

T-122  
124

CHAPTER 4

(2)

*Emotions*

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Current scientific knowledge regarding emotion has its roots in the Galenical medicine of the Middle Ages. Four "humors"—sanguine, choleric, phlegmatic, and melancholic—were considered to determine temperamental differences in reactivity. The humors were thought to be bodily secretions, and modern biomedical research has supplanted these primitives with a host of endocrine hormones. The hormones must, of course, even today be seriously considered in any comprehensive treatment of the biological regulations that determine emotions.

In addition to the multiplication and specification of humors, two other major developments have occurred in the scientific study of the biology of emotions. The first one of these developments points to the role of nonhumoral mechanisms in the emotional process: Lange's "visceral" theory made famous by William James (1890) and Nina Bull's "muscle" based attitude theory (1951) are probably the most important of these.

The second major development shows brain mechanisms to be central and critical to understanding. The realization that the brain is involved in the experience and expression of emotions began with the work of Gall and Spurzheim (1809) at the beginning of the nineteenth century and achieved considerable sophistication by its end. Thus William James (1890) could write:

If the neural process underlying emotional consciousness be what I have now sought to prove it, the physiology of the brain becomes a simpler matter than has been hitherto supposed.

Supposing the cortex to contain parts, liable to be excited by changes in each special sense-organ, in each portion of the skin, in each muscle, each joint, and each viscus, and to contain absolutely nothing else, we still have a scheme capable of representing the process of the emotions. An object falls on a sense-organ, affects a cortical part, and is perceived; or else the latter, excited inwardly, gives rise to an idea of the same object. Quick as a flash, the reflex currents pass down through their preordained channels, alter the condition of muscle, skin, and viscus; and these alterations, perceived, like the original object, in as many portions of the cortex, combine with it in consciousness and transform it from an object-simply-apprehended into an object-emotionally-felt. No new principles have to be invoked, nothing postulated beyond the ordinary reflex circuits, and the local centres admitted in one shape or another by all to exist (Vol. II, pp. 472-474).

And Sigmund Freud (1895) could develop a detailed neurological model of emotional development in his *Project for a Scientific Psychology*:

The primary brain . . . would, to put it plainly, be a *sympathetic ganglion*. (S. E., p. 303).

. . . there must [therefore] be "secretory" neurones which when they are excited, cause the generation in the interior of the body of something which operates as a stimulus upon the endogenous paths of conduction . . . (S. E., pp. 320-21).

. . . the endogenous stimuli consists of *chemical products*, of which there may be a considerable number (S. E., p. 321).

. . . *urgency* is released along the motor pathway [and] to *internal change* (expression of the emotions, screaming, vascular innervation). But, as was explained at the beginning [p. 297], no such discharge can produce an unburdening result, since the endogenous stimulus continues to be received the tension is restored. The removal of the stimulus is only made possible here by an alteration in the external world (supply of nourishment, proximity of the sexual object) which can be brought about in definite ways. At first, the human organism is incapable of bringing about the specific action. It takes place by *extraneous help*, when the attention of an experienced person is drawn to the child's state. In this way this path of discharge acquires a secondary function of the highest importance, that of *communication*, and the initial helplessness of human beings is the *primal source of all moral motives* (S. E., pp. 317-18).

Two central themes can be identified in these quotations, and they persist in practically all today's biological approaches to emotion: one theme draws out the relationship between visceral-glandular reactions and the brain in producing emotion; the other deals with the quantitative relationship between neural excitation and emotion. As we see later, these relationships, although substantial, by themselves neither form an adequate framework for understanding the complexities of emotional processes nor for understanding the intricacies of the relevant neural apparatus. Nonetheless, they do provide a familiar starting point for inquiry and the basis for developing a more comprehensive view that encompasses the results of recent neuropsychological research.

## A LABILE-STABILE DIMENSION

### The Visceral Theme

The impact of the visceral theme has been great and is reflected everywhere in our language. "He couldn't be expected to swallow that"; "she has no stomach for it"; "he broke her heart"; "the guy has no guts"; "he sure is bilious today," and so on. In fact, until 1800 A.D. the Galenic medical world subscribed to the notion that while thoughts circulate in the ventricles of the brain, emotions circulate in the vascular system. Gradually, medical and psychological science has become liberated from this view by the accrual of facts showing it to be in error. But the retreat has been a slow and guarded one, partly because old theories do not die easily and partly because this view has gotten hold of an important part of the truth. The most famous formulations that signal a step-wise retreat and liberation from this view are those of James and Lange, of Cannon and Bard, and of Papez and MacLean.

As noted in the introduction, James and Lange faced fully the accumulated knowledge of the functions of the circulatory and nervous systems of the previous century. They offered the following propositions: when an organism's reaction to a situation involved

visceral structures, the sensations aroused by visceral function are perceived as emotional feelings. This proposition provoked a good deal of experimentation. A summary taken from Cannon's critical examinations of the James-Lange theory of emotions (1927) is paradigmatic in showing the theory's weaknesses: (1) Total separation of the viscera from the central nervous system does not alter emotional behavior. (2) The same visceral changes occur in very different emotional states and in nonemotional states. (3) The viscera are relatively insensitive structures. (4) Visceral changes are too slow to be a source of emotional feeling. (5) Artificial induction of the visceral changes typical of strong emotions does not produce those emotions.

In place of the visceral theory, Cannon proposed a thalamic theory of emotions: emotional *expression* results from the operation of hypothalamic structures; emotional *feeling* results from stimulations of the dorsal thalamus. This theory was based on the observations that "sham," emotionlike behavior, could be elicited in decorticated and decerebrated preparations, but not when thalamic structures are additionally ablated (Bard & Rioch, 1937). Further, a variety of expressive and visceral responses were obtained when the thalamus was electrically stimulated (Von Bechterev, 1911). Finally, patients with unilateral lesions in the thalamic regions were described as sensing excessively what were to others ordinary cutaneous stimulations, for example, a pin prick would elicit excruciating pain, warmth, intense delight, and so on (Head, 1920).

Probably more is known about the functions of these core portions of the brain than about any other. This stems in part from the fact that these mechanisms are relatively "peripheral" in the sense that they are relatively directly connected to the organism's receptor mechanisms. In fact, some of these structures contain receptive elements sensitive to a variety of physical and chemical agents that circulate in the blood stream and cerebrospinal fluid. In addition, the core mechanisms exert considerable direct control over the agent to which they are sensitive. This control through feedback was termed "homeostasis" by Cannon and has proved to be a powerful conception in a variety of biological and engineering applications.

But of equal importance is the fact that the processes controlled are highly autonomous, that is, self-regulating. Visceral and endocrine regulation is performed with a light hand via two distinct portions of the autonomic nervous system, the sympathetic and the parasympathetic, which balance each other. Experimental evidence was accumulated, especially by Hess (1954), to demonstrate the existence in the hypothalamic region of a trophotropic, energy-conserving process, working primarily through the parasympathetic peripheral division of the autonomic nervous system, and an ergotropic or mobilizing system, working through the sympathetic division.

The balance between ergo- and trophotropic is not static, of course. When tipped in one direction or the other, a temporary rebound or an "answering effect" (Fair, 1963) could occur as the balance was restored. And indeed both processes could be activated simultaneously so that they would, in effect, work additively. And this was not all. When such activation occurred, somatic, as well as visceral, musculature was involved.

An assumption that paralleled, if not actually guided, these studies was that an understanding of the organization of thalamically regulated processes would provide the key to an understanding of the organization of emotional processes. Once the thalamus and hypothalamus were identified as the neural substrata of emotions, this assumption followed logically.

But Lashley (1960) tellingly criticized the evidence on which this identity was assumed.

to rest. He pointed out that the type of disturbance on which the theory is based is as often seen to follow lesions elsewhere in the nervous system. "Hyperalgesia is not a result only of lesions within the thalamus but may arise from damage anywhere along the afferent path." He also raised the question of whether "emotional disturbance" in the true sense ever occurs with thalamic lesions: "In no case was the affect referred to the source of emotional stimulation . . . but always to sensations of somatic reaction to the stimulus." He does agree that "in the hierarchy of motor centers we may recognize the thalamic region, especially the hypothalamus, as the region within which the complex patterns of expressive movements are elaborated. It does not follow from this, however, that the pathological phenomena of hyperexcitability of emotional reactions are due solely to release from cortical inhibition or that the thalamic motor center for expressive movement contributes to the emotional experience." Clearly, the dissociation between emotional expression and feeling, which is such a common clinical and experimental observation, can be leveled against both the James-Lange and the Cannon-Bard theories. Unfortunately, Lashley provided no alternative to the theories he so effectively deprecates.

Recently, the James-Lange and the Cannon-Bard views have been superseded by the one proposed by Papez and elaborated by MacLean (1950). The earlier theories had been firmly based on the evidence that the hypothalamus and dorsal thalamus were at the apex of the hierarchy of control of visceral or autonomic functions. With the development of modern techniques for electrical brain stimulation, viscera were shown to be under the surveillance of the cerebral cortex (Kaada et al., 1949). One portion of this cortex came into focus for special attention: the limbic portion of the forebrain. Papez (1937) had suggested that the anatomical interconnections among limbic structures were ideally constituted to handle the long-lasting, intense aspects of experience which are usually associated with emotion. MacLean added to this idea the facts of the relationship between this part of the brain and viscera, thus suggesting that here at last is *the* visceral brain—the seat of emotions. The persuasive power of this suggestion is great: Galen, James and Lange, Cannon and Bard, are all saved; visceral processes are the basis of emotion; an identifiable part of the brain is responsible for emotional control and experience because of its selective relations with viscera. James and Lange were wrong only in leaving out the brain; Cannon and Bard were wrong only in the part of the brain they had identified with emotion; the limbic forebrain, not the thalamus, is the responsible agent. The path from the "emotions in the vascular system" to "emotions in the forebrain" had finally been completed, and each step along the way freed us from preconceptions popularly current when the step was taken.

Despite its persuasiveness and still-present popularity, there are some important criticisms to be levied against the visceral brain theory of emotions. Just as the theory gains in power from its implicit acceptance of the James-Lange and the Cannon-Bard views, so it falls heir to the criticisms leveled against the earlier theories. Just as the relationship between thalamic structures and emotion fails to be an exclusive one, so the relationship between limbic structures and viscera, or, for that matter, limbic structures and emotions fails to be exclusive. It has been demonstrated experimentally (Wall & Pribram, 1950) that other parts of the cerebral mantle, when electrically stimulated, also give rise to visceral response. Emotional changes are observed to accompany lesions in parts of the forebrain other than the limbic areas. Further, ablation and stimulation of limbic structures influence problem-solving (cognitive) behavior in selective ways that cannot be attributed to changes in emotions. In humankind, in fact, a very obvious and specific "memory"

deficiency follows limbic lesions, while obvious changes in "emotion" cannot be ascertained. Obviously, the Papez-MacLean theory, like its predecessors, has only a part of the problem in hand.

### The Activation Theme

As one turns from the visceral to the activation theories of emotion, one can again distinguish between peripheral and central subtheories. Here, however, the argument has not been so sharp. Peripheralists have gladly accepted the diffuse nonspecific reticular activating system as the central locus on which and from which peripheral excitation focuses. And centralists, in turn, have been as concerned with the peripheral as with the central effects of adrenergic and cholinergic substances (e.g., Arnold, 1960). Activation theory can be said, on the whole, to be less specific, less controversial, and considerably more factually oriented than visceral theories (cf. Lindsley, 1951). For example, a classical visceral theorist would have to say that a certain amount of adrenocortical hormone circulating in the blood stream would be correlated with a specific pattern of peripheral and central neural response (in hypothalamus or visceral brain), which in turn corresponds to one or another of the varieties of emotional experience or expression. An activation theorist states merely that a correlation exists between the amount of hormone, amount of neural excitation, and amount of emotional arousal. Considerable evidence can be marshaled in favor of activation theory.

This state of affairs should clearly declare activation theory "in"—which, of course, it is. But again, common observation and introspection caution that something may be missing. For example, weeping is not just more laughing; fear is not just more love—although there is some truth to the notion of quantitative continuity in these processes. Once more, the suggestion arises that activation theory, while part of the story, is not in itself the whole story.

### A New Approach

A part of the difficulty comes from the view of activation as an elementary process opposed only to another elementary process, inhibition. True, activation can be viewed as an indicator of behavioral arousal: a temporary state of disequilibrium, a perturbation of patterns of organism-environment interactions. Also, disequilibrium is often sudden, explosive, and has the feel about it of agitation. But this does not necessarily mean that neural impulse transmission is facilitated; rather a different state of organization or disorganization may suddenly have materialized. This difference is expressed as a difference in configuration and not necessarily as a difference in the amount of neural activity. For instance, heart rate may be slowed, cortical rhythms desynchronized, peripheral blood flow diminished, but cerebral blood flow augmented. Cerebral activation, in this context, is an indicator of a configurational incongruity between input arrival patterns and established ongoing neural events.

This view of activation as an indicator of configurational change implies that the organism is fitted with a mechanism that provides a stable baseline from which such change can take off. This baseline is provided by the process of habituation of the orienting reaction. Experimental evidence has accumulated in the past two decades

(Sokolov, 1960) to show that habituation of orienting is not due to a progressive raising of threshold to input, but to the formation of a "neuronal model"—a neuronal configuration against which subsequent inputs to the organism are matched. In essence, such neuronal configurations form the sum of an organism's expectancies. The evidence runs like this: a person is subjected to an irregular repetition of a sound stimulus of constant intensity, frequency, and duration. Initially, the person shows a set of physiological and behavioral reactions that together form the orienting response. Among these reactions is "cerebral activation"—that is, a desynchronization of the electrical rhythms recorded from the brain. As the repetition of the sound stimulus proceeds, less and less orienting takes place. This lessening of orienting is called "habituation." For many years it was thought to be due to a simple rise in threshold to input. But "dishabituation"—that is, a recrudescence of the orienting responses—occurs when the intensity of the sound stimulus is decreased or if the duration of sound is shortened. In this latter situation, the orienting reaction occurs at the offset of the stimulation—to the "unexpected" silence.

There can thus be no question about the configurational nature of activation. But these experiments—and the many everyday experiences that they confirm—also account for the importance of visceral and autonomic functions in providing the stable baseline from which the organism's reactions can take off.

Each interaction between environment and organism involves at least two components: (1) discrete interaction by way of the brain's sensory-mode specific classical projection systems and its core homeostats and (2) a "nonspecific," relatively diffuse interaction by way of reticular and related formations. These nonspecific systems act as a bias on the specific reactions; the set point or value toward which a specific interaction tends to stabilize is set by the nonspecific activity. Visceral feedback constitutes, by the nature of its receptor anatomy and diffuse afferent organization, a major source of input to this biasing mechanism; it is an input that can do much to determine set-point. In addition, visceral and autonomic events are repetitiously redundant in the history of the organism. They vary recurrently, leading to stable habituations; this is in contrast to external changes that vary from occasion to occasion. Therefore, habituation to visceral and autonomic activity makes up a large share, although by no means all, of the stable baseline from which the organism's reactions can take off.

Another major source of recurrent input that determines bias or sets the level at which change can be sensed is that from the somatic musculature and skin. These somesthetic and proprioceptive inputs give rise to baseline configurations that have been conceptualized in terms such as the "body image" and "perceptual motor organization." Configurational changes in these inputs can also give rise to incongruities that disturb the stable baseline.

Whenever the reaction to incongruous input is sufficient to disturb these baselines, the orienting reaction will include the dishabituation of visceral and autonomic activities. Such dishabituation may be subjectively felt as a mismatch between expected and actual heart rate, sweating, "butterflies," and so on. The sensing of such discrepancies is the basis for the visceral theories of emotion.

If cerebral activation is conceived as a change in the state of organization of neural patterns related to the configurational incongruity between input and established neural activity, what then is its converse? As already indicated, overall neuronal facilitation or inhibition are not involved. Rather some indicator of congruity, of unperturbed, smoothly progressing neuronal activity must be sought. This indicator, at present, is found in the

patterns of electrical activity recorded from the central nervous system. There is considerable evidence (Li et al., 1955a, 1956b; Adey et al., 1962) that the slow graded activity of neural tissue, rather than the overall inhibition or facilitation of nerve impulse transmission per se, is involved in the generation of such electrical patterns. The assumption is that the graded electrical activity recorded from the brain reflects the relative stability of the neural system. Such stability would admit increments of change provided these did not disrupt the system. Nor is it implied that incongruity, and therefore activation, are necessarily initiated by input. An input that may ordinarily be processed smoothly may perturb the system if that system is already unstable; or an internal change in the organism may initiate incongruity where match had previously existed. The configuration of activation of the nervous system thus can predispose the organism toward perturbability or imperturbability.

A considerable body of evidence has recently accrued about the neurophysiological and biochemical mechanisms that regulate these predispositions. As already noted, the nonspecific neural systems are primarily involved in setting the bias toward which more specific organism-environmental interactions tend to stabilize. These diffuse systems are largely made up of fairly short, fine fibers with many branches. Such neuronal organizations are especially sensitive to the chemical influences in which they are immersed. A potent set of such chemical influences are the catecholamines, and they have been shown selectively present in the diffuse systems (Kety, 1966). Further, these brain amines have been shown to be the important locus of action of the pharmacological tranquilizers and energizers that have been so successful an adjunct in altering maladaptive emotional reaction.

But these are not the only chemical influences at play. The importance of humoral factors in determining emotional states has already been noted. *Hormones* are chemicals that exert their influence on the brain via receptors located in its core. In addition to this sensitivity to hormones produced by glands such as the gonads, thyroid, adrenal medulla, and cortex, the core brain receptors monitor a host of other chemical and physical constituents of the internal environment of the organism. A respiratory control mechanism is sensitive to the partial pressure of CO<sub>2</sub>; a temperature sensor monitors the warmth of the blood stream; sex hormones are selectively absorbed at one location and adrenal steroids at another; the difference in the concentration of sugar in the venous and arterial circulation is monitored as is the concentration of salt and therefore, reciprocally, the concentration of water. Chemicals secreted by the walls of the gut and by the kidney and a host of others are being investigated because some experiments indicate that they too are sensed by cells in the core of the brain (see Pribram, 1971; chaps. 9 & 10, for review).

Further, this part of the brain is a veritable cauldron of chemicals locally secreted by aggregates of cells in one or another location. Catecholamines such as norepinephrine (closely related to the hormone epinephrine—adrenaline—secreted by the adrenal medulla) and dopamine (which metabolizes into norepinephrine); indole amines such as serotonin; and peptides such as endorphin (an endogenous morphinelike substance) abound. As might be expected, sensitivities to these neurohumors are also built into the mechanism.

Walter Cannon, in his classical studies (1927), determined that the relationship between the sensor and its chemical was such that the concentration of the chemical, although fluctuating, was maintained constant around some set point. He enunciated this relationship as the principle of homeostasis. The sensor monitors the quantity of the variable and signals by way of neural pathways or chemical secretions when the variable rises above or

falls below a certain level. Such signals compose a negative feedback because their sign is opposite to that which characterizes the deviation of the quantity of the variable from the baseline. Often the mechanism that counteracts the decrease of the variable—the appetitive phase—is separate from that which counteracts the increase—the satiety phase.

Individual homeostatic mechanisms are multiply interlinked into complex organizations. Thus the thermostat regulating temperature is linked to the glucostat regulating food intake and these are linked to the osmoreceptors (the salt-water sensors) to control thirst and the thyroid sensitive mechanism controlling activity. Through various metabolic interrelationships such as breathing that take place in the body these homeostatic mechanisms in turn regulate the partial pressure of CO<sub>2</sub>, and so on (see Brobeck, 1963, for review).

In short, the core of the brain (mesencephalon, diencephalon, and the basal ganglia and limbic systems of the forebrain) uses chemical regulations to control body functions. The configuration of concentrations of these chemicals, although fluctuating around some set point, is sufficiently stable over periods of time to constitute steady "states." These states are apparently experienced as hunger, thirst, sleepiness, elation, depression, effort, comfort, and so on. (For a more complete discussion of how an experimenter infers what an observed organism might be experiencing, see Douglas & Pribram, 1966; Pribram, 1971, Chap. 6. More direct evidence is obtained by psychopharmacological experiments where the effect of drugs of known neurochemical action on the psychological state is assayed.) Although the chemical characteristics of each state are as yet incompletely specified, enough is known to allow one to say that the concentration of glucose is involved in the hunger mechanism; the concentration of salt in the thirst mechanism; the concentration of the indole amine serotonin and norepinephrine (a catecholamine) in the sleep mechanism (norepinephrine in dreaming); the concentration of dopamine (another catechol) in feelings of effectiveness—that is, of elation and depression; the concentrations of endorphins (endogenous secretions of morphinelike substances) in those of temperature, novelty, and pain; and the concentrations of the enkephalins (adrenocorticotrophic hormones of the pituitary) in those of effort and comfort (for reviews, see Pribram, 1971, 1977a; Stein, 1978).

#### AN EPICRITIC-PROTOCRITIC DIMENSION: BRAIN STEM SHELL AND CORE

The control of temperature and of pain falls into the homeostatic mold. But temperature and pain are also skin senses that share a common spinal pathway; thus the question arises about whether the skin components of these sensitivities are processed separately from those involved in internal regulations. The answer to this question is that part of the skin components of temperature and pain are processed separately and part in conjunction with the chemical homeostats of the core brain.

The part of the skin components of temperature and pain sensitivity processed separately (in the parietal lobes of the cortex) from the homeostatic mechanism is characterized by what is called in neurology the "local sign." This means that the sensation can be located on the skin and that the duration of the sensation is limited. Henry Head labeled such sensory experiences "epicritic" to distinguish them from more diffuse experiences that are obtained during early regrowth of severed nerves.

The remainder of the skin's temperature and pain sensitivities are processed in conjunc-

tion with the chemical core homeostatic mechanisms. The spinal temperature and pain tracts end in structures (such as the substantia gelatinosa of the dorsal spinal cord; the periaqueductal grey of the midbrain; and the amygdala of the forebrain) loaded with endorphins. Responses to hot and cold and pain are dramatically altered by electrical stimulations of these core portions of the spinal cord, brain stem (Liebeskind et al., 1974), and forebrain and not affected by stimulations of the parietal cortex or the tracts leading to it (Chin et al., 1976; Richardson & Akil, 1974). The assumption is that the stimulations increase the local (and perhaps general) secretions of endorphins.

What is common to the homeostatic internal mechanisms and these aspects of pain and temperature processing is that they are sensitive simply to amounts, the quantities, of chemical and neural excitation. Processing does not lead to identification of location in time and space (or to other qualitative aspects of the stimulus such as color). Hebb termed the quantitative "diffuse" aspects of sensitivity "protopathic" because in his experiments they arose, while the regenerating nerves were in a pathological condition. The term needs to be modified to "protocritic" in order to include current evidence that such sensitivities are part of the normal control of the temperature and pain (and probably other sensory) mechanisms. As noted, protocritic processes are homeostatic—that is, they control the quantitative aspects of stimuli and are thus determinants of neural states. Chin et al. (1976) and Pribram (1977a) provide a more complete review.

The protocritic dimension of experience, devoid of the epicritic local sign, is therefore characteristically dependent on the quantity, the intensity of the stimulus. Quantity and therefore intensity in a homeostatic system is, in turn, dependent on change and rate of change of the state of that system. Controlled changes of moderate amounts are apparently experienced positively, while more abrupt and overly intense changes of state lead to negative feelings (the Yerkes-Dodson Law in Hebb, 1955). Here we are at the frontier of knowledge. As noted, the pain and temperature systems run together in the spinal cord and brain stem to terminate in and around the amygdala and frontal cortex. Do the elaborations of the temperature systems accrue to the experiencing of comfort as the elaborations of the pain systems accrue to suffering? Or is suffering experienced only when the limits of tolerable comfort are exceeded? Brain stimulations in human beings that protect against pain are accompanied by the feeling of cold (Richardson & Akil, 1974). In short, are there two neural systems—one for pain and one for temperature, or is there only one? And if there are two, how do they interact to produce a more or less unitary experience along a hedonic dimension?

Although there are no definitive answers to this question yet, it has become clear that a host of neural systems become engaged in the rostral extensions of the pain and temperature mechanism. At the brainstem level up to the forebrain, electrical excitations of these systems produce self-stimulation in animals and hedonic experiences in man. Closely intertwined, but perhaps more laterally placed, are locations from which electrical stimulations produce aversive effects—turning off the stimulus and, in the more caudal placements evidence of discomfort in animals.

In the forebrain, these systems focus on structures such as the basal ganglia and limbic formations about which we have a considerable amount of information regarding their relationship to emotion (and motivation). The evidence involved can be organized to show that three separate categories of systems can be discerned to influence electrocortical desynchronization—evidence that goes beyond that reviewed in the previous section, of "The Activation Theme." This evidence (detailed by Pribram & McGuinness, 1975)

shows that three separate systems can be discerned to influence electrocortical desynchronization. One system regulates phasic desynchronization (i.e., brief, lasting at most several seconds), another tonic desynchronization, while a third coordinates the other two (over a longer period of time—the duration of an attention span).

Phasic desynchronization we called "arousal." The system responsible for arousal centers in the forebrain on the amygdala, a basal ganglion of the limbic forebrain. Removal of the amygdala eliminates the visceral and autonomic responses that ordinarily accompany orienting and alerting to a change in stimulus conditions (Kimble et al., 1965; Bagshaw et al., 1965; Bagshaw & Benzie, 1968; Pribram et al., 1974; reviewed by Pribram & McGuinness, 1975). Furthermore, this elimination of the viscerosautonomic responses apparently leads to a failure of behavioral habituation that normally occurs when the novel stimulus is repeated. The viscerosautonomic reaction appears necessary for familiarization with the stimulus to occur. Thus contrary to Lange and James, the visceral input appears not to be experienced directly as an emotion, but leads to rapid habituation of the input. As shown by Sokolov (1960) habituation forms a stable neural representation. Such a stable state is necessary for appreciating subsequent change—the novelty which then arouses (emotional) interest and when the novelty exceeds certain limits, the experiencing of (emotional) upset. James and Lange were correct in suggesting that visceral input is important to emotion, but erroneous in the specific role they assigned to it in the emotional process.

The second system involved in the desynchronization of cortical electrical activity (in this instance a tonic—minute long—activation) is centered on the nonlimbic basal ganglia of the forebrain—the "caudate nucleus" and "putamen" (reviewed by Pribram, 1977b). These structures are concerned with maintaining the (motivational) readiness of the organism: postural readiness, motor readiness, and the readiness produced by the establishing of sensory (i.e., attentional) sets (Spinelli & Pribram, 1966, 1967; Reitz & Pribram, 1969; Lassonde, Pfito, & Pribram, 1975). It is this second system that forms the neural basis for "attitudes"—much as suggested by Nina Bull (1951).

A third system centers on the hippocampus and coordinates arousal and readiness. Arousal phasically interrupts ongoing tonic readiness. The balance between interruption and continuation must be coordinated, and neurobehavioral and neurophysiological evidence points to the hippocampal system as serving such a function (Isaacson & Pribram, 1976). Coordination has been shown to involve neural work, that is, to take effort (Benson Symposium, 1975).

Neurochemically, the three systems also differ (reviewed by Pribram, 1977a). As already noted the amygdala is rich in endorphins and the caudate and putamen are characterized by dopamine. The hippocampal system is involved in the pituitary-adrenal hormonal controls, selectively absorbing the adrenocortical hormone (Bohus, 1976; McEwen et al., 1976) and being acted on by the adrenocorticotrophic hormone (ACTH) and related enkephalins (Riezen et al., 1977).

The humoral, visceral, and activation theories of emotion (and motivation) are thus converging into a more comprehensive view that subsumes the earlier ones. The momentary arousal produced by novelty (or its complement, familiarity) appears related to endorphin homeostasis, the activation of motivational readiness is based on a dopaminergic system, and coordinating effort (or its inverse, comfort) is experienced as a result of operations of the brain representation of the pituitary-adrenal hormonal stress mechanism.

The model of emotional feelings that emerges from these data centers on a set of

corebrain neurochemical states that comprise the experience of "familiarity." Familiarity implies equilibration, a feeling of reasonable amount of stability and smooth transition from one state to another. This set of stable states can be altered by novel or pain producing events and what is perceived as novel—or painful—is dependent on the configuration of the states that determine what is familiar. The distinction between novelty and pain is one of intensity *only* [e.g., electrical stimulations of the amygdala in animals and man produce orienting (interest), avoidance (fear), attack and escape (pain) as a function of ascending stimulus intensity (Gaustaut, 1954)]. In contrast to the arousing disequilibrations produced by the novelty-pain mechanisms, the maintenance of states is effected by tonic operations of the readiness system. This system may have evolved from, or in close coordination with, the temperature system. There is a considerable body of evidence that the maintenance of a stable basal temperature involves the food appetitive, water balance, and tonic muscular readiness systems, among others (see Brobeck, 1953, for review). When the demands of arousal are pitted against those of continuing readiness, the feelings of stress and effort are experienced. These experiences are allayed by a coordinating mechanism that adjudicates smooth transition from state to state within some comfortable band width of tolerance.

The data briefly noted in this section make it necessary to look carefully at another often neglected distinction. Ordinarily, we use the terms emotion and feelings as synonymous. Feelings generated by readiness to respond are more akin to motivations and intentions than to emotions, however. The next section makes explicit therefore a distinction between emotions and motivations and the feelings that are generated by both.

#### AN EFFECTIVE-AFFECTIVE DIMENSION: BASAL GANGLIA AND LIMBIC FOREBRAIN

Since Darwin's classical treatise on the expression of emotion (1965), it has been customary to separate emotional experience from emotional expression. Emotional experiences are classes of feelings, and I have elsewhere (1970, 1971) made the case for using the category "feelings" to encompass a range of experiences which can be separated from those that allow us to perceive objects beyond our skin:

I once had the opportunity to examine some patients in whom the medial part of the temporal lobe—including the amygdala—had been removed bilaterally. These patients, just as their monkey counterparts, typically ate considerably more than normal and gained up to a hundred pounds in weight. At last I could ask the subject how it felt to be so hungry. But much to my surprise, the expected answer was not forthcoming. One patient who had gained more than one hundred pounds in the year since surgery was examined at lunch time. Was she hungry? She answered, "No." Would she like a piece of rare, juicy steak? "No." Would she like a piece of chocolate candy? She answered, "Umhumm," but when no candy was offered she did not pursue the matter. A few minutes later, when the examination was completed, the doors to the common room were opened and she saw the other patients already seated at a long table eating lunch. She rushed to the table, pushed others aside, and began to stuff food into her mouth with both hands. She was immediately recalled to the examining room and the questions about food were repeated. The same negative answers were obtained again, even after they were pointedly contrasted with her recent behavior at the table. Some-

how the lesion had impaired the patient's *feelings* of hunger and satiety and this impairment was accompanied by excessive eating!

As yet we understand little of how this impairment comes about. Nevertheless, this example points clearly to the folly of believing that a direct match exists between observations of any particular type of behavior and introspectively derived concepts. Are we to say that the patient *felt* hungry because she ate ravenously despite her verbal denial? Or are we to take her statements at face value and seek elsewhere for an explanation for her voracious eating? The paradox is resolved if, as in earlier chapters on perception, we consider the behavioral function to be composed of several processes, one of which is the feeling state reported verbally.

At the hypothalamic level a similar paradox has plagued investigators. As already noted, when lesions are made in the region of the ventromedial nucleus of the hypothalamus, rats will eat considerably more than their controls and will become obese. But this is not all. Although rats so lesioned ate a great deal when food was readily available, they worked less for food whenever some obstacle interfered . . . (Miller, Bailey, & Stevenson, 1950).

It was also found that the more palatable the food, the more the lesioned subject would eat (Teitelbaum, 1955), giving rise to the notion that the lesioned animals did not show greater "drive" to eat but were actually more "finicky" than their controls. Recent experimental results obtained by Krasne (1962) and by Grossman (1966) added to the paradox: electrical stimulation of the ventromedial nucleus stops both food and water intake in deprived rats and chemical stimulation of the cholinergic mechanism produces foot stamping (in gerbils, Glickman, personal communication) and fighting if provided (King & Hoebel, 1968).

Grossman summarizes these results with the succinct statement that medial hypothalamic manipulations change affect not appetite. But we are once again faced with our earlier dilemma. If the medial hypothalamic mechanism does not deal with motivation, how does eating, drinking, etc., come about? The data hold the answer. The ventromedial and lateral hypothalamic regions form a couplet, the lateral portion serving as a feeding, a "go" mechanism (which, when ablated, will produce rats which tend to starve), and the medial portion contains the "stop" mechanism.

. . . The paradox is resolved by the hypothesis that processes ordinarily involved in taking the organism "out of motion" also generate affects or feelings of e-motion. Thus an important distinction between motivation and emotion becomes clarified: the term "motivation" can be restricted to the operations of appetitive "go" processes (such as those converging in the lateral hypothalamic region) that ordinarily result in behavior which carries forward an action, and the term "emotion" to the operations of affective "stop" or satiety processes of reequilibration. (Pribram, 1971/1977, pp. 192-194).

Thus neurobehavioral data make imperative a reference to an encompassing category, feelings, with the subcategories emotion and motivation clearly distinguished. Emotion is found to be derived from processes that *stop* ongoing behavior: affective reactions accompanying the satiety mechanisms as in the foregoing quotation, arousal as in the orienting reaction to distracting stimuli, and more generally when behavior is interrupted (Mandler, 1964). By contrast, the organism is considered motivated when his readiness mechanisms are activated, when he is ready to "go" and to continue "going." These responses are (as noted in the previous section) critically organized by the basal ganglia (Pribram, 1977b) and have as their physiological indicators the CNV (Walter, 1967) and heart rate slowing (Lacey & Lacey, 1974).

The distinction between emotion and motivation is not a novel one. In his opening paragraph on emotions William James suggests that "emotional reaction usually terminates in the subject's own body," while motivation "is apt to go farther and enter into practical relations with the exciting object" (1890, Vol. II, p. 442). In a similar fashion, J. R. Kantor, whose interbehavioral analyses of psychological processes influenced B. F. Skinner so profoundly, distinguishes between affective and effective interactions: in affective interactions "the person is responding above all with internal body mechanisms," while effective interactions generate readinesses or overt responses toward the stimulus object (Kantor & Smith, 1975).

In short, for behavior, as well as for the neurophysiology of feelings, it becomes useful to distinguish emotional from motivational antecedents. Motivational antecedents imply that the organism is preparing to or actually acting on the environment, while emotional antecedents imply only that internal processing, internal control mechanisms, are in force. The distinction becomes manifest in the connotative differences between the meaning in English of the term "behavior" and its continental counterpart in German and French: "Verhaltung" and "comportment" both connote how one "holds oneself"—one's positive and negative attitudes, whereas the English "behavior" has the more pragmatic and active meaning of "entering into practical relations with the environment."

An important consideration arises at this point. If the expression of emotions is affective (rather than effective), that is, emotional expression terminates in the subject's own body, how then can we observe and work with such expressions in terms of behavior? Ordinarily, an experimentalist is concerned with the environmental consequences of behavior (e.g., the cumulative record in an operant situation). In this situations, according to our definition, behavior is motivated, not emotional. Thus the behaviorist has had some difficulty in finding measures of emotional expression. Conditioned suppression of responses, boluses of rat feces and the like have been used, but they fail to reflect the richness of (especially the pleasant and positive) emotional (internal) states (reactions that terminate at the skin) which the observed organism can experience. Furthermore, ethologists working with social behavior have followed Darwin's lead and shown that organisms can "read" each other's emotional expressions and be influenced by them.

Thus emotional expression does have a practical influence beyond the emoting organism, but only in a communicative setting. In such a setting the practical influence is completely dependent on the ability of other socially receptive organisms to sense the meaning of the expression. Effectiveness therefore does not depend on what the emoting organism does, but on what the socially sensitive recipient is able to do. However, an intelligent self-aware organism such as *Homo sapiens* can use these emotional expressions motivationally—that is, to manipulate the social situation. Such manipulations, when deliberate and planned characterize the "con" artist, actor, and administrator. But often, through imitation and conditioning, the emotional expressions become automatic, leading to stereotyped interactions. Much of the social display behavior of animals (e.g., birds) is apparently of this type: internal and/or external stimuli set in motion an emotional reaction, which, when expressed, triggers another emotional reaction in a socially receptive conspecific (e.g., Hinde, 1954, 1960). In these animals, behavior sequences are thus concatenated of emotional expressions (and labeled "instinctive.") Such concatenations comprising instincts can also be elicited when an organism becomes completely adapted to an ecological niche in the nonsocial environment (Miller, Galanter, & Pribram, 1960, Chap. 5). By contrast, organized motivations ("plans") are constructed within the or-

ganism's brain and "mean to enter into practical relations with the exciting object." The adaptive consequences of motivated behavior is a function of that behavior. The adaptive consequence of emotional expression is a function of the social matrix in which it occurs or of a stability attained in the evolutionary process, which eliminates the occurrence of the expression in nonadaptive situations.

In summary, *emotional behavior* is defined as an expression of positive and negative emotional feelings that are inferred to reflect certain internal neurological states of the organism. The term "feelings" is therefore not synonymous with the term "emotion," since it is possible to identify additional internal neurological states and the behaviors they determine. One such additional category encompasses motivational feelings and behavior. Emotions are distinguished from motivations in that emotional reactions ordinarily "terminate within the organism's body," while motivations are "apt to go farther and enter into practical relations with the exciting object." An exception arises in social behavior, however. When a socially sensitive organism can be influenced by the expression of emotions or when an organism is totally adapted to his ecological niche, the sequential triggering of emotional expressions can lead to automatic (instinctive) behavior that is often, although not always, highly adaptive. Note, however, that the adaptation is due not to the expression of emotion but to the forces operating in the social and physical environment. We have already dealt with these "triggering" stimuli for emotional expression: the protocritic dimension was seen to be critical. But what neural control mechanisms determine how an emotional feeling will be experienced?

## AN ETHICAL-ESTHETIC DIMENSION

### The Cortical Contribution to a Labeling of Feelings

The biological contribution to an understanding of feelings in general and emotional feelings in particular cannot rest here. A basic problem set out at the beginning of this chapter in the quotations from William James and Freud has to be faced. Freud proposes that the critical neurological mechanisms involved in emotion are neurochemical and derive from body stimulation (the endogenous paths), which affect a certain portion of the brain. The work reviewed here has given substance to Freud's proposal and enlarged it: a protocritic dimension of stimulation was identified, a dimension describing much of the input through visceromotoric (endogenous) paths, but also receiving a contribution from exteroceptors (exogenous paths) especially those of the pain and temperature senses. Further, the processing of this protocritic dimension was found to take place in limited portions of the brain—the core brain systems of the brain stem and the limbic forebrain.

William James, in the passage from which the earlier quotation was taken, faces the possibility that such separate neural processing of emotion occurs:

And yet it is even now certain that of two things concerning the emotions, one must be true. Either separate and special centres, affected to them alone, are their brainseat, or else they correspond to processes occurring in the motor and sensory centres already assigned, or in others like them, not yet known. If the former be the case, we must deny the view that is current, and hold the cortex to be something more than the surface of "projection" for every sensitive spot and every muscle of the body. If the latter be

the case, we must ask whether the emotional *process* in the sensory or motor centre be an altogether peculiar one, or whether it resembles the ordinary perceptive processes of which those centres are already recognized to be the seat. Now if the theory I have defended be true, the latter alternative is all that it demands (Vol. II, pp. 472-474).

James opts for the cortex as we saw in the remainder of this quotation, which appears in the introduction to this chapter. Was he wrong?

I do not believe so. There is more to feeling than the protocritic dimension. Schachter (Schachter & Singer, 1962) in a classical set of experiments has delineated two aspects to feeling: one that devolves on its intensity (which has been discussed here as the protocritic dimension) and the other that "labels" the feeling. Labels are specific; they identify the feeling with respect to a spatial and temporal or other qualitative context. In short, labeling is epicritic, and we should turn, as James proposed, to the cerebral convexity in the search for the neural mechanisms that are involved.

According to James, what needs to be demonstrated is that "the reflex currents pass down through their preordained channels, alter the condition of muscle, skin and viscus; and these alterations, perceived, like the original object, in as many portions of the cortex, combine with it in consciousness and transform it from an object-simply-apprehended into an object-emotionally felt."

The foregoing work reviewed has demonstrated that "the condition of muscle, skin and viscus" need not, in fact, be altered. A stable representation, a neural representation of bodily function, including its quantitative hormonal composition, is interposed between "muscle, skin and viscus" and the cortex. All that needs to be established is that the representation (and its potential or actual perturbation) be addressed. The pathways whereby this can occur have now been thoroughly established both anatomically and physiologically (Kemp & Powell, 1970; Reitz & Pribram, 1969; Nauta, 1964; Lassonde, Ptito and Pribram, submitted; Goldman & Nauta, 1977).

The cortical contribution to the regulation of more primitive functions is, as might be expected, complex. Sense can be made of this complexity, however, by relating the myriad of observations on the effect of cortical lesions and excitations to the two simpler dimensions that have been delineated thus far. The cerebral isocortex is directly connected both to brain stem (core and shell portion) and to the remainder of the forebrain (basal ganglia and limbic formations). These connections can therefore modulate the epicritic-protocritic and the affective-effective dimensions of experience and behavior that are regulated by the more primitive structures.

The protocritic-epicritic dimension is reflected in the cortex by a front-back distinction in function. The anterior frontal cortex is so intimately related to the limbic systems that it can be conceived as the "association area" for these systems (Pribram, 1954, 1958a, 1958b). Anatomically the anterior frontal (frontal intrinsic) cortex receives projections from the n. medialis dorsalis of the thalamus (an "intrinsic" nucleus, since it is only indirectly connected with extracerebral inputs), which lies embedded within nuclei that project to limbic cortex. Behaviorally, resections of frontal intrinsic cortex result in deficits in delayed alternation performance, deficits also obtained when lesions are made of limbic structures but not when the posterior cortical convexity is damaged. By contrast, damage to the posterior cortical convexity (the posterior intrinsic cortex that receives its input from the pulvinar, another intrinsic thalamic nucleus) produces deficits in discrimination learning and performance, which remain unaffected by frontal and limbic lesions. The difference between alternation and discrimination has been conceptualized to reflect

the difference between context-sensitive, episode-specific reactions on the one hand and context-free, automatic information processing on the other (Pribram, 1978).

Recent evidence from the human neurological and neuropsychological clinic and from the recording of electrical brain activity in human beings has suggested that the effective-affective dimension receives a cortical contribution that is to some extent lateralized, that is, the left and right hemispheres of the cerebral cortex contribute unequally to the regulation of behavior and the monitoring of feelings (Sperry, 1974; Gazzaniga, 1970, Galin, 1977; Schwartz, 1975). The fact of right hand dominance (dexterity) and that linguistic expression is regulated by the functioning of the left cerebral hemisphere in most right-handed persons has been well known for a long time. What is new is evidence that the right hemisphere may also be specialized in the direction of a more holistic, parallel processing, experiential mode of operation.

The front-back and right-left distinctions of cortical regulation converge to produce a new dimension that I have labeled esthetic-ethical (Pribram, 1968). This dimension is based on the distinction between the processing of "external space" and the processing of a "body image" or "self." Processing that results in the effective use of local sign (the epicritic dimension) is a function of a band of cortex surrounding the three major cerebral fissures: sylvian, rolandic (central), and calcarine. (The continuity between perirolandic and pericalcarine cortex is established at the apex of the cortical convexity: in the monkey brain this is at the confluence of the intraparietal, superior temporal and lunate sulci. The continuity between perisylvian and perirolandic cortex lies at the foot of the central fissure).

In primates, including man, the growth of the cortex surrounding these major fissures has split the remaining cortex into two subdivisions: (1) a posterior focused on the inferior parietal lobule on the lateral surface and the precuneus on the medial (connected via the medial extension of the confluence between intraparietal and lunate sulci) and (2) the cortex covering the poles of the frontal and temporal lobes (interconnected by the fibers of the uncinate fasciculus and adjacent to the orbitofrontal—anterior insular—periamygdaloid cortex, which is a part of the limbic systems). The functional connectivities of these divisions and subdivisions of the cortical mantle have been most clearly demonstrated by strychnine neuronography (Von Bonin & Bailey, 1947; Pribram & MacLean, 1953) and have been confirmed histologically by the use of silver staining techniques (Nauta, 1964; Jones, 1973).

The behavioral evidence showing that the perifissural cortex processes "external space," while the remaining cortex processes "self" is so extensive that only the highlights can be listed here: (1) Beginning with the precentral (prerolandic) cortex, Pribram, Kruger, Robinson, and Berman (1955) showed that the environmental consequences of movement, not movements or muscle constructions per se, are encoded in this "motor" cortex (see review by Pribram, 1971). (2) The postcentral and superior parietal cortex deals with the somatosensory (haptic) discrimination of objects in external space (Kruger & Michel, 1952; Pribram & Barry, 1956; Wilson, 1957; Brody & Pribram, 1978; Mountcastle, Lynch, Georgopoulos, Sakata, & Acuna, 1975). (3) The pericalcarine cortex deals with visual processing (see Weiskrantz, 1973, for review) and its extension into the inferior temporal gyrus, with making visual discriminations (see Pribram, 1974, for review) (4) The posterior perisylvian cortex is involved in auditory processing (see D. Neff, 1961, for review) and its extension into the superior temporal gyrus with auditory discriminations (Dewson, Pribram, & Lynch, 1969; Dewson & Cowey, 1969; Dewson, 1977). (5) The anterior perisylvian cortex in the depths of the fissure and extending

forward to the temporal pole and orbital surface of the frontal lobe processes gustatory information (Bagshaw & Pribram, 1953; Pribram & Bagshaw, 1953) and is also involved in olfactory (Brown, 1953; Brown, Rosvold, & Mishkin, 1963), and, as noted earlier, temperature discriminations (Chin, Pribram, Drake, & Green, 1976).

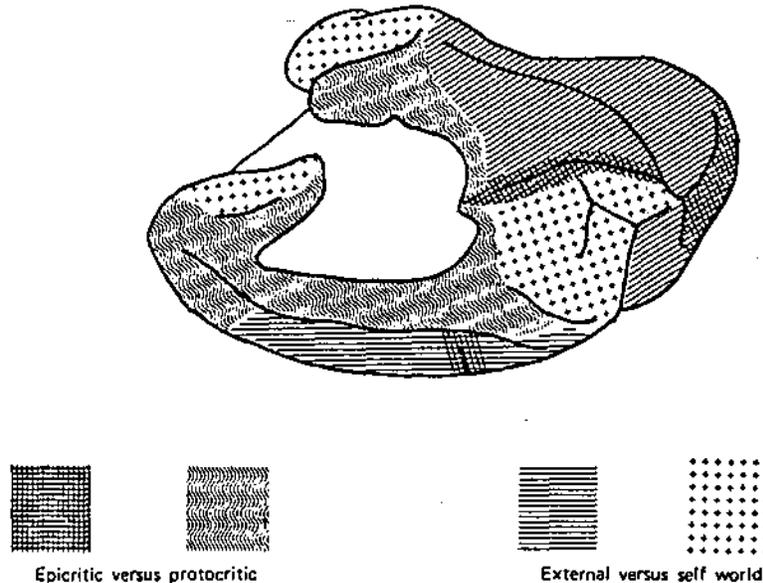
By contrast to these clear-cut results of experiments relating the perirhinal cortex to processing of "external space," the evidence for processing "self" by the remaining cortex is somewhat more difficult to interpret. Initially, data were believed to point to the anterior frontal cortex as the main source of an image of self. Recent experimental results show, however, that this conclusion was oversimplified and to a large extent erroneous (Brody & Pribram, 1978). Furthermore, clinical evidence has shown the inferior parietal lobule to be concerned with body image: lesions of this cortex lead to severe "neglect" of the opposite side of the body and this is especially severe when the lesion is in the right hemisphere. The lesions are often deep involving the precuneus and its connections (Pribram & MacLean, 1953) with the cingulate and retrosplenial portions of the limbic cortex (Geschwind, 1965).

What seems to be a more accurate reading of current available evidence is that there is a balance between the parietal and frontal (including temporal pole) portions of this cortex which processes self. While lesions of the parietal cortex lead to neglect, lesions of the frontal and temporal poles lead to its opposite (Teuber, 1972; Geschwind, 1965). Patients with frontal and temporal lobe involvement tend to talk and write voluminously about themselves and, as noted, to lose control over behavior that is context-sensitive, that is, depends on some stable mnemonically organized self.

To summarize (see Figure 1), the cortical contribution to emotion relates the affective-effective dimension to the protocritic-epicritic in such a way that a new dimension, labeled ethical-esthetic, emerges. This new dimension is based on the construction of a self-concept, which is organized and enhanced by parietal—and selectively inhibited (made context sensitive) by frontal cortical functioning. The construction is achieved in human beings by combining a frontolimbic protocritic versus cortical convexity epicritic axis with a right hemisphere affective versus left hemisphere effective axis. The poles of each axis have been found to oppose each other (Spinelli & Pribram, 1967; Pribram, Lassone, Pfitz, and Pribram in preparation; Lassonde, Pfitz, and Pribram in preparation) in such a way that a combinatorial balance of control is achieved (Jackson, 1873).

The cortical contribution to the regulation of the forebrain stem is thus made up of four parts: frontolimbic and posterior convexity portions each of which is composed of extrinsic and intrinsic parts (Pribram, 1958). Neurobehavioral experiments (see review by Pribram, 1978) and clinical neurological evidence (Wood & Kinsbourne, 1977) have shown that the frontolimbic forebrain is involved in context sensitive, episode specific processing leading to controlled, prepared interactions with the environment. By contrast the posterior convexity of the brain processes information in a skilled, relatively context-free, automatic fashion leading to participatory experiencing of the environment (Pribram, 1967, 1969).

The extrinsic parts of these cortical systems are defined by their fairly direct connections with extracerebral structures. Thus the extrinsic parts of the frontolimbic forebrain are the limbic cortical extensions of the corebrain such as the amygdala (i.e., its corticomedial sections) and the hippocampus with their chemical and visceral sensitivities. The extrinsic parts of the posterior convexal cortex are the primary sensory-motor projection systems that relatively directly connect to the sensory receptors and muscle effectors of the body (Pribram, 1958).

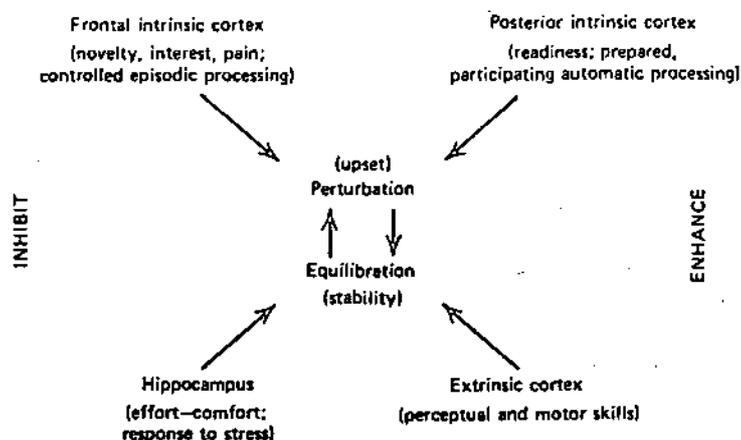


**FIGURE 1.** Diagram of a hemisphere showing how the epicritic versus protocritic dimension becomes corticalized. The efferent-afferent dimension becomes lateralized in hemispheric specialization. These two dimensions interact in the intrinsic (association) systems to form a dimension of extrapersonal and intrapersonal space, that is in a representation of the external world and of self.

The intrinsic parts of the cortex have no such direct connections with extracerebral structures. Rather their connectivity is intimately bound and restricted to the basal ganglia (including the amygdala) and thalamus (the last way station of input to the cortex).

These connections and their effect on the neurochemical corebrain can be summarized in a highly schematic and oversimplified form as presented next (see Figure 2). The opposing processes, although they may on occasion be called into simultaneous operation, are assumed to balance each other. Evidence of their convergence onto single units in the afferent system has been obtained (Spinelli & Pribram, 1967; Pribram, Lassone, & Ptito, in preparation). The process that becomes dominant is, of course, dependent on a variety of, as yet, undetermined variables.

Putting it another way, and with particular emphasis on its relation to the problem of emotion, this model deals with the manner in which the brain controls its own input. The model recognizes two mechanisms: one depends on internal, the other on external control for its stability. Internal control is achieved at the neuronal level through the process of self-inhibition; external control at the neuronal level involves lateral inhibition in the afferent mechanism. Self-inhibition stabilizes the ongoing neuronal activity and tends to



**FIGURE 2.** A highly schematic diagram which portrays cortical influences on a basic neuronal mechanism that regulate stable states. The perturbation  $\rightleftharpoons$  equilibration couplet is composed of inhibitory interactions. Lateral inhibition pushes the couplet toward perturbation, while recurrent inhibition acts as a negative feedback to stabilize and equilibrate. The data base for the arrows from the various cortical regions to the central couplet is derived from recovery cycle experiments. When a cortical stimulation increased the variance of an initial potential evoked by abrupt peripheral stimulation (in the visual, auditory, and somatosensory modes), the stimulus was considered to inhibit equilibration. This effect was obtained when the hippocampus was electrically stimulated. Conversely, a decrease in such variability signaled an enhanced equilibration, a result obtained when the primary sensory and motor cortical regions were stimulated. Further, the second of a pair of such stimuli ordinarily evokes a diminished response (due to a lag in recovery of the channel) when administered over short interstimulus intervals (the recovery cycle). When the duration and level of diminution is increased, the input channel becomes desynchronized—that is perturbation is enhanced. This effect is obtained when the posterior intrinsic cortex is electrically excited. The converse, inhibition of perturbation, is signaled by a more rapid recovery of the second potential evoked by the sensory stimulation. Such an effect is produced by electrical excitation of the frontal intrinsic cortex. Thus the intrinsic cortical regions manifest their effect in the recovery cycle data; the extrinsic and hippocampal formations influence the variability of the initial evoked response directly. Both the intrinsic and extrinsic-hippocampal effects are balanced: pronomalimbic formations exert their influence through inhibition (INHIBIT, a result that has been independently obtained in several series of experiments), while the cortical convexity operates via excitation (ENHANCE). This four-fold mechanism thus provides exquisite control over central neural stability and its potential and actual perturbations.

counteract change in the configuration of input. Lateral inhibition enhances such change in input configuration and thus assures more rapid equilibration with that input. Either mechanism, if left unrestricted, would become maladaptive. Left alone, a self-inhibitory mechanism would increase redundancy in the afferent system and leave the organism hyperstable and unreactive. Unless countered, the lateral inhibitory mechanism would, by reducing the redundancy of the activity of the afferent channels, continually enhance contrast and make the system so attuned to input that in the face of continual change no residual (i.e., memory) of experience could remain. Fortunately for the construction of the organism, the two forms of afferent inhibition are bucked one against the other, and so a balance between them is achievable. Further, such balance can be exquisitely regulated by controlling devices that enhance or inhibit each of these two primary afferent processes.

The model is developed from data showing that such efferent control does exist and spelling out four systems that appear to function in this fashion in the primate brain.

### The Cybernetics of Emotion

The significance of this demonstration of cerebral control is manifold. The fact that this control shows two opposing tendencies is of direct relevance to the problem of emotion. One tendency reinforces the habituated baseline that provides a self image by extracting invariances from the perturbations produced by novelty, distraction, and other uncertainty-enhancing information. The other tendency computes the variations produced by orienting reactions to novel inputs, and so on, and thus monitors regularities (redundancies) in the perturbations of the system. In searching for adjectives for these two tendencies, these two were deemed appropriate: episodic and participatory. An "episodic process" is one that prepares the organism for further interaction by encoding the structure of redundancy as context within which subsequent action is framed. A "participatory process" enhances contrast and processes the resulting invariances as information. Information processing deletes redundancy and thus increases sensitivity to novelty, and thus "esthetic" sensitivity. Both processes are effected through feedbacks, as indicated in Figure 2. Episodic operations are "ethical" in that they are conservative and even self-defensive; they often deal with input by deemphasis and elimination. Participatory operations are "esthetic," and by enhancing the effect of input serve to increase the likelihood that the system itself will be changed.

Episodic and participatory processes lead to different types of stability; respectively, they tend to lead the organism toward either internal control or external control. Episodic processes tend to achieve relatively lasting—that is, prospective—stability by recourse to an earlier, retrospective organization; this type of stability is termed "internal control." Participatory processes tolerate the temporary instability produced by incongruities by achieving reciprocal constancies with aspects of the environment, thus "realizing" the here-and-now (external control). Episodic processes reestablish stability through chunking (Miller, 1956; Pribram & Tubbs, 1967; Simon, 1974) at the cost of simplification. Participatory processes tolerate transience for the gain of flexibility through a more complex organization.

In terms of information measurement theory, these emotional processes effect a subtle balance between maximum redundancy, through episodic processing; and maximum information density, through participation (Rothstein, 1965). In this way environmental input (reality) is selectively structured according to its relevance (i.e., how useful it is) to the ongoing plans of actions: irrelevant inputs are screened out, enhancing redundancy and conserving former plans; by contrast, relevant inputs are taken in, leading to greater complexity and thus uncertainty, which calls for a modification or ramification of the ongoing plans.

As detailed elsewhere (Pribram, 1960a, 1965b), the achievement of external control is conceived through the accommodation of past experience to current input to lead to what is subjectively felt as satisfaction. The latter occurs when similarities are identified, when congruities between past experience and concurrent input develop. On the other hand, the achievement of internal control, through the fulfillment of intentions or the restoration of ongoing plans, is conceived to result in what is subjectively experienced as gratification. The organism is gratified when there is congruity between present outcomes and past

plans, when it can do things about as much as it intended to do them. This formulation, derived from neurobehavioral data, fits the neurophysiological facts. Whereas the process labeled participation is accomplished largely through the posterior intrinsic or "association" mechanism, the process labeled episodic processing is effected through the functions of the frontolimbic system, which is conceived of as the "association cortex" for the limbic forebrain.

Stated in this fashion, the relevance to emotion of the two forms taken by cerebral control over its stability becomes self-evident. Episodic and participatory feedbacks, from the cerebral cortex to the input channels, make the central nervous system a giant servomechanism that has these two modes of operation at its disposal. The implications of such a "cybernetic" approach to emotion thus seem well worth exploring. Let us examine more closely some of the characteristics of each feedback process, giving examples of their operation, and then focus on what determines the choice between episodic processing and participation.

The clinical and experimental literature are replete with examples of episodic processes. Concepts such as "repression", "suppression", "perceptual defense mechanisms," and so on, can be interpreted as episodic processes, for they are forms of defensive "gating out", that is, the ignoring or repudiation of aspects of the situation initiating the emotional state. Facets of sleep also have this "shutting out" characteristic, especially the syndromes of cataplexy and narcolepsy, which are often accompanied by affective charges (Dement, 1965; Kleitman, 1963). Whereas the foregoing examples probably refer to the efferent control of afferent input at the neural level, other states represent the preparation for control of input through motivated action. Of the latter, Cannon's fight-flight reactions are probably the best known. In these "emergency" states, the organism prepares for the elimination of input. Also, at the behavioral level, is the state of "vigilance": here the organism becomes prepared or set for the rapid elimination of perturbing input.

By definition, episodic processes do not accommodate the organisms to the input; rather they are internal stabilizing responses eradicating perturbation. The system is prepared to make itself independent of input—in effect, to make itself temporarily autonomous of concurrent input. Reequilibration is directed toward some status quo ante. As detailed later, fear, anger, apprehension, disgust (and, to some extent, guilt, shame, and depression) have in common the intent, implicit or explicit, to change the situation so that the organism can repair to the previous equilibrated state out of which it was so rudely jarred. In this way, the ongoing plans of action are conserved, providing the episodic processes are successful in eliminating input.

But attempts to eliminate input are often not successful. Fight-flight reactions do not always result in their intended outcome; the source of the disturbing input remains and the perturbation may become incessant. Moreover, when episodic processes are directed to the input processing channels, they have the disadvantage of not disposing of the source of the inputs responsible for disequilibrium. Under such circumstances, the "episode" may become chronic, for the incongruities arise again and again. Repetition, (as in repetition compulsions) progressively lead to the hyperstability of complete internal control; the organism becomes divorced from reality; the plans of action become inflexible. Thus, more and more, novel inputs become appraised as irrelevant, that is, infeasible to the ongoing plans. When this hyperstable, inflexible state is finally disrupted by an input that cannot be eliminated, the entire system becomes perturbed. And as the saying goes, "All hell breaks loose."

By contrast, participatory processes deal with incongruity by searching and sampling the input and accommodating the system to it. In this case, reequilibration does not take the form of achieving the status quo ante; rather the experience becomes part of the organism and the plans of action are appropriately modified. Reequilibration, by incorporating input, proceeds to alter—to restructure the organization so that it can again function with a minimum of disequilibrium. Participatory processes have in common some kind of involvement, engagement with environmental events that extend beyond the organism, but do not operate on them as do motivational processes.

In the extreme, participatory reactions can lead to overwhelming "passionate" external control. Since this makes the systems highly dependent on environmental vicissitudes, with little recourse to a core organization, the organism's ongoing plans are likely to become fragmented and the continuity of the psychological process and of behavior sacrificed. The system becomes unstable, hyperreactive; the organism overly distractible.

Under more ordinary circumstances, the importance to the psychological process of cybernetic regulation has as yet been only partially explored. On the input side, external control, that is, information processing (an increase in potential uncertainty) is involved when interest and sensory participation are called forth: internal control helps focus and restrict the organism's sensory interaction with the situation. As noted, the two processes are ordinarily balanced, for they converge on the same input mechanisms, even on some of the same cells in the mechanism (Spinelli & Pribram, 1957). It is likely that the adjustment of this balance differs in different individuals in different situations.

### The Neuropsychology of Individual Differences

Here is an example of a dimension along which individual differences and differences among individuals may be produced from occasion to occasion. Some individuals are more inclined to sensory participation with their environment, and some situations tend to evoke participation more than others. Such evocation is the essence of esthetic endeavor, and for this reason information processing can be thought of as a mechanism underlying an esthetic mode of reaction. The opposite, an increase in internal control, tends to focus and remove the organism from participation and to turn him inward. He is therefore responsive more to his own neural organization than to the organization of his environment. This mode of reaction is characteristically displayed, for instance, when ethical considerations are involved (as when a person asks whether he is being true to himself).

A convergent line of evidence concerning this dimension comes from observations of behavior. Here, also, two processes are identified, and the processes bear a resemblance to those already identified. In a recent study Schachter (1967) examined the determinants of eating in obese and nonobese persons and showed that the obese person's eating is more under the control of external than of internal determinants, while the opposite is true of the nonobese person. In other words, most people eat when their physiological state demands; the gourmand responds to opportunity.

Another convergence comes from psychophysiological experiment. Lacey (1969) has used heart rate and other measures of autonomic nervous system reactivity to gauge the receptivity of an organism to stimulation. The evidence is that two modes exist—one "open" and one relatively "closed": "Cardiac deceleration accompanied and perhaps even facilitated ease of 'environmental intake' whereas cardiac acceleration accompanied

or facilitated 'rejection of the environment.' " Data are presented to show that cognitive problem solving demanding "internal" work produces cardiac acceleration, while situations demanding anticipatory vigilance, an "external orientation," are accompanied by cardiac deceleration. Clearly, an "open-closed" dimension is discernible in these results. It remains to be shown that the convergence with the recovery cycle data is real and not spurious: simultaneous recording of heart rate and evoked recovery functions in the two types of situation is an indicated next step.

The delineation of the esthetic-ethical dimension finds parallels in conceptions derived from still other types of observations. Developmental studies led Piaget to formulate the suggestion that two complementary processes guide cognitive growth. One process he labels "accommodation"; the other, "assimilation." "In their initial directions, assimilation and accommodation are obviously opposed to one another, since assimilation is conservative and tends to subordinate the environment to the organism as it is, whereas accommodation is the source of changes and bends the organism to the successive constraints of the environment" (Piaget, 1954, p. 352). Thus "the nursling's psychic activity is at first only simple assimilation of the external environment to the functioning of the organs. Through the medium of assimilatory schemata, at first fixed, then mobile, the child proceeds from this elementary assimilation to putting means and ends into relationships such that the assimilation of things to personal activity and the accommodation of schemata to the external environment find an increasingly stable balance. The undifferentiated and chaotic assimilation and accommodation that characterize the first months of life are superseded by assimilation and accommodation simultaneously dissociated and complementary" (Piaget, 1954, p. 350). Accommodation thus resembles the effect that a neurologically based external control, information processing mechanism would be expected to exert; assimilation could well be effected by enhancement of internal control.

This convergence of conceptions does not in itself mean that accommodation is necessarily accomplished through external control and that assimilation occurs through an increase in the synchronous operation of the organism's internal control mechanism. However, as hypotheses these possibilities can be fruitfully explored, since the parts of the brain responsible for shifts in external and internal control are known, as are the effects of removal of these parts on problem solving in adult primates. Thus removal of the appropriate structure in young animals should have effects predictable from Piaget's formulation.

Other convergences come to mind. Factor analytic methods of studying subjects with brain lesions have been undertaken by Halstead (1947), Reitan (1966), and Teuber's group (Semmes, Weinstein, Ghent, & Teuber, 1960). Of particular relevance here is the fact that most factor analytic studies have yielded some sort of introversion-extroversion dimension. Petrie some years ago (1952) presented in detail carefully controlled evidence that frontal leukotomy leads to changes "on test measurements associated with the dimension of extraversion-introversion." The finding that these changes occur in the direction of greater extraversion is convergent with the model here presented: removal of the influence of frontal lobe tissue leads to enhanced external control in the input channels and hence "greater sensitivity to the complexities of the input." More recently Petrie (1967) has extended her work by devising a set of behavioral tests with which she has delineated additional ways of characterizing persons: a stimulus augmentor-stimulus reducer dimension and an autonomy-externally controlled dimension. She is at present engaged in a series of studies, using neurosurgical patients, aimed at relating her behavioral observations to their neural substates. Should this current work be combined with some simple

neurophysiological observations, for example, elucidating recovery functions as in the experiments on which Figure 1 is based, another convergence among models could readily be accomplished. On the whole, electrophysiological data taken in conjunction with factor analytic analysis should prove extremely fruitful. Pioneering studies of this sort have been undertaken. Pawlik and Cattell (1965) have analyzed the organism's readiness to be aroused, and Barratt (1959a, 1959b) has investigated the forementioned stable-labile dimension of readiness to react established by the work of Lacey and Lacey (1958).

Considerably more remote would be studies that relate the neurologically derived models with those based on social-cultural observations. Nonetheless, I believe such studies are possible. For example, Riesman (Riesman, Glazer, & Denny, 1955) has, from social-historical observation, delineated what he calls "inner-directed" and "other-directed" individuals. It could be that developmental exigencies mold some individuals along primarily external control, accommodative modes of communicative intercourse. And it could be that other circumstances yield primarily internal control, assimilative modes of communicative discourse. In this way a person (or even a whole population) would become primarily esthetic or primarily ethical in interpersonal interactions, depending on the formative culture.

Many questions can be raised within the framework of these observations: for instance, is inner- and other-direction synonymous with introversion and extroversion? Are there indeed more gourmards in other-directed societies, as the Schachter experiments might suggest, or is the relationship between inner- and other-direction specific to a reaction mode? Can the balance between esthetic and ethical sensitivity be altered by later experience or is there a limited "critical" period during development that "sets" the organism on one or another course? Does society and its culture determine not only the balance between the esthetic and ethical mode, but also the emotional consequences of each reaction?

## CLINICAL APPLICATIONS

What sort of cultural sets and settings give rise to these different processes? The following suggestions are derived from clinical psychiatric experience, psychoanalytic literature (Freud, 1920; Engel, 1962), ethological experiments (Kaufman, 1960; Scott, 1962), and the results of experimental manipulations of behavior (Dollard et al., 1959; Mandler, 1964). The central theme is this: the subjective aspects of emotion—emotional feelings—reflect both current control of equilibration of the neural system and the expectations based on past experience that control can be achieved despite current disequilibrium. Combinations of current and prospective feelings lead to different and specific emotional experience.

After a novel input perturbs the system, the restoration of equilibration through habituation is reflected in what we call "pleasant feelings." As noted earlier, these pleasant feelings are of two types (Pribram, 1950b): (a) gratification occurs when there is a return to internal control; (b) satisfaction takes place when external control is accomplished. Gratification is thus a return to the status quo ante, and the accompanying feelings are relief, calmness, tranquility, and so on. Satisfaction goes beyond this, signaling an effective reorganization of neural systems: the associated feelings are those of delight, relish, joy, exhilaration, aesthetic appreciation, and so on. In this way, it is possible for a person

to be gratified (e.g., calm), but still dissatisfied (e.g., apathetic). Failure to achieve stability by either internal or external control is signaled by displeasure. Displeasure may take the form of either distress (i.e., the lack of gratification), during which episodic arousal occurs, or dissatisfaction, during which uncertainty and perplexity mount.

Since the prospective feelings arise in connection with the expectation of control they can be divided into optimistic and pessimistic feelings. Optimistic feelings occur when novelty is appraised as relevant—that is, when it appears that the input can be made use of such that control will be achieved. Examples of optimistic feelings are interest, hope, enthusiasm, and affection. It can be seen that most of these are affiliative in nature, indicating the tendency toward external control, control that is shared among members of the group. Confidence and self-esteem are based on feelings of competency to maintain internal control and therefore reflect optimism with reference to the efficacy (White, 1963). These feelings of efficacy readily merge into motivations toward successful action. This explains why it is “fun to work,” providing that the outcome of the work is expected to be successful and the work itself offers some challenge that calls forth an emotional appraisal.

Rosenberg (1962) has shown that low self-esteem is associated with the experience of anxiety. Anxiety occurs when there is ambiguity about reinforcement (Wolpe, 1958) and therefore the ability to achieve control. Anxiety and apprehension are prospective, pessimistic feelings which indicate that considerable risk is involved in the situation. Attempts at excessive internal control in the form of defensive processes are especially prone to be accompanied by pessimistic feelings.

Other pessimistic feelings are fear, depression, guilt, shame, and anger. Some degree of anxiety underlies all of these (Freud, 1926), indicating risk. But whereas with anxiety the outcome is ambiguous, fear arises when the risk to continuing control is fairly clear-cut, such as with the threat of injury (Cannon, 1927). Such a threat portends loss of control, for the spatial vehicle of control—the body—is jeopardized.

Depression, along with the accompanying feelings of helplessness and hopelessness, is also a pessimistic feeling. Depression frequently stems from the interruption of shared motivations, thereby making the achievement of external control seem unlikely. An object loss—the loss of a person, thing, or process that is important for a person's ongoing function—is a frequent prelude to depression (Stenback, 1965). The loss of loved ones, the loss of a job, and the loss of mental capabilities are examples of object losses. The restriction of activity and attempts at excessive internal control seen in depression serve to reduce offending input and are akin to an infant's “giving up” after perturbation in the absence of the care-taking person.

Guilt signals the expectation of disapproval for not having met up to the expectations of others, for not having achieved the kind of external control inculcated by parental and social demands. Whereas guilt reflects pessimism stemming from the transgression of external (i.e., moral) roles, shame deals with the failure to achieve internal (i.e., ethical) standards set for oneself. Shame is pessimistic in that it portends that the maintenance of one's own plans may again, in the future, be inadequate. Both guilt and shame have episodic aspects, such as expiation and reaction formation, which attempt to undo the previous transgressions.

At any given moment, the subjective feeling always represents a composition of current (pleasure and displeasure) and prospective emotion (optimism and pessimism). Which feeling becomes predominant depends on the achievement and anticipation of both inter-

nal and external control with regard to certain dispositions and inputs. As previously stated, guilt and shame are largely pessimistic, but they also reflect current displeasure. Anger is a prime example of a composite emotion; it has pleasant and unpleasant, as well as optimistic and pessimistic, aspects. Anger occurs when there is an attempt to keep interrupted motivation operating despite obstacles. Unlike depression, where there is relinquishment of motivation in the face of an insurmountable loss or barrier, anger is more optimistic in that there is the expectation that the external blockade can be removed. In addition, anger often reflects an admixture of underlying episodic and participatory operations; with a "fine anger," input is taken in to enhance motivations aimed at eliminating the blockade. Whereas this type of anger is primarily participatory, rage is predominantly episodic and pessimistic; rage reflects a last-stage attempt to maintain internal control by destroying the source of offending inputs.

Also, confusion and uncertainty may take place even though a person is gratified (i.e., having achieved internal control), but at the same time the person is pessimistic about his possibilities of achieving relatedness, that is, external control. Compassion and sympathy are condensations of current dissatisfaction and prospective optimism that revolve around the maintenance of shared motivations; the loss or illness of a group member impairs external control, but the strengthening of interindividual bonds through participation attempts to restore the group to harmonious action.

As already noted, emotions can become maladaptive when episodic and participatory processes lead either to extreme internal or external control. Hence, novel input might be screened out by episodic processes initiated earlier or irrelevant input taken in by a participatory process disengaged from any possible motivation. The resulting perceptions and behavior may become either rigid and inflexible, stemming from the hyperstability induced by episodic processes, or distractible, random, and disorganized, reflecting the uncertainty enhanced by participation.

Panic occurs when neither episodic nor participatory processes are successful. In such instances, the emotions may become disequilibrating inputs themselves, for emotion becomes progressively divorced from motivation. Hence, anxiety spirals, and the individual experiences something akin to the uncontrolled distress of an untended and helpless infant.

Acute grief occurs when there is "the sudden cessation of social interaction," often induced by an unexpected loss of a loved one (Lindemann, 1944). Shared motivations are thus interrupted. The first stage of grief is shock and disbelief—"it cannot be true; I don't believe it" (Engel, 1962a). This is obviously an episodic process. Aimless restlessness, depression, and "inability to initiate and maintain organized patterns of activity" take place later (Lindemann, 1944). A large component of the normal "grief work" is the "emancipation from the bondage to the deceased" and the "formation of new relationships" (Lindemann, 1944). In this sense, restitutive episodic and participatory processes attempt to equilibrate the organism and restore motivation.

The reaction to disaster can be interpreted as an overwhelming swing to episodic processing in order to keep motivations operating. In his analysis of the Hiroshima disaster, Lifton (1964) points out that the survivors, while immersed in death and horror all around them, exhibited a "psychic closing off"—a cessation of emotional feeling and expression for their fellows. Later, an "identification with the dead" took place, perhaps as a mean to conserve previous motivations.

Identity diffusion occurs when an individual, operating mainly through external con-

trol, is faced with a choice among many motivations, resulting in too much uncertainty. Erikson (1959, p. 123) states: "A state of acute identity diffusion usually becomes manifest at a time when the young individual finds himself exposed to a combination of experiences which demand his simultaneous commitment to *physical intimacy* . . . , to decisive *occupational choice*, to energetic *competition*, and to *psychosocial self-definition*." Confusion, bewilderment, and anxiety result from this plethora of possible involvements. If this state is not countered by a strong conservative process that arranges the motivation in some hierarchical order, panic supervenes. Mania also clearly involves overactive participatory processes. The individual is distractable and takes everything in. Irrelevancies are incorporated into disjointed motivations that are often carried out with regard to outcomes.

In light of these insights, the task of psychotherapy comes into sharper focus: excessive emotion, whether episodic or participatory, must be turned into moderated motivation; paralyzing passion must be phased into graceful action. Conversely, action must be appraised in terms of current and future competency to maintain control. Impulsive motivations should be tempered by giving pause through emotional work, achieving sensitive control through episodic and participatory processes. This meshing of passion and action is the crux of the matter; it extends beyond the analysis of the patient's past and yet gives continuity beyond the restricted reconditioning of behavior patterns. Within this framework, present psychotherapeutic techniques (including analysis, behavior therapy, family and social therapies, and so on) can better be brought to bear on the essential problem of achieving happiness—that is, the fulfilling of each person's potential for equilibrated emotional and motivational aspirations.

## CONCLUSION

Clearly considerable progress has been made in recent years in our understanding of the biology of emotions. In this review, the details of evidence have been organized along several "dimensions" that hopefully capture the essence of the issues that have been investigated. One such basic issue concerns emotion as an indicator of upset—an upset of a stable biological order that has been achieved or is once again to be achieved. Stability is conceived of, however, not as some absolute immobility, but as a dimension that has as its other pole an activated labile organism. The neurohumoral, homeostatic, and activation theories of emotion were thus seen to address the same basic issues.

Any change in lability or stability assumes a triggering stimulus. The trigger may be internal or external and the issue arises about how to characterize such stimulations. As reviewed, a protocritic-epicritic dimension was identified: epicritic, signifying extension and thus local sign, and protocritic, the intensive aspects of stimulation.

Another issue, one that plagues most analyses of emotion, is the confusion between emotional feeling and emotional expression. As detailed in the review, emotional feelings are but one class of several types of feeling: viscerosomatic and motivational being major other categories. The distinction between emotional and motivational feelings causes especial difficulty and an attempt was made to clarify by invoking an affective-effective dimension. Data to support the distinction both at the brain and the behavioral level were presented.

Finally, the issue of complex labeling of emotions was addressed. Evidence was pre-

sented that cortical control over subcortical core-brain mechanism was involved in such labeling. Next, it was shown that two reciprocal processes were operating. One process tended the organism toward environmental participation; the other constrained him to controlling the experience, chunking it into episodes for readier processing. The reciprocal processes were arranged along an esthetic-ethical dimension: participation leading to esthetic attunement to the environment, episodic processing to ethical decisions regarding best internal fit.

The aim of this review and the conceptualizations that organize it has been to bridge ever-widening gaps between experimentally and clinically interested psychologists and between biologically and behaviorally oriented practitioners. The evidence shows that such gaps are artificial and that they impede understanding. Clinical neuropsychology can become the vehicle for closing the gaps, fostering more complete understanding and thus more effective diagnosis and therapy.

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