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CHAPTER 11

A Neuropsychological Model: Some Observations on the Structure of Psychological Processes

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My argument in this paper will be to the effect that a multilevel analysis of the psychological process can add fruitfully to our understanding of emotion in man. Indeed, such an analysis is one powerful tool for unraveling the complexities of the problem. Emotion, studied from these several levels, encompasses shades of phenomena from a primary process disruptive of the organism's equilibrium to a complexly patterned state that influences both the results of sensory inputs and of thoughtful activities.

Let me begin where Dr. Knapp in his introductory chapter left off: with Freud's "Project for a Scientific Psychology" written in 1895. My reason for beginning here is that as I read the Project, I find in it a neurological model of things psychological which is more sophisticated than any of the more current popular models. This came as a surprise to me. I originally read the Project for historical reasons, but found it to be an up-to-date useful research tool. To summarize this usefulness, I will use modern neurological and behavioral language, often derived directly from the German, rather than abide by the more usual psychoanalytic English translations to which we have become accustomed.

Some Primary Definitions

First and briefly, some primary definitions. Reference can be made to the accompanying diagram for further clarification. A more comprehensive treatment of the neurological model presented in the Project is available (Pribram, 1962a).

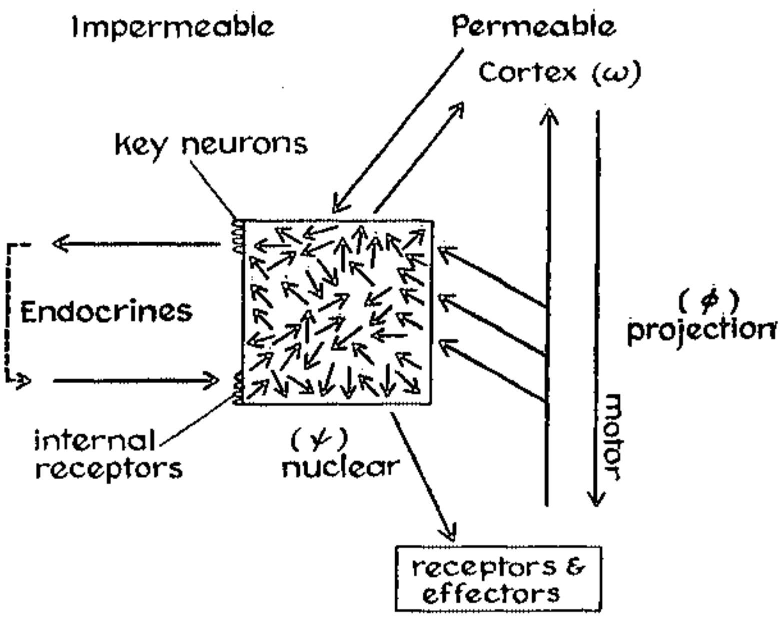

Figure I

A simplified diagram of the major system relationships of the neurological model proposed by Freud in the "Project for a Scientific Psychology." See text for amplification.

Excitation: Organisms are alive; they therefore make transformations on systems of energy. Metabolic processes are one example of such transformations. Behavioral interactions with chemical and physical stimuli (i.e., psychological processes) are another. These interactions must be quantifiable. The problem is, what to measure. The nervous system is intimately involved in regulating behavior—why not use indices of neural excitation as measures of the transformations of energy involved in the psychological process? And so, the nerve impulse, recorded electrically, is used as a measure of propagated neural activity. That leaves local, nontransmitted excitation. Electrotonic potential changes (and in today's language, other graded response mechanisms of neural tissue such as dendritic and synaptic potential changes) serve as indices of this type of neural activity. Freud uses the term *cathexis* to denote this localized neural excitation. The transformations of energy involved in the psychological process are therefore to be understood as changes in the neural processing of the interactions between the organism and its physical and chemical environment.

Cathexis: The excitation of neural tissue is measured as change in electrical activity recorded from the tissue. Abrupt potential change—the nerve impulse—is a measure of propagated excitation. Recently the attention of neurophysiologists has again focused (as it did in the latter half of the nineteenth century) on the nontransmitted electrical activities of neural tissue: the graded, spontaneously waxing and waning mechanisms characteristically found where synaptic and dendritic fields predominate. These electrotonic manifestations of local neural excitability are measures of the cathexis of the tissue. Cathexis, therefore, refers to the amount of local, nonpropagated, neural excitation which leads to impulsive, transmitted excitation only under certain special circumstances.

Resistance: The property of synapses that counters the propagation of quantity of excitation in a neural net. The transmission of frequency patterns of nerve impulses is not altered by resistance. Synapses have no other property. Current neurophysiological knowledge has not been looked at from this viewpoint—the techniques to study the transmission of patterns of frequency are in their infancy.

Memory: Synapses have only one property—they resist the transmission of quantity of excitation through the neural net. (They do not distort the propagation of frequency patterns, however.) Synaptic resistance is usually overcome only when the quantity of excitation on *both* sides of the synaptic junction builds up above some threshold. Resistance can also be overridden by excessive excitation. Repeated lowering of resistance at a particular synapse leads to a permanent conduction path through that synapse. Such permanent facilitation is the basis of memory. In the projection and cortical systems synaptic facilitation is relatively complete due to fairly direct contact with an ever exciting environment—their local patterns of excitation are therefore determined for the most part by the inputs to these systems. The nuclear systems, on the other hand, somewhat more isolated from external stimulation, provide the locus where synaptic facilitation can be selective. Here, therefore, patterns of excitation are dependent as much or more on traces left by previous synaptic facilitations as on those produced by current stimulation. The structure of memory at any moment is thus a function of these nuclear system traces as they are currently activated.

Motive: Each cell within the nuclear system is in multiple contact with its neighbors. If resistance were overcome with equal ease at all these contacts, transmission would be random. The organism does not behave randomly—its behavior is directed, i.e., motivated. To account for this the assumption is made that the resistances of the various synaptic contacts of a cell are differentially affected in the nuclear system. All parts of a neuron must therefore not necessarily behave in the same way at any moment. That this is so has been demonstrated conclusively, at least in the invertebrate nervous system. Neurons therefore are the selectors of the paths of conduction that build up the memory trace. The function of this selection is to give direction to behavior—i.e., to motivate. The pattern of pathways of lowered resistance that are based on the selection form the memory trace.

Notes on the Structure of Awareness

Now for the secondary definitions. These are all predicated on the notion that awareness is a function of certain neural processes—that awareness results when the cortical mechanism is excited not only by input from peripheral receptors but also by Freud's memory-motive mechanism.

Pain: A sudden, dramatic increase in cortical cathexis follows noxious stimulation of somatic receptors. The psychological concomitant of this increase is pain. Not only are the usual frequency patterns of neural impulses transmitted to the cortex through the projection systems, but a large quantity of excitation erupts from the nuclear systems because synaptic resistances are overwhelmed. With removal of the stimulus there is a sudden drop in cortical cathexis and thus a relief from pain.

Strain: All noxious excitation cannot be escaped: e.g., stimulation of the neuroreceptors in the core of nuclear systems. Such excitation must be held at a minimum by actions on the part of the individual and his environment—e.g., actions designed to reduce the amount of the chemical substances that stimulate the neuroreceptors. The gradually increasing cathexes produced by such stimulations, when transmitted to the cortical systems, are experienced as strain (i.e., as unpleasure).

The Affects: The excitations that initiate and relieve pain and strain intimately involve the nuclear system; traces of these excitations are left in this system; these traces facilitate conduction paths so that on future occasions they will be selectively activated. As already noted, these selectively activated neural networks are the basis of memory and motive. Cathexis of the cortical system derived from the excitations in these networks of the nuclear system is the neural concomitant of the affects.

Under what conditions, asks Freud, do affects occur and what are their components? Negative affects cannot be differentiated on the basis of whether the irritant was external or internal, for there is in the nuclear system considerable convergence of the pathways initiated by the somatic and by the internal neuroreceptors. In fact, Freud points out that the nuclear system is endowed in its midline portion with secretory mechanisms and these are activated whenever the quantities of excitation in the system reach a certain level. This is one reason why strain cannot be simply relieved: stimulation of the internal neuroreceptors activates the nuclear system; when a certain level of excitation has been reached, the neurosecretory cells are discharged; this in turn results in the production of more of the chemical substances that stimulate the internal receptors. The cycle can be interrupted only through external intervention designed to diminish abruptly the chemical stimulation, e.g., by feeding or by sexual release. So also, when a noxious external stimulus results in marked increase in the quantity of excitation in the nuclear system, chances are that this will activate the neurosecretory elements to pour out the chemical substances that stimulate the internal neuroreceptors. As an example, should one burn one's hand and withdraw it ever so quickly, there is nonetheless a temporary increase in the adrenalin circulation in the blood. Freud postulates a neurosecretory, i.e., a neurochemical stimulation of the adrenal rather than (or in addition to) the direct neural stimulation of this gland.

Thus, the neural traces left by stimulations initiated either externally or internally come to include the effects of internal excitation. Negative affects therefore are based on more than a one-to-one reproduction of the initiating experience. The neural concomitants of the negative affects, i.e., increases in cortical cathexis, are the results of the interactions of the affects of the initiating experience with those of the organism's internal reactions to the experience.

Positive affects are based on an additional complication. Whenever stimuli excite the nuclear system, they activate not only the paths associated with an increase, but also those that on prior occasions had led to a decrease in excitation. The effects from these trace excitations are to activate efferent motor discharge and so to diminish cathexis in the cortical system; thus the organism experiences a positive affect. Should circumstances be similar to those that relieved the strain on prior occasions, positive affect accompanies actions that lead to pleasure. Should circumstances have changed significantly, however, then strain will not be relieved by these actions.

What recent support is there for this conception of affect? There is one well-controlled experiment done by Schachter and Singer which is of extreme interest to us in this context. Schachter and Singer (1962) injected people with adrenalin (and controls with saline) just prior to making them take verbal tests—very difficult tests. The person who had been injected was not alone, however. In one situation the group taking the test made light of the whole affair. Another group griped and made nasty remarks about the tester and the whole experiment. The affect experienced by the adrenalin injected subjects was entirely different in these two situations. In one case, elation, stimulation, and excitement were expressed; and in the other, hostility and depression. The same amount of the same physiological substance, adrenalin, produced opposite effects that depended on the *social* context in which the subject was tested. Only the complexly structured memory traces activated by the social context can account for these differences in affect.

All recent experimental results do not so easily fit Freud's framework, however. You all know of the Olds (1956) experiments on self-stimulation. In their simplest aspect these data seem, superficially at least, at odds with the model presented in the Project. Yet, Olds is now using self-stimulation to condition isolated neural units in the cortex—so Freud's model may be found to fit even this exciting experimental result.

Suggestions Concerning the Structure of Adaptive Processes

Defenses and Satisfactions: These mechanisms invoke yet a third level of complexity: this level is predicated on the adaptive mechanisms to which Dr. Spitz referred earlier in this Symposium. Prolonged and intense excitation can be initiated by an affect, i.e., by awareness of a memory of pain and strain and the situations that led to their alleviation. Such remembrances can stimulate the neurosecretory cells of the nuclear system—and thus start the accruing strain spiral anew. The normal organism is not continually strained—Freud postulates, therefore, that the individual develops a *defense* against this release of neurosecretions. The defense mechanism is conceived as a lateral distribution of excitation in the neural network of the nuclear system, i.e., a distribution in a direction other than the transmission of excitation to the neurosecretory and cortical cells. The defense consists therefore of a diffusion of excitation that brings into functional contact an increasingly larger pool of neurons in the nuclear system and so delays and often prevents the transmission of excitation to the neurosecretory and cortical cells. Defense mechanisms so conceived prevent the build-up and maintenance of excessive strain.

The emphasis throughout the Project is on the interpersonal as well as on the neurological bases of the intrapsychic process. Freud therefore takes this opportunity to define as hostile those people whose actions could induce affects that would lead to strain. Defense in this context deals with hostilities. More of this in a moment.

Just as defenses develop to prevent affect from producing prolonged or overly intense strain, so satisfactions develop when affects result in pleasurable actions. The characteristics of satisfactions are rather different from those of defenses. The neural mechanisms of satisfactions involve primarily the cortical system. When the organism repeatedly experiences pleasure—i.e., the relief of strain—memory traces of the experience are built up in the nuclear system. When these traces are activated for whatever reason and the excitations are transmitted to the cortical system, the person becomes aware of positive affects. When the actions he undertakes on the basis of these positive affects are in concordance with the current situation, they lead to an experience of satisfaction. "As we showed in the beginning of the discussion, no discharge can bring about any permanent relief of tension as long as endogenous stimulations continue to be initiated and, in the nuclear system, excitation continues to be re-established. The removal of these stimulations can only be effected by actions which will more or less stop the release of chemical substances in the interior of the body."

Again the emphasis is on the interpersonal: "The excitation of the cortical system thus acquires an extremely important secondary function—that of bringing about an understanding with other people. The infant is so constituted that an extraneous helper must carry out specific actions in the external world on its behalf. Only when these are accomplished is the infant in a position by means of reflex contrivances to perform what is necessary in the interior of his body in order to remove the endogenous stimulus. This total series of events constitutes the basis of an experience of satisfaction: persons become a prime source of satisfactory (and unsatisfactory) experience; further, the actions undertaken to obtain satisfaction usually involve other persons—thus moral motives are built up. But these are only some of the momentous consequences in the functional development of the individual" (Freud, 1895).

Before we go on to other momentous consequences a *brief review* is in order: At the simplest level Freud differentially defines pain and strain. Pain is consequent upon somatic receptor excitation and strain ensues from excitation of the neuroreceptors in the center of the brain. Pain can usually be escaped by removing the receptor from the excitant. Strain cannot be so easily done away with, especially since the neural mechanism into which the excitation feeds (the nuclear system) contains neurosecretory elements whose secretions directly regulate the chemical substances that presumably excited the neuroreceptors in the first place. The vicious spiral of accruing excitation that results in prolonged and excessive strain can be prevented only by the intervention of a complex series of actions undertaken by the organism or by others on his behalf.

The excitations that accompany experiences of pain and strain and their alleviation leave traces in the nuclear system. These traces, when they minimally change cathexis in the cortical system, are the basis of the affects. Affects may be set off by the current situation or they may be internally triggered. Affects are based on experience and they motivate (i.e., give direction to behavior).

Accruing excitation that could accompany affects has to be defended against. Neural defense mechanisms are conceived in terms of the development of lateral pathways in the nuclear system which act to diffuse excitation and so prevent, or at least delay, its transmission to neurosecretory and to cortical cells. Thus the organism is relatively protected against the prolonged unremitting strain that would otherwise be initiated by hostility, pain, and the stimulations of neuroreceptors that recur in the ordinary course of events.

Satisfactions are obtained when positive affects are congruent with reality, i.e., when the inputs to the cortical system from the projection and the nuclear systems are comparable, so that actions undertaken on the basis of positive affects lead to the relief from current strain. Pleasure can occur by happenstance; satisfaction depends always on achieving a match between the record of experience and stimulations produced in the current situation.

Learning: Freud contends that learning results through the experience of satisfaction. When learning takes place, interconnections must be facilitated between trace and new neuronal excitations in the nuclear system; thus the initial network is functionally extended so that subsequent excitation will cathect this larger network. Freud notes that this conception of the learning process assumes a fundamental "law of association by simultaneity." His mechanism of learning is also a physiological-drive-reduction theory of reinforcement.

There is a difference, however, between Freud's conception and that which characterizes current drive-reduction theories. In much of current learning theory, drive reduction is assumed invariably to initiate the association of an environmental stimulus with the organism's response to this stimulus. For Freud, drive reduction is achieved as a *consequence* of an association by contiguity between the input from an environmental stimulus and memory traces left by prior drive-reducing experiences. Only when these associations lead to adaptive actions that reduce internal excitation for a fairly prolonged period can learning be said to have taken place. When, on the other hand, the situation has changed, and the actions taken are incongruous to the situation, no learning results. Nonetheless, reinforcement continues to occur by virtue of a temporarily effective discharge of the cathexis of the nuclear system. But this is accomplished only at the price of a rebound of even greater strain: the initially exciting stimulation is not removed; on each subsequent occasion it cathects a larger network of nuclear neurons. Thus there is an increasing likelihood that the defense mechanism will be overrun—unless it is simultaneously strengthened—and the accruing neurosecretory-neuroreceptor spiral of excitation established. In Freud's scheme, therefore, a nonadaptive neural process can be reinforced. Again Freud has anticipated struggles that learning theorists have had with a problem.

Thinking: Freud now has the basis for making a distinction between two types of thinking, productive (cognitive) and reproductive (wishful). When an affect is modified (because a disparity between a memory and the reality situation is recognized), or when a new affect replaces the old, productive thinking is taking place. When, on the other hand, such a change in affect does not take place, thinking is purely reproductive.

Reproductive thinking results when the cathexis of the neural networks involved in the positive affect overrides that produced by the current input. Such reproductive or *wishful* thinking carried to the point of hallucination involves a complete expenditure of the lateral cathexis (defense) in the nuclear system and is noted by Freud to be a *primary process,* since excitation is thus completely though temporarily escaped. Moderations of the total escape from excitation—i.e., the maintenance of some cathexis in the nuclear system—is the *secondary process.* Correct exploitations of the indications of reality are possible only when there is sufficient lateral cathexis (i.e., defense) in the nuclear system to delay or prevent the accruing of excitation through the vicious spiral of neurosecretory-neuroreceptor stimulation. This defense against excessive discharge by dispersal of excitation within the nuclear system Freud calls the organism's *ego function.*

The case of cognitive thinking is the more puzzling one for Freud from the neurological standpoint. When the thought about a possible external object is initiated by a positive affect, i.e., when a *wish* has been initiated and this wish and an external object are perceived to be similar but not identical, a "judgment" is made. There must be some mechanism to compare the similarities and differences between the excitation set up by the memory trace and that initiated by the current input. What that mechanism might be was far beyond the scope of nineteenth-century neurology and Freud could not even hazard a guess as to its nature.

But recent work on the habituation of orienting reactions has begun to fill gaps in Freud's model of cognitive thinking: We have heard Dr. Lacey present his model of the opening and closing of organisms to sensory input. Taken together with the work of the Russians and some of our own neurophysiologists on habituation of the orienting reaction, a story emerges that may be summarized as follows. Again, these observations have been spelled out in greater detail elsewhere (Pribram, 1962b). For our purpose, however, a summary suffices.

1. When exposed to a novel event an organism "takes this in"—and this stage is accompanied by desynchronization of the electrical activity of both the isocortical and basal allocortical formations of the endbrain. The only behavioral concomitants of this stage are "reflex" orientation movements that focus the stimulating event. Lacey has noted that this stage corresponds pretty much to "primary attention" as this was defined in introspective psychology.

2. Should this novel event recur repeatedly, remain unchanged, or change relatively slowly, another process supervenes. This is characterized by continued desynchronization in the electrical activity recorded from the isocortex, but a change in the activity recorded from allocortical structures (especially of Ammon's formation). From this neural location slow waves (i.e., hypersynchrony) can now be recorded. Behaviorally, searching characterizes the activity of the organism. This is the orienting reaction—the organism follows the stimulating event; searches when changes occur, especially once habituation is underway. In many respects this is similar to the secondary attention described by the "introspectionists."

3. After repeated exposure to the unchanging or recurrent event, habituation has resulted. The desynchronous electrical activity recorded from isocortex has become restricted to relevant input channels and slow activity has disappeared from allocortical structures. Here, electrical phase has shifted from precedence of brainstem input to precedence of input from isocortex. And any noted change in the situation is immediately and specifically accompanied by recrudescence of the electrical activities in both the iso- and allocortex characteristic of stage 2 (the orienting stage).

Thus when an organism is repeatedly exposed to a stimulus which on the first occasion was a novel one, electrical activity is concomitantly recorded from the brain; gradually, the electrical patterns that are characteristically recorded only during the organism's exposure to novelty drop out. That this "habituation" to the novel stimulus is not due to fatigue of nerve cells has been shown. For instance, dishabituation (reorientation) occurs immediately when, after habituation to a tone of a certain frequency and intensity has been in effect, the intensity of that tone is suddenly diminished. Dishabituation also occurs when the duration of the tone is shortened; the electrical patterns characteristic of orientation begin only at the moment the tone is turned *off* and persist for the duration of the "expected" length of the tone: traces representative of the stimuli aroused by the situation must be built up in the nervous system during habituation so that the input of the moment can be matched against these traces. Response depends on this match or "judgment."

Electrical patterns have also been demonstrated to be characteristic of various phases of problem solution (Adey, 1962; Freeman, 1960). Certain electrical patterns recorded from limbic areas of cats during the early stages of training recur during later stages of training only when the animal makes an error. And two very sophisticated analyses of these electrical records have been interpreted to show that a "comparator" must be located in the regions from which the recordings are made!

Summary: For Freud, learning takes place only when the memory traces of initially pleasurable, i.e., strain-relieving, experiences are modified by the current situation. On the other hand, reinforcement occurs whenever excitation in the nuclear system is discharged. A rebound from the discharge results when the actions on the basis of the memory trace are inappropriate to the situation—i.e., when affect is inadequately modified or unmodified by the input of the moment. In such instances, the thinking that accompanies the discharge is termed wishful or reproductive. Satisfaction results only when the affect is modified sufficiently to take into account the current situation; so that the actions undertaken change the situation until it becomes conducive to lasting relief from strain. The thinking that accompanies this type of discharge is productive—i.e., cognitive—and entails a judgment of comparison between a wish and the reality of the moment. This comparison leads to the modification of the memory traces that initiated the wish—the modification necessary for learning to take place.

Beginnings of a Structural Analysis of the Antecedents of Action

Apperception: I want to turn now to the final point in the discussion which bears upon what we heard earlier in this Symposium. So far we have been concerned with the structure of awareness, the structure of our image of the personal, physical, and social world. But there is, of course, much more to the interpersonal process. This has to do with the ordered sequences of behavior, Freud's "complex series of actions undertaken by the organism or by others on his behalf," to which Prof. Bateson has addressed his remarks and which were so beautifully illustrated by Dr. Birdwhistell. Dr. Spitz dealt with this problem under the label apperception. Certain events are reinforced and other things drop out. Dr. Spitz showed that the structure of the apperceptive mass is dependent on the anticipation of ordered behavior sequences. We have called these antecedents to ordered action "Plans" (Miller, Galanter, and Pribram, 1960). Computer scientists call them programs. The Plan is based on a Test-Operate-Test-Exit sequence: this unit is derived from recent neurophysiological evidence that necessitates the replacement of the reflex-arc concept with one that takes into account the universal presence of feedback.

The TOTE: Livingston (1958) and Granit (1955a) have thoroughly reviewed the large body of evidence that receptor activities are under efferent control from the central nervous system. With respect to muscle spindles, one third of the efferents in the ventral spinal root serve this function

(Kuffler and Gerard, 1947; Kuffler and Hunt, 1952). In the optic and otic systems (Galambos, 1956; Granit, 1955b), experiment has shown that the afferent activity originating in the receptors can be directly modified by central nervous system excitation. These facts make it difficult to maintain any longer the uncomplicated view of the functions of the central nervous system in behavior that are based on the simple S-R reflex arc. Bruner (1957) has suggested some of the ways that psychology could be enriched by taking into account these new data. It is worth while, therefore, to reexamine for a moment the concept of the reflex arc and to see whether a useful alternative to this war horse can be found.

Sherrington, more than anyone else, is responsible for the popular conception of the reflex arc. Yet Sherrington (1906), more than anyone else, cautions again and again against oversimplification: "The simple reflex-arc is a useful fiction"—used by Sherrington to explain the behavior of the spinal preparation. The most quoted example of the "simple" reflex is, of course, the stretch reflex, e.g., the knee jerk. Sherrington expressly states that he does not conceive this reflex to be an example of his "simple" reflex. Indeed, he questions whether the stretch mechanism is a reflex at all. The reflex arc was invented by him to explain the difference between the observed properties of nerve trunks and the properties that had to be inferred to describe the neural tissue that intervenes between receptor stimulation and effector response. Nerve trunks transmit in either direction; characteristically, signals are of the all-or-none type. Reflex action, on the other hand, is unidirectional and is characterized by graded response. Sherrington explained the differences by espousing the neuron doctrine. This doctrine proposes that the nervous system is made up of discrete neural units (cells) which have the properties of nerve trunks; intercalated between these units are discontinuities which he christened synapses, and these have the properties unique to reflexes. In Sherrington's discussion of the interaction of reflexes, these synaptic properties become complicated indeed. Central excitatory and inhibitory states, simultaneous and successive spinal induction, and convergence and divergence of pathways are only a few of the most important intervening variables he postulated to explain reflex action of the spinal preparation. These properties are a far cry from the ubiquitous S-R reflex-arc diagrams that grace (more appropriately, one wants to say "disgrace") today's texts.

The evidence that receptors are under efferent control from the central nervous system makes possible a revision of the reflex-arc concept that is at the same time more in keeping with the data and is definitely in keeping with the richly flexible nervous system that the psychologist needs if he is to have any useful conception of what goes on in the central nervous system during behavior. Since World War II, communications and control engineers have publicized the utility of a device that "feeds back" to a sensing mechanism the results of the actions of the machine of which the sensing mechanism is a part. This device is called the simple servomechanism, and neurophysiologists were quick to see that many of the processes that they had been studying in the central nervous system have the properties of simple servos (von Foerster, 1951). In fact, the central regulation of receptor activities makes it necessary to conceive of even the simplest reflex mechanisms in these terms.

What are the essential differences for psychology between the S-R reflex-arc concept and the simple servomechanism concept? Most important is a shift in emphasis. The shift is from the notion that an organism is a relatively passive protoplasmic mass whose responses are controlled by the arrangement of environmental stimuli to a conception of an organism that has considerable control over what will constitute stimulation. This control is exercised both through regulation by central processes and through a double feedback to receptors from response through environment and through the nervous system. Anyone who has spent any effort on the intricacies of "shaping" an animal or human preparatory to an operant conditioning experiment should sympathize with the validity of this shift in emphasis.

In detail, then, the alternative to the simple S-R notion of the reflex arc is a double mechanism that is constituted of one neuronal aggregate that is sensitive to a variety of inputs and another aggregate that is reciprocally connected to the first and effects the changes initiated by the first. Peripherally, the sensing mechanism includes the receptor; the effecting mechanism, the muscles, and the glands. Miller, Galanter, and Pribram (1960), among others, have developed in detail the idea that the essential characteristic of the sensing mechanism is to test for incongruities and that the essential characteristic of the effecting mechanism is to operate on other units (that may include the environment) so as to decrease incongruity in the sensing mechanism. They speak of this sequence as Test-Operate-Test-Exit (TOTE) and suggest that this, rather than the S-R reflex arc, is the basic unit that controls action. A diagram of the simple feedback unit is given in Figure II.

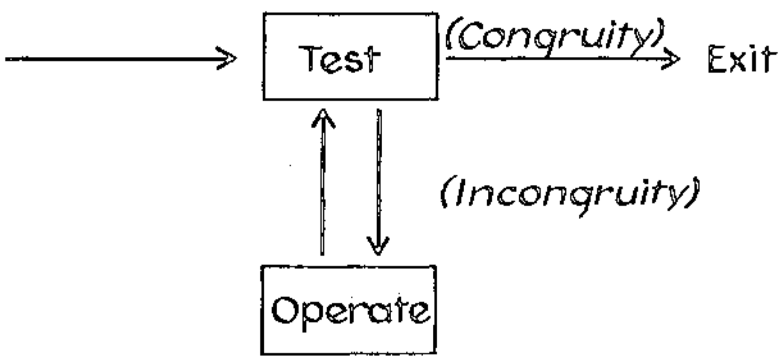

FIGURE II

The TOTE (Test-Operate-Test-Exit) unit, a feedback alternative to the reflex arc. Note that exit occurs when matching or congruity is achieved in the test phase, and *not* as a consequence of the operation or action per se.

The Plan: This TOTE unit includes characteristics which go beyond the simple notion of feedback. Test-Operate-Test-

Exit units are organized into larger aggregates both sequentially and hierarchically. Dr. Birdwhistell speaks about the

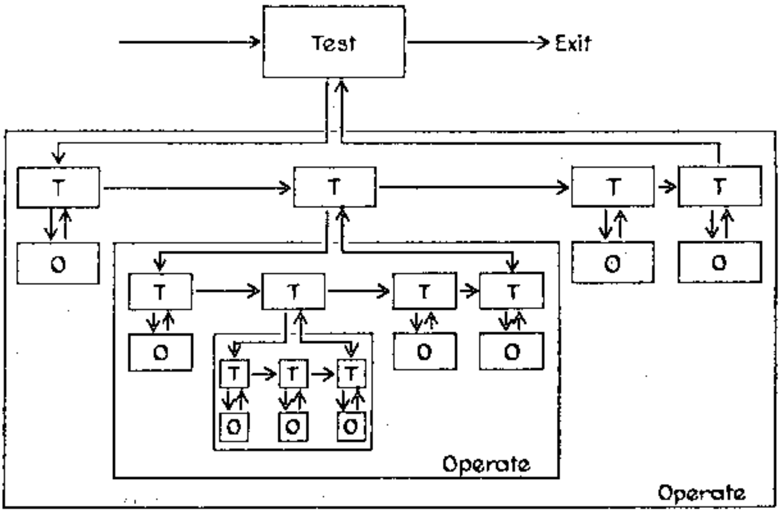

FIGURE III

The hierarchical arrangement of TOTES within TOTES: ordered behavior sequences always occur with contexts. Alternate notations that denote the same relationships are the "trees" used in set theoretical mathematics, the "lists" used in writing computer programs, and the outlines made as preparations for manuscripts.

structure of interpersonal interaction in terms of action and context. Action isn't just a string or chain of behavior. Action occurs always against context—action always influences the congruity or incongruity of the image against which the action occurs. And what is context for one organism is, of course, the behavior of the other and vice versa: this is the burden of Prof. Bateson's remarks.

Conclusion

So we are returned to the Image as context against which an expressive activity must be tested. But, interestingly, this image, this context itself occurs *within the operate portion* of the plan of next higher order. Context arises only when the results of tests for incongruity (at another level) demand that some operation be performed on the test or its input.

Let me illustrate these points with a simple example taken from some observations made by Prof. Bateson and myself on the octopus. This invertebrate has a dual system for changing skin color: (a) some reflector cells that can be uncovered and protruded so that the animal can reflect to varying degrees the color of its surroundings; and (b) melanophores that actually alter the amount of dermal pigment exposed at any time.

Although the variety of shades and colors is great, one can nonetheless make categories and give them labels. My hope was to use these categories as indices of the "emotional state" of the octopus. Thus it would be possible, in this relatively simple beast, to come up with a relatively simple description of emotion based on the observed expression of state. To my surprise, even in this remote corner of phylogeny, no such simple relationship holds. A purple hue may be expressive of some process elicited by the observer jabbing the arms of the octopus; it may be equally expressive of some process elicited by putting live snails within the view of the beast. Blanching may occur in response to prodding that leads to retreat; blanching also indicates that a hearty meal has just been completed. So, the beloved octopus turned out to be as difficult to fathom as the fair sex of our own species—blushing or flushing of her face may indicate embarassment, love, or the fact that she has been in the sun all day and the burn is just beginning to show, aided by the preprandial ingestion of a bit of alcohol. Taken by themselves, the skin-color changes of the octopus or of the girl are meaningless. Taken in a context created by the activities in which each is engaged, these same changes are interpretable. The single-level approach, even when only behavioral observations are under consideration, is found wanting. One is pushed by the data to a multilevel approach when one examines the problem of emotional expression, even in the octopus. When interest encompasses the neural mechanisms of emotion, and/or emotion in man (and woman), one seems to have no choice but to have recourse to this most powerful tool of analysis.

These are the rambling impressions brought forth by the preceding papers. I have not excluded neurophysiological data when they are relevant—just because this is primarily a group of psychiatrists. Nor have I shunned data derived from an experiment on social context just because my own competence lies primarily in the neurological sciences. I have even discussed observations on the octopus and admitted analogy to computers when I deemed this to be appropriate. I have made such extensive use of all of these because I believe that by detailing structure at several adjacent levels of discourse, body is given to the psychological process. This method is certainly not the only one—neither is it to be belittled, however. From my reading of the Project I suspect that a not inconsiderable part of Freud's strength as the pioneer psychoanalyst derives from his firm foundation in and significant contributions to such a multilevel structural analysis. After all, he was brought up in the sophisticated neuropsychological tradition that is clinical and experimental neurology and neuropsychiatry.

So too, I have not deleted references to verbal descriptions of introspections. All science, not only psychological science, begins with such verbal descriptions. And this level of discourse cannot be excluded without impoverishing psychology and excising analytic psychiatry from the scientific universe. Such exclusion is unnecessary when inclusion is guarded by certain constraints which are spelled out elsewhere (Pribram, 1962b; Miller, Galanter, and Pribram, 1960). So profitable has this approach proved that it has been given a name: "subjective behaviorism." Thus as a neuropsychologist and subjective behaviorist, I rest my argument: the untapped power of observation and experiment at adjacent levels of discourse.