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Some Observations on the Organization of Studies of Mind, Brain, and Behavior

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THE ASSIGNED TOPIC OF alternate states of consciousness intrigues me because it reflects on another that I believe to be fundamental to our understanding of the organization of mind and brain. Psychology has made great strides over the past century and a half in making experimental observations in an area of inquiry that had hitherto been the exclusive domain of philosophical analysis. However, the science of psychology is now beset by the problem of organizing its data into a coherent body of knowledge. The lack of organization becomes a critical factor when the results of neurobehavioral experiments are to be reported: The relationship of brain organization to mind as adduced from the effects of brain lesions and excitations must be framed coherently in order to be communicated. Yet, for example, I have completed some thirty experiments—in as many years—on the functions of the frontal cortex in order to obtain some idea of what might have been the effects of the human lobotomy procedures only to find that these effects can be couched in the language of motivation and emotion, or decision theory, or operant reinforcement theory, or in the paradigms used by experimentalists interested in attention or in cognitive learning or in memory, or even in perception. Now, it is certainly possible that all psychological

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processes are influenced by the frontal lobe of the brain, but if this is so, there should still be a way of systematically reporting how. And for an understanding of mechanism one must have at least a rudimentary idea of what one is searching a mechanism for—in short, what is the *relationship* among emotion, motivation, decision, reinforcement, attention, cognitive learning, memory, and perception.

In a trivial way, the connection between alternate states of consciousness and the alternate conceptual and experimental frames of psychological inquiry is obvious. Each school of psychology is conscious mainly of its own body of evidence but only dimly aware that alternate schools exist. Such dim awareness can take the form of complete dissociation and denial or of a more or less mild "putdown" or of active conflict. Only rarely (e.g., Estes, 1970; Pribram, 1970a) is any effort made to examine the relationship of the alternate conceptual-evidential frames to one another.

The recent literature on alternate states of consciousness follows a somewhat similar pattern. Each state is more or less fully described; however, in contrast to scientific psychology, at least occasionally the route that leads from one state to another is also taken into account. It is this additional description that gives me the hope that by pursuing the problem of the organization of mind and brain in alternate states of consciousness I can discern in a nontrivial manner a way to come to grips with the tower of Babel that now is scientific psychology.

Definitions

The definition of the assigned topic presupposes that consciousness is organized into states—that psychological processes operate within one or another frame or state that by definition excludes for the time being other states. There is evidence, some of which will presently be reviewed here, to the effect that a good deal of behavior, behavior modification (learning), verbal communication, and verbal report of awareness and feeling is state dependent. This presentation will therefore accept the definition that consciousness is organized into alternate states, with the provision that considerable supportive evidence for this initial acceptance will follow.

In diverse literature on consciousness (see reviews by Ornstein, 1972, 1973; Tart, 1971) a surprisingly long list of states exists. The most commonly agreed to are: (1) states of ordinary perceptual awareness;

(2) states of self-consciousness; (3) dream states; (4) hypnagogic states; (5) ecstatic states, such as are experienced orgastically; (6) socially induced trance or trancelike states; (7) drug induced states; (8) social-role states; (9) linguistic states, as when a multilingual person thinks in one rather than another language; (10) translational states, as when one linguistic universe is being recorded (e.g., in stenotyping) or communicated in another; (11) ordinary transcendental states, such as those experienced by an author in the throes of creative composition; (12) extraordinary transcendental states, which are achieved by special techniques; (13) other extraordinary states, such as those that allow "extrasensory" awareness; (14) meditational states; (15) dissociated states, as in cases of pathological multiple personality; and (16) psychomotor states manifest in temporal lobe epilepsies.

Most of us have personal experience with close to a dozen of these alternate states and so know at first hand the mutual exclusiveness of at least some of them, not only in the moment but also in memory. Let us therefore consider this aspect of the problem in more detail to see whether a clue to the organization of mind and brain can be provided by the analysis.

Consciousness as Control

Characteristic of the separateness of the various states listed is that their distinctive quality depends on overall organization, not on elements of content. Thus, the same elements can be identified in a dream as in an ensuing hypnogogic period and in ordinary awareness. A bilingual person (see Kolers, 1966, 1968) refers to the same content in both languages, but not at the same time or according to the same rules of reference (or perhaps even grammar). What is created during transcendental authorship is recognized later in ordinary perception—it only seems strange that authorship should have occurred at all. Even extraordinary states share considerable content with ordinary ones (see Barron, 1965).

At least three sources can be identified as giving rise to the events operated upon in consciousness: sensory stimuli, physiological "drive" stimuli arising within the body, to which the central nervous system is directly sensitive, and mnemic stimuli stored within the brain tissue. The fact that diverse conscious states share to some considerable extent the content given by these sources suggests that the separateness of these states cannot be attributed to sensory processes, to mechanisms arising in

body physiology, or to the way in which memory storage occurs. This does not mean that such stimuli cannot serve as triggers that initiate one or another of the conscious states—in fact, there is good evidence (Ornstein, 1972, 1973; Tart, 1971) that triggering stimuli of all three sorts abound. However, the organization of a particular conscious state cannot be coordinate with stimulus content but must reflect some particular brain state.

What, then, characterizes a particular brain organization in one or another conscious state? We have already ruled out the structure of the memory store as critical. Accordingly, there must be involved some organizational process akin to that responsible for retrieval. Such processes usually are referred to as *programs* or as *control functions* (Miller, Galanter, & Pribram, 1960). These map the array of anatomical receptor-brain connectivities into ambiences that process invariances in the stimulus into more or less coherent and identifiable structures. In short, the conclusion to be drawn is that alternate states of consciousness are due to alternate control processes exercised by the brain on sensory and physiological stimulus invariants and on the memory store.

The Regulation of Input

Even before the heyday of classical behaviorism, it was considered a truism that the brain controlled motor function as expressed in behavior. This control was conceived to take place by way of abstractive and associative mechanisms that progressively recoded the input into adaptive motor organizations. Today there is a considerable body of evidence in support of the conception that neural systems provide "feature analyses" and that an "association by contiguity" takes place in the brain. However, additional insights into feature organization and the meaning of the term *contiguity* have been achieved (see Pribram, 1971, chap. 14, for a review).

The best known of these insights is that everywhere in the central nervous system closed loops are formed by neural connections. These closed-loop circuits feed part of the output signal back to their input source. Thus, subsequent input is influenced by its own previous output. When this feedback is inhibitory it regulates the circuit. A good number of the neurophysiological studies of the 1950s and the early 1960s, some in my own laboratory, were addressed to discerning the feedback characteristics of such circuits (see Pribram, 1974; Pribram & McGuinness, 1975).

Neural control circuits have long been well known. Walter Cannon's laboratory (Cannon, 1929) established the concept of homeostasis to describe the finding that physiological stimulation from an organism's body was under feedback control. More recent is the discovery that feedback control exists everywhere in the central nervous system and regulates sensory as well as physiological input to the brain (for a detailed example see Dowling, 1967).

The ubiquity of feedback control made it necessary to alter our conception of what constitutes association (Pribram, 1971, chap. 14). Contiguity no longer refers just to an accidental coincidence in time and place but also to a controlled influence of temporally and spatially connected feedback units. Homeostats were found (Ashby, 1960; Pribram, 1969) to be multilinked to produce stable systems that could be perturbed only by gradually establishing new and independent input circuits (habituation). Such systems have the characteristic of matching input to the stable, current organization—perturbations indicate novelty; their absence, familiarity. The stable system provides the context in which the input or content is processed. Association by contiguity therefore turns out to refer to a context-content matching procedure not just to a simple, haphazard, conjoint happening.

In addition, it was possible to establish which parts of the brain accounted for the maintenance of a stable context and which were directly involved in habituation to novelty. A feedback model of the associative functions of the brain thus emerged from a variety of neurophysiological and neurobehavioral studies (see Pribram & McGuinness, 1975, for a review).

Cognitive Processes

Meanwhile, theorists, neurophysiologists, and psychologists independently became interested in another aspect of the organization of mind and brain (e.g., Miller, Galanter, & Pribram, 1960). Beginning in the mid-1960s, concerted effort was directed to the study of cognitive processes and of information processing by the brain. A new theoretical distinction was achieved when it was realized that open-loop, helical organizations characterized certain brain organizations, making voluntary and other forms of preprogrammed behavior possible (e.g., MacKay, 1969; McFarland, 1971; Mittelstaedt, 1968; Pribram, 1971; Teuber, 1960). Such behavior runs its course, insensitive to the effects it is producing. Of course, most behavioral processes combine feedback and feed-

forward operations, but there is a sufficient number of relatively pure cases of each to make the analysis possible.

The classical example of feedforward behavior is eye movement. Once initiated, an eye movement is insensitive to feedback from that movement. Corrective influence must await its completion (see discussion by McFarland, 1971; Pribram, 1976). The problem of control is limited to initiation and cessation, although of course a program must have been constituted either through the genes or through previous learning for the behavior to be carried to completion. Thus, feedforward control is programmed control; it shows considerable similarity to the operations performed in today's serial computers.

The distinction between closed-loop, associative, feedback control and open-loop, helical, feedforward control is not a new one in science. Feedback control is error-sensitive control. It is sensitive to the situation, the context in which the operation takes place. In contrast, feedforward control operates by virtue of preconstituted programs that process signals essentially free from interference from the situation in which the program is running. Interference can only stop the program. As already noted, homeostatic mechanisms are error-processing mechanisms: Every action begets an equal and opposite reaction when the feedback is inhibitory, leaving the system essentially unchanged. Feedforward control, on the other hand, proceeds to change the basic operating characteristics of the system. This change can be quantitatively represented as a change in efficiency of operation.

These concepts were initially embodied in the first and second laws of thermodynamics. The first law deals with the inertia or stability of systems, their resistance to change. The second law provides a measure—entropy—of the efficiency of operation of the system: the amount of work—i.e., organization—that the system can accomplish per unit time. More recently, the second law has been shown to apply not only to engines but also to communications systems, where the term *information* is used to indicate the reciprocal of entropy. Feedforward systems that exercise control through programs are therefore properly called information-processing systems (Brillouin, 1962).

Primary and Secondary Processes

The distinction between error-processing feedback organizations and programmed information-processing feedforward control is a useful one. Elsewhere (Pribram & Gill, 1975) I have detailed the suggestion that this

distinction brings into sharp focus an earlier one made by Freud. Psychoanalytic metapsychology, which concerns the mechanisms that underlie psychological processes, distinguishes between primary and secondary processes. Primary processes are composed of homeostatic, feedback, associative mechanisms; secondary processes are cognitive, volitional, and programmed, under the control of an executive (the ego) much as in today's time-sharing, information-processing computer systems. The terminology *primary* and *secondary processes*, however, is not unique to psychoanalysis. Other biologically oriented disciplines have expressed similar insights. Thus, at a recent meeting of experimentalists working on hypothalamic function, it was proposed and agreed to that primary, diencephalic, homeostatic regulations were influenced by secondary, higher order programs originating in the forebrain.

The distinction between primary and secondary processes, which was based originally on clinical observation, has thus been given a more substantive theoretical foundation, based on a variety of experimental and analytical techniques. Often, clinically based concepts by necessity are plagued by considerable vagueness, which gives rise to unresolvable conflict of opinion. The sharpening that occurs when data from other disciplines become available to support and clarify a distinction is therefore a necessary preliminary if the conceptions are to become more generally useful in scientific explanation.

Psychology Today

This caveat holds not only for clinically derived definitions and concepts but also for any that are based on a single discipline or technique alone. As indicated previously, theoretical psychology is today made up of narrowly based concepts, rigorous in definition and rich in detail but poorly understood in relationship to one another. Let us therefore consider these relationships in the light of some of the issues discussed in this presentation.

First we discerned that the organization of the memory store could be distinguished from the organization of alternate states of consciousness. Memory psychologists and biologists conceptualize a distinction between long-term and short term memory. This often, though not always, corresponds to the distinction made here. In order to correspond, the data must deal with the organization of the memory store, not with the recognition or recall of remote experience. Recognition and recall

obviously involve retrievals and control operations that are therefore as well the domain of decision and attention theory. Decisions may be arrived at consciously or unconsciously; attention is usually defined as involving awareness.

But controls are often exercised by programs, as we have seen. And these programs also demand storage. Thus, the memory store must be composed in part of items representing events and in part of programs that organize the items into information. Programs come hierarchically arranged—some simply act as assemblers, others constitute executive controls that determine priorities. Ordinary language and philosophy speak of such programs as constituting the intentions of the organism.

We do not as yet know the nature of the anatomical distinction between item storage and program storage in the brain. Nor do we know how programs act to assemble items. Still, some initial experimental analyses have been accomplished (Pribram, 1971). The important point learned so far, however, is that the two types of neural storage can be distinguished.

Another point must be added. Not all storage occurs in the brain. Environmental storage in repeatedly experienced situations also is acted upon by control programs. Thus, we may make internal searches of our brain's memory or externally search a library for the same items of information.

The actualization of the operation of a control program on stored items is the decision process. We can distinguish conscious decisions from unconscious ones. Conscious decisions involve attention, defined as the *holding* (Latin *tendere*, to hold) to one rather than to another program at any moment.

It must, of course, be kept clearly in mind that the initiation and cessation of the operation of a program may be determined reflexly—i.e., by homeostatic processes. The neural substrates of these "go" and "stop" mechanisms have been thoroughly investigated (for reviews see Pribram, 1971; Pribram & McGuinness, 1975). The "stop" signals appear to be the more primitive and homeostatic; whereas "go" involves the entire intentional system of neural programs.

The identification of stop and go mechanisms also has eased problems of definition that have beset the concepts emotion and motivation (Pribram, 1971, chaps. 9, 10, 11). The difficulties disappear in part by initially correlating emotion with stop mechanisms and motivations with go mechanisms. More complete resolution comes when the more subtle distinction is made between feeling and expression (Pribram, 1970a, 1970b). Feelings, both emotional and motivational, are found to be

homeostatically controlled. Thus, the stop mechanisms (which process input from both physiological drive and sensory stimuli and are located in hypothalamic and other core brain structures) sense equilibrium and match, which corresponds to the emotional feelings of stability and satiety, or they sense perturbation and mismatch, which corresponds to the motivational feelings of appetite and affect. Expression or intended expression, on the other hand, involves the (basal ganglia-centered) go mechanisms of the brain. It is interesting to note that the legal definition of guilt respects this formulation. A person is declared guilty of a crime on the basis of his intentions, not his emotional or motivational feelings, though these may be taken into account in sentencing. Thus, a crime may be committed for love or for need, both eminently respectable motives in our society. It is the intended or actual expression of these motives in behavior that is judged (Miller, Galanter, & Pribram, 1960).

Alternate States of Consciousness

On concluding this essay I return to the definition of attention as "holding" to one rather than another program that has been initiated by some homeostatically based emotional or motivational feeling and actualized by a decisional mechanism to organize mnemic or sensory invariants into an information process. Holding implies span, competency, and effort, all topics of considerable interest and the focus of much experimental activity in contemporary attention theory (Kahneman, 1973; Pribram & McGuinness, 1975). Holding implies also that certain consistency over time which characterizes a state. Therefore, different conscious states are due to the maintenance in operation of different neural programs that structure mnemic events and sensory invariants in different ways. Memory theorists investigate the organization of the storage of mnemic events and the programs that are used to process these items. In like manner, students of perception investigate the organization of sensory invariants and the programs that are used to process these invariants. Decision theorists are concerned with the emotional and motivational mechanisms that result in one rather than another stored program's becoming actualized. Attention theorists take over from decision theorists at this point and attempt to characterize the limitations on competency that determine whether the operation of one or another (or perhaps several) program(s)--cognitive processes—can be main-

tained over a sufficient reach of space and time to be recognizable as a state of consciousness. Investigators of consciousness are interested in the decisional steps that lead from one such state to another and in describing the content of these alternate states. Contemporary experimental psychology now makes sense to me: Obviously, the tower of Babel results from alternate emotional, motivational, decisional, attentional, and cognitive processes—in short, alternate states of consciousness.