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BY POINTING UP SIMILARITIES AND DIFFERENCES BETWEEN BRAINS AND COMPUTERS, WE PRESENT CYBERNETIC CONCEPTS WHICH MAY PROVE RELEVANT TO THE MENTAL HEALTH WORKER IN HIS INVESTIGATION OF MENTAL PROCESSES. WE FOCUS ESPECIALLY ON THE MENTAL DEVELOPMENT OF THE CHILD, AND USE AS TENTATIVE ILLUSTRATIONS THE PROBLEM AND SYMPTOMATOLOGY OF INFANTILE AUTISM AND THE SO-CALLED "CHILDHOOD SCHIZOPHRENIAS." THIS PAPER WAS SUBMITTED FOR PUBLICATION TO THE AMERICAN JOURNAL OF ORTHOPSYCHIATRY AND WAS PRESENTED AT THE 45TH ANNUAL MEETING OF THE AMERICAN ORTHOPSYCHIATRIC ASSOCIATION (CHICAGO, MARCH 1968). (AUTHOR)

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A CYBERNETIC APPROACH TO MENTAL DEVELOPMENT

With some comments on infantile autism and the childhood schizophrenias†

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(Running Head: Cybernetics of Mental Development)

Abstract

By pointing up similarities and differences between brains and computers, we present cybernetic concepts which may prove relevant to the mental health worker in his investigation of mental processes. We focus especially on the mental development of the child, and use as tentative illustrations the problem and symptomatology of infantile autism and the so-called "childhood schizophrenias".

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I. FRAMES OF REFERENCE

The human being rarely functions with the logic of science, though science tries to understand him through its logic, leaving a conceptual gap too often filled by semantic refinements of theory. Essentially, the normal brain will learn almost anything you teach it, but the normal young child has tremendous difficulty in comprehending that he cannot be in two places at once (physically); cannot be both big and little at the same time, and cannot have and not have at the same moment. He gets unhappy, furious, tearful and vaccilatory when confronted with this. We do not speak solely of frustrated wishes, but of a genuine ideational neural confusional experience far more implicative than has been recognised.

Watzlawick, Beavin and Jackson [44] in their study of the "Pragmatics of Human Communication" have distinguished between digital communication which is based on an arbitrary system of symbols (such as the conventions of the English language, outside of which convention "there exists [almost] no other correlation between any word and the thing it stands for") and analogic communication in which there is something 'thing-like' in what is used to express the thing†--they cite (p. 62) "posture, gesture, facial expression, voice inflection, the sequence, rhythm and cadence of the words themselves, and any other nonverbal manifestation of which the organism is capable, as well as the communicational clues unfailingly present in any context in which an interaction takes place."

We shall use a similar distinction in talking of information, digital

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† Their distinction was based on the distinction between digital computers, which store numbers as strings of symbols (as in binary or decimal notation), and analog computers which store numbers continuously (e.g. by setting a voltage to a value proportional to the number to be stored). However, the importance of this history is small. By programming the equations of an electrical circuit into a digital computer, we can make that digital computer simulate an analog computer. Thus when, in what follows, we talk of the utility of simulating a model on a computer we shall mean that the model is represented as a program for a digital computer even if the model involves what we shall define below as analogic information.

information being that conveyed in the crisp this-or-that terms of a well-defined symbol system, while analogic information may be somewhat inchoate, expressed by a continuum of interacting variables. What we are trying to stress is the distinction between the logical mode of expression society teaches a child and the emotional-neural-chemical substrate which is the child's initial endowment. Digital information comes to claim more and more of our attention, but the analogic substrate is always there. It is only by realising this that we may come to grips with the problem raised in the first paragraph.

In Aristotelian models a thing or experience cannot be-and-not-be at the same time.† People, however, function this way all the time. They want and do not want, at the same time. The fact that the clinician speaks of "mixed feelings" does not mean that the feelings are, in fact, mixed (as salt and pepper), but may represent primarily the effort of the clinician to comprehend the actual state of affairs (being and not being simultaneously) through imposing his familiar digital conceptions on the situation. To what extent has our learned approach for understanding and classifying mental and emotional functioning led us to confuse our systems of analysis with the actual basic functioning processes of the thing being dealt with?

Information theory, computer science and cybernetics may help us evolve a more appropriate, objective, frame of reference for our consideration of these matters, despite their drawbacks. Our fundamental emphasis will be on process, of which digital behavior is but a manifestation. In this vein, the symptoms of a disease, such as disordered behavior, must be regarded as the outward signs of mal-process, and the concern of the mental health worker must be to correct the underlying process, not merely to remove the symptoms. It is to the underlying processes that cybernetics must address itself to be of use to the mental health worker. The analogy to finding and correcting the errors in computer programs is clear, though as yet the gap between the form of our computers and the understanding of our brains is too great to make it fruitful.

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† Korzybski [21] has suggested a non-Aristotelian approach to logic.

We shall name "metainformation" those data that tell how other data are to be used, thus giving "meaning" to the data rather than just having it stored as a string of symbols. The question which most interests us, and to which we shall sketch in section 2 the beginnings of an answer (for more details, see [2]), is "How does the analogic information possessed by the neonate come to provide the metainformation required to handle the digital information provided by the environment?" (This is not as uniquely human a problem as we sometimes think--the baby octopus must learn that the visual pattern of a crab shell is a symbol for a meal!)

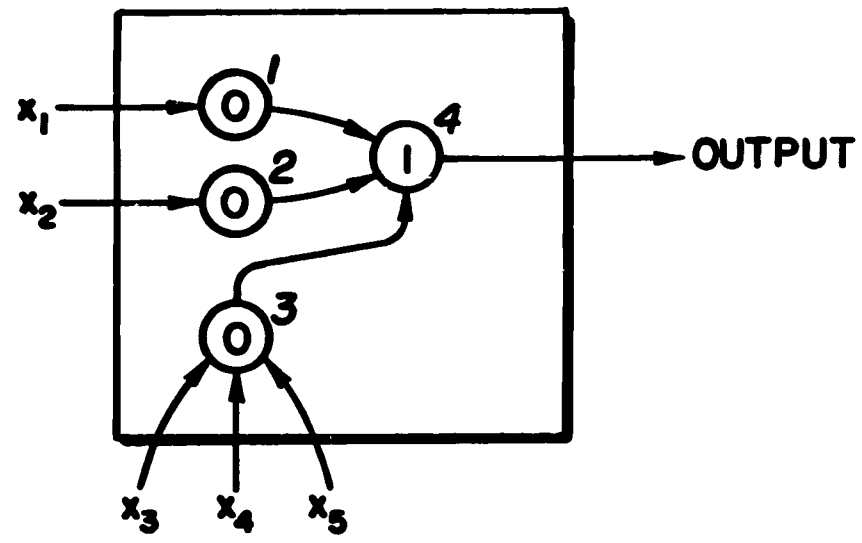
Viewing the brain as an information processing device; and feelings as information, albeit of an analog type, the human organism, like the computer, can mis-operate on two major bases: (1) something may be wrong with the "hardware", e.g. the wiring, circuitry, dampers or unmodifiable aspects of the overall program or the internal environment (as in biochemical defect), or (2) something may be incorrect about the "software" or program, e.g. the information fed into the machine for processing, or the way or sequence in which it is fed.

With our emphasis on process, we should like to take special pains to protect the reader from the error, all too common in the psychological literature, which thinks of each mental process as requiring a separate region of the brain, and vice versa. In systems theory we often analyse a system S and find it to be equivalent in behavior to an interconnection of systems S_1 and S_2 each with well-defined functions--and feel that we have learned much about S from such a decomposition--even though there is no way of carving S up spatially in such a way as to yield 2 systems equivalent to S_1 and S_2 respectively [1]†. The point is worth emphasising by a detailed, although simple, example--and we urge the non-mathematical reader to persevere, despite the symbolism involved.

Consider the simple neural network of Figure 1(a) made up using the simplest of all neuron models--the McCulloch-Pitts neuron. (The particular network is new here. The type of neuron was introduced in [29]--for an exposition, see [0].) The network behavior is determined by which of the nerve fibers are firing at regular intervals, say a millisecond long.

† This implies that systems and processes need be examined rather than their end-products, behavior, in order to comprehend the bases of mental health and illness.

(a)



(b)

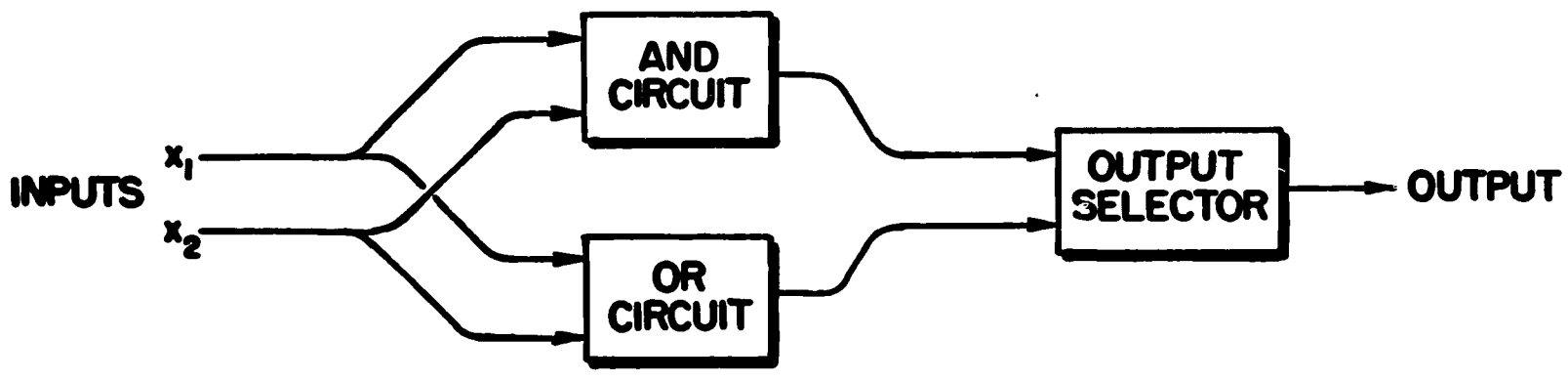


Figure 1: (a) A simple neural net.
(b) A block diagram for the neural net of (a).

We label each "neuron" with a number θ, its threshold, and decree that a neuron shall fire at time $t+1$ (measured in our millisecond intervals) only if more than θ of its inputs fire at time $t+1$.

Neuron 1, like 2, is just a delay element, in that its output fires at time $t+1$ if and only if its input fires at time t. Neuron 3 detects whether any of its inputs are firing--by firing at time $t+1$ if and only if at least one of its input fired at time t. Neuron 4 is the most interesting: if the input from neuron 3 is firing, only one more input is required to trigger it, and it will fire if neuron 1 or neuron 2 fires (or both); however, if the input from neuron three is not firing, it needs two more active inputs and so it will only fire if both neuron 1 and neuron 2 fires. In the first case, we say it acts as an OR gate, in the second case as an AND gate.

In a sense then we may consider our 4-neuron "brain center" as having 2 "data" inputs x_1 and x_2 and 3 "control"inputs x_3, x_4, and x_4. The box will act as an AND gate unless one of the control lines is activated, in which case it will act as an OR gate.

Functionally, then, we might represent the box as in Figure 1(b), but we know that in the actual structure of Figure 1(a) the AND and OR circuits cannot be separated.

If one of the lines x_3, x_4 or x_5 were to be severed, then the box would exhibit an apparently erratic behavior, failing to act as an OR gate on many occasions when it should. Or suppose a "disease" were to cause x_3 to go into a mode of continual firing. Then neuron 4 would always function as an OR gate, and the function AND would never be activated.* This example is meant to emphasize that we cannot deduce, just because a function is missing, that an actual brain locus is unactivated. Failure to activate a function does not imply failure to activate a neuron net, only failure to activate the net in a certain way. Thus we may have a brain

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* We may emphasize the problem the psychologist, as opposed to the neurologist, faces (or does not have to face?!) by noting that exactly the same malfunction would result from a "chemical change" which lowered the threshold of neuron 4 from 1 to 0.

in which all neurons are activated, all gross neural tracts are connected appropriately, but errors of detailed connections or thresholds may lead to malfunction.

The reader may also understand that we can describe neural networks wherein not only does each neuron take part in several functions, but also where functions are distributed over several anatomically distinct parts of the network. (See [0, Chapter 3] for a discussion of why this might be a good strategy for obtaining reliable behavior from a brain composed of unreliable neurons.)

This brief introduction to a new vocabulary may help in our brief discussion of ways which Cybernetics, Computers, Communications and Systems Theories may be of use to the mental health worker in the future:

(1) In helping us to re-examine our frames of reference for understanding mental processes.

(2) In helping us avoid the pitfalls of those theoretical languages which tend to freeze process into labels since they fail to make internal process visible.

(3) Through making process observable, they may clarify our thinking about brain function as it actually operates (rather than through its end-products like behavior), and may enable us to replicate certain hypothesized internal conditions and vary them to learn about the effects of such variations on end-products (and do this without injury to persons or feelings).

(4) They may provide leads, and eliminate blind alleys, in our efforts to comprehend theoretically, or modify clinically, certain internal processes. It may be possible to examine and test our own psychological theories and fantasies about how the brain works through using computers as an arena in which informational input can be selectively controlled, modified, and observed while it is in the process of being processed.

This cannot be done normally in the human brain, yet would yield invaluable information about the process of processing itself, in brains.

People and present-day machines are different in a variety of ways. Age factors are crucial in a child's developmental sequence. It is not true that unless you program a computer at a specific point in time, it may fail of development and never be programmable. The machine does not have an inherent developmental sequence of its own, which can develop well or poorly, but will develop. This stresses that factors not found in machines do exist in people. However, computer programming is sufficiently flexible that we may simulate such developmental factors in the computer, albeit at the information-processing level, not at the hardware level. Our human concern that computers could never be used to deal with such seemingly intangible and amorphous aspects of human functioning as feelings, non-verbal communication, etc., may not be as real as is our fantasy of it--provided the psychologist can provide analogues and measures, or definitions and parameters, suitable for definition and redefinition in or by computer programs. We think that analogic information processing exists internally as well as interpersonally, and is a normal mode of information processing in humans--one which may be amenable to computer analysis as process. Indeed, we consider analogic forms of information processing as necessary precursors in normal brain development.

It might also be wise to remind the reader that Freud in his "Project for a Scientific Psychology" [10] anticipated that neural substrates would be found to his theoretical formulations. The error has been ours if we have assumed these many years that these substrates would have to be tied to specific locations rather than involving the type of process formulations and systems analysis we are here seeking to describe, and which do involve neurochemical systems. When we think of ego psychology terminology and psychoanalytic formulations we find that all too often the efforts to deal with process rather than labels and end-products have fallen short of the intent. All too often, the logic with which science operates fails to fit the actual operating mechanisms of the human brain. The analysis of process seems more relevant and applicable, and computers are eminently suited to such efforts. The reader may explore at leisure

the potentials and pitfalls of such activity. Are "thresholds"--whether of analogic intensity or frequency types--analogous to "conscious" and "preconscious"? Is super-ego definable as certain "tagged-data" which yields certain effects in an overall program? These questions have been touched on elsewhere [2]. What is significant here is that the processes which occur in the interactions in the machine will actually define each term as a process, not the actual wording. Computer process analysis might define and redefine a given term as new programs (new contexts) and new analogues are introduced into the process analysis; but in the long run it would be the process which would define the term or concept. Word-definitions or labels could be modified afterwards to fit the realities. What is needed is the development of more accurate and more subtle computational systems for integrating inter-systems feedbacks to interplay digital and analog-simulation programs in order to cope with psychological concepts.

In all this we do not wish to imply that at this moment computers exist which can perform all the operations we suggest in their full complexity. Nor do we wish to rule out the possibility of biochemical factors affecting various systems under discussion (as indeed they do [15]). Rather, we appeal for an openness of attitude to allow for modifications of theory rather than searches for verification of entrenched dogmas. We seek this because we may have been having many of our difficulties in conceptualizing process, treating and especially in describing mental illness because we are using something-other-than-the-best-possible frame of logical reference. Perhaps our efforts have been hampered by the unrealized conviction that only one kind of logic is available for constructing needed systems and models for understanding brain-function, particularly in psychoses.

To illustrate one fashion in which computers and cybernetic theory may be useful in mental health efforts, the discussion that follows focuses on the symptomatology and possible cybernetic formulations of the condition known as infantile autism, and seeks to separate it from the so-called "childhood schizophrenias". We shall thus present implicitly aspects of the cybernetic view of development which we have developed explicitly in [2].

II. EARLY INFANTILE AUTISM AS THE VISIBLE PROJECT OF A POSITED FAILURE IN INFORMATION PROCESSING

The normal process of development in children moves from general to specific. This seems to hold true in motor spheres and interpersonal relationships, and would also appear to be true in information processing in cybernetic terms. The brain functions move from sensitivity on analogic bases (analogically processed as variations of intensity of the internal state or external inputs) to digital-with-analogic data (being more binding internally and, say, form or sound) in normal development. The infant eventually comes to be recognized (digitally) as a person or to tolerate collar. But tension in the infant is essentially an analog situation, matter of intensity rather than of specific issues. Tension-relief is merely a variation in intensity, from the infant brain's point of view, a change in state which registers in an analogue fashion. Eventually, as memory develops and the self becomes segregated from the mother and the world, an internal model of the environment is created in the brain, and, with learning, digitally based reactions become more and more pre-dominant [2]. We shall view psychosis in children and infants as an arrest or failure in this progression to the "normal" processing of information.

The classical descriptions of infantile autistics describe the child as "different from birth," or "like a sack of flour"--essentially unresponsive in infancy, and "undemanding"*. The later behavior of the infantile autistic suggests that great inner tensions exist [4], but these remain focused on inner states and on maintaining a state of "aloneness" to the environment, usually in some specific regard. How does this come about, cybernetically speaking? We posit here that the processes which normally

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* Not all autistics are so described, and such clinical pictures have been presented in detail. However, it is also true that in recent work, Rimland [38] found a bi-modal curve on a check list of infantile autistic behavior--as seen in later childhood,--and if one restricts the term infantile autism to the lower hump of this curve, those definitely autistic, a correlation may be obtained with early unresponsiveness. In this regard, the autistics with speech by the age of 5 differed considerably from the never-speaking ones (see speech section later).

serve to build up the internal model of the world are subtracted at, or very soon after, birth. No systematic digital association is made between mother and tension-relief. We further posit that, as a result, the operation of the brain's homeostatic mechanisms dealing with input or feedback tend to be highly restrictive. The introduction of new materials would upset a balance and thus all input would tend to be shut out by the homeostatic mechanisms which would be incapable of modifying more than a small segment of the internal systems--and such modification itself would then throw the balance off without adjustments elsewhere. In order to maintain some semblance of process continuity, new inputs would have to be 'excluded' when the balance was threatened. Many inputs, perhaps including those from the child's own body, would not be subject to feedback modification. In a sense, 'tension relief' which is a feedback process would not be possible, or be only minimally possible in a statistical sphere--for tension relief is dependent on feedback processes and analogic variations in the brain which regulate or activate somewhere along the line.

The autistic child is like no other child, but the diagnosis remains extraordinarily difficult. This is partly because behavior (which is the end-product of process--serves as the criterion for diagnosis, and true autistics show behavior similar to (and sometimes identical with) behaviors found in a large miscellany of other conditions. Yet they are different enough to constitute a separate classificatory group--infantile autism* --and we shall discuss them here to illustrate some of the possibilities existing in the cybernetic world for viewing mental process. While we find some clues in these illustrations, we do not, as yet, feel we have proved a difference in process--only strongly inferred such a difference.

As concerns affects: Affects are either non-existent overtly (as in the demonstrations of pleasure, capacity for play, body relaxation or joy)

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* For detailed clinical and etiological descriptions of infantile autism, the reader is referred to the works of Kanner [18-19], Rimland [30], Reiser [36], Bettelheim [5], Mahler [26, 27, 28], whose observations we have drawn on in addition to Kahn's clinical experience with autistic and schizophrenic children.

or they are wildly exaggerated (as in violent rages which suddenly and "inexplicably" arise). Affects seem to be autistically and randomly expressed against objects, people or self, and laughter is very rare and unclear as to significance.

Since pleasure expressions imply a modification in internal state, usually associated with a lack of tension, or tension release, this inability to show pleasure--which is long standing--suggests that internal modifications of analog systems (or feeling systems?) either does not occur or occurs via disruption of an established pattern or program. Initial infantile "pleasure" may be an analogic state of information processing based on variations occurring as the result of feedback from the infant's closure. Without such information processing, what kind of program of "tension relief" is possible?

Pribram, in a neuropsychological theory (37), has viewed emotion as essentially a set of processes reflecting the state of relative organization or disorganization of an ordinarily stable configuration of neural systems, one which also reflects the mechanisms which operate to reinstate any imbalance--not through action but through the regulation of input. More centrally, Pribram essentially suggests two types of feedback in the organization of emotion. One process entails the incorporation of input into existing neural systems through an alteration of neural mechanisms or models operating inside the person. This is called "participatory". The other allows input to make it congruent with the existing neural mechanisms (even if it excludes new inputs to effect this) and is called "preparatory". To quote Pribram (8):

> "When preparations are directed to input processing channels, 'tending to shut them out' they have the disadvantage of not dispensing of the source of the inputs responsible for the disequilibrium.*"

*By disequilibrium here is apparently meant neuronal patterns or activity representing affectual states arising from non-congruence of input with some internal plan--or program--or model. The concept advanced by some that infantile autism represents a condition in which certain biochemical body products are noxious to other body chemicals or each other. The "allergy theory" of autism-yielding disturbance in behavior--may be better viewed informationally in terms of two or more internally originating neural processes which are mutually antagonistic, precluding the reduction of internal equilibrium, or of "tension relief".

Under such circumstances preparations become chronic, repeated preparations progressively lead to hyperstability of complete internal controls, the organism becomes divorced from reality, the plans of action become inflexible. Thus more and more inputs become appraised as irrelevant. When this hyperstable inflexible state is finally disrupted by an input which cannot be eliminated, then the entire system becomes perturbed and, as the saying goes, 'all hell breaks loose'."

The above description is relevant, as the reader can see, to the affectual functioning of infantile autistics--even in later years.

Withdrawal is a second hallmark of the autistic. Since much of the autistic's behavior involves a shutting out of as much input as possible, his behavior seems equivalent to saying 'get out of my universe, you are messing it up'. There is the implication here of a rigid, static internal universe, according well with our suggestion of the restrictive function of homeostatic brain mechanisms in the autistic. In an organism with ten billion brain cells, and with neural systems spread over large geographic areas of the brain, withdrawal would appear more related to systemic functioning than to [illegible] functioning. It is also related to the behavior we [illegible] in the autistic called 'a need for sameness' by [illegible] psychologists and psychiatrists.

The Need for Sameness. If there is any predictable reaction in the older autistic child, it is rage when his internal universe is 'messed up' by an input somehow incompatible with what was there before. This 'need for sameness' in the environment can be extensive and pertain to many objects or just a few, or even to a sequence of events, a schedule. This is a [illegible] bit of functioning, however, for the sameness makes no objective sense. Why do the chairs have to be kept there, and facing just in that direction in the middle of the kitchen? [illegible] We can account for the [illegible] reasons, and shall bypass dynamic interpretations. Though the behavior ties in closely with 'rigidity', something structurally comprehensible may be adduced.

Normals learn to deal with the world by filtering incoming information and by being selective in their storage of data. Even with ten billion cells it is hardly a useful strategy to store everything as

discrete pieces of information. The autistic, when he "insists" on sameness may be indicating that material (or input) has streamed in, but that he cannot do anything with it. It remains digital--stored as datum without any instructions (metainformation) save perhaps in terms of matching up (superimposing, as it were) the external input and the previous internal datum registration. The rage he demonstrates is inappropriate--from the outsider's point of view--but it may reflect an upsetting of digitally oriented homeostatic brain mechanisms (when change occurs), and not a real emotional connection between past experiences nor an "investment" in the objects themselves. A program has been upset. Normals build, slowly, an internal model of the world about them--a cognitive map, as it were, which they evolve freely picking the best possible routes ("optimizing", cybernetically) or one that will do ("satisficing", cybernetically) This enables them to manage their trip through the world and include new territories. The autistic seems to have an internal use of such a map--he has only a template to match the world with, a template of bits of datum. He has a still-photo for a cognitive map rather than a motion picture. Incidentally, there is experimental evidence that monkeys and cats whose brains have been modified surgically can react to movement with recognition, although the same object at rest seems "unperceived" by them. Viewed thus, the concepts of pleasure-displeasure may not be relevant or meaningful concepts for the understanding of the autistic. The processes involved here be significant, however, for one implication is that the nature of memory in the autistic fits with the basic processes of memory in non-autistics, but is different in terms of analogic communicability. The autistics' reactions seem to operate like a fire alarm which switches on and off in response to a signal--without having an ego which is perceiving the presence of fire. The "need for sameness" occurs in terms of location and in terms of daily routine, at times.

Autistics react to movement of the static object, but can, and will, manipulate simple moving machines endlessly (possibly because the mirroring nature of the machine's motion does not stir the homeostatic mechanisms into action). Interestingly enough, he may not react overtly at all if something is removed from the field of vision--and all too often what he

"insists" on is the presence of a thing--a human body, say--to fill a given space, rather than on the presence of a specific, real person. The outer world must match the template, or the alarm goes off.

The precocious talents and excellent motor coordination uniformly reported in autistics--taken together with digital storage--might make the autistic appear "brilliant", and yet he would actually be functioning at a severely retarded level. It would appear that rather than brilliance the autistic has "registrations" without any metainformation. In trying to build an internal model of the world, he simply has bits of data in his memory, rather than actual useful intelligence which would imply a different information processing system--one with metainformation feed-in and modification occurring through feedback. The possibly real "talents" of the autistic unfortunately do not seem aimed at any recognizable end, and exist in isolation.

A peculiar variability in behavior towards physical inputs has been noted in infantile autistics, even when older (7, 11), to these inputs in the form of sound, light or touch (pain). The thresholds seem variable with regard to effectiveness of input registration.* Cybernetically, we would

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* Another note of some interest is that while older (7 to 12 year old) autistics seem peculiarly impervious to the usual punishment inputs--such as spanking, Lovaas has found that (for as yet unknown reasons) the mild electrical shock of a standard conditioning grid or floor grill will "get through" and bring about immediate rage reactions. The autistic will then modify behavior under a well-planned and well-executed conditioning program. Why electricity more than any other input carried mentally from the body periphery should work (where even toothaches won't) is an interesting problem. Similarly, why conditioning techniques should be efficacious in a system otherwise generally (a) not self-modifying and (b) non-responsive to normal external stimuli is an open matter. The present paper does not account for this, and this suggests one direction in which it needs extension. Lovaas also found that once he had conditioned autistics to talk, they had nothing to say--e.g. had data, but did not have anything to do with it (25). It has been mentioned here that modification in the autistic's internal system would be isolated and not generalized, if they occurred--especially if no connection existed between analog and digital systems of functioning. Perhaps the conditioning modifies isolated segments in the brain system through the presence of "inescapable" (electrical) input initially, which forces the homeostatic mechanisms to modify in these areas or minor systems.

view this more as a variability of output. An input of the same stimulus strength might well register every time, but, at one moment, yield no apparent output, and at another time will produce a reaction all out of proportion to the input strength. Perhaps some of the sudden "inexplicable" rages are delayed from previous inputs--but this is unanswerable speculation right now.

Delayed and unconnected-to-immediate-stimulus responses appear arbitrary and capricious and "inexplicable". Since inputs do not find immediate appropriate (or inappropriate) affectual or motor responses, the impression of variability of input threshold may be reasonably created. In programming for a computer, the difference between variability of input and variability of output would be a major one--and is now raised as the kind of question a cybernetic theorist would ask. With regard to the seeming lack of response to input it would appear that, in Pribram's terms, the inputs are being handled in a "preparatory" fashion by the autistic by trying to adjust the input registration rather than by modifying the internal brain processes or neural system to make the inputs acceptable. (This again is reminiscent of the reactions of children and infants where the internal affective or physical state constitutes the entirety of the universe, and where analog variations are the only measures and systems of internal functioning. The analytic concept of fixation seems relevant here.) The analogic functioning here seems dominant, but is divorced from the digital.

The sense of self is based essentially on internal modelling processes. Within the ego psychology framework, much of the internal model is based on "basic trust". Viewed cybernetically, these may be translated into problems of long-term memory and of time. In many ways the autistic appears to have no sense of self. Frequently he behaves as though his own body parts are not attached to any central self.[1] There is, however,

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[1] The reader may experience this for himself by holding his arms up at eye level almost straight out forwards from the shoulders and the elbow bent so that the hands are now at the sides of the eyes and a little forward (15" to 20") from the temples. Focussing eyes directly forward and waving hands will produce the impression that hands are not attached to the body.

much controlled bizzare posturing, and strange repetitive motions are indulged in endlessly; facial grimacing and ritual-like touching abound.[‡] But through all this the appendages appear to have a separate existence--just pieces of data. The apparent lack of self-image accords well with the lack of a central coordinating system for integrating proprioceptive experiences and feedbacks into an ongoing internal model in long-term memory. The feedbacks from proprioceptors do not get integrated into a single entity. The excellent motor coordination reported exists without unitary representation in the brain, as a series of automatic righting reflexes, visual-motor coordination units from short term memory and feedbacks from balance centers. This does not vitiate the presence of both long and short term memory functions in autistics (in the computer sense) but strongly suggests a communication problem or a difference in system-functioning (a weakening, as it were) in the way they function in processing information.

In the development of the normal child, data fed into the system and stored as long term memories is eventually integrated, and comes to constitute an internal model of the self, the outside world, or anything else that is so treated. Such an internal model, with a clear distinction between self and external world, appears to be lacking or deficient in the autistic. Long-term memory in the autistic seems to comprise disjointed data, without correlation and without the making of adaptive generalisations.

"Basic trust" comes into being via consistent tension relief. Eventually this tension relief--which is first analogic and internally based in terms of feedback from viscera, etc.--becomes connected and registered

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‡ Sometimes, in the framework of ego psychology, the bizzare motions are referred to as "magic rituals", and, indeed, at times they seem to serve some defensive role. However, if communications and cybernetic theories can reduce conceptions of "magic" to systems operations and neural functioning, a certain clarity will indeed have been introduced into our thinking about human behavior; although at the present the concept of magic is a useful and somehow very attractive one.

digitally to its source (usually the mother) along with the analog components of relief (for more details, see [2]). Then these cues (mother) come to have "meaning", and serve as signals for impending tension relief for the child. "Metainformation" comes to exist. We stress here the word impending for it implies a sense of continuity in the child--an ongoing time sense with the previous and the present somehow connected experientially. "Basic trust" (the confidence of tension relief?) starts after Anna Freud's "need-object" phase--a phase the autistic does not seem to enter at all. The autistic's "need for sameness" implies a sense of environmental discontinuity based on template matching rather than any time-sense of continuity. Any disruption of the template threatens or disrupts neural homeostasis, thus bringing homeostatic mechanisms into play, and also producing rage reactions or a more massive denial of the external environment, if such is possible. Which of these occurs would depend on the momentary condition of the internal state. In either case, neither "basic trust" nor its precursive "need object" phase can develop; and, in the autistic, neither does. Prerequisite to both is a sense of time-continuity. In terms of mother-child interactions we also note that the lack of object relationship and of "empathy" in autistics are common observations [7, 14, 28, 34] and one wonders about their relationship to maternal feedback systems. †

The usual lack of speech in autistics may be one of the clues as to the nature of defective systems in the autistic's brain. In the autistic, speech is rare, and where it occurs it is usually either echolalic or just sound-utterances. Some autistic children are said to have "had speech" and then (usually around 18 to 24 months) to have "lost it". Speech is seldom attached to needs, wishes or feelings, and usually is limited to a specific object or two. Kanner and Eisenberg [18] found that out of 19 autistic children without speech by the age of 5, only ONE seemed to improve enough to "go to school", while out of 23 who were said to have shown some speech by the age of 5 (whether later "lost" or not) 13 were capable of such improvement. Is it possible that speech system (not area) activation, when it occurs, somehow impinges on or activates or otherwise creates new available systems or areas or processes

†Kilmer and McCulloch have described computers and programs wherein two computers, each with only partial information, interact and modify refine each other until final concensus as to behavior is reached. The analogy to mother-child interactions is evident, and suggests that mother-child programs may be created or simulated in machines.

in the brain for development? The use of speech, of course, also implies digital thinking, for labels are possible. The absence of speech to a great degree impedes this.

Critical Periods: One wonders why the age of 5 or 5 1/2 should loom so important, although it is clinically evident that it does. Rimland [38] thinks that at age 5 1/2 learning moves from conditioning paradigms to more cognitive understanding types of functions, and thinks that operant conditioning succeeds because conditionability is still intact from earlier phases of brain development. Studies of reading readiness have found that a jump in the curve of readiness occurs at age 5 1/2 in normals. For Freud, the ages 4 to 5 1/2 were, of course, the Oedipal period, culminating in a new system-functioning for the superego. In certain EEG studies, Gray Walter [43] concluded that the changes at age 6 paralleled the acquisition of the concrete operations of Piaget's scheme. In the cybernetic terms we are using here, this would be a changeover from primarily analogic information processing techniques and relationships to a marked modification of process leading to greater use of digital modification of inputs and metainformation--although the process changeover may have been germinating for some time. It also appears that after the age of 5 1/2 the special diet for PKU children may not be as effective--or possibly not necessary--since changes in myelinization occur at 5 1/2,†

† Note: While no one should attempt to diagnose infantile autism on the basis of the foregoing description of clinical highlights, the clinical picture also should not be confused with that of Phenylketonuria (PKU), which is similar in some respects. PKU is, of course, a biochemically-based disorder. Some differences clinically are: (1) the autistic always walks, while the PKU child often does not; (2) the autistic's motor coordination is excellent, that of the PKU is not; (3) 80% of high grade PKU show abnormal EEGs, the autistic usually does not; (4) 66% of the PKU children show hyperactive reflexes--not the case with autistics; (5) 68% of PKU children show microcephaly. There are no reports of this in autistics. The PKU child is described as "having a stiff gait, with short steps, a stooping walk" or "stumbling gait", not the case in autism. Some points they share in common are: a tendency towards incessant action, either with part or all of the body (hyperkinesis); restless hyperactivity (only at times in autistics), speech disturbances, and emotional outbursts. In both types "none could be described as friendly, placid or happy. They are restless." [20] But the PKU child is described as overtly "fearful"--something which does not show in the autistic. In both, the mood, if any is ascertainable, is one of tension or withdrawal.

70% of the parents of autistic children surveyed by Rimland said their children had "changed" at age 5 1/2, but they all remained autistic [38]. Kuttner [22] theorizes that the CNS becomes less plastic as it matures and that language must activate before the CNS fully matures if the individual is to make full use of it.

This age factor suggests that the concept of "crucial periods", as applied to child development, may be significant. These have been touched on by Weiland and Rudnik [46], Spitz [42] and Bettleheim [5] among others. Scott [39] has suggested three crucial periods. We place any crucial failure at 0 to 3 months in the autistic, but consider that "hardware" defect is probably responsible for the lack of unfolding in that period. In terms of the analogic functioning and digital functioning of the autistic, this time estimate appears reasonable. Relating the crucial-period phenomenon and imprinting to the study of infantile autism raises many interesting questions. In animals the period for imprinting can be relatively short--a day, an hour, a week or two. Whatever evidence we have relating to imprinting phenomena in more complex animals suggests that any period for imprinting (or should we call it learning in humans) would probably extend over a longer period of time than in lower phylogeny. There may be an activation of a neural system by an imprint or a memory, or there may be a failure to activate neural systems, or at least a failure to activate them in a certain way. This leads us into the question of mis-programming, which we shall take up in the next section. Rather than consider infantile autism as the 3σ or 5σ point on a continuum, we view that the total failure of process-developmental sequences to occur as a form of process different from an abnormal unfolding of development--in which process still occurs, but along lines distorted more by "software" factors than by basic "hardware" injury. Basic hardware "injury" precludes mal-development of normal process, by aborting the process itself, while "software" injury distorts or blocks process without totally aborting it, and is also more specific about the processes involved than is the more generalized "hardware" defect in the autistic.

III. MIS-PROGRAMMING AND MENTAL DISORDERS

Are we merely translating one set of clinical ego psychological abstractions into another set of computer cybernetic abstractions--and perhaps injuring these complex abstractions in the process? In common with ego psychology, answers and techniques are being sought here to investigate process as such. Our aims are to provide leads as to ways to begin setting up computer programs to replicate autism and to study its process functioning. Basically, in autism, inputs and responses seem divorced or not connected through metainformational processes, or fail because of lack of processes to integrate digital and analogic information. In the so-called "childhood schizophrenias" the inputs and the responses, however, do NOT seem to be divorced. The responses, though inappropriate, DO occur. Cybernetically, so to speak, infantile autism appears to suggest at least as a meritorious hypothesis a basically different process from the so-called "childhood schizophrenias", and in this sense should not be considered an extreme example of the "schizophrenic" process at all. We do not consider this word-play, for if cybernetics can demonstrate that the realities of brain functioning underlying the two systems are different in terms of processes and systems, we will have at least the awareness of where to begin looking in each of these conditions.

Computer simulation aids the investigation of process rather than behavior by allowing internal observable programs, which are the determinants of process for the computer. Just as the behavior of a person constantly feeds back and modifies his next piece of behavior, so the computer program may be modified by the execution of a routine or subroutine. In present-day computers hardware is not so modified, but it will help our model-making if we think of all processes as involving both "hardware" and "software". Viewing mental illness (and health) as processes, certain psychoses need not involve structural changes, while others may. In normal functioning, brain systems actively seek information from the environment and are not ones of mere passive registration.

At this stage, we shall find it useful to distinguish between incompatible and misprogrammed systems as follows:

A "misprogrammed" system may result when the external "significant other" or environment has consistently or inconsistently fed information into the brain which is either (a) not congruent with reality as perceived by other senses, or (b) fed in information which is inconsistent with itself (e.g. the words and feelings do not go together and may be "contradictory"--yielding a new affect process not adequately described in digital terms), or (c) may be incongruent with the ongoing internal state of the child (e.g. mother fails to "pick up" or reflect accurately the needs and separateness of the child). The "double bind" [3] is a form of "misprogramming".

An "incompatible" system is based on a "hardware" defect where internal states are (a) incompatible with each other (leading to mechanisms for reducing general input) such as underlies the "allergy" theory of infantile autism or (b) lead to failure to develop processes for refinement of analog information by digital information inputs or (c) the internal feedbacks are unacceptable or incompatible to ongoing internal brain systems (for example, "tension relief" fails to be processed or internal input fails to activate (or dampen) certain ongoing processes). Basic to incompatible systems is the concept of an inbuilt process (defective or not) or structure such that inputs produce a consistent pattern within an already-damaged system yielding consistently atypical behavior (which itself need not be consistent), or a rigidity of internal systems so great that it breaks down early and then fails to develop. The rigidity of the inbuilt system (hardware) may then cause a breakdown in developmental sequence so that the data and the metainformation fail to classify the data, and the child stores data without any instructions as to how to use them. At the same time that this is going on, both analogic (quantum or feeling relationship) information processing and digital information (content) fail to modify each other or to develop processes for such modification. The child fails to learn how to learn. Thus the end-product behavior remains inappropriate or nonexistent with regard to a given input.

There are other forms of childhood psychosis, and these appear more related to misprogramming than to hardware defect: the brain has been taught to malfunction, e.g. is misprogrammed. This can result from the acceptance into a normally functioning system of inappropriate inputs which have modified an originally adaptive system so that it malfunctions. Since the normal brain can learn almost anything you teach it, the system can adopt (or create) programs of instructional data execution of which, if they consistently yield disasters, eventually modified so that they do not yield the disaster. If the input is inappropriate, but countering the input yields, say, rejection, the program will eventually come to accept the inappropriate input as though it were appropriate. One result can be that feedback modification begins to destroy the basic structure of the system itself. Lidz et al [24] and others have pointed to family interaction patterns which fit this paradigm at the inter-personal level--the double bind situation [3] in which digital data and analog data (in the sense of nonverbal communications, or instructions) are noncongruent--which produces an absence of appropriate metainformation. The adaptive system may maladapt to reality in the double bind situation to avoid the conflict between input and feedback. Computers may prove useful in varying programs to see whether this occurs, and under what kind of reprogramming the adaptive aspects of the system which remain may best be used for cor ctive purposes. At present, in these cases, psychotherapy or family therapy may be efficacious, and the concept of transference becomes a relevant one. However, in infantile autism many basic processes seem not to develop at all, and the child is often, and classically, seen as having been "different from birth". It is not as though he has been taught not to learn, for example, but as though storage and memory systems and analog processes make only certain aspects of input recoverable and almost none useable. This stands in contrast to other psychoses of childhood (and to normal functioning) where recovery of data modified by metainformational processes, produce partial reverberatory anxiety types of responses.

In the "childhood schizophrenics"--to use one term for a multitude of different disorders--a range of affects or analogs are invariably

expressed, albeit inappropriately to the situation, at times. Efforts seem to be made to modify internal neural processes to accommodate inputs--but unlike the normal, these inputs are then processed inappropriately, and the resultant accommodations are maladaptive. This process is what Pribram calls "participatory". In contrast to the "preparatory" operations of the autistic,

> "Participatory processes deal with incongruity (of input) by searching out and sampling the input and accommodating the internal system to it.... The experience becomes part of the organism, and the plans of action are appropriately modified." [33]

Where inputs are inappropriate, the internal system of the "childhood schizophrenic" (which has already moved to the point of being competent to execute participatory processes, and is thus more than 3 months old developmentally) will also modify itself to accommodate or gain congruence with the inappropriate inputs--yielding "mislearnings" or "childhood schizophrenia". The normal adult can tolerate a moderate amount of inconsistency in his internal model--mental disorder results when the inconsistencies yield gross instabilities. The younger the child, the less-developed the model, and the more disruptive the misprogramming.

The basic processes involved in infantile autism (as derived from the symptomatic behavior, and from theoretical considerations) and those of "childhood schizophrenia" thus appear cybernetically different. In this sense, they may be thought of as not parts of the same continuum.

We have suggested that there exists a separate clinical condition which may be labelled "infantile autism", involving chronic malfunction within the brain system (as against a progressive disease or transitory disorder), in the analysis of which the study of neural malfunction (whether structural, functional or the result of the disordered biochemical genetic environment) is relevant; while an analysis of the so-called "childhood schizophrenias" may well be done at the level of psychological interactions.

We have shown that these problems may be presented in terms of cybernetic concepts and language, and that such models cast light on underlying processes. We stress that this entails no assumption as to uni-causality, and no assumption as to locus (other than neurochemical) at the outset. There is an assumption that events external to the organism can modify internal functioning. Infantile autism may come to be shown (as has been done for PKU) to result from a biochemical or DNA-RNA error or other body deficit. Our present models neither imply nor deny such a causation--they seek to elucidate the information processing development of the child in order to analyze what deficits therein may yield results similar to infantile autism irrespective of their cause. When we postulate that infantile autism is a condition in the neonate, the existence of this very internally generated condition may so disturb the mother (the primary source for external inputs) as to cause impaired mother-child interactions, thereby further aggravating the condition. This reminds us that cybernetic analysis of mental health and disorder must take into account both internal malfunction and relational malfunction.

Cybernetics, Computers, Communication Theory and System Analysis help to clarify the functional nature of differences between mental health and various disorders, and aid in the elaboration of the neural mechanisms involved. In this fashion, we may provide new definitions for the theorist and process-management suggestions for the clinician, leading, in the future, to new concepts of the processes underlying mental and emotional functioning.

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