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CHAPTER 19

Psychophysiological basis of emotion

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> She puzzled over this for some time, but at last a bright thought struck her. 'Why, it's a looking-glass book, of course! And if I hold it up to a glass, the words will all go the right way again.'
>
> Lewis Carroll, *Through the looking-glass*

Marcus Aurelius, Rome's philosopher-emperor, developed a formula for coping with this troubled world. He pointed out that, if one tries to consider problems all-of-a-piece, one is overwhelmed. His prescription was simple: segment the reach of awareness; attend to only one facet of the situation at any one time; act upon that facet and then proceed to another. Too-much-too-soon is upsetting. Segmentation reduces the demands upon awareness and thereby produces imperturbability.

This bit of wisdom can serve as the kernel for a modern neuropsychological theory of emotion. A theory crystallized from this kernel would look considerably different from those presently in vogue, but must account for the popularity of these views. Furthermore, current difficulties must be met and resolved.

Current theories of emotion – in fact, psychological theories in general – are couched in two major modes of discourse, two classes of conceptual frames of reference: the social-behavioral, which includes the subjective or 'intrapsychic'; and the biological, which includes the physical, chemical, and, of course, the neurological. Terms are all too often taken from one frame of reference and applied to another in haphazard and uncritical fashion. In this presentation every effort will be made to keep the two universes of discourse clear. The assumption is, however, that because each of these conceptual universes denotes some body of events common to both, different aspects of this common body will be illuminated by approaching it from different points of view.

Although the initial focus of this presentation will be on the neurological realm of discourse, the proposal is not made just in neurological terms, but interdigitates the subjective-behavioral approach with the neural. The neurological aspects of this proposal describe the organized operations in processing inputs and outcomes; the subjective-behavioral aspects deal with the communicative signals – termed affects, the 'feelings' and emotional expressions – that reflect the neural processes.

It is our view that these communicative signals are, as it were, optical isomers, mirror-images (Pribram 1965) of the ongoing neural mechanisms, and that both processes are organized to function-in-view-of-the-same-ends (MacKay 1962). Different universes of discourse are used to describe the mirror-images – which may therefore display dif-

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ferent characteristics in the two contexts – but the events described are identical. More concretely, according to this view description of a given neural excitatory pattern does not produce what we call anxiety; rather, the two reflect one another. The distinction is somewhat like that between the compiler language used to program a computer and the electromagnetic sequencing carried out by the computer: the events are very much the same as is their sequential organization; yet the language used to describe them differs. In this sense, then, the present proposal will attempt to describe processes in both neural and subjective-behavioral terms.

Preview of the proposal

> 'Do you think it's going to rain?' Tweedledum spread a large umbrella over himself and his brother, and looked up into it. 'No, I don't think it is,' he said, 'at least - not under *here*. Nohow.'
> 'But it may rain *outside*?'
> 'It may – if it chooses,' said Tweedledee.
> 'We've no objection. Contrariwise.'
>
> Lewis Carroll, *Through the looking-glass*

The proposal delineates what we call emotions as a set of processes which (1) reflect the state of relative disorganization of an ordinarily stable configuration of neural systems, and (2) reflect those mechanisms which operate to redress this imbalance not through action but by the regulation of input. Two such mechanisms have been identified: one achieves stability by mobilizing the already available subsystems to the exclusion of input; the other reorganizes the system to include input. These 'preparatory' and 'participatory' processes thus achieve control by two routes, an 'internal' and an 'external'. Much of the presentation is devoted to setting forth the evidence upon which the mechanisms of internal and external control are based, and to suggesting some of the implications which this evidence calls forth.

Neurological theories have, in the past, influenced the general view by emphasizing the relations between viscera and emotion or by linking emotion quantitatively with an amount of neural excitation. These relationships, though substantial, take into account neither the complexities of the emotional process nor the intricacies of the relevant neural apparatus. Characteristic of the latter is the hierarchy of self-regulating, equilibrating mechanisms, each of which controls its subunits, but submits to regulation by a larger system. This set of systems provides the organism with stability, imperturbability.

Stated in another way, the organism's continuing stability depends on neural programs or plans which organize the perception and behavior of the organism (Miller et al. 1960). These programs consist of hierarchies of servomechanisms, feedback units which have been diagrammed as nests of test-operate-test-exit units or TOTE units (Fig. 1). The essential characteristic of the test mechanism is to sense incongruities, i.e., novelties; the essential characteristic of the operate mechanism is to appraise changes effective in decreasing the incongruity in the test mechanism. Sufficiently incongruous input can temporarily interrupt the ongoing plans; there is a temporary discontinuity, literally e-motion. The word emotion comes from the Latin *emovere*, which means to be 'out of' or 'away from' motion.

Thus, the proposal is concerned with delineating one set of emotions that reflect the concurrent state of order or disruption of the ongoing neural organization. A second set involves returning the system to control. The steps involved (Fig. 1) are as follows: (1) the sensing of incongruity through the process of dishabituation or orienting to the

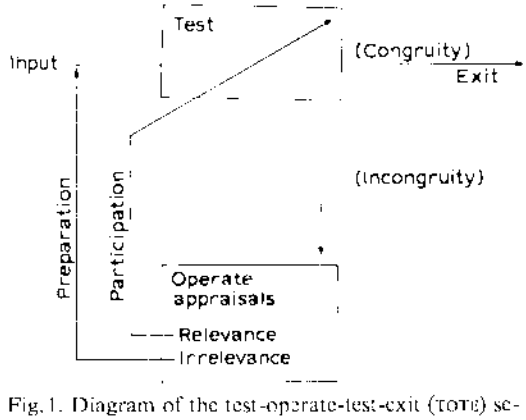

Fig. 1. Diagram of the test-operate-test-exit (TOTE) sequence which shows the two forms (participatory and preparatory) of feedback involved in the emotional process. During participation, feedback influences the test phase to allow congruence with input; during preparation, feedback influences input to facilitate congruence with the test.

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'novelty'; (2) operating on this incongruity by appraising its relevance to the ongoing plans. Relevancy is appraised on the basis of past outcomes of processing similar incongruities. A successful outcome occurs when the system re-equilibrates; an unsuccessful outcome is associated with previous failures to achieve stability. It is by way of these two steps – the sensing of incongruity and the resolution of incongruity through the appraisal of outcomes – that re-equilibration becomes organized. When re-equilibration is effected by control over input rather than by action on the environment, the process is e-motional rather than motivational.

What forms does this regulation or control take? On the basis of experiments to be presented, the suggestion is made that the organization of emotions centers around two types of feedback which deal with the efferent control of input. As seen in Fig. 1, they are termed *participatory* and *preparatory* processes. The uncertainty induced by incongruous input is appraised in terms of the risk associated with outcomes: reliance on external control through participation presupposes stabilities in the configuration of the input to exist; reliance on internal control by way of a preparatory process runs the risk of perpetuation through self-regulation and progressive alienation from the 'reality' situation. Participatory processes allow for the incorporation of input, and congruity is eventually achieved by alterations of the neural mechanism (or 'model') against which the input is tested. On the other hand, preparatory processes alter input, thereby accomplishing congruity by manipulating the input which led to the incongruity. The system, perturbed by an incongruous input, is returned to the *status quo ante* by preparatory processes. External control is achieved by the development of new congruities and internal control is accomplished by the return to previous congruities. Or, in terms of the ongoing plans, external control achieves the development and ramifications of plans and internal control achieves their conservation. Thus, as a result of underlying preparatory or participatory processes, stability can be reached either through the attainment of a higher order of complexity (external control) by disposing the system to establish reciprocity with the here-and-now, or through simplification (internal control) by maintaining past organization.

The proposal is therefore concerned with delineating two sets of emotions: those which reflect concurrent order in the neurophysiological system and those which reflect expectation of order. The affects – the signals of perturbation and its cessation, and of the initiation of processes necessary to re-establish control – can thus be divided into the 'concurrent' and the 'prospective'. The concurrent affects reflect the degree of congruity or incongruity in the here-and-now. Incongruity is signalled by arousal; the achievement of congruity is characterized by satisfaction and by gratification, depending on whether it is accomplished by a participatory or preparatory process. The prospective affects can be divided into optimistic and pessimistic. Inputs appraised as relevant are associated with feelings of optimism (e.g., interest, confidence, hope, and zest), since appraisal has tapped memories of successful outcomes associated with these inputs. By contrast, inputs appraised as irrelevant are accompanied by pessimistic feelings (e.g., annoyance, apprehension, hopelessness, and depression), since the memory of past outcomes has led to the expectation of failure to achieve control. At any given moment, of course, the emotional state of the organism is expressed as a composition of concurrent and prospective affects.

So much for an overview of the proposal to be presented. For substantiation, the presentation will begin with a summary of current neurophysiological theories, proceed to the neurological data which allow them to be superseded, and then go into a more detailed view of the proposal as best it can at present be formulated by us. Finally, we will explore some of the possible applications of the proposal to problems posed in subjective-behavioral terms.

Current neurological theories

> 'What a curious plan!' exclaimed Alice.
> 'That's the reason they're called lessons,' the Gryphon remarked, 'because they lessen from day to day.'
> Lewis Carroll, *Alice in Wonderland*

There are two central themes in practically all of today's biological approaches to emotion: one

theme draws out the relationship between visceral-glandular reactions and emotion; the other deals with the quantitative relationship between neural excitation and emotion. It is our contention that these relationships, though substantial, do not provide an adequate framework for understanding the complexities of emotional processes nor of the intricacies of the relevant neural apparatus.

THE VISCERAL THEME

> His heart stood still, aghast with fear.
>
> Lewis Carroll, *Phantasmagoria*

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 bastard has no guts'; 'he sure is bilious today', etc. In fact, until 1800 A.D. the Galenic medical world subscribed to the notion that, whereas 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 and partly because this view has got 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.

James–Lange theory

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 proposition: 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 examination 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 non-emotional 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.

Cannon–Bard theory

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 observation that 'sham', emotion-like behavior, could be elicited in decorticated and decerebrated preparations, but not when thalamic structures are additionally ablated (Bard and 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, e.g., a pin prick would elicit excruciating pain, warmth, intense delight, etc. (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, which 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, i.e., self-regulating. Visceral and endocrine regulation is

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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 trophotrophic, energy-conserving process, working primarily through the parasympathetic peripheral division of the autonomic nervous system, and an ergotrophic or mobilizing system, working through the sympathetic division.

The balance between ergo- and trophotrophic 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. Nor was this 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 substrate of emotions, this assumption followed logically.

But Lashley (1960) tellingly criticized the evidence upon 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 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 levelled against *both* the James–Lange and the Cannon–Bard theories. Unfortunately, Lashley provided no alternative to the theories he so effectively deprecates.

Papez–MacLean theory

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 emo-

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tions. 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 levelled 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 and 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 man, 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

> She was a good deal frightened by this very sudden change.
>
> Lewis Carroll, *Alice in Wonderland*

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 non-specific reticular activating system as the central locus upon 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. e.g., 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 marshalled 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 – 'expectation' and the configuration of neural activation

> As one who strives a hill to climb,
> Who never climbed before:
> Who finds it, in a little time,
> Grow every moment less sublime,
> And votes the thing a bore.
>
> Lewis Carroll, Dyscomfyture, *Phantasmagoria*

A part of the difficulty comes from the view of 'activation' as an elementary process opposed only by 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, disequilibration 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.

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This view of activation as an indicator of configurational change implies that the organism is fitted with a mechanism which provides a stable base-line from which such change can take off. This base-line is provided by the process of habituation of the orienting reaction. Experimental evidence has accumulated in the past several years (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 which together form the orienting response. Among these reactions is cerebral 'activation' – i.e., 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 – i.e., a recrudescence of the orienting responses – occurs when the intensity of the sound stimulus is *de*creased or if the duration of sound is shortened. In this latter situation, the orienting reaction occurs at the *off*set 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 which they confirm – also account for the importance of visceral and autonomic functions in providing the stable base-line 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; (2) a 'non-specific', relatively diffuse interaction by way of reticular and related formations. These 'non-specific' 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 non-specific 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 which 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 which vary from occasion to occasion. Habituation to visceral and autonomic activity makes up, therefore, a large share, though by no means all, of the stable base-line 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 base-line configurations which 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 which disturb the stable base-line.

Whenever the reaction to incongruous input is sufficient to disturb these base-lines, 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', etc. The sensing of such discrepancies is the basis for the visceral theories of emotion. But it is our view that such experiences are only one facet of the emotional processes. The awareness of these visceral and autonomic processes is a concomitant of emotional reactions; the visceral processes are not conceived – as in the James–Lange theory – to *produce* different types of emotional awareness. The Jamesian mechanism is thus relegated to the developmental stages of the organism; the mechanism is important for the development of a stable neuronal model – an habituated base-line against which input is tested – but is not productive of emotional reactions *per se*. According to our view, the awareness of visceral-autonomic activities is often an indicator of reactions to incongruous input, but it need not reflect the organization of the emotional process called forth. Support for this conception comes from the work of Lacey et al. (1963) and of Barrett (1959a, b) who have distinguished between two

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classes of variables in their studies of the visceral-autonomic system. One class is derived from measures of the variability of steady-state autonomic activity along a stabile–labile dimension; this dimension deals with the organism's responsivity, his predisposition to impulsive reaction to input. The other class of variables stems from measures of the response patterns of visceral autonomic function. This dimension has been shown to affect the organism's *receptivity* to input – a dimension about which the model to be presented has much to say.

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. 1956a, b; 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 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 which 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 which regulate these predispositions. As already noted, the non-specific neural systems are primarily involved in setting the bias toward which more specific organism–environment 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 which have been so successful an adjunct in altering maladaptive emotional reaction.

A neurological model and some data

> The executioner's argument was, that you couldn't cut off a head unless there was a body to cut it off from...
>
> Lewis Carroll, *Alice in Wonderland*

But these are not the only data relevant to the problem. As already noted, 'activation' is not to be simply opposed to 'inhibition'. In fact, the relationship between these two processes is complex. Perhaps the simplest way in which to draw out this complexity is to present a neuropsychological model of these processes, and then turn to the experiments which generated the model.

The model also concerns habituation and its perturbation, orienting. Both habituation and orienting are conceived to be dependent on the occurrence of inhibitory processes in the afferent channels of the nervous system. Afferent neural inhibition is of two sorts: collateral, in which the activity of a cell inhibits the activity of its neighbors; and self-inhibition, in which the activity of a cell inhibits its own activity through negative feedback. Both types of afferent inhibition are ubiquitous. The model states that orienting is a function of collateral inhibition and habituation a function of self-inhibition. The basis for this statement is that self-inhibition is a stabilizing mechanism that tends to return the system to the *status quo ante*, thus minimizing any perturbation, and that collateral inhibition functions to enhance contrast imposed on the system by input, thus temporarily maximizing perturbation.

The focus of the model is on the efferent control over afferent inhibition which is exerted by cerebral structures. The intricacies of the model call for a four-fold controlling process: enhancement of both types of afferent inhibition as well as their

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inhibition. For the problem of emotion the important distinction is between control which reinforces the *status quo ante* through increasing the redundancy of neural activity, and control which occurs through redundancy reduction. Redundancy is reinforced either by enhancing self-inhibition or by inhibiting collateral inhibition; redundancy reduction is accomplished either through enhancement of collateral inhibition or through inhibition of self-inhibition. For reference the complete model is diagrammed in Fig. 2. A detailed presentation for the evidence for this model has been written up elsewhere (Pribram 1967).

Some of the neurophysiological data on which the model is based were obtained in collaboration with Drs. D. N. Spinelli and James Dewson (Spinelli and Pribram 1966, 1967; Dewson et al. 1966). Recovery functions were plotted in awake monkeys and cats when visual and auditory stimuli were presented. The speed of recovery of a population of neurons within an afferent system can be gauged by presenting the organism with two stimuli (flashes or clicks) in rapid succession. The relative amplitude of the response to the second stimulus when compared with the response to the initial stimulus is an indication of the proportion of units in the system that are still 'occupied' in processing the initial stimulus when the second one arrives. A recovery function is obtained by plotting proportional amplitude against varying inter-

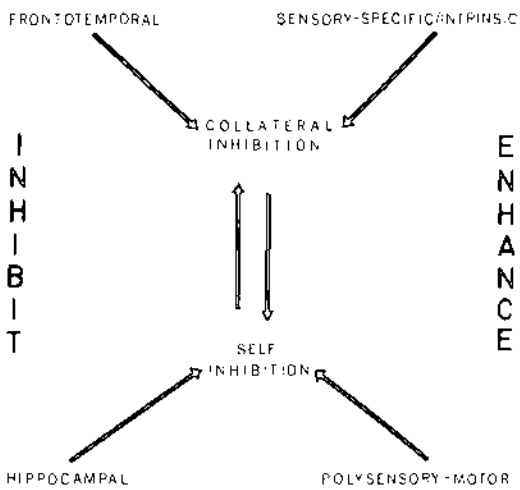

Fig. 2. Diagram of the model of cortical control over afferent inhibitory processes.

stimulus times. In these experiments, concurrent stimulations and ablations of various forebrain structures showed that recovery functions were altered by these procedures. Electrical stimulation of the sensory-specific intrinsic (so-called 'association') cortex, concurrent with flash and click presentation, depresses recovery, while ablation of this same tissue enhances it. Electrical stimulation of the frontal cortex and of the amygdala concurrent with sensory stimulation speeds recovery, thus producing an effect opposite to that of stimulation of the posterior, sensory-specific intrinsic cortex.

These results were interpreted to mean that stimulation of the posterior intrinsic cortex enhances, while stimulation of the frontal cortex and amygdala inhibits, collateral inhibition. On the assumption that our electrical stimulations mimic normal function, the posterior cortex is assumed to enhance orienting, while the frontal mechanism ordinarily speeds the erasure of concurrent input, thereby returning the system to its prior ongoing neural activity.

These opposing processes, though they may on occasion be called into simultaneous operation, are assumed, as a rule, to balance each other. Evidence of their convergence onto single units in the afferent system has been obtained (Spinelli and Pribram 1967). Which process 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 collateral inhibition in the afferent mechanism. Self-inhibition stabilizes the ongoing neuronal activity and tends to counteract change in the configuration of input. Collateral 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

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organism hyperstable and unreactive. Unless countered, the collateral 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 which enhance or inhibit each of these two primary afferent processes. The model is developed from data which show that such efferent control does exist, and spells out four systems which in the primate brain appear to function in this fashion.

The cybernetics of emotion

> '...one Rule seems to be that, if one Knight hits the other, he knocks him off his horse, and if he misses, he tumbles off himself...'
>
> Lewis Carroll, *Through the looking-glass*

The significance of this demonstration of cerebral control over its own input is manifold. The fact that this control shows two opposing tendencies is of direct relevance to the problem of emotion. One tendency accentuates orienting reactions and thus the perturbations of the system initiated by input to it. The other tendency reinforces the habituated base-line, i.e., the prior neural activity, by de-emphasizing these perturbations. In searching for adjectives for these two tendencies, the following – mentioned earlier – were deemed appropriate: *preparatory*, or better, prerepairatory, and *participatory*. A preparatory process is one that prepares the organism for further interaction by repairing its perturbed system to its previous stability. A participatory process utilizes perturbation to adapt the system to the current input. Both processes are effected through feedbacks, as indicated in Fig. 1. Preparatory operations are conservative and even defensive; they serve to deal with input by de-emphasis and elimination. Participatory operations enhance the effect of input and so serve to increase the likelihood that the system itself will be changed.

PERTURBATION AND THE CONTROL OF INPUT

> 'I generally hit everything I can see – when I get really excited.'
> 'And *I* hit everything within reach,' cried Tweedledum, 'whether I can see it or not!'
>
> Lewis Carroll. *Through the looking-glass*

Preparatory and participatory processes lead to different types of stability; respectively, they tend to lead the organism toward either internal control or toward external control. Preparatory processes tend to achieve relatively lasting, i.e., prospective, stability by recourse to an earlier, i.e., 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). Preparatory processes re-establish continuity 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 preparation, 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 action: 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 1960b, 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 fulfilment 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

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between present outcomes and past plans – when it can do things pretty much as it intended to do them. This formulation, derived from neurobehavioral data, fits the neurophysiological facts; whereas the process labelled participation is accomplished largely through the posterior intrinsic or 'association' mechanism, the process labelled preparation is effected through the functions of the frontolimbic system, which is conceived 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 almost self-evident. Preparatory and participatory feedbacks, from the cerebral cortex to the input channels, make the central nervous system into a giant servomechanism which has at its disposal these two modes of operation. The implications of such a 'cybernetic' approach to emotion thus seem well worth exploring. We will first outline some of the characteristics of each feedback process, giving examples of their operation, and then focus on what determines the choice between preparation and participation. After this, the relationship between emotion and motivation will be spelled out.

Preparatory processes

> 'Her paw went into your eye? Well, that's *your* fault, for keeping your eyes open – if you'd shut them tight up, it wouldn't have happened.'
>
> Lewis Carroll, *Through the looking-glass*

The clinical and experimental literature is replete with examples of preparatory processes. Concepts such as 'repression', 'suppression', 'perceptual defense mechanisms', etc., can be interpreted as preparatory processes, for they are forms of defensive 'gating out', i.e., the ignoring or repudiation of aspects of the situation which initiated the emotional state. There are facets of sleep which also have this 'shutting out' characteristic, especially the syndromes of cataplexy and narcolepsy which are often accompanied by affective changes (Dement 1965; Kleitman 1963). Whereas the above examples probably refer to the efferent control of afferent input at the neural level, there are other states which 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, preparatory processes do not accommodate the organism to the input; rather they are internal stabilizing responses for the eradication of perturbation. The system is prepared to make itself independent of input – in effect, to make itself temporarily autonomous of concurrent input. Re-equilibration is directed toward some *status quo ante*. As will be 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 preparatory 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 preparations are directed to the input processing channels, they have the disadvantage of not disposing of the source of the inputs responsible for disequilibration. Under such circumstances, preparations may become chronic, for the incongruities arise again and again. Repeated preparations 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, i.e., infeasible to the ongoing plans. When this hyperstable, inflexible state is finally disrupted by an input which cannot be eliminated, then the entire system becomes perturbed. And, as the saying goes, 'all hell breaks loose'.

Participatory processes

> 'What is it you want to buy?' ... 'I don't quite know yet,' Alice said very gently. 'I should like to look all round me first, if I might.'
>
> Lewis Carroll, *Through the looking-glass*

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By contrast, participatory processes deal with incongruity by searching and sampling the input and accommodating the system to it. In this case, re-equilibration 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. Re-equilibration, by incorporating input, proceeds to alter, restructure, the organization so that it can again function gracefully – i.e. with a minimum of disequilibration. Interest, affection, compassion, admiration, awe, and wonder – all partake of this participatory quality. Such examples of participatory process have in common some kind of involvement, engagement, or commitment to environmental events or plans which extend beyond the organism.

In the extreme, participatory reactions can lead to overwhelming external control. Since this makes the system 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.

THE APPRAISAL OF OUTCOMES: DISPOSITIONS AND RELEVANCE

> 'Not like cats!' cried the Mouse, in a shrill, passionate voice. 'Would you like cats if you were me?'
>
> Lewis Carroll, *Alice in Wonderland*

What influences the direction re-equilibration will take? What accounts for the choice between preparatory and participatory processes? What determines which process will emerge? So far we have suggested only that the choice is made on the basis of relevance to the ongoing plan. Obviously we mean something more by 'relevance' than congruity. It is not too difficult to build a model of the match-mismatch operation which tests for congruity out of neurons. But how does one model relevance? In brief, the proposed answer is this: the nature of the control over input is determined by the appraisal of outcomes. The appraisal of outcomes is based on (a) the concurrent *disposition* or prepotent subplan, and (b) the *relevance* of input to this dispositional context. Relevant inputs are those which can be usefully incorporated into the concurrent disposition; they are inputs which can be acted upon in the sense of making *use* of them rather than getting rid of them. Relevant inputs are not congruous inputs; rather, they are inputs which are expected, on the basis of past experience, *to lead to* congruity or stability (Fig. 1). In this sense, mismatch in the initial test phase is appraised within the operate phase of the TOTE unit; it is an evaluation of the expected consequences; and this evaluation stems from the memory of similar input-dispositional configurations which either did or did not lead to stability. Thus, relevance is established by experience.

Another way of stating this is to say that relevance is established through the process of reinforcement. The process of reinforcement has been discussed elsewhere (Pribram 1963). Briefly, the suggestion was made that during learning and during performance, reinforcing events serve different functions. During learning reinforcers are informative; during performance reinforcers value (i.e., guide) behavior along familiar paths. Whenever the outcomes of sequences of actions (including those of looking, listening, and otherwise perceiving) become incorporated into the concurrent neural context, *reinforcement* takes place. Reinforcement is conceived to result from the structuring of con-sequences, i.e., sequences of neural operations which fit the dispositional context, thereby allowing congruity in the test phase to become re-established. Through incorporation, relevant inputs lead to reinforcement while learning (i.e., a change in the neuronal configuration, the dispositional plan) is taking place. But once learning has occurred (i.e., during performance) relevant inputs are already congruous, and evaluation no longer occurs within the organism; rather, its behavior and perceptions proceed automatically. In this case, reinforcement leads to the maintenance of the status quo. When viewed at a more inclusive level, the process is somewhat similar to that produced by the mechanism of internal control. But in this instance the familiar input is included rather than an irrelevant input screened out.

It is on the basis of the memory of these satis-

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factions (stabilizing outcomes of learning) and gratifications (stabilizing outcomes of performance) that incongruities are appraised as either relevant or irrelevant for a given dispositional context. Relevant inputs are either familiar or those which indicate that external control can probably be achieved. Inputs which are appraised as irrelevant are those which, in terms of past outcomes, are not expected to lead to external control: preparatory processes set in, attempting to establish internal control by removing the incongruous input.

Thus, dispositions determine whether similar inputs occurring on different occasions are appraised as relevant. For example, being stopped by a parade when rushing to an important engagement makes the parade irrelevant; on the other hand, when out for a Sunday drive with the family, a parade may be highly relevant. Or the unexpected meeting of an old acquaintance can be a relevant input which becomes incorporated into one's plans for the day; but if this acquaintance had, on a previous occasion, absconded with one's wife, the dispositional context would be quite different. Preparation, rather than participation, might well take place. Clearly, the suggestion here is that the choice between preparatory and participatory processes depends on the remembered outcomes of previous appraisals in similar situations.

Support for this suggestion comes from an interesting series of ingenious experiments devised by Schachter and Singer (1962). A group of student subjects was given an injection of adrenaline; another control group was injected with saline. All subjects were placed in a perturbing situation – an examination – but with this difference: half of each group took the test in a setting which evoked possibilities of dire consequences; the other half took the test in a setting which evoked pleasant or rewarding possibilities. After the completion of the test, all subjects were asked how they felt. For the most part, the subjects who experienced upset in the situation of 'dire' outcomes said they felt threatened and uneasy; they labelled the task 'difficult'. Those who experienced perturbation in surroundings of 'pleasant' consequences said they felt pleased and happy; they labelled the task 'easy'. Also, those subjects who had received adrenalin reported an exaggeration of feeling; those in the 'dire' situation were fearful and depressed, and even felt hatred for the examiner; those in the 'pleasant' situation felt elated and euphoric.

This experiment provides a straightforward answer to several questions: (1) Is there a connection between different types of emotional reactions and the expectation of consequences? The answer is yes. (2) Does the secretion of a glandular substance specify the reaction? The answer is no, at least in the case of adrenalin. Reactions were amplified but not differentiated by the hormone. (3) What does determine how we react to a perturbing situation? The answer is: the appraisal of the risk involved in outcomes. (4) How is this appraisal made? Through experience with outcomes in similar situations. (5) Having made the appraisal, what determines the nature of the reaction? The criterion of relevance. (6) Finally, how is relevance established? Through practice.

With regard to the last statement, it is through practice and experience that inputs become appraised as relevant. The more repertoires available, the more likely an input will be found relevant. The organization of sequences of behavior into hierarchically arranged programs gives the organism flexibility and adaptability. External control becomes possible. These sequences get built up something like this: a hole is to dig; a meal is to cook and then to eat; a luau is to dig, to cook, to eat. The behavior sequence 'dig–cook–eat' is not, however, just a chain of activities. Each of the activities subsumes many relatively independent subactivities – e.g., cooking involves procurement of produce, lighting a fire, placing the produce in the appropriate vessels, etc. And both fire and vessels must be arranged together. It is on the basis of the ability to interdigitate sequences through the operation of hierarchies of TOTE units (i.e., plans) that inputs become appraised as relevant, allowing for participation rather than preparation.

As already noted, the details of the neuronal mechanism involved in the operation of appraisal are as yet undiscovered. First steps have been taken, as we have seen, leading to a reformulation of the functions of the limbic systems in emotion. Certain divisions of the limbic system, especially

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the hippocampus and the amygdaloid complex, have been identified to control the registration of reinforcement and the evaluation of errors (Bagshaw et al. 1965; Kimble et al. 1965; Pribram 1966; Douglas and Pribram 1966). And the importance of limbic structures to the organization of sequences of behavior – to the plans that control behavior and perception – is fairly well documented (Pribram 1958, 1960a, b). Most of the earlier studies, it will be remembered, had centered on the control exerted by these structures over behavior. Only recently has their relationship to input come into focus. Paradoxically, whereas an organism has a good deal of control over input, he has much less control over the outcomes of his behavior, except in very restricted situations. Input can be ignored if necessary, but action always begets risk: one cannot be sure of what will happen in the environment as a consequence of the action. Risk is countered only by experience in the appraisal of outcomes. And the limbic formations appear to be an integral part of the mechanism of appraisal – perhaps they maintain the balance between participatory and preparatory reactions to incongruity and thus insure the flexibility of the organism's ongoing plans. Many of these functions of the limbic forebrain are shared by the frontal eugranular isocortex – the part of the brain so often involved in the psychosurgical procedure of leukotomy (lobotomy). There is much anatomical and neurobehavioral evidence to suggest that the frontal cortex serves as an 'association' area for the limbic systems (Pribram 1958, 1960a, b).

EMOTION AND MOTIVATION

> 'Living backwards!' Alice repeated in great astonishment. 'I've never heard of such a thing!' ... 'But there's one great advantage to it, that one's memory works both ways.'
>
> Lewis Carroll, *Through the looking-glass*

An ongoing preperceptual and prebehavioral organization – some dispositional context or plan – is thus so fundamentally related to the emotional processes of preparation and participation that it clarifies the relationship between motivation and emotion. Just why these two psychological categories are so often juxtaposed is hardly ever mentioned in the literature. And when psychologists are asked to make the relationship explicit, the explanations are often muddled: 'both are related to physiological drives' (how?); 'sometimes an emotion is motivating' (in what way?); 'there really isn't any difference' (then why use both words?). However, in light of the present theory, once it is clear that emotions are not just viscerally derived, that they stem primarily from dispositional contexts, from ongoing plans – the enigma is resolved. *Motive* implies *action*; to *e-mote* implies to be *out of* or *away from* action. In terms of the TOTE unit (Fig. 1), the emotions are concerned with the regulation of input, i.e., with the feedbacks, the preparatory and participatory processes effecting efferent control over input. In essence, then, the emotions are the result of appraisals which aim to regulate input when the result of such appraisal involves the temporary interruption of action, literally e-motion. On the other hand, motives involve the organism in action, in the execution of its plans. Emotion and motivation, passion and action: these are the two poles of Plan.

The suggestion is that those terms we call 'emotions' can also serve as names for 'motives': love as an emotion has its counterpart in love as a motive. Fear the emotion has its mirror image as fear the motive. Being moved by music can be apposed to being moved to make music. And so on. Emotions and motives can, of course, be gracefully interdigited, i.e. responsive to each other. Only when this is accomplished can action be selective and adaptive. When emotions and motives are not interdigited, i.e., when either the passive or active mode of the Plan becomes prepotent, maladaptation is likely to occur. Too much emotion leads either to disruption through participation or to rigidity through preparation. Furthermore, the emotion may become a disequilibrating input in itself, for it begets further incongruities which cannot be acted upon. Too much planned action, on the other hand, leads to a narrowness of purpose and a poverty in values.

The dissociation of emotion and motive can occur either as a result of preparatory or participatory processes. When preparatory, a temporary reorganization of neural patterns takes place in the event that the perturbing incident will dis-

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appear. This does not mean that preparatory reactions can find no expression in behavior. But it does mean that such behavior is relatively more responsive to feedback, the outcome of the expression, than to the input that generated it. In other words, behavior in this case is internally controlled and when this control breaks down, behavior is apt to be explosive – or its converse, frozen; in short, it becomes then 'blind' and 'unreasoning'.

Similarly, participatory reactions can, in the extreme, be paralyzing. Puppy love and great passions (both 'passive' and 'passion' are derived from the same Latin roots) can lead to complete immobilization: the infatuated adolescent moping around the house; the romanticist pining away, consumed by the flame of the torch he is carrying. Somewhat milder is the rapture with which we listen to great music, the enjoyment with which we bask in the sun at the beach, etc. Again, expression of these participatory reactions, to the extent that they are emotional, are relatively actionless. The watering of eyes, blushing or pallor of the face, aimless pacing, intent or relaxed postures: the stimulus bound not-doing of this or that characterizes the emotional expression of participation. In a social situation, of course, these expressions of emotions, the affects, may serve as signals to other organisms, signals on which their action can be predicated. And in the fully self-aware organism, these same signals can be used as outcomes – the consequences of his reaction to the situation.

However, this 'paralyzing' function of participatory emotions poses an apparent internal inconsistency in the theory. Participatory emotions are said to take place when an input is relevant, i.e., when it can be acted upon and made use of. This appraisal is made on the basis of past consequences of reaction to such an input. Now, how can an input be relevant and not acted upon? How can a relevant input become paralyzing? The input can result in participatory emotions which lead to the motive to be temporarily actionless, i.e., as psychiatrists would say, to regress in service of the ego. Thus, participatory emotion *per se* does not as a rule produce immobilization which goes on willy-nilly, without control. Participatory 'paralysis' is due to a giving up of internal, in favor of external, control. However, when such external control fails to be achieved, disruption results and this in turn may demand a repairing to the process of internal control.

TIME SENSE AND EMOTION

> 'You see a minute goes by so fearfully quick.'
>
> Lewis Carroll, *Through the looking-glass*

Thus far, the thesis has been that the emotions are important for the regulation of input such that the opportunities for reinforcement are maximized, thereby safeguarding continuing stability. Since these functions involve precisely timed feedbacks, many of the central issues can be rephrased in the time domain: rather than asking *what* inputs trigger dishabituation and orienting, the question becomes *when* is an input disequilibrating. A change in temporal pattern is just as potent in producing perturbation as is a change in another stimulus parameter (Sokolov 1960). The question of whether an incongruous input is appraised as relevant or irrelevant, reflects, in part, the estimation of the temporal order in which the input must be processed. Temporal order, in turn, depends on the length of processing time to be devoted to each incongruity.

With regard to duration, if reinforcement is to occur, then the processing of an incongruous input must extend until the incongruity is resolved through either preparation or participation. Since the incongruity may persist in memory, without the external presence of the inciting input, the duration of the processing may be quite long; thus, emotional reactions frequently outlast the inciting stimulus (Grinker et al. 1956). In this way, the emotions may be thought of as a 'carry-over' system which temporally apposes changes in input with changes in action and their outcomes.

According to this view, the matching of expected consequences with actual outcomes (reinforcement) is, in large part, dependent on the *speed* of execution of the sequential acts. By varying the speed of actions, the sequential order of the ongoing plan can be maintained intact while the organism adapts to inputs. Monitoring of rates and rhythms is thus a key function of the emotional processes, for the emotions both maximize sub-

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sequent reinforcement and maintain present organization.

What evidence is there for this relationship between timing mechanisms and emotions? Everyday experience tells us that, in states of participation, clock time seems to pass swiftly; on the other hand, when defensive, preparatory processes are in effect, clock time seems to 'drag'. Our language also portrays this relationship between time sense and emotion, e.g., 'rushing like mad' and 'happy as a clam'. But the evidence is on firmer ground than this: objective measures of time perception in psychiatric patients showed a marked speeding up of subjective time with reference to geophysical time during 'unpleasant' emotional disturbances (Melges and Fougerousse 1966). This means that clock time seemed to go slowly when compared to personal time, making judgments of elapsed time shorter than the standard asked for. Furthermore, Pearl and Berg (1963) demonstrated this speeding up of personal time when patients were presented pictures specific to their conflicts. Also, correlative changes of emotion and time perception have been induced by posthypnotic suggestion (Fogel and Hoffer 1962), psychotomimetics (Aronson et al. 1959), and sensory deprivation (Vernon and McGill 1963).

Does the 'cybernetic theory' of emotion account for these changes in the perception of personal tempo in different emotional states? Changes in redundancy are known to affect processing time. Also, since time can be defined as relative motion, such as the movement of the hands of a clock over the stationary dial, subjective time can be conceived as a relation between events occurring within the organism and those external to it. While preparatory processes are in operation, there is an effective decoupling between 'inside' and 'outside' with a good deal of internal processing going on. Subjective time would therefore be perceived as fast when compared to geophysical time, making clock time *seem* to go slowly.

What is there about preparatory processes which would give rise to greater relative motion within the system? The answer is essentially twofold: (1) Incongruous inputs which are appraised as irrelevant must be rapidly eliminated if internal control is to be achieved. If they are not speedily eliminated, then dishabituation accrues, entailing greater instability and internal 'motion' relative to the previously established base-line. (2) With preparation, redundancy is enhanced in the input channels; this speeds information processing, and the amount of information to be processed is cut down. Clock time then seems to 'drag' since not much seems to be going on 'outside' compared with the internal motion. On the other hand, by taking in input, participatory processes produce greater uncertainty within the system. In an uncertain situation, each item in a sequence contains more potential information. There is more information coming from the environment per unit time; and yet, since redundancy is reduced, the internal processing of input is slowed. Thus, a great deal is 'expected' from the environment; search actively engages input, and 'the world' appears rich compared to the internal state; geophysical time then seems to whiz by.

The proposal also helps explain why temporal perspective – the orientation in time according to past, present, and future – can become distorted during extreme emotional distress (Melges and Fougerousse 1966). Since preparatory processes are aimed at the elimination of input, the organism becomes relatively divorced from the continuity of ongoing external events. Internal control may take over to such a degree that the system depends almost exclusively on its past organization for its present stability. There is then a greater focus on the present *per se* rather than interweaving present experience with past and future outcomes.

Finally, should internal or external control break down completely, disrupting the person's plans, the telescoping of past, present, and future may occur; and this state often characterizes the acute, severe psychotic state (Melges and Fougerousse 1966).

In summary, the emotions are fundamental to the adaptive timing of behavior sequences in that they provide a mechanism for processing appraisals of expected outcomes *before* action is taken. Changes in time perception accompany this anticipatory reflection (El'kin 1965). These changes depend a good deal on whether a preparatory or participatory process is called forth. Preparation, by increasing internal redundancy, speeds information processing and thus slows the perception

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of clock time. Participatory processes, by reducing redundancy, slow information processing and thus make geophysical time seem to go fast.

Subjective-communicative applications

> 'Will you, won't you, will you won't you, will you join the dance?'
>
> Lewis Carroll, *Alice in Wonderland*

Behaviorally oriented experiments consonant with the proposals made here have, over the past few years, been accomplished independent of, and in parallel with, the neurobehavioral and neurophysiological. These have been effectively presented by Mandler (1964) and Schachter (1967). Further, the effects of interpersonal communication on control of social systems such as the family, have also been spelled out in detail (e.g., Bateson 1963; Watzlawick et al. 1966). We will here, therefore, restrict ourselves to pointing out some central themes which help to phrase the proposal in the subjective-communicative realm of discourse.

At this point, it should be clear that memory plays a fundamental part in this neuropsychological proposal: (1) it is through the memory of recent input that incongruities are sensed; (2) it is through the memory of past reinforcements that outcomes are appraised. The arousal of a confluence of memories by a given incongruity, the organism's dispositional context, is reflected in what we call the affects. When such arousal is accompanied by a significant loss of control, displeasure is experienced; re-establishment of control after perturbation has occurred is reflected in what we call pleasure. According to this view, then, affects are idiosyncratically determined by the organism's experience. In some respects, this emphasis on memory in the genesis of affect is different from currently held views and deserves exploration here.

Another area where this neurophysiologically inspired proposal may be pertinent to is psychopathology which, in our, as well as the common view, is due primarily to maladaptive emotional reactions. In fact, much of psychodynamics, its normative development and its pathology, can be productively reviewed in terms of this proposal.

THE DEVELOPMENT OF EMOTIONS

> Alice knew it was the Rabbit coming to look for her, and she trembled till she shook the house, quite forgetting that she was now about a thousand times as large as the Rabbit and had no reason to be afraid of it.
>
> Lewis Carroll, *Alice in Wonderland*

There are three key questions which recur in the study of subjective feelings and emotional expressions: (1) What is the relationship of visceral-autonomic equilibration to reinforcement? (2) Why is it that object relations – the relations between members of a group – are so fundamental to emotional processes? (3) How do signals of diffuse distress and pleasure in the infant become differentiated into the adult emotional experience of depression, confidence, perplexity, love, etc.? These questions intimately involve the development of the organism's psychological structure.

Psychoanalytic theory has attempted to answer these questions by using a drive-tension reduction model. Since this theory has achieved the widest recognition for a model of emotional development, it will be used as a point of departure and contrast for the present formulation. As systematized by Rapaport (1960), psychoanalytic theory states that, early in development, the caretaking person (the mother or mother substitute) is important for 'drive action on the object' and consequent 'drive gratification'. In the absence of this caretaking person, 'affect reactions' become the '"sally gates" for drive tension' (Freud 1920). Later in development, a 'structuralized delay' becomes a 'means' or 'detour activity' by which 'some action yielding satisfaction is eventually achieved' (Engel 1962a). At this later state, according to Engel (1962a) the communicative aspect of emotion becomes prepotent: the affect is no longer purely a 'discharge' which solicits a response from the environment, but 'now serves more as an intrapsychic signal to mobilize defense and control mechanism of ego in service of the reality principle'.

Although the psychoanalytic formulation interweaves object relations, drives, and action – all fundamental to any theory of emotion – there are some pertinent difficulties which can be posed by rephrasing the three questions asked at the outset

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of this section: (1) Are drives fundamentally the only events which provoke affect? (2) Are affects always signals of displeasure? (3) What processes underlie the 'structuralized delay' and how are affects related to these processes?

To answer these three questions, let us recast the classical psychoanalytic formulations, as well as the extensive observations on which they are based, into the terms of the present proposal to see if a more comprehensive framework emerges. The present theory departs from the psychoanalytic in three fundamental ways. First, drives are de-emphasized. They still play a role but only as one class or set of stimuli which can give rise to incongruities. In this sense, they are no different from any other inputs (Estes 1958). The incongruities of drive stimuli are imbalances of physical-chemical substances which are detected by the core homeostats lining the third ventricle (Pribram 1960b). They are processed, like any other incongruity, by dishabituation and the appraisal of outcomes. In this way, drives lose their 'push', or *a priori* directional property, as well as the cognate energetic concept of 'drive discharge'. The drives are thus 'need stimuli' or 'imbalance stimuli'; they are incongruities necessitating certain kinds of sequences to take place in order for matching (congruity) to occur. For example, in the context of hunger, one must eat for a match to reoccur. But note carefully: it is the stimuli – the context – which determine the nature of the matching. This context may have genetically determined constraints which specify the requirements for a match, but this is different from saying that there are inherited, specific energies with built-in goals; rather, the match for an incongruous drive stimulus is established through experience, *a posteriori* (Birch 1961).

Second, according to the present proposal, affects are not just the end result of drives (or even of 'drive stimuli'), but rather they are signals which reflect feedback processes involved in the processing of any of a variety of incongruities. The feeling tone can be pleasant or unpleasant, depending on to what degree control is expected or already achieved. Thus, affects are multidimensional; they pertain to the monitoring of reinforcements in relationship to *any* incongruity in the setting of *any* dispositional context, or plan. But since, for a group-living species, continuing stability and reinforcement often involve the execution of *shared* plans of action, the affects frequently arise in connection with object relations – the relationships between members of the group (Hamburg 1963; Hall 1966).

Third, in the light of the current formulation, the nodal points for development and refinement of behavior do not reside solely in the psychosexual unfolding of 'instinctual drives', but center rather in the whole spectrum of sensorimotor maturation (Piaget 1962; see Flavell for review, 1962), of which reactions to drive stimuli form only a part of the total pattern. The child's increasing capacity for planned perception and action allows him to imitate others, to reinforce himself, to produce consequences in his environment, and to solicit responses from that environment. In this way, the child becomes progressively less dependent on the actions of the caretaking person and begins to assume a reciprocal (i.e., externally controlled) relationship with his surroundings, especially with members of his family.

Having outlined this framework, we can now examine in greater detail how the infant's global excitement and distress signals become progressively refined into specific communications of affection, fear, elation, etc. We will not go into the time-table of emotional differentiation described by Bridges (1932), but will focus on the mechanism which makes differentiation possible. According to our theory differentiation results from the development of plans through the process of reinforcement, especially the reinforcements stemming from participatory processes.

For the infant, stability is maintained in large part through the cyclic visceral-autonomic functions of breathing, heart rate, peristalsis, etc., which provide the major sets of inputs to be fashioned into a neuronal model, especially since the large requirement for sleep reduces variegated input from the peripheral senses (Kleitman 1963). When this highly redundant pattern is interrupted by an incongruous input, such as a loud noise, pain, or drive stimuli (hunger, thirst, etc.), then disequilibration takes place. The latter is accompanied by signs of distress (restlessness and crying), which prompt action on the part of the mother,

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such as rocking or feeding, thereby returning the infant to its redundant, stable base-line. Thus, reinforcement (or matching) is initially accomplished by the caretaking object effecting a return to internal control. However, even this early pattern involves an *inter*individual plan of reinforcement, and as such, forms the nidus for the complex interactions demanded later by plans shared among members of a group.

The energetic aspect of the drive formulation is unnecessary in this view, but there is an important feature of drive stimuli which has been pointed up by psychoanalytic theory: since they come from within the organism, they cannot be escaped (Freud 1915). In our framework, this means that incongruities induced by drive stimuli can only be eliminated by the incorporation of some other input, calling forth participatory operations. For example, hunger is eliminated only after attention has been given to food. Thus, from the beginning, preparatory processes become balanced by participatory operations. The stability of the internal milieu (Bernard 1927) is therefore maintained not only by establishing internal control, but also by meeting the environment half-way through relationships expressing the process of external control.

Because the efficacy of external control in the infant is so dependent on the action of the caretaking person, the absence of the latter precipitates a preponderantly preparatory operation which Engel (1962b) terms 'depression-withdrawal'. Here, the infant seemingly 'gives up' and frequently falls asleep, thereby gating out disequilibrating input. Engel posits that the neonate's restlessness is the primitive anlage for anxiety and the 'giving up' is the precursor of depression.

Later in development, with the accrual of memories of successes and failures in the face of perturbing input, the child begins to anticipate both reinforcement and non-reinforcement. At about four to six weeks of age, the smile becomes a prelude to feeding, indicating a readiness to participate (Spitz 1946). At about eight months of age, when the mother begins to leave, the child emits distress signals which attempt to maintain the participatory process. The 'separation anxiety' of Spitz (1950) is thus conceived to stem from the disruption of external control. Still later, after the child has become motorically capable of acting for himself, i.e., capable of reinforcing himself, these emotional signals become progressively more functional as inner cues which reflect his experience in coping with loss of control, thereby enabling him to change his course of action. Hence, the infantile expression of emotions differentiate into the more internalized affects on two accounts: (a) the build-up of a memory structure (from experienced inputs and outcomes) which allows more precise appraisal; and (b) the increasing capacity for independent action. Of course, a crucial variable is the degree of independent action encouraged by the mother.

The thesis is that progressively more individuated control is maintained by the evocation of participatory operations in the face of changes in the internal and/or external environment. The applicability of this thesis can be demonstrated by citing some animal experiments which have impaired emotional development. Sensory deprivation or relative isolation early in development can produce drastic emotional reactions when the animals are later exposed to the average expectations of a 'normal' environment. What is 'expected' by the normal organism proves to be 'novel', i.e., incongruous and disequilibrating to the deprived animal. By contrast, adequate (or 'greater') stimulation in early infancy appears to make animals less reactive to environmental stimulation later in life (Levine 1962). Loss of control, an inability to cope, characterizes the initial reaction to disequilibration for sensory deprived animals (Mason and Sponholz 1963; Konrad, in preparation). Recourse to an exaggerated form of internal control may supervene: restriction of social reinforcement by isolating rhesus monkeys from their mothers gives rise to markedly abnormal emotional behavior later in life, characterized by self-clasping, rocking, thumb-sucking, and postures of withdrawal (Harlow and Harlow 1962). As a corollary, any shift in the complexity of environmental input patterns is apt to produce an impairment of external control and thus emotion, as shown by acute sensory deprivation experiments in adult humans (Pollard et al. 1963).

In effect, all of these experiments have manipulated the expectancy of input and outcome and produced emotional changes.

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In summary, a cybernetic model of emotional development, by redressing the balance among the variety of memory-based processes which guide affect, meets the limitations of the current psychoanalytic formulation, while deriving strength from the problems posed by this formulation: what we call emotional signals, affects, are assumed to reflect disequilibration, an appraisal of outcomes, and re-equilibration, leading to either internal or external control. As signals which tend to maximize the opportunities for reinforcement, the affects interweave the outcomes of object relations with the processing of incongruities, including those of drive stimuli, into progressively more complex, yet specific plans of action.

THE DIFFERENTIATED AFFECTS: TOWARD A CLASSIFICATION

> They shuddered to think that the chase might fail,
> And the Beaver, excited at last,
> Went bounding along on the tip of its tail,
> For the daylight was nearly past.
>
> Lewis Carroll, *The hunting of the Snark*

As repeatedly stated, the differentiation of the emotions into the adult feelings of anxiety, depression, confidence, etc. extends far beyond the view of emotions as dependent on visceral-autonomic regulation: according to our proposal, the different affects reflect the results of appraisal of occasions for reinforcement in terms of past outcomes in similar contexts; these results lead to feedback processes which either conserve or modify the ongoing plans of action. These plans control the organism's stability.

But what sort of settings give rise to the different affects? The following suggestions are derived from clinical psychiatric experience, psychoanalytic literature (Freud 1920; Engel 1962a), 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 reflect both concurrent order in the system and the expectation of order. Combinations of concurrent and prospective feelings lead to different and somewhat specific affective signals.

The concurrent affects

> Alice stood looking after it, almost ready to cry with vexation at having lost her dear little fellow-traveller so suddenly. 'However, I know my name now,' she said; 'that's *some* comfort.'
>
> Lewis Carroll, *Through the looking-glass*

After an incongruous input perturbs the system, the restoration of order through the achievement of congruity is reflected in what we call pleasant feelings. These pleasant feelings, according to this proposal, are of two types (Pribram 1960): (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, etc. Satisfaction goes beyond this, signaling an effective reorganization of plans; the associated feelings are those of delight, relish, joy, exhilaration, aesthetic appreciation, etc. In this way, it is possible for a person to be gratified (e.g., calm), but still dissatisfied (e.g., apathetic).

If incongruity persists, then this failure to achieve stability by either internal or external control is signalled by displeasure. Displeasure may take the form of either distress (i.e., the lack of gratification), during which arousal accrues, or dissatisfaction, during which uncertainty and perplexity mount.

The prospective affects

> 'Now I can do no more, whatever happens. What *will* become of me?'
>
> Lewis Carroll, *Alice in Wonderland*

Since the prospective affects arise in connection with the expectation of order (i.e., with the appraisal of outcomes), they can be divided into optimistic and pessimistic affects. Optimistic feelings occur when incongruous input 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, affection, etc. It can be seen that most of these are affiliative in nature, indicating the tendency toward external control and the ramification of plans of action shared by members of the group. Confidence and self-

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esteem shade into more lasting states, such as moods and attitudes, but they are still affects reflecting the general feeling of optimism with reference to the efficacy of the ongoing plans to effect control (White 1963). These feelings of efficacy reflect the tendency 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 which calls forth an emotional appraisal.

Rosenberg (1962) has shown that, whereas high self-esteem is often antithetical to anxiety, low self-esteem is frequently associated with the experience of anxiety. Anxiety occurs when there is ambiguity about subsequent reinforcement (Wolpe 1958). Anxiety and apprehension are prospective, pessimistic affects which indicate that, through the appraisal of outcomes, there is considerable risk involved in the situation. The pessimistic affects thus arise when incongruous inputs are appraised as irrelevant, i.e., when past outcomes lead to the expectation of failure to achieve control. Preparatory, defensive processes are especially prone to be accompanied by pessimistic affects. Since irrelevant inputs are screened out or avoided, they are thus rarely incorporated for later appraisals of input when different dispositional contexts are present. Furthermore, a predominantly internally controlled system *may* operate on the dictum: once irrelevant, always irrelevant. It is tempting to speculate that this may account for the inflexibility of certain psychopathological states.

Other proposed pessimistic affects are fear, depression, guilt, shame and anger. Some degree of anxiety underlies all of these (Freud 1926), indicating the risk associated with irrelevant inputs. But whereas with anxiety the outcome is ambiguous, fear arises when the risk to continuing stability 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 the ongoing plans – the body – is jeopardized.

Depression, along with the accompanying feelings of helplessness and hopelessness, is also a pessimistic affect. Depression frequently stems from the interruption of a shared plan of action, thereby making the achievement of external control seem unlikely. An object loss – the loss of a person, thing, or process which 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 slowing down and restriction of activity seen in depression serves to reduce offending input, to conserve existing plans, and is akin to the infant's 'giving up' after perturbation in the absence of the care-taking object.

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) rules, shame deals more 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 preparatory aspects, such as expiation and reaction formation, which attempt to undo the previous transgressions.

Combinations

> The music of Midsummer-madness
> Shall sting him with many a bite,
> Till, in rapture of rollicking madness,
> He shall groan with a gloomy delight...
> Lewis Carroll, *Phantasmagoria*

At any given moment, the subjective feeling state always represents a composition of concurrent affects (pleasure and displeasure) and prospective affects (optimism and pessimism). Which affect becomes predominant depends on the achievement and anticipation of both internal and external control with regard to certain dispositions and inputs. As stated above, guilt and shame are largely pessimistic, but they also reflect concurrent displeasure. Anger is a prime example of a composite affect; it has pleasant and unpleasant as well as optimistic and pessimistic aspects. Anger occurs when there is an attempt to keep an interrupted plan operating despite obstacles. Unlike depression, where there is a relinquishment of a plan in the face of an insurmountable loss or barrier, anger is more optimistic in that there is the

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expectation that the external blockade can be removed. In addition, anger often reflects an admixture of underlying preparatory and participatory operations; with a 'fine anger', input is taken in to enhance subroutines which are aimed at eliminating the blockade. Whereas this type of anger is primarily participatory, rage is predominantly preparatory 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), yet at the same time pessimistic about his possibilities of achieving relatedness, i.e., external control; this pessimism is due to ambiguity with respect to the relevance of inputs. Finally, compassion and sympathy are condensations of concurrent dissatisfaction and prospective optimism which revolve around the maintenance of shared plans of action; 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.

EMOTIONAL EXPRESSION

> To the horror of all who were present that day,
> He uprose in full evening dress,
> And with senseless grimaces endeavored to say
> What his tongue could no longer express.
>
> Lewis Carroll, *The hunting of the Snark*

Of course, the affects are often more than mere internal signals; they are frequently key communications in the regulation of group behavior (Hamburg 1963). Emotional expression is often a prelude to the change of a plan of action shared by members of the group. Signs of distress may mobilize others to come and help. Aggression, the emotional expression of anger, may keep others at a distance, preserving territorial rights (Scott 1962). Pleasant feelings, with their manifold expressions of laughter, contact, play, exuberance, etc., are often invitations for others to join in and participate, to become a member of the group and share its plans. Thus, like the internal affects, the expression of emotion has concurrent-prospective as well as preparatory-participatory dimensions with reference to the maintenance and development of cooperative plans of action.

DISRUPTIVE EMOTIONAL SYNDROMES

> And sickened with excess of dread,
> Prone to the dust he bent his head,
> And lay like one three-quarters dead.
>
> Lewis Carroll, *Phantasmagoria*

Without making any attempt to cover the vast area of psychopathology, we will nevertheless review a few emotional syndromes in light of the present proposal. Emotions can become maladaptive when preparatory and participatory processes lead either to extreme internal or external control. Hence, novel input might be screened out by preparatory processes initiated earlier, or irrelevant input taken in by a participatory process disengaged from any permanent plan. The resulting perceptions and behavior may become either rigid and inflexible, stemming from the hyper-redundancy induced by preparatory processes, or distractible, random, and disorganized, reflecting the uncertainty enhanced by participation.

We posit that panic occurs when neither preparatory nor participatory processes are successful in effecting stability. In such instances, the emotions may become disequilibrating inputs themselves, for emotion becomes progressively divorced from planned action. Hence, anxiety spirals, and the individual experiences something akin to the uncontrolled distress of the 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). According to our view, a shared plan of interaction is 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 a preparatory 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 preparatory and participatory processes attempt to restore a modified plan of action.

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The reaction to disaster can be interpreted as an overwhelming swing to preparatory processes in order to keep former plans 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 means to conserve previous plans of action.

Identity diffusion occurs when an individual, operating mainly through external control, is faced with a choice among many plans, resulting in too much uncertainty. Erikson (1959, page 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 outcomes. If this state is not countered by a strong conservative process which arranges the plans in some hierarchical order, panic supervenes.

Finally, mania also clearly involves overactive participatory processes. The individual is distractable, and takes everything in. Irrelevancies are incorporated into disjointed plans which are often carried out without regard to outcomes. The unexpected matching of fleeting incongruities with rapidly changing plans and contexts makes the behavior appear humorous. But the attempt to block any – albeit fleeting – plan results in anger. In the course of time, the runaway plans, unmodified by preparation, lose all order and continuity. The organism becomes progressively more uncertain, ordered action becomes impossible, and his plans are totally disrupted.

PSYCHOTHERAPY

> All the time the Guard was looking at her, first through a telescope, then through a microscope, and then through an opera-glass. At last he said, 'You're travelling the wrong way...'
>
> Lewis Carroll, *Through the looking-glass*

In light of this proposal, the task of psychotherapy comes into sharper focus: excessive emotion, whether preparatory or participatory, must be turned into moderated motivation, paralyzing passion into graceful action. Conversely, untempered action must be appraised in terms of past and future consequences. The impulsive execution of plans should be given pause by the emotional appraisal, thereby achieving sensitive control through preparatory 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 – by emphasizing plans – gives continuity beyond the restricted reconditioning of behavior patterns. Within the framework of the proposal, present psychotherapeutic techniques (including analysis, behavior therapy, family and social therapies, etc.) can better be brought to bear on the essential problem of the regulation of planned action. Since individual plans and experience are always idiosyncratic, no overall psychotherapeutic prescription can apply to all individuals. Yet, leaving aside the content of individual experience, the *process* of segmentation, of precise and ordered feedback, of action monitored by passion, and passion molded into timely action, can lead to the realization of Marcus Aurelius' dictum for the troubled mind. Having come full circle, this is the theory of emotion which emerges from today's neurological knowledge. This is the process which allows for tempered risk, without which, in the words of Alice *(Through the looking-glass)* '...there'd be an end to all my adventures'.

Conclusion; theorizing on theory

> 'If there's no meaning in it,' said the King, 'that saves a world of trouble, you know, as we needn't try to find any.'
>
> Lewis Carroll, *Alice in Wonderland*

A theory systematizes, explains, and predicts. We have proposed a common theme which can be viewed from different levels of discourse: we have focussed on the neural and the neurobehavioral, and then searched subjective modes for validation. The common theme is that ongoing plans organize the perceptions and behaviors of organisms and that these plans continually juxtapose emotion and motivation, affect and anticipation, and pas-

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sion and action. We have attempted to make the proposal specific enough to be tested – i.e., confirmed or refuted by observable determinate consequences derived from the hypotheses generated (Nagel 1961). We believe that the hypotheses formulated within each level of discourse are testable. But whether the 'correspondence rules' *between* the various realms of discourse are capable of precise examination remains a question. To some degree, the answer appears to be yes. Shagass' (1963) work on neural recovery functions in various psychiatric syndromes is an opening lead in this direction. Also the work of Lacey et al. (1963) and of Stewart and Dean (1965) points up the relationship of autonomic nervous system function to perceptual-cognitive behavior.

As noted in the proposal, changing a frame of reference can provoke a good deal of displeasure and uncertainty, since a former plan which has given order and thus led to much reinforcement must be relinquished or incorporated into a more complex context. Fortunately for our emotions, theories do not spring up *de novo*. They are often extensions and reorganizations of data and relationships collected in other frames of reference (Bronowski 1956). Following Freud's brilliant pioneering efforts, psychoanalysis found it necessary to employ concepts like 'repression', 'unconscious processes', 'regression', and 'ego development' to account for the data at hand. In the 'Project for a scientific psychology', Freud attempted to detail a neurological model which would account for behavioral and subjective relationships, and there are many aspects of this model which are still up-to-date (Pribram 1962). But we believe that present-day psychoanalytic theory, by overemphasizing the drive-tension aspects, which were added later, detracts from the universality of the model. Current neurophysiological data not only provide a neural base for some of the analytic notions, but the theory derived from those data is more consonant with the earlier (ego-based) model, and so redresses the imbalance. Further, these data and the proposal presented cast the analytic formations into more testable form in a variety of levels of inquiry. For example, the relation of repression, of suppression, and even of unconscious processes, to anxiety takes on a new dimension in the light of the demonstrated efferent control over input. The concept of regression and of ego development achieves new perspective in terms of the relationship between the appraisal of reinforcements in terms of ongoing plans which guide perception and action. Perhaps a rapprochement between the neural and subjective-behavioral views is finally at hand. As Freud said: 'I have no inclination at all to keep the domain of the psychological floating as it were in the air, without any organic foundation... Let the biologists go as far as they can and let us go as far as we can. Some day the two will meet.'

REFERENCES

ADEY, W.R., R.T.KADO and J.DIDIO: Impedance measurements in brain tissue of animals using microvolt signals. Exp. Neurol. 5 (1962) 47–66.

ARNOLD, M.B.: Emotion and personality, Vol. II. Neurological and physiological aspects. New York, Columbia University Press (1960).

ARONSON, H., A.B.SILVERSTEIN and G.D.KLEE: The influence of lysergic acid diethylamide (LSD-25) on subjective time sense. Arch. gen. Psychiat. 1 (1959) 469–472.

BAGSHAW, M.H., D.P.KIMBLE and K.H.PRIBRAM: The GSR of monkeys during orienting and habituation and after ablation of the amygdala, hippocampus and inferotemporal cortex. Neuropsychologia (Oxford) 3 (1965) 111–119.

BARD, P. and D.RIOCH: A study of four cats deprived of neocortex and additional portions of the forebrain. Johns Hopk. Hosp. Bull. 60 (1937) 73–147.

BARRETT, E.S.: Relationship of psychomotor tests and EEG variables at three developmental levels. Percept. Motor Skills 9 (1959a) 63–66.

BARRETT, E.S.: Anxiety and impulsiveness related to psychomotor efficiency. Percept. Motor Skills 9 (1959b) 191–198.

BATESON, G.: Exchange of information about patterns of human behavior. In: W.S.Fields and W.Abbott, eds.: Information storage and neural control. Springfield, Charles C Thomas (1963) pp. 1–44.

BERNARD, C.: An introduction to the study of experimental medicine. New York, The MacMillan Company (1927).

BIRCH, H.G.: Animal research. 3. The pertinence of animal investigation for a science of human behavior. Amer. J. Orthopsychiat. 31 (1961) 267–275.

BRIDGER, W.H. and I.J.MANDEL: A comparison of GSR fear response produced by threat and electric shock. J. psychiat. Res. 2 (1964) 25–30.

BRIDGES, K.M.B.: Emotional development in early infancy. Child Developm. 3 (1932) 324–341.

BRONOWSKI, J.: Science and human values. New York, Harper and Row (1956).

CANNON, W.G.: The James–Lange theory of emotions: a critical examination and an alternative theory. Amer. J. Psychol. 39 (1927) 106–124.

DEMENT, W.C.: An essay on dreams: the role of physiology in understanding their nature. In: New directions in psychology, II. New York, Holt, Rinehart and Winston (1965) pp. 137–257.

DEWSON, J.H., K.W. NOBEL and K.H. PRIBRAM: Corticofugal influence at cochlear nucleus of the cat: some effects of ablation of insular-temporal cortex. Brain Res. (1966) 151–159.

DOLLARD, J., L.W. DOOB, N.E. MILLER, O.H. MOWRER and R.R. SEARS: Frustration and aggression. New Haven, Yale University Press (1959).

DOUGLAS, R.J. and K.H. PRIBRAM: Learning and limbic lesions. Neuropsychologia (Oxford) 4 (1966) 197–220.

EL'KIN, D.G.: Time perception and anticipatory reflection. Sov. Psychol. Psychiat. (N.Y.) 3 (1965) 42–48.

ENGEL, G.L.: Psychological development in health and disease. Philadelphia, W.B. Saunders Company (1962a).

ENGEL, G.L.: Anxiety and depression-withdrawal: the primary affects of unpleasure. Int. Psycho-anal. 43 (1962b) 89–97.

ERIKSON, E.H.: Childhood and society. New York, W.W. Norton & Co. (1950).

ERIKSON, E.H.: Identity and the life cycle. Psychol. Iss. (1959) 1–171.

ESTES, W.K.: Stimulus-response theory of drive. In: M.R. Jones, ed.: Nebraska symposium on motivation. Lincoln, University of Nebraska Press (1958) pp. 35–68.

FAIR, C.M.: The physical foundations of the psyche. Middletown, Wesleyan University Press (1963).

FLAVELL, J.H.: The developmental psychology of Jean Piaget. Princeton, Van Nostrand Co. (1963).

FOGEL, S. and A. HOFFER: Perceptual changes induced by hypnotic suggestion in the post-hypnotic state. I. General account of the effect on personality. J. clin. exp. Psychopath. 23 (1962) 24–35.

FREUD, S.: Instincts and their vicissitudes. (1915) Collected papers 4. London, Hogarth Press (1948) pp. 60–83.

FREUD, S.: Beyond the pleasure principle. (1920) London, Hogarth Press (1948).

FREUD, S.: The problem of anxiety. (1926) New York, Psychoanalytic Quarterly and Norton (1936).

GOLDSTEIN, M.J., R.B. JONES and M.I. KINDER: A method for the experimental analysis of psychological defenses through perception. J. psychiat. Res. 2 (1964) 135–146.

GRINKER, R.R. et al.: Theoretical and experimental approach to problems of anxiety. A.M.A. Arch. Neurol. Psychiat. 76 (1956) 420–431.

HALL, K.R.L.: Social learning in monkeys. In: P. Joy, ed.: Explorations in primate social behavior. New York, Holt, Rinehart and Winston (1966).

HAMBURG, D.A.: Emotions in the perspective of human evolution. In: P.H. Knapp, ed.: Expressions of the emotions in man. New York, International Universities Press (1963) pp. 300–317.

HARLOW, H.F. and M.K. HARLOW: The effect of rearing condition on behavior. Bull. Menninger Clin. 26 (1962) 213–224.

HEAD, H.: Studies in neurology. Oxford, Medical Publications (1920).

HESS, W.R.: Diencephalon: autonomic and extrapyramidal functions. New York, Grune & Stratton (1954).

KAADA, B.R., K.H. PRIBRAM and J.A. EPSTEIN: Respiratory and vascular responses in monkeys from temporal pole, insula, orbital surface and cingulate gyrus. A preliminary report. J. Neurophysiol. 12 (1949) 347–356.

KAUFMAN, I.C.: Some ethological studies of social relationships and conflict situations. J. Amer. psychoanal. Ass. 8 (1960) 671–685.

KETY, S.S.: Catecholamines in neuropsychiatric states. Pharmacol. Rev. 18 (1966) 787–798.

KIMBLE, D.P., M.H. BAGSHAW and K.H. PRIBRAM: The GSR of monkeys during orienting and habituation after selective partial ablations of the cingulate and frontal cortex. Neuropsychologia (Oxford) 3 (1965) 121–128.

KLEITMAN, N.: Sleep and wakefulness. Chicago, Univ. of Chicago Press (1963).

LACEY, J.I., J. KAGAN, B.C. LACEY and H.A. MOSS: The visceral level: situational determinants and behavioral correlates of autonomic response patterns. In: P.H. Knapp, ed.: Expressions of the emotions in man. New York, International Universities Press (1963) pp. 161–208.

LASHLEY, K.: The thalamus and emotion. In: F.A. Beach, D.O. Hebb, C.T. Morgan and H.W. Nissen, eds.: The neuropsychology of Lashley. New York, McGraw-Hill Book Company (1960) pp. 345–360.

LEVINE, S.: Psychophysiological effects of infantile stimulation. In: E.L. Bliss, ed.: Roots of behavior. New York, Paul B. Hoeber (1962) pp. 246–253.

LI, C.L., C. CULLEN and H.H. JASPER: Laminar microelectrode analysis of cortical unspecific recruiting responses and spontaneous rhythms. J. Neurophysiol. 19 (1956a) 131–143.

LI, C.L., C. CULLEN and H.H. JASPER: Laminar microelectrode studies of specific somatosensory cortical potentials. J. Neurophysiol. 19 (1956b) 111–130.

LIFTON, R.J.: On death and death symbolism: the Hiroshima disaster. Psychiatry 27 (1964) 191–210.

LINDEMANN, E.: Symptomatology and management of acute grief. Amer. J. Psychiat. 101 (1944) 141–148.

LINDSLEY, D.B.: Emotion. In: S.S. Stevens, ed.: Handbook of experimental psychology. New York, John Wiley & Sons (1951) pp. 473–516.

MACKAY, D.B.: Self-organization in the time domain. In: M.C. Yovits, G.T. Jacobi and G.D. Goldstein, eds.: Self-organizing systems. Washington, Spartan Books (1962) pp. 37–48.

MACLEAN, P.D.: Psychosomatic disease and the 'visceral brain', recent developments bearing on the Papez theory of emotion. Psychosom. Med. 11 (1950) 338–353.

MANDLER, G.: The interruption of behavior. In: D. Levine, ed.: Nebraska symposium on motivation. Lincoln, University of Nebraska Press (1964) pp. 163–220.

MASON, W.A. and R.R. SPONHOLZ: Behavior of rhesus monkeys raised in isolation. J. psychiat. Res. 1 (1963) 299–306.

MELGES, F.T. and C.E. FOUGEROUSSE: Time sense, emotions and acute mental illness. J. psychiat. Res. 4 (1966) 127–139.

MILLER, G.A., E.H. GALANTER and K.H. PRIBRAM: Plans and the structure of behavior. New York, Henry Holt & Comp. (1960).

NAGEL, E.: The structure of science: problems in the logic of scientific explanation. New York, Harcourt, Brace & World, Inc. (1961).

PAPEZ, J.W.: A proposed mechanism of emotion. Arch. Neurol. Psychiat. (Chicago) 38 (1937) 725–743.

PEARL, D. and P. BERG: Time perception and conflict arousal in schizophrenia. J. abnorm. soc. Psychol. 66 (1963) 332–338.

POLLARD, J.C., L. UHR and C.W. JACKSON: Studies in sensory deprivation. Arch. gen. Psychiat. 8 (1963) 435–454.

PRIBRAM, K.H.: Neocortical function in behavior. In: H.F. Harlow and C.N. WOOLSEY, eds.: Biological and biochemical bases of behavior. Madison, (1958) pp. 151–172.

PRIBRAM, K.H.: The intrinsic systems of the forebrain. In: J. Field and H.W. Magoun, eds.: Handbook of physiology. Vol. II. Neurophysiology, Washington, American Physiological Society (1960a) 1323–1344.

PRIBRAM, K.H.: A review of theory in physiological psychology. In: Annual review of psychology. Palo Alto (Calif.), Annual Reviews Inc. (1960b) pp. 1–40.

PRIBRAM, K.H.: Reinforcement revisited: a structural view. In: M. Jones, ed.: Nebraska symposium on motivation. Lincoln, University of Nebraska Press (1963) pp. 113–159.

PRIBRAM, K.H.: Freud's project: an open, biologically based model for psychoanalysis. In: N.S. Greenfield and W.C. Lewis, eds.: Psychoanalysis and current biological thought. Madison, University of Wisconsin Press (1965a) pp. 81–92.

PRIBRAM, K.H.: Proposal for a structural pragmatism: some neuropsychological considerations of problems in philosophy. In: B. Wolman and E. Nagel, eds.: Scientific psychology: principles and approaches. New York, Basic Books (1965b) pp. 426–459.

PRIBRAM, K.H.: The limbic systems, efferent control of neural inhibition and behavior. In: T. Tokizane and J.P. Schadé, eds.: Progress in brain research. New York, Elsevier Publishing Co. (1966) pp. 318–336.

PRIBRAM, K.H.: Steps toward a neuropsychological theory. In: D.C. Glass, ed.: Neurophysiology and emotion. New York, Rockefeller University Press–Russell Sage Foundation (1967) pp. 3–39.

RAPAPORT, D.: The structure of psychoanalytic theory: a systematizing attempt. Psychol. Iss. 2 (1960) 1–158.

ROSENBERG, M.: The association between self-esteem and anxiety. Psychiat. Res. 1 (1962) 135–152.

ROTHSTEIN, D.A.: Psychiatric implications of information theory. Arch. gen. Psychiat. 13 (1965) 87–94.

SCHACHTER, S.: In: D.C. Glass, ed.: Neurophysiology and emotion. New York, Rockefeller University Press–Russell Sage Foundation (1967).

SCHACHTER, S. and J.E. SINGER: Cognitive, social and physiological determinants of emotional state. Psychol. Rev. 69 (1962) 379–397.

SCOTT, J.P.: Hostility and aggression in animals. In: E.L. Bliss, ed.: Roots of behavior. New York, Paul B. Hoeber (1962) pp. 167–178.

SHAGASS, C. and M. SCHWARTZ: Neurophysiological dysfunction associated with some psychiatric disorders. Psychiat. Res. (1963) Rep. 17.

SOKOLOV, E.N.: Neuronal models and the orienting reflex. In: M.A.B. Brazier, ed.: The central nervous system and behavior. New York, Josiah Macy Jr. Foundation (1960) pp. 187–276.

SPINELLI, D.N. and K.H. PRIBRAM: Changes in visual recovery functions produced by temporal lobe stimulation in monkeys. Electroenceph. clin. Neurophysiol. 20 (1966) 44–49.

SPINELLI, D.N. and K.H. PRIBRAM: Changes in visual recovery function and unit activity produced by frontal cortex stimulation. Electroenceph. clin. Neurophysiol. 22 (1967) 143–149.

SPINELLI, D.N., K.H. PRIBRAM and M. WEINGARTEN: Centrifugal optic nerve response evoked by auditory and somatic stimulation. Exp. Neurol. 12 (1965) 303–319.

SPITZ, R.A.: The smiling response: a contribution to the ontogenesis of social relations. Genet. Psychol. Monogr. 34 (1946) 57.

SPITZ, R.A.: Anxiety in infancy: study of its manifestations in first year of life. Int. J. Psycho-anal. 31 (1950) 138–143.

STENBACK, A.: Object loss and depression. Arch. gen. Psychiat. 13 (1965) 144–151.

STEWART, K.D. and W.H. DEAN: Perceptual-cognitive behavior and autonomic nervous system patterns. Arch. gen. Psychiat. 12 (1965) 329–335.

VERNON, J.A. and T.E. MCGILL: Time estimations during sensory deprivation. J. gen. Psychol. 69 (1963) 11–18.

VON BECHTEREW, W.: Die Funktionen der Nervencentra. Berlin, Fischer-Verlag (1911).

WALL, P.D. and K.H. PRIBRAM: Trigeminal neurotomy and blood pressure responses from stimulation of lateral cortex of *Macaca Mulatta*. J. Neurophysiol. 13 (1950) 409–412.

WATZLAWICK, P., J. BEAVIN and D. JACKSON: Pragmatics of human communication; a study of interactional patterns, pathologies and paradoxes. New York, W. W. Norton Co. (1966).

WHITE, R. W.: Ego and reality in psychoanalytic theory. Psychol. Iss. 3 (1963) 1–210.

WOLPE, J.: Psychotherapy by reciprocal inhibition. Stanford, Stanford University Press (1958).

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