, void, wash, dress, eat (or search for food in more primitive society), motor actuate to a work place, work for deferred compensation for food and other necessities (In the peasant, the dinosaur, and the high 'executive' the work time occupies an inordinately large percentage of total waking time, typically 80% or more. That food is not the only hunger involved is, of course, the reason for telling this story), etc., all become programmed into a fairly uniform routine.

It is clear, even if the reasons are not fully understood, that a weekly pattern of work has had to be established for humans. (Since biblical times at least, "and the Lord made the earth in six days, and on the seventh, he rested..." Another more subtle piece of information is contained in the lack of success of establishing a 5-day week in the French Revolution, and the Russian Revolution. Five days for the week does not fit; 7 does. This does not preclude the fact that a more complex, higher stressed civilization pattern may not require some further reoptimalization of the work week. However, since biblical times, 7 days has fit.) One possible clue, not strongly, is a gonadal hormonal cycle in males of the order of 7-8 days.

(f) *The system is in a state of sleep*; *rest*; *talk*; *attention*; *motor practice*; *interpersonal attention*; *escape* can all be similarly analyzed. Of course these elements all have the character of dealing with deferred hungers, and they have considerable internal complexity. They probe at or 'prove' the computer character of the brain (i.e., they involve present computation for deferred - only loosely connected, not sharply deterministically connected, but really probabilistically connected - hunger situations). We have rushed to come to the next class - the classical 'emotions'.

(g) *The system is in a state of anger, anxiety, euphoria, disinterest* (*boredom*), *laughter, aggression, fear, envy, greed.* These states are not really different hunger states from the other. They are hunger states for internal systems. They are marked by well defined internal systems' response (although some further degree of specificity and independence still has to be established physiologically). They tend to exhaust the major behavioral patterns.

Are there really hungers that these dynamic states satisfy? Our answer is: yes. The human system cannot roll out day by day along a routine path with a routine response that is never sufficiently mismatched that the system will not become angry or show fear. The fear-fight-flight-reactions are further high frequency descriptors. All sorts of brain excitation show the abstract piecewise structure of these responses.

What is really basic to the plastic higher brain - reticular core - cortex - basal ganglia is the alternation in state between two essential poles of inward behavior; for want of a better name, an anxious or dysphoric state and the euphoric state. In the higher animal, it is the cooperative impact of all signalling interferences that produce the longer time scales. The periodicities may be in the few per day to one per 2-3 week time scale.

45. For the longer time scale, the predominant note is the great flaring maturational instabilities. The first is that of birth itself. In this phase, the newborn infant faces the development of a routine of oscillations whereby its greatest sensory interface - the oral interface - is encompassed within a 'satisfying' schedule. This develops in the brain as a dual mother (or surrogate)-child 'symbiotic' oscillator system, a constellation. Anxiety follows upon euphoria; motor patterns stuffed with ritual fill develop. The unfolding maturing nervous system brings new sensory interfaces (anal, gastro-intestinal and urethral, motor, visual, kinesthetic, etc.) into the field. The plastic brain encompasses these. Priorities and patterns emerge.

The second lesser flare occurs when the system 'masters' its primitive routines. There is spare computational capacity. As an integrated 'Gestalt', the system grasps its freedom from the immediate 'mother-child' milieu. The system seeks out its own kind, its mirror images, its peers, its chums. It plays.

The third great flare is the adolescent sexual maturation. The genital interphase explodes on the scene. The system is now chemically and biologically prepared for reproduction.

The fourth lesser flare is then the integration into a 'Gestalt' (a view) of comfortable orbit with a sexual partner. (It does not have to be. However, in many species and all mammals, it is the pattern that insures a continuation of the species by protection of the unprepared young system.)

4. A LONGER TIME SCALE FOR BEHAVIOR. THE FOCAL IMPERATIVE

With this extended, somewhat formally outlined introduction, we can now begin to discuss the longer range character of behavior.

A recent popular book, R. Ardrey, The Territorial Imperative, has received quite critical review notices (see, for example, E. Leach, N. Y. Review of Books, Dec. 15, 1966).

Its appeal to Lorenz' On Aggression, and its parallelism may be noted. There is no intent to attempt a 'popular' parallel to the former book, or even to another book which has become quite popular, Berne's Games People Play. However, there is need to consciously note that this section may be regarded as suffering from similar faults of oversimplification, and perhaps ignorance. Nevertheless, we have been propelled to a key thesis for individual behavior, as the jumping-off point for social behavior, through the central physiological theme of homeokinesis and orbital synchrony involving the patterned response of internal oscillator chains. The previous section has taken the description of behavior up to the weeks period, offering the female menstrual period as a most significant yardstick. In this section an introduction to long-time behavior is begun.

The great flaring instabilities associated with the newborn infant within the infant-mother orbital constellation; the child within the peer (chum) group constellation; the adolescent with the heterosexual constellation; the young adult within the mother-father-child constellation, all cast light on the orbital configurations that represent a large segment of the behavioral foci. What are the other foci, in particular, the other long-range foci for the complex human animal? The following speculative schema is proposed:

At one or more times within the child-chum-adolescent-young adult stages, there arise particularly favorable orbital configurations - 'experiences' - that are 'attractive' or 'pleasurable' to the individual. A regularized pattern grouping of internal and external oscillators - neural, sensory, organistic, motor chain - that are attractive and non-anxiety producing, occurs. These make an impression. They are learned as analogues. The system forms 'crushes' ('attractive', 'non-anxiety producing' are not as yet operationally defined).

Out of a complex of such possible patterns, the orbits gradually shorten, become smoother, more practiced; the system slides around and through and encompasses these into a more determinate pattern of orbital paths, that then make up the 'life' postures. The system begins to lock into a more permanent (not absolutely so, just more common) pattern. These orbital choices circulate around the foci of the system, i.e., there exists a focal imperative. The system does not drift through life aimlessly. It is unstable. It seeks to entrain, selects foci of behavior around which it entwines its orbital patterns. These 'suit' the individual. They involve more and more routines that become sub-cortical. They begin to form a patterned field in the brain. Man becomes doctor, lawyer, Indian Chief; bootlegger, swindler, loafer, woman-chaser, boozer, intellectual, politician.

This must be dramatized verbally even more forcefully. Imagine a focal center on the stage of life. Man sees it. He chooses it for his own. It does not matter whether he is good or bad, whether the choice is good or bad, whether he is competent or incompetent, he makes his choice. If the times permit, he can lock onto his focus.

To barely introduce the social boundary milieu, if perchance there are some standers-about, and an individual's orbital gyrations of the moment have a style that suits their fancy, they will then applaud and he is famous (i.e., he has achieved 'approval', that is, a repeatable interpersonal attention). The significance, truth, validity, of the patterned dance matters not a bit. To achieve this there has been an interaction between the internal and external patterns.

It is clear that there are ingredients that tend to suit one period, or one group, or one milieu better at one social-ecological spot than another. It is clear that speech and body demeanor (i.e., motor patterns of the body and from the mouth) are quite influential, and that the making of tomorrow's catch phrases or clichés (things that become orbitally repetitive verbal patterns) holds central significance. (This says that content and meaning is of little significance in practically all interpersonal exchange. The significance of how sharp ideas are broken down by the populace, by adaption to their own orbital-verbal patterns, is quite well stressed by Aldous Huxley in Tomorrow and Tomorrow and Tomorrow).

A fundamental observation to make about the content of behavior is that externally it does not appear to have a strong metric, whereas internally it may have. What this proposed principle means is that, internally, in the heterarchy of oscillator chains, there is a parity of measure by which the priority of effects and probable sequencing (more diffusive than rigorously wave-like, and more probabilistic than rigidly deter-

ministic) of oscillator states has some deterministic but weak connectivity. Externally, the response to input sequences is 'irrational', i.e., not highly ordered in regular sequence, for the individual. He may get mad at a trivial input; he may disregard obviously near-infinite forces; he will run uphill; adore the indifferent; be swept into step by the outrageous; mistrust his most certain guides. His 'tastes' and 'fancies' have traditionally defied accountability. Yet internally there is a psycho-logic of sorts. We thereby most often know our man.

Here then is the central theme of a man's behavior - a choice of his life's focal pattern that fits his 'ego ideal' (rather which becomes part of his changing 'ego ideal').

Many more physically inclined colleagues will continue to express surprise at these Freudian bits. Nevertheless, it would be an injustice to the history of ideas not to give credit to Freud's identification of a 'super ego', which represents an individual's image of conduct. With what detailed characteristics Freud endowed it - in his most complete view - is somewhat lost in his mixed metaphors. In the present context, the ego ideal is a very primitive integrated pattern of internal operative states - involving the many body images that are projected into the brain - which provides a satisfying state for the total organism (e.g., involving surface temperature, pressure, sound field, light field, interpersonal constellations, etc.). 'Satisfying' states are those that were likely associated with early satisfying physiological experiences. The ego ideal is not a 'valued' pattern, but an abstract pattern.

It emerges in essential form by age three. This arises because it has had the first two years of life to develop in the mother-child constellation (the toddler stage) and the third year within the mother-father-child constellation (as the child becomes an active motor system). This ego ideal pattern lasts through all life. Its subsequent more socialized development simply represents a veneer on the basic structure.

Longer term behavior may be represented by the continued effort to shift the internal state patterns so as to attempt to bring them into concordance with the ego ideal.

Another significant ingredient for man's behavior may be suggested, namely the basis for interpersonal attractive 'force'. It is quite obvious that there are 'forces' that bind people together. Sexual 'attraction' is the most common example cited. However, a broader base is needed for the wider range of attractions, which may be noted from infancy on. A model is suggestively found in the quantum mechanical system known as exchange forces. There is a tendency, it would seem, within an observational field for people to exchange body images. If in the exchange, there is congruence or complementarity, if the fitting suits the ego ideal, an 'exchange' force system is created, an empathy arises. There is a willingness to form constellations.

At this point we would like to consider some of the consequences of these thoughts:

1. (A social consequence:) You cannot bring up children all the way. The infant-mother orbit, the play group that the parent, unwittingly, provides the child helps establish rudimentary patterns of 'which way is up'. (The determination is unwitting because it would take an infinite amount of 'wit' to form an excellent play group. The recent discussion of western psychiatrists of the Israeli kibbutzim indicates fairly clearly that they are not in any real position to specify a uniquely 'satisfying' play group. Nor are the 'wealthy' capable, at great cost, of providing a better choice.) What no one knows is what subsequent key 'experiences', patterns, become so much the ideé fixe that the organism is willing to commit the rest of its life to that pattern. 'You can lead a horse among many lakes of water, but you cannot thereby make him drink'.

2. The time scale of such fixation (i.e., of individual 'socialization') appears to be of the order of 5-10-20 years. The individual's style does not change so much, but his pattern of life changes over such periods and becomes well practiced and entrained.

3. (A social consequence:) The concept of a focal imperative is not enough to define social behavior, but a beginning at organizing and bounding social behavior, for the next level of the behavioral problem begins with how a group of individuals, who are brought together within an ecology with a given childhood-peer bringing up, tend to coalesce and form socialized patterns. (It is certain that many pertinent experiments - both primitive and sophisticated - have been performed. Such investigators as Skinner or, more recently, exciting beginnings in the work of Calhoun on rat societies in crowded areas with subsequent opportunity for immigration to new frontiers come to mind.)

4. (A social consequence:) If historical recognition has nothing to do with the individual's long-term value to society, but only to his 'popularity' (i.e., on the ability to manipulate a self-chosen orbit into the attention of the surrounding boundary population), how can one rate or eval-

uate the historical significance of that individual or orbital configuration? Our views of this problem may be joined to comments in an earlier study (Iberall, 1966). The period of gestation of significant ideas was given there, in estimate, as about 175 years. It is the repetition over such a time that prepares the groundwork for the one who captures fancy. How far it (or he) - the idea or the individual - captures the boundary public's attention depends then on how extensive the interpenetrating orbits become. (Here the propagation of attention-getting is diffusive. How many individuals' orbital patterns are fitted by any particular idea at any time - Billy Graham, the hula-hoop, relativity, the automobile, hair spray, Clara Bow - is related to the random walk problem with quite complex constraints.)

5. (An individual consequence:) A point that was not obvious before but is implicit in the concept that man is an unstable system (which was translated as suggesting that its gain is indeterminate at zero frequency) now comes into focus. If the gain is indeterminate, yet man's behavioral life consists of forming enduring orbits, it is not very possible for him to make meaningful long-range plans. Before he proceeds very far in any long period orbital plan, so many excitations and cues cross his path to trap him into shorter time orbits that his view of 'up' must be rocked. His long-range plans must tend to be full of mistakes and, thus, required many, many corrections. This is not meant to suggest that he cannot make long-range plans, but that it is inordinately difficult. (The child who will go to college, or adopt a particular career, or marry a youthful sweetheart seldom nourished this 'idea' through all its growth period. It received many transfigurations before a final settling upon, and all sorts of accidents could have influenced it.)

6. (Two general social questions:) Two major questions that arise are the significance of morality and intellect in man's behavior. Morality appears to be the social regularization of patterns that fit social groups. Its 'value' is to society, not the individual. It attempts to transfer to 'subcortical' levels such conduct modes, i.e., patterns, that fit the society with ease. Its major property appears to be that it fits the patterns of the society 'elites' (Iberall, 1966). The 'elites' were defined as the individuals regularizing the most mass-energy in the society, i.e., those whose orbits they involve or influence is measured by considerable 'people energy'. They drag around their foci the attention of many people, or the most time-orbitals of other people. It is the patterns that fit them, within the ecology, that define the morality of society. (Often it is the pattern that the rest of the people should take to best fit the elite's patterned orbits that defines morality - e.g., 'Thou shalt not steal - from me!')

7. The second major question revolves around the status of intellectual achievement. In an earlier study on research (Iberall, 1965), the conclusion was reached that approximately one in 100 scientists played a creative role in an organization. The thought was based on institutional examination in the USA; the USSR; England; the continent. Does this mean more generally that 1% of the population makes creative contribution? In the world today there are 2×10^9 people; perhaps 10^{11} people through all time. Does this mean that 10^7 people now, or 10^9 people through all time have made meaningful creative contribution? The tentative answer is 'no!' The selectivity of the technical population - nominally devoted to 'rationality' - is deceptive.

Another extreme estimate may be made as follows: The numbers of 'books' written is the order of 10^7 - at least this is the magnitude available in the great libraries. How many original ideas are contained in these? One might guess 10^4. (One can read at near maximum rates 10 books per week, 500 books per year, $1\text{-}2 \times 10^4$ books per lifetime. It may be suspected that, even with great selectivity, it would be difficult to uncover more than 10^4 original creative outlines.) Thus perhaps 10^4 men were essentially creative through recorded social history. If the number of men (over a gestation period of 175-200 years) who contributed to the line of thought was perhaps 10, one obtains 10^5 creators throughout history. Thus a better gage is that $1\text{-}3 \times 10^4$ people perhaps are presently creative. In the USA today, this might represent 3 000 - 10 000 people. One can intuitively feel that this may be right. Thus one in 100 are locally creative, one in 10 000 are truly creative.

This must furnish the (crude) background for intellectual-type activity. (While the term 'creative' certainly implies others than the intellectually creative, the numerology was conducted to highlight the verbal-motor type of creativity, rather than manual-motor.) Perhaps one in 100 people fall into orbits that are 'intellectual' (i.e., cortically guided activities that result in 'original' verbal or manual patterns). Most of it is rehash. (The rest of the populace's 'cortical' activity is not original, but a repetition of a limited repertoire of material.) Perhaps one in 10 000 people create significant original patterns. How-

ever, it takes '200 years' before the idea pattern becomes adopted. Thus the experimental conclusion that it is essentially impossible - in a statistical sense - to get a new idea accepted (which has been found by experience and was discussed previously (Iberall, 1965)) and the converse, that every idea, almost independent of how mad it is, will have its day, in that there will be some people who will accept it for their patterned orbits, both really have a theoretical foundation.

8. (A moral consequence:) In response to the salient thought, 'Then how shall a man live ?', it is possible to illustrate, not a scheme that is necessarily satisfactory for all times, but one that fits this culture.

The mature adult may form a relation with a person of the opposite sex - and with one other focus. Today the first is stabilized in marriage and the second in career (or life work).

9. An important characteristic of behavior - likely as with the other physiological oscillator patterns - is that short and long time behavioral patterns are 'independent', i.e., there is negligible correlation among various cycles. (This does not mean no correlation, only negligible correlation.) Eating, sleeping, attending, short-time anxiety, etc. come off independent of the long-time style of behaving. Yet the major property is that each physiological involvement seems to propagate like a wave through the system. Vaguely it appears that it is this wave motion which may tend to correlate one cycle type to another cycle type. Thus, while the direct coupled cycle cues are weak (such as those arising from concentration changes), it is the nonlinear coupling of complex chains (such as enzyme-hormone links) that possibly provides the coupling.

10. A remaining topic is introductory to the overall 'systems logic' of the brain and behavior. In an earlier report (Iberall et al., 1965), three brain logics were listed. They were the logic of naming (i.e., recognition); the logic of indefinite ordinal numbering (i.e., arithmetic operation); and the logic of field cognition (identification of geometric continua). The question is how this fits within the present description of behavior.

The precursor to these logical algorismic operations is the operation of slicing the object field into finite signal sequences. This may be handled in more than one place. If the signal sequence is not promptly recognized, it is passed on to the cortex to be named or identified. The naming must take place by selection of some previously constructed analogue that seems related, be it cortical or basal ganglia. If this happens a number of times, the analogues that have been called up are mixed together to form an ordinal number 'name', a routine now represented by a taped analogue, perhaps in the cortex, perhaps in the basal ganglia. These systems now have a new analogue 'name' (i.e., the name is not a 'thing', but an action analogue of the ordered slicings by which the 'thing' is received. It is now patterned. It is another taped melodic pattern somewhere in the brain).

If now this analogue is called up many times, the cortex begins to be called up in passing in enough different contexts that a Gestalt now exists (i.e., the cortex will now 'take on a habit' to reduce the naming analogue into an abstract field thing).

11. It is clear that, in physiology, Bernard-Sechenov-Cannon's concept of homeostatic regulation of the watery internal milieu is invoked as a guiding principle, but there has been no operational way to relate it to the brain and behavior. This obviously was impossible to realize if one was limited to static and linearly approximate approaches to equilibria. The concept of 'homeokinesis', of dynamic regulation through mediation of non-linear oscillators - engine cycles or motor actuating chains in simple language - offers a foundation. The orbital weaving of 'satisfying' paths through two handfuls of primary oscillator chains into operative patterns becomes the form of the driving brain's algorism. Such a system is operational, it can be built, it can be modified in how it runs. In fact one way that is 'obviously' known to modify it is by chemical concentrations of pharmacological agents - drugs. (The intent is not to impress an audience with brilliant novelty, but to bring all parts of a simple, clear, reasonable picture together into coherence and consistency. The use of alcohol and nicotine is so common that it may be overlooked.) 'Drugs' are known to induce sleep, hunger, its lack, sexual interest, its lack, voiding, its prevention, more recently release of anxiety, heightening of tension, etc. It is clear that there is no precision in such effects as drugs are used today. It is no surprise, with present knowledge, that a drug that affects one chain interacts with others. It may have 'side effects'. Some day more specific control may be known.

However, in similar fashion, as the nature of the physical -chemical -mechanical -hydraulic chains become better known the possibility of influencing them by various means can grow.

12. It appears clear to us that a first aim of an objective psychology (in this case an orbitally

patterned psychology) is the need for a language to describe behavior and the brain's response and a logic to deal with it. The following is a crude beginning. As descriptors (or descriptions) of some of the elements that go to make up behavioral patterns, the following can be, and have been recognized:

(a) the reflex arc (Sechenov)

(b) the acquired (Pavlovian) reflex. There is discussion that proposes to deny the reality of this patterned step. Yet it is quite clear that an 'analogue' pattern will develop, i.e., be 'wired' together, by which a smooth rapid action response is obtained from coupled phenomena. It is certainly true that such rules as Hull was able to put together or that are being studied by such investigators as Lettvin attempt to construct some kind of pattern of the more rapid behavioral elements.

(c) the 'Gestalt'. It seems also clear that out of a miscellaneous collection of information about some action system, the brain 'suddenly' fashions an integrated picture, a 'Gestalt' of the action system. (This is secured as a geometric total field in the sense that all of its attachments are non-denumberable in any finite time and cannot be ordered in a denumerable fashion. Specifically, an example, the sudden Gestalt of 'my long-lost cousin' from a few scraps of observation, can involve an outpouring of memory without end.)

(d) Some Freudian elements - the erotic, erroneously viewed sometimes as a libidinous, flux. As a name, not for a purely sexual excitation, but for an overall informational flux or, more likely, a total measure of the informational buzz, particularly the quest for the more satisfying informational buzz, the concept is not a bad one. The question is whether it can be provided with operational meaning and structural identity. If not, the concept is useless.

The present insistence upon the need for such a descriptive construct is based on the problem of what it would require to take a mechanistic motor system - an automobile, for instance - and fix up an adaptive computer control system capable of indefinitely self-programming the action of that system. If the system is programmed for intermittent operation - which likely will mean that a patterning of orbits will emerge as has been postulated here - there is certainly a need (at least in a first generation of modelling) for a unitary optimalization function in addition to any detailed responses to specific sensed inputs. Postulating an erotic flux measure for such a function thus appears reasonable.

The id (*the "es"*). As a name for the total informational signal and the memory of signal that the system handles, this name, the 'it' of the system also seems fair.

The ego. As a name for the imprint of the 'it' of the system upon actual structures throughout the brain, as well as the integrated view of these imprints, this is also reasonable.

The super-ego (*or the ego ideal*). A loosely connected view of the behavioral patterns that are 'satisfying' may be thus named. The super-ego is regarded, not as a detailed system of verbalized 'values', but as patterned response states of the internal oscillators that have been formed early in life into a functionally satisfactory group. ('Satisfying' is not a value judgment, but a statement of arithmetic compatibility in a non-linear system; i.e., it meets temporal-spatial boundary conditions. If about 20-40 internal oscillator patterns must come off - eating, voiding, etc. - and there are space-time cues, one may not be surprised that early experience, say as initially guided by the mother, helps establish an orderly sequence that rings the changes of these patterns. Else, one may imagine, serious disturbances in the system's operation may ensue.)

Consider the analysis and synthesis problem. Given a physiological machine which is turned out by mass-production, it has insufficient fixed motor action routines and only an unstable 'plastic' guide system. Left to itself (if human) it would die. It must be taught. If the system were rigidly mechanistic, 'teaching' could only set switches and a pattern would emerge with certain limited adaptive possibilities. The problem is to encompass a rich enough adaptive process.

We suggest that by trial and error between mother and child, involving many elements of chance, the oscillator patterns are loosely threaded (that is, no one completely unsatisfying oscillation element - such as the removal of feces - is left unattended without very serious consequences for the child). The plastic brain encompasses this arithmetized link-to-link chain of behavior into an overall field view of behavior. Thus one might begin a synthesis by the following scheme.

In man, there seems to be internal physiological endowment for 'knowing' its internal states, as well as the external states. (In what sense 'knowing' is meant or carried on is irrelevant at the moment.) Archeological - anthropological - sociological - biological study seems to suggest that there are definite 'poles' of behav-

ior that must be satisfied and others that likely have to be satisfied. Thus boundary conditions can be specified (i.e., games can be played) in which we can be immersed and a pattern of behavior will emerge. Descriptively, perhaps stochastically, the patterns can be described, at least for limited periods (namely - seconds, minutes, hours, days, months behavior can be discussed. It is perhaps only years behavior that may be weakly described). Outside of the question of compactness, systems could be built that behave like us in establishing patterns (for the middle range of time). These solutions may not be that unique and to get really isomorphic ones will be even more difficult. *However, a successful functioning humanoid model could be built* that will take care of the patterning among the poles. This must be the beginning of human model constructing. For example, it certainly can satisfy physiology. We cannot start from the large philosophic questions: What is large memory, what is consciousness, what are values, what is the 'meaning' of life, etc. Only, first, we can start from how does one get a system to eat, void, breathe, drink, become anxiously unstable enough to keep going over its polar check list, become euphorically stable enough to persist in its orbits for a while, etc.

In summary, a very crude view of internal structure which may be formed for descriptive purposes of behavior (as time goes on it does not have to remain crude) the following suggests itself (fig. 2).

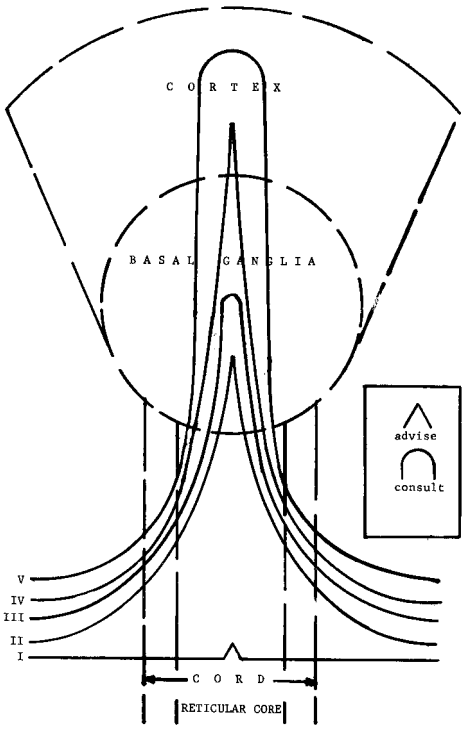


Fig. 2. A primitive model of 5 levels of behavioral response, all passing through the reticular core and being routed toward higher centers of the brain.

5. SOME FINAL COMMENTS ON OVERALL BRAIN STATES

Thus far the brain has been saddled with discrete jumps in logic, a smooth alternation between a 'euphoric' and 'anxious' point of view, a quantized nature of information transmission in neural nets, and a number of other computer-like functions. A recent article (E. Diamond, Interpretation of Dreams (continued), N. Y. Times Magazine Section Feb. 12, 1967) furnishes the basis for some further hypotheses on the structural nature of brain states. The character of sleep is therein delineated for the educated layman in a popular fashion, although based on the latest findings of the research chain - Kleitman, Aserinsky, Shapiro, Dement, Snyder, Jouvet, MacLean. The essential elements described are:

1. There is a series of repetitive incidents, of approximately 90 min duration during nightly sleep which is characterized by 10-20 min episodes of rapid eye movement (REM).

2. There are approximately 4-5 such incidences each night.

3. If these are prevented, then there appears to be a cumulation of them on successive nights. For example with complete prevention, the sequence of such attempted incidents on successive nights may be 7, 10, 13, etc.

4. During these incidents, a person dreams during a fraction of this time. The dream can be verified by waking him.

5. The content of the dreams appears to have a considerable amount of emotive overtone - namely symbolic content, sexual and aggressive content. There appears to be some relation to the individual's daily program of problems.

6. Typically the first episodes are more related to daily problems; the later episodes - near 4 a.m. - are related to childhood images; the last episodes return to the next day's problems.

7. A second major stage in sleep is the deep sleep phase (characterized by large slow 'delta' brain waves).

The following hypothetical interpretation is offered for these descriptions:

1. REM are quite obviously an indicator of instability.

2. The totality of drama being played out in dreams - involving all kinds of visualized motor activity - is obviously practically a real sensory-motor drama, except for a few elements. The total postural mechanisms are inactive; the total motor range of the system is diminished except for some body thrashing, penile erection, vocalization, and the REM, and similar. (A wild fantasy distortion, and preoccupation of subject matter does not seem pertinent at the moment.)

3. The reality of the drama is reinforced by the essential normality of physiological response. Heart rate, ventilation, adrenaline flow, even sensory involvement (namely all available cues from the milieu, as shown by adding such stimuli as water, sound, heat, etc.) all respond as in a practically normal waking animal, except for the absence of posture and motor activity.

4. The dominance of the cortex by visual signal, the thought that the cortex can inhibit all the motor systems except its own driving input system, the eye, and the thought that the reticular core has considerable control over the eye motion suggests that two systems must be coupled to produce the instability during REM sleep. The eye-cortex system thus must share an interface between two systems. During the inhibition of all other motor systems, the cortex cannot inhibit the eye motor system. Thus the unstable REM. (The cortex can shut other motor systems. It cannot shut its own signal producing source, the motorized eye.)

5. The cortex cannot inhibit its own ego imprint, also the instability does not interfere with the regularized internal computer flux of information from memory in lower structures. Thus an internal drama is played out.

6. However, as is pointed out in the article, referring to the work of MacLean, there are two brains, which are here proposed as being somewhat competitive - the old rhinencephalon, and the new cortex. The older structure cannot release the inhibited motor systems, except for its central control themes, of smell, sex and aggression. It is no wonder, under such circumstances, that the dream content is quite stressful - and can drive the eye.

7. An elementary but compelling illustration of the possibility of decoupling the cortex is the two companion piece reactions of people. In any boring conversation, the system yawns and tends towards sleep. In any interpersonal exchange, if the concentration is intense the system begins REM (i.e., it acts as if parts of the brain can be decoupled).

8. Must it be this way? This is obviously far from clear. What is suggested are slightly coupled brains, in which one cannot completely decouple from the other; in which the normal waking state involves coupled brains; in which REM indicates the slightness of coupling, as one brain - the cortex - is in process of releasing fatigue products; and which, in that case, the remaining portion of deep sleep involves a discharge of the fatigue products of the routine memory rhinencephalon structure, i.e. then they both sleep, as evidenced by the returning activity of the postural mechanisms. (At this time the reticular core 'has the duty'.)

9. The old brain may carry the 'it' - the information flux and its memory, and perhaps even the ego - the imprint of the information flux. It does not carry the superego - the ego ideal that the brain attempts to steer toward. Thus the system lacks a superego structure to match when the cortex shuts down. The system is then unstable and fantasy ensues. The reticular core on the other hand never shuts down.

10. Thus the patterning richness - the 'color' of human behavior must come from the cortex, in which its intrinsic instability is what creates such color.

11. However, the cortex operates with a marginal soft instability; namely the system does not release itself immediately into instability, but by mediating the stability of other oscillators - for example, perhaps reverberation networks in the reticular core - it modulates the instability of the cortex.

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