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On Brain, Conscious Experience, and Human Agency

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Abstract
Neuropsychologist Karl Pribram tells of what 20th-century brain research and psychology from the time of Freud and William James into the 1990s has discovered about the basic equipment for the active mind we humans bring to evolution.

Key words
Brain, brain and behavior, plans, *Plans and the Structure of Behavior*, cognitive science, feedback, feedforward, Freud, excitation, neural inhibition, images, holographic processes, consciousness, unconsciousness, William James, intentionality, attention, volition, feelings, emotion, motivation, perception, frontolimbic forebrain, transcendental consciousness and spirituality, Laszlo's quantum-vacuum field theory.

Western thought has alternated between two views of humanity's relation to the Universe: One view holds the human organism to be passively shaped by the environment. The other emphasizes an active role, manipulative and selective not only of artifacts but of sense data as well. Recent neuropsychological contributions to behavioral science point to a resurgence of the latter view, emphasizing once again the dignity of the human as a scientific as well as a political and humanistic tenet.
(Paraphrased from Pribram, 1963, pp. 101–111)

The Issue. Over the past two centuries, since the pioneering observations of Frances Gall (1809–1969), it has become common knowledge that there is a special relation between brain tissue and the variety of conscious experiences. Gall initiated the procedure of comparing the locus of brain pathology with aberrations of behaviors of the patients whose brains he examined—a procedure which is continued today in the active field of clinical neuropsychology. Gall inaugurated the view that the faculties of mind are based in brain function. When Gall applied for admission to the French Academy of Science, his view was countered by Napoleon, who felt that evil would be stamped out by appropriate social innovation (see Pribram, 1969).

Though on the whole we today accept the special relation between brain and conscious experience, we are not at all agreed upon the basic nature of the relationship nor, any more than in 1800, upon the consequences our understanding of this nature might have for our understanding of ourselves as agents in our relation to our physical environment and in our relation to others.

Despite such apparent disagreements, brain research *has* shown that physical and social environments become enmeshed by sensory and neural processes to make up our conscious experiences. This chapter reviews some of this research as *I* have experienced it. The dictionary definition of experience is "to try." The research findings reported here have certainly "tried me," and I am seriously "trying" to collate and communicate them so others can also experience them. Perhaps the most trying of these collations is to bring them into harmony with those presented by Laszlo regarding quantum-vacuum field theory and its impact on the human condition. Section 5 of this chapter does at least take a step in this direction.

Section 1 traces my journey of a half-century of research, with special emphasis on the concept of *plans as guides to action* and *images (especially images of achievement) as the origins of the guides.* Section 2 grounds this research as it entails *states of mind* as these were described in the works of William James, Franz Brentano and Sigmund Freud. Section 3 organizes my research results regarding the topics *attention and volition*, which relate states to content and contents to states. Section 4 deals with research in perception—the *contents of consciousness*, especially with the distinction between an allo- and egocentric appreciation of a corporeal "me" versus a narrative "I" composed of episodes and events. Section 5 provides a transcendental synthesis.

1. Sources of a Model of Brain Functions in Consciousness

Some Case Histories

A patient has a tumor removed from the occipital lobe on one side of his brain. The surgery leaves him unable to report the sight of objects presented to him on the side opposite the removal, yet he can correctly point to the location of the objects and even correctly respond to differences in their shape (Weiskrantz, Warrington *et al.*, 1974; Weiskrantz, 1986). Even when repeatedly told that he is responding well, he insists that he is not aware of seeing anything and is only guessing. This is called blind-sight.

A similar occurrence follows a stroke or other injury to the parietal lobe. Now the arm and hand on the side of the body opposite to the injury perform automatically without the conscious participation of the person. One such patient called her absent-from-conscious arm "Alice," and noted that "Alice doesn't live here anymore" (Pribram and Bradley, 1997).

Another patient has the medial structures of the temporal lobes of his brain removed on both sides. He performs well on tests of immediate memory such as recalling a telephone number just read out loud to him, but a few minutes later is not only unable to recall the number but the fact that he had heard a number or even that he had been examined. Even after 20 years of regular exposure to an examiner, the patient fails to recognize her as familiar (Scoville and Milner, 1957). Yet, this same patient, when trained to respond skillfully to a complex task or to discriminate between objects, etc., can be shown to maintain such performances over years despite the disclaimer on his part that he was ever exposed to such a tasks (Sidman *et al.*, 1969).

Still another patient with a similar but more restricted bilateral lesion of her temporal lobe has gained over a hundred pounds of weight since surgery. She is a voracious eater, but when asked whether she is hungry or has any special appetites, she denies this, even when apprehended in the midst of grabbing food from other patients (Pribram, 1965).

This is not all. A patient may have the major tracts connecting his cerebral hemispheres severed with the result that his responses to stimuli presented to him on opposite sides are treated independently of one another. His right side is unaware of what his left side is doing and vice versa. The splitting of the brain has produced a split in awareness (Sperry, 1980; Gazaniga, 1985).

More common in the clinic are patients who are paralyzed on one side due to a lesion of the brain's motor system. But the paralysis is manifest especially when the patient attempts to follow instructions given to him or which he himself initiates. When highly motivated to perform well-ingrained responses, as when a fire breaks out or as part of a more general action, the paralysis disappears. Only intentional, volitional control is influenced by the lesion.

Observations such as these have set the problems that brain scientists need to answer. Not only do they demonstrate the intimate association that exists between brain and human experienced consciousness, they also make it necessary to take into account the dissociation between conscious awareness, feelings, and intentions on the one hand and unconscious, automatic behavioral performances on the other.

Perhaps it is not too surprising therefore that a division in approach to the mind–brain problem has recently occurred. While behavioral scientists and neuroscientists have, for the most part, eschewed a Cartesian dualism in an attempt at rigorous operational and scientific understanding, some thoughtful brain scientists and philosophers have inveterately maintained a dualistic stance (Popper and Eccles, 1977). A brief review of my own struggles with the problem may be helpful in posing some of the issues involved.

Plans

The struggle began modestly with a recounting in the late 1950s and early 1960s of case histories such as those used above. These were presented as an antidote to the radical behaviorism that then pervaded experimental psychology (Pribram, 1959/1962). The formal properties of a more encompassing view were presented in terms of a computer programming analogy in *Plans and the Structure of Behavior* (Miller *et al.*, 1960) under the rubric of a "Subjective Behaviorism." The analogy has since become a fruitful model or set of models known as "Cognitive Science," which, in contrast to radical behaviorism, has taken verbal reports of subjective conscious experience seriously into account as problem areas to be investigated and data to be utilized.

Computer programming has proved an excellent guide to understanding and experimental analysis. Further, a host of control engineering devices have been known to serve as models for the brain scientist. Of special interest here is the distinction that can be made among such models between feedback and feedforward operations, a distinction that is critical to our understanding of the difference between automatic and voluntary control of behavior.

Feedback organizations operate like thermostats—for example, Cannon's (1927) familiar homeostatic brain processes that control the physiology of the organism. More recently it has become established that sensory processes also involve such feedback organizations (see Miller *et al.*, 1960 and Pribram, 1971, chs. 3, 4, and 11, 1990 for review). Thus, feedback control is one fundamental of brain organization.

But another fundamental has emerged in the analyses of brain function. This fundamental goes by the name of feedforward, or information processing (see, e.g., McFarland, 1971, ch. 1). I have elsewhere (Pribram, 1971, ch. 5, 1981; Pribram and Gill, 1976, ch. 1) detailed my own understanding of feedforward mechanisms and their relation to the feedback control. Briefly, I suggest that feedbacks are akin to the processes described in the first law of thermodynamics (the law of conservation of energy) in that they are error processing, reactive to magnitudes of change in the constraints that describe a system. They operate to restore the system to the state of equilibrium. By contrast, feedforward organizations process "information" that increases the degrees of freedom of the system.

The manner by which feedforward is accomplished is often portrayed in terms of Maxwell's demon and Szilard's solution to the problem posed by these "demons," that is, how energy can be conserved across a boundary (a system of constraints), a boundary that "recognizes" certain energy configurations and lets them pass while denying passage to others (see Brillouin, 1962, for review). In such a system the energy consumed in the recognition process must be continually enhanced or the "demon" in fact tends to disintegrate from the impact of random energy. Feedforward operations are thus akin to processes described by the second law of thermodynamics, which deals with the amount of organization of energy, not its conservation. Information has often been called neg-entropy (see, e.g., Brillouin, 1962; Pribram, 1991, Lecture 2), entropy being the measure of the amount of disorganization or randomness in a system. In the section on volition we will return to these concepts and apply them to the issues at hand.

19th-century psychophysicists and psychophysiology dealt directly with feedforward operations. Thus Helmholtz (1924) describes the mechanism of voluntary control of eye movements in terms of a parallel innervation of the muscles of the eye and a "screen" upon which the retinal input falls so that voluntary eye movements are accompanied by a corollary corrective innervation of the cerebral input systems. When the eyeball is pushed by a finger, this corrective innervation is lacking, and the visual world jumps about. Brindley and Merton (1960) performed the critical experiment: When the eye muscles are paralyzed and a voluntary eye movement is undertaken, the visual world rushed by even though the eye remains stationary.

Of especial interest is the fact that Freud (1895/1966) anticipated this distinction between feedback and feedforward in his delineation of primary and secondary processes (Pribram and Gill, 1976). Freud distinguished three types of neural mechanisms that constitute primary processes. One is muscular discharge; a second is discharge into the blood stream of chemical substances; and a third is discharge of a neuron onto its neighbors. All three of these neural mechanisms entail potential or actual feedback. Muscular discharge elicits a reaction from the environment and a sensory report of the discharge (kinesthetic) to the brain. The neurochemical discharge results, by way of stimulation of other body chemicals to which the brain is sensitive, in a positive feedback, which Freud labels "the generation of unpleasure." (This is the origin of the unpleasure—later the pleasure—principle.) Discharge of a neuron onto its neighbors is the basis of associative processes that lead to a reciprocal increase in neural excitation (cathexis) between neurons (a feedback), which is the basis for facilitation (a lowering of resistance) of their synapses (learning).

By contrast, secondary or cognitive processes are based on a host of hierarchically arranged neural mechanisms that delay discharge through neural inhibition. These delays convert wishes (the sum of excitatory facilitations) to willed voluntary acts by allowing attention (a double feedback that matches the wish to external input—a double comparison process that allows control to be exercised as in setting a thermostat by hand) to operate a reality-testing mechanism. Thus, an attentional conscious comparison process is an essential mechanism allowing voluntary cognitive operations to occur.

For Freud and 19th-century Viennese neurology in general, consciousness and the resultant voluntary behavior was a function of the cerebral cortex. Thus the greater portion of brain, which is noncortical, regulates behavior of which we are not aware—behavior that is automatic and unconscious. What then do we know about cortical function and conscious awareness?

Images

Thus plans are not enough. As indicated by the case histories described earlier, today's neuroscientist shares with 19th-century neurology the necessity to understand the special role of the brain cortex in the constructions that constitute consciousness. Freud tackles that problem by distinguishing the "qualitative imaging" properties of sensations from the more quantitative properties of association, memory, and motivation. The distinction remains a valid one today: In *Plans and the Structure of Behavior* the sums of these tests, the comparisons between input and report of the consequences of operations, are called "images." How then are "images" constructed by the brain cortex?

Images are produced by a brain process characterized by a precisely arranged anatomical array that maintains a topographic isomorphism between receptor and cortex but that can be seriously damaged or destroyed (up to 90 percent) without impairing the capacity of the remainder to function in lieu of the whole. These characteristics led me to suggest in the mid-1960s (Pribram, 1966) that in addition to the digital computer, brain models need to take into account the type of processing performed by optical systems. Such optical information processing is called holography, and holograms display exactly the same sort of imaging properties observed for brain; namely, a precisely aligned process that distributes information. In the brain the anatomical array serves the function of paths of light in optical systems and horizontal networks of lateral inhibition perpendicular to the array serve the function of lenses (Pribram, 1971; Pribram *et al.*, 1974).

I have proposed specific brain functions to be responsible for the organization of neural holographic-like processes (Pribram, 1971, chs. 1 and 2). This proposal involves the graded electrical potential changes—changes in polarizations—that occur at junctions between neurons and in their dendrites. Inhibitory interactions (by hyperpolarizations) in horizontal networks of neurons that do not generate any nerve impulses are the critical elements. Such inhibitory networks are becoming more and more the focus of investigation in the neurosciences. For instance, in the retina, they are responsible for the organization of visual processes—in fact, nerve impulses do not occur at all in the initial stages of retinal processing (for review see Pribram 1971, chs. 1 and 3). The proposal that image construction in man takes place by means of a neural holographic-like process is thus spelled out in considerable detail, and departs from classical neurophysiology only in its emphasis on the importance of computations achieved by a web of reciprocal influences among graded, local polarizations, which are well-established neuropsychological entities. No new neurophysiological principles need be considered.

For the mind–brain issue, the holographic model is of special interest because the image that results from the holographic process is projected away from the hologram that produces it. We need therefore to be less puzzled by the fact that our own images are not referred to eye or brain, but are projected into space beyond. Von Bekesy (1967) has performed an elegant series of experiments that detail the process (lateral inhibition—the analogue of lenses in optical systems) by which such projection comes about. Essentially the process is similar to the one that characterizes the placement of auditory images between two speakers in a stereophonic music system.

From this fact, it can be seen how absurd it is to ask questions concerning the "locus" of conscious experience. The brain processes organize our experience—

but that experience is not of the brain process per se but of the resultant of its function. One would no more find "consciousness" by dissecting the brain than one would find "gravity" by digging into the Earth.

Over the past decades important advances have occurred in our understanding of brain holographic-like processing. Research results have shown that the best mathematical description of the process is holonomic rather than purely holographic—that is, the analogy with a patch or strip hologram serves better than that of an undivided, unlimited hologram. In a patch hologram the holographic surface is made up of patches of hologram spatially ordered with respect to one another. Each patch is bounded and is thus described by what Denis Gabor (1946), the inventor of the hologram, described as a "quantum" of information. The brain process can therefore be conceived as an information process in which the units are quanta of information (Pribram and Carlton, 1986; Pribram, 1990).

Another development has been a system of programming that derives from holography and simulates the properties of neural processing. These "neural networks" implement parallel distributed processing (PDP) in currently available computers (Rumelhart and McClelland, 1986). Computer programming and optical holography thus provide metaphors, analogies, and models of processes that, when tested against the actual functions of the primate brain, go a long way toward explaining how human voluntary and imaging capabilities can become differentiated from unconscious automatic processes by the human brain.

2. Dimensions of Conscious States

States of Mind

What we mean by conscious experience is most readily illustrated by asking the following question: would you say that your pet dog is conscious? Why, you answer, of course he is. We all attribute awareness to organisms when they mind their environment, when they appear to pay attention. The behaviorist philosopher Gilbert Ryle (1949) made note of this when he pointed out that the English term "mind" is derived from minding—and William James in his *Principles of Psychology* (1901/1950) asks whether in fact we need the term "consciousness" since what we mean by it is so intimately interwoven with attention and its limited span. We ordinarily distinguish consciousness from unconsciousness much as do the physician and surgeon: when someone responds to prodding (e.g., by grumbling "Oh leave me alone! Can't you see I'm trying to get some sleep!") we attribute to him a conscious state. When, on the other hand, his response is an incoherent thrashing about, we say he is stuporous, and if there is no response at all, we declare him comatose.

Note that we are now distinguishing between various nervous system *states* that for the most part are subcortical and that are coordinate with such states of consciousness as sleep and wakefulness and states of unconsciousness–unresponsiveness (such as stupor and coma). The interesting thing about such states is their mutual exclusiveness regarding experience: what is experienced in one state is not available to experience in another. Such state exclusiveness emerges in all sorts of observations: state-dependent learning in animal and human experiments; the fact that salmon spawning pay no attention to food, while when they are in their feeding state sexual stimuli are ignored; the observation in hypnosis that a person can be made unaware post-hypnotically of suggestions made during hypnosis (although he carries out these suggestions) and the dissociation between experiences (and behavior) taking place during "automatisms" in temporal lobe epileptics and what is experienced in their ordinary state. I would add to these the mutual exclusiveness of natural language systems that make translation so difficult.

The evidence obtained in all of these situations suggests that the same basic neural substrate becomes variously organized to produce one or another state. Hilgard (1977) and I (Pribram and Gill, 1976) have conceptualized this substrate as being subject to rearrangements similar to those that take place in a kaleidoscope: a slight rotation and an entirely new configuration presents itself. Slight changes in relative concentrations of chemicals and/or in neural depolarizations and hyperpolarizations in specific neural locations could, in similar fashion, result in totally different states.

Intentionality as Characteristic of the Human Condition

William James distinguishes consciousness from self-consciousness and suggests that self-consciousness occurs when we become aware of states of bodily functions. James sees no special problem here, but his contemporary Brentano (Freud's teacher) identifies the issue of self-consciousness as central to what makes man human.

The emphasis by Brentano is on intentional consciousness, which arises from the distinction between the contents of awareness and the person who is aware; the duality between subjective mind and objective matter (brain), which also holds in the writings of Ernst Mach (1914) and of René Descartes (1927). Although Cartesian dualism is perhaps the first overt nontrivial expression of the issue, the duality between subject and object and some causal connection between them is inherent in language once it emerges from simple naming to predication. Neumann (1954) and Jaynes (1977) have suggested that a change in consciousness occurs somewhere between the time of the Iliad and the Odyssey. My interpretation of this occurrence links it to the invention and promulgation of phonemically based writing. Prehistory was transmitted orally/aurally. Written history is visual/verbal. In an oral/aural culture a greater share of reality is carried in memory and is thus personal; once writing becomes a ready means of recording events they become a part of extrapersonal objective reality. The shift described is especially manifest in a clearer externalization of the sources of conscience—the gods no longer speak within the person to guide individual man and woman.

Ever clearer distinctions between personal and extrapersonal objective realities culminates in Cartesian dualism and Brentano's "intentional inexistence," which was shortened by Husserl to "intentionality." It is this reading of the subject–object distinction that philosophers ordinarily mean when they speak of the difference between conscious and unconscious processes.

Brentano derives his analysis from the scholastics and uses intentionality—the "aboutness" of perceptions, that experience is about something—as the key concept to distinguish observed from observer, the subjective from the objective. I have elsewhere (Pribram, 1976) somewhat simplified the argument by tracing the steps from the distinction between intentions and their realization in action, to perceptions and their realization as the objective world.

How is Brentano's distinction between subject and object related to the dualism of Descartes? Brain must always be a part of the objective world even if it is the organ critically responsible for the subjective—from which in turn the objective is constructed. Brentano is perfectly clear on this point and suggests that the study of intentional consciousness is the province of the philosopher–psychologist, not the brain physiologist. However, clinical neuropsychological experience amply demonstrates that brain physiology does in fact have something to say even about intentional consciousness. The case histories presented at the outset of this paper make Brentano's general point perhaps more strongly than any philosophical argument: minding is of two sorts, instrumental and intentional. However, as these and other case histories show, neuroscience has a great deal to say about *both* instrumental *and* intentional consciousness, more in line with James's formulation than with Brentano's. Of special interest is the fact that a pupil of Brentano's, Sigmund Freud, as an outstanding neurologist, also became in his psychoanalytical investigation the champion of the distinction between conscious and unconsciousness processes in determining everyday and pathological behavior, but did not follow Brentano's dictum that intentional conscious experience be left to philosophical investigation. Instead, he opted for an investigation in psychological *science* (Pribram and Gill, 1976).

Consciousness and Unconscious States

Instrumental determinants of consciousness are *not* what Freud or most philosophers have meant by the term. Freud had training both in medical practice and in philosophy. When he emphasized the importance of unconscious states, was he applying the medical definition or the philosophical? Did he mean instrumental consciousness to be "the unconscious"? Most interpretations of Freud suggest that unconscious states operate without awareness in the sense that they operate automatically, much as do respiratory and gastrointestinal processes in someone who is stuporous or comatose. Freud himself seems to have promulgated this view by suggesting a "horizontal" split between conscious, preconscious and unconscious states with "repression" operating to push memory-motive structures into deeper layers where they no longer access awareness. Still in Freud's *Project for a Scientific Psychology* memory-motive structures are neural programs—located in the core portions of the brain that access awareness by their connections to cortex. When the neural program becomes a secondary process, it comes under voluntary control, which involves reality testing and thus consciousness. To use language as an example, one might well know two languages but at any one time "connect only one to cortex," and thus the other remains "unconscious" and unexpressed.

The linking of intentional consciousness to cortex is not as naive as it first appears. As the recently reported cases of Weiskrantz *et al.* (1974; Weiskrantz, 1986) that introduced this chapter have shown, "blind-sight" results when patients are subjected to unilateral removal of the visual cortex. As noted, these patients insist they cannot see anything in the field contralateral to their lesion, but when tested they can locate and identify large objects in their blind hemifield with remarkable accuracy. Furthermore, there are patients with unilateral neglect following parietal lobe lesions (see Pribram and Bradley, 1997; Heilman and Valenstein, 1972, for review). Neglect patients often can get around using their neglected limbs appropriately. Thus, blind-sight indicates that a cortical system is involved in determining an *allocentric*, objective world while somatosensory neglect indicates, as William James suggested, that an *egocentric* subjective aspect to consciousness is also organized by a brain system. H.M., the patient described in the introduction who sustained an amygdala-hippocampal resection, has been trained in operant tasks and the effects of training have persisted without decrement for years, despite protestations from the patient that he doesn't recognize the situation and that he remembers nothing of the training (Sidman *et al.*, 1969). In monkeys with such lesions we have shown almost perfect retention of training after a two-year period, retention that is better than that shown by unoperated control subjects. These monkeys and H.M., the blind-sight and neglect patients, are clearly conscious in the medical instrumental sense. What has gone wrong is their ability to reflect on their behavior and experience, an inability within the impaired sphere of clearly distinguishing personal from extra-personal reality. This leaves them with impaired consciousness in the philosopher's sense: behavior and experience are no longer intentional.

The thrust of contemporary psychoanalytical thinking, as well as that of experimentalists such as Hilgard (noted above), is in the direction of interpreting the conscious–unconscious distinction in the philosophical sense. For instance, Matte Blanco (1975) proposes that consciousness be defined by the ability to make clear distinctions, to identify alternatives. Making clear distinctions would include being able to tell personal from extrapersonal reality. By contrast, unconscious processes would, according to Matte Blanco, be composed of infinite sets "where paradox reigns and opposites merge into sameness." When infinities are being computed the ordinary rules of logic do not hold. Thus, dividing a line of infinite length results in two lines of infinite length, that is, one equals two. Being deeply involved allows love and ecstasy but also suffering and anger to occur. In keeping with this, Carl Jung (1960) defined unconscious processes as those involving feelings.

My interpretation of this conscious–unconscious distinction as it relates to *human* behavior and experience is in line with Matte Blanco's and others that are closely related to the philosophical distinction, and not to the medical. Thus, bringing the wellsprings of behavior and experience to consciousness means the making of distinctions, to provide alternatives, to make choices, to become informed in the Shannon (Shannon and Weaver, 1949) sense of reduction of uncertainty. One of these distinctions distinguishes episodes of *feeling* states and relates them to one another.

An important change in views becomes necessary when these interpretations are considered seriously: unconscious states as defined by psychoanalysis are not completely "submerged" and unavailable to experience. Rather, they produce feelings that are difficult to localize in time or in space and difficult to identify correctly. The unconscious states provide the emotional dispositions and motivational context within which extrapersonal and personal realities are constructed. As the classical experiments of Schachter and Singer (1962) showed, feelings are to a large extent undifferentiated, and we tend to cognize and label them according to the circumstances in which the feelings become manifested. (For a recent review of other experiments that have led to such a view see Hermans *et al.*, 1992.)

It is in this sense that behavior comes under the control of the unconscious states. When I have burst out in anger, I am certainly aware that I have done so and of the effects of the anger on others. I may or may not have monitored the build-up of feeling prior to the blow-up. And I may have projected the build-up onto others or introjected it from them. But I could have been aware of all this (with the guidance of a friend or therapist) and still found myself in uncontrolled anger. Only when the events leading to the anger become clearly separated into alternative or harmoniously related distinctions is unconscious control converted into conscious control. It is ridiculous to think that a person with an obsession or compulsion is unaware, in the instrumental sense, of his experience or behavior. The patient is very aware and feels awful. But he cannot, without aid, differentiate controls on the behavior generated by his feelings.[1]

3. Attention and Volition as Conscious Processes

Consciousness and Attention

Just as did Freud, William James (1901/1950) emphasized that most of the issues involved in delineating "consciousness" from unconscious states devolve on the process of attention. James, however, took the problem one step further by pointing out that attention sets limits on competence—the limits of attention span. As noted, Gilbert Ryle (1949) has reminded us that in fact the term "mind" is derived from "minding," that is, attending.

For a half a century my laboratory (as well as many others) has been investigating the neural mechanisms involved in attention. A comprehensive review of these data (Pribram and McGuinness, 1975, 1992) discerned three such controlling processes: one deals with short phasic response to an input (arousal and familiarization); a second relates to tonic readiness of the organism to respond selectively (activation and selection); and a third (effort and comfort) acts to coordinate the phasic (arousal) and tonic (activation) mechanisms. Separate neural and neurochemical systems (Pribram, 1977a, 1990; Pribram and McGuinness, 1992) are involved in the phasic (arousal) and tonic (activation) processes: the phasic centers on the amygdala; the tonic, on the basal ganglia of the forebrain. The coordinating system (effort) critically involves the hippocampus, a phylogenetically ancient part of the neural apparatus.

Evidence (reviewed by Pribram and McGuinness, 1992) from the analysis of changes in the electrical activity of the brain evoked by brief sensory stimulation has shown that the arousal and activation systems operate on some more basic process centered on the dorsal thalamus, the way-station of sensory input to the cerebral cortex. Brain electrical activity evoked by sensory stimulation can be analyzed into components. Early components reflect processing via systems that directly (via the thalamus) connect sensory surfaces with cortical surfaces. Later components reflect processes initiated in the thalamocortical and related basal ganglia systems that operate downward onto the brain stem (tectal region), in turn, influencing a thalamic "gate" that modulates activity in the direct sensory pathways. It is the activity reflected in these later components of the brain electrical activity that constitutes "activation."

The thalamic "gate" is, however, also regulated by input from the system centered on the amygdala—the arousal system. This system, when stimulated, produces an effect on the "gate" opposite to that of the activation system.

The evidence also indicates that the coordination of phasic (arousal) and tonic (activation) attentional processes often demands "effort." When attention must be "paid," the hippocampal system becomes involved and influences the arousal system rostrally through frontal connections with the amygdala system and influences the activation system caudally via connections in the brain stem. Paying attention becomes conscious in the intentional sense. Thus at this juncture the relation of attention to intention as used in the ordinary sense—that is, volition and will—comes into focus. Again, William James had already pointed out that a good deal of what we call voluntary effort is the maintaining of attention or the repeated returning of attention to a problem until it yields solution.

Consciousness and Volition

William James had apposed will to emotion and motivation (which he called "instinct"). Here, once again, brain scientists have had a great deal to say. Beginning with Walter Cannon's (1927) experimentally based critique of James, followed by Lashley's critique of Cannon (1960), to the anatomically based suggestions of Papez (1937) and their more current versions by MacLean (1949), brain scientists have been deeply concerned with the processes that organize emotional and motivational experience and expression. Two major discoveries have accelerated our ability to cope with the issues and placed the earlier more speculative accounts into better perspective. One of the discoveries has been the role of the reticular formation of the brain stem (Magoun, 1950) and its chemical systems of brain amines (see, e.g., review by Barchas *et al.*, 1982; Pribram and McGuinness, 1992) that regulate states of alertness and mood. Lindsley (1951) proposed an activation mechanism of emotion and motivation on the basis of the initial discovery and has more recently (Lindsley and Wilson, 1976) detailed the pathways by which such activation can exert control over brain processes. The other discovery, by Olds and Milner (1954), is of the system of brain tracts that, when electrically excited, results in reinforcement (increase in probability of recurrence of the behavior that has produced the electrical brain stimulation) or deterrence (decrease in probability that such behavior will recur).

In my attempts to organize these discoveries and other data that relate brain mechanisms to emotion, I found it necessary (as had Darwin, 1872) to distinguish clearly between those data that referred to experience (feelings) and those that referred to expression, and further to distinguish emotion from motivation (reviewed by Pribram, 1971). Thus feelings were found to encompass both emotional and motivational experience—emotional as affective (arousal and familiarization) and motivation as centered on a readiness (activation and selection).

The wealth of new data and these insights obtained from them made it fruitful to reexamine the Jamesian positions with regard to consciousness and unconscious processes (Pribram, 1981). I found James in error (a) in his overemphasis on the visceral determination of emotional experience (attitudinal factors depending on sensory feedback from the somatic musculature were included by James but not emphasized) and (b) in his failure to take into consideration the role of expectations (the representational role of the organization of familiarity and, therefore, novelty) in the organization of emotions. On the other hand, James had rightly emphasized that emotional processes take place primarily within the organism while motivation and volition will reach beyond into the organism's environment. Further, I found that James was almost universally misinterpreted as holding a peripheral theory of emotion and mind. Throughout his writings he emphasizes the effect that peripheral stimuli (including those of visceral origin) exert on brain processes. The confusion comes about because of James's insistence that emotions concern bodily processes, that they stop short at the skin. Nowhere, however, does he identify emotions with these bodily processes. Emotions are always the resultant of their effect on the brain. James is in fact explicit on this point when he discusses the nature of the input to the brain from the viscera. He points out two possibilities: emotions are processed by a separate brain system, or they are processed by the same systems as are perceptions. Today, we know that both possibilities are realized: parts of the frontolimbic forebrain (especially the amygdala and related systems) process visceroautonomic bodily inputs, and the results of processing become distributed via brain stem systems that diffusely influence the perceptual systems (Pribram 1961, 1991).

The distinction between the brain mechanisms of motivation and will are less clearly enunciated by James. He grapples with the problem and sets the questions that must be answered. Clarity did not come until the 1960s, when several theorists (e.g., MacKay, 1966; Mittlestaedt, 1968; Waddington, 1957; R. Ashby, personal communication, 1970; McFarland, 1971; Pribram 1971) began to point out the difference between feedback, homeostatic processes on the one hand and programs, which are feedforward, homeorhetic processes, on the other. Feedback processes depend on error processing and are therefore sensitive to perturbations. Feedforwards, by contrast, process information.

Clinical neurology had classically distinguished the mechanisms involved in voluntary from those involved in involuntary behavior. The distinction rests on the observation that lesions of the cerebellar hemispheres impair intentional (voluntary) behavior, while basal ganglia lesions result in disturbances of involuntary movements. Damage to the cerebellar circuits is involved in a feedforward rather than a feedback mechanism (as already described by Ruch in the 1951 Stevens *Handbook of Experimental Psychology*, although Ruch did not have the term "feedforward" available to him). I have extended this conclusion (Pribram, 1971) on the basis of microelectrode analyses by Eccles *et al.* (1967) to suggest that the cerebellar hemispheres perform calculations in fast-time; that is, they extrapolate where a particular movement would end were it to be continued and send the results of such a calculation to the cerebral motor cortex, where they can be compared with the target to which the movement is directed. Experimental analysis of the functions of the motor cortex had shown that such targets are composed of "Images of Achievement" constructed in part on the basis of past experience (Pribram, 1971, chs. 13, 14 and 16, 1991, Lecture 6; Pribram *et al.*, 1955/1956, 1984).

Just as the cerebellar circuit has been shown to serve intentional behavior, the basal ganglia have been shown to be important to involuntary processes. We have already noted the involvement of these structures in the control of activation, the readiness of organisms to respond. Lesions in the basal ganglia grossly amplify tremors at rest and markedly restrict expressions of motivational feelings. Neurological theory has long held (see, e.g., Bucy, 1944) that these disturbances are due to interference by the lesion of the normal feedback relationships between basal ganglia and cerebral cortex. In fact, surgical removals of motor cortex have been performed on patients with basal ganglia lesions in order to redress the imbalance produced by the initial lesions. Such resections have proved remarkably successful in alleviating the often distressing continuing disturbances of involuntary movement that characterize these basal ganglia diseases.

So far we have noted that experience can be classified as instrumental or intentional to differentiate conscious from unconscious states. We have also explored intentionality in terms of the attentional and volitional processes that activate intentional states to heed certain contents. We now proceed to review the organizations of conscious content initiated and achieved by these states and processes.

4. Perception—The Contents of Consciousness

Objective Consciousness—The Posterior Cerebral Convexity

Surrounding the major fissures of the primate brain lie the terminations of the sensory and motor projection systems. Rose and Woolsey (1949) and Pribram (1960) have labeled these systems "extrinsic" because of their close ties (by way of a few synapses) with peripheral structures. The sensory surface and muscle arrangements are mapped more or less isomorphically onto the perifissural cortical surface by way of discrete, practically parallel lines of connecting fiber tracts. When a local injury occurs within these systems a sensory scotoma, or a scotoma of action, ensues. A scotoma is a spatially circumscribed hole in the "field" of interaction of organism and environment: a blind spot, a hearing defect limited to a frequency range, a location of the skin where tactile stimuli fail to be responded to. These are the systems where what Henry Head (1920) called "epicritic processing" takes place. These extrinsic sensory-motor projection systems are so organized that movement allows the organism to map an "objective" experience and project the results of processing away from the sensory (and muscular) surfaces.

In between the perifissural extrinsic regions of cortex lie other regions of cortex variously named "association cortex" (Fleschig, 1900), "uncommitted cortex" (Penfield, 1969), or "intrinsic cortex" (Pribram, 1960). These names reflect the fact that there is no apparent direct connection between peripheral structures and these regions of cortex that make up most of the convexity of the cerebrum.

Corporeal and Extracorporeal Reality

Lesions of the intrinsic cortex of the posterior cerebral convexity result in sensory-specific agnosias in both monkey and man. Research on monkeys has shown that these agnosias are not due to failure to distinguish cues from one another, but due to *making use* of those distinctions in making choices among alternatives (Pribram and Mishkin, 1955; Pribram, 1969). This ability is the essence of information processing in the sense of uncertainty reduction (Shannon and Weaver, 1949), and the posterior intrinsic cortex determines the range of alternatives, the sample size that a particular informative element must address. A patient with agnosia can tell the difference between two objects but does not know what the difference means. As Charles Peirce (1934) once noted, what we mean by something and what we mean to do with it are synonymous. In short, alternatives, sample size, choice, cognition, information in the Shannon sense, and meaning are closely interwoven concepts. Finally, when agnosia is severe it is often accompanied by what is termed "neglect." The patient appears not only not to know that he doesn't know but to actively deny the agnosia. Typical is a patient I once had who repeatedly had difficulty in sitting up in bed. I pointed out to her that her arm had become entangled in the bedclothes—she would acknowledge this momentarily, only to "lose" that arm once more in a tangled environment. Part of the perception of her body, her corporeal consciousness seems to have become extinguished.

In monkeys the disturbances produced by restricted lesions of the convexal intrinsic cortex are also produced by lesions of the parts of the basal ganglia (implicated in activation, readiness) to which those parts of the cortex project. Further, recent experiments have shown that the neglect syndrome can be produced in monkeys by lesions of the dopaminergic nigrostriatal system (Wright, 1980). This special connection between intrinsic (recall that this is also called "association") cortex and the basal ganglia further supports the conception that these systems make possible, on the basis of use, the distinction between an egocentric objective corporeal self (the "me") and an extracorporeal allocentric experience (see Pribram, 1991, Lecture 6 for detailed exposition of how this process operates). However, this objectively experienced "me" can be sharply distinguished from a subjectively experienced "I." An excellent review of the history of differentiating this corporeal objective "me" from a subjective "I" can be found in Hermans *et al.*, (1992). The next section develops the relation between brain processing and the "I."

Narrative Consciousness—The Frontolimbic Forebrain

As is well known, frontal lesions were produced for a period of time in order to relieve intractable suffering, compulsions, obsessions, and endogenous depressions. When effective in the relief of suffering and depression, these psychosurgical procedures revealed in humans the now well-established functional relationship between frontal intrinsic cortex and the limbic forebrain. This relationship was established by research undertaken in nonhuman primates as a result of clinical experience (Pribram 1950, 1954, 1958). Further, frontal lesions can lead either to perseverative, compulsive behavior or to distractibility in monkeys, and this is also true of humans (Pribram *et al.*, 1964; Oscar-Berman, 1975). Thus, a failure to be guided by the outcomes or the consequences of a patient's behavior can be accounted for—as well as its opposite: the alleviation of obsessive–compulsive behavior. Extreme forms of distractibility and obsession are due to a lack of "sensitivity" of a selective readiness process to feedback from consequences. Both the results of experiments with monkeys (Pribram, 1959/1962) and clinical observations attest to the fact that subjects with frontal lesions, whether surgical, traumatic, or neoplastic, fail to be guided by consequences (Luria *et al.*, 1964; Konow and Pribram, 1970).

Consequences are the outcomes of behavior. In the tradition of the experimental analysis of behavior, consequences are reinforcers that influence the recurrence of the behavior. Consequences are thus a series of events (Latin *ex-venire*, out-come), outcomes that guide action and thereby attain predictive value (confidence estimates). Such consequences—that is, sequences of events that form their own confidential context—become in humans, envisioned eventualities (Pribram, 1964, 1971, 1991, Lecture 10 and Appendix G).

Confidence implies familiarity. Experiments with monkeys (Pribram *et al.*, 1979) and humans (Luria *et al.*, 1964) have shown that repeated arousal to an orienting stimulus habituates; that is, the orienting reaction gives way to familiarization. Familiarization is disrupted by limbic (amygdala) and frontal lesions (Pribram *et al.*, 1979; Luria *et al.*, 1964). Ordinarily orienting leads to repeated distraction and thus a failure to allow consequences to form. When the process of familiarization is disrupted, the outcomes-of-behaviors, or events, become inconsequential. When intact, the familiarization process is segmented by orienting reactions into episodes within which confidence values can become established.

In such an episodic process the development of confidence is a function of coherences and correlations among the events being processed. When coherence and correlation span multiple episodes, the organism becomes *committed* to a course of action (a prior intention, a strategy), which then guides further action and is resistant to perturbation by particular orienting reactions (arousals). The organism is now *competent* to carry out the action (intention-in-action, or tactic). Particular outcomes now guide competent performance; they no longer produce orienting reactions (Brooks, 1986; Pribram, 1980).

This cascade that characterizes episodic processing leads ultimately to considerable autonomy, or confidence in, the committed competence. Envisioned events are woven into coherent subjectivity, a story, a narrative, the myth by which "I" live. This narrative composes and is composed of an intention, a strategy that works for the individual in practice, a practical guide to action in achieving stability in the face of a staggering range of variations of events (Pribram, 1991, 1992).

Consciousness is manifest (by verbal report) when familiarization is perturbed; an episode is updated and incorporated into a larger contextual scheme (the narrative) that includes both the familiar and novel episodes (Pribram, 1991, Appendices C and D). Consciousness becomes attenuated when actions and their guides cohere—the actions become skilled, graceful and automatic (Miller *et al.*, 1960).

5. Transcendental Consciousness—The Spiritual Nature of Humankind

Transcending conscious and especially unconscious determinants of experience was *the* central concern of philosophers and psychologists in the late 19th century. Freud is famous for his formulations of the import of unconscious processes and their emergence in mythology (e.g., the Oedipus Syndrome); Jung was devoted to exploring the collective unconscious; and James published an essay on religious experience. The esoteric tradition in Western culture and the mystical traditions of the Far East are replete with instances of uncommon states that produce uncommon contents. These states are achieved by a variety of techniques such as meditation, Yoga, or Zen. The contents of processing in such states appear to differ from ordinary feelings or perceptions. Among others, experiences such as the following are described (see Morse *et al.*, 1989 and Stevenson, 1970, for review). One type of experience is known as the "oceanic," namely, a merging of corporeal and extracorporeal reality. Another is known as "out-of-body"; namely, corporeal and extracorporeal realities continue to be clearly distinguished but are experienced by still another reality: "a meta-me." In still another type of experience the "I" becomes a transparent experiencing of everything everywhere and there is no longer the segmentation into episodes, nor do events become enmeshed in a narrative structure. All of these experiences have in common a transcendental relationship between ordinary experience and some more encompassing organizing principle.

It is this relationship that is ordinarily termed "spiritual." As will be developed below, the spiritual contents of consciousness can be accounted for by the effect of excitation of the frontolimbic forebrain (involved in narrative construction) on the dendritic microprocess, which characterizes cortical receptive fields in the sensory extrinsic systems (involved in the construction of objective reality).

In addition to the gross correspondence between dendritic receptive fields in the brain cortex and the organization of sensory surfaces that gives rise to the overall characteristics of processing in the extrinsic systems, a microprocess that depends on the internal organization of each dendritic field comes into play. This internal organization of dendritic fields embodies, among other characteristics, a spectral domain: dendritic fields of neurons in the extrinsic cortex are tuned to limited bandwidths of frequencies of radiant energy (vision), sound, and tactile vibration. I have reviewed this evidence extensively on a number of occasions (Pribram, 1966, 1971, 1982, 1991; Pribram *et al.*, 1974).

Perhaps the most dramatic of these data are those which pertain to vision. The cortical neurons of the visual system are arranged as are the other sensory systems so as to reflect more or less isomorphically the arrangement of the receptor surfaces to which they are connected (thus, the "homunculi" that Wilder Penfield (e.g., 1969) and others have mapped onto the cortical surface of the extrinsic projection systems). However, within this gross arrangement lie the receptive fields of each of the neurons—a receptive field being determined by the functional dendritic arborization of that neuron that makes contact with the more peripheral parts of the system. Thus the receptive field of a neuron is that part of the environment that is processed by the parts of the system to which the neuron is connected. Each receptive field is sensitive to approximately an octave (range from one-half to one-and-a-half octaves) of spatial frequency. It is this frequency-selective microprocess that operates in a holographic-like manner.

Processing can thus be conceived as operating somewhat like the production of music by means of a piano. The sensory surface is analogous to a keyboard. Keyboard and strings are spatially related to provide the organization of the process. When individual strings are activated they resonate over a limited bandwidth of frequency. It is the combination of the spatial arrangement and the frequency-specific resonance of the strings that makes the production of music possible.

The gross and micro-organization of the cortical neurons in the extrinsic systems resembles the organization of a multiplex or patch hologram. A patch hologram is characterized by a Gabor elementary function, which Gabor called a "quantum of information" (Gabor, 1946; Pribram, 1991, Lectures 2 and 4). Technically, what is known as a "Gaussian envelope" constrains the otherwise unlimited sinusoid described by what is known as a "Fourier transform" to make up the Gabor function. Experiments in my laboratory (Spinelli and Pribram, 1967; Pribram *et al.*, 1981) have shown that electrical excitation of frontal and limbic structures relaxes these Gaussian constraints, which inhibit reception. When this occurs during ordinary excitation of the frontolimbic systems of the forebrain, processing leads to narrative construction (for details see Pribram, 1991, Lecture 10). When frontolimbic excitation becomes overwhelming, experience is determined by an unconstrained holographic process.

Holograms of the type involved in brain processing are composed by converting (e.g., via Fourier transformation) successive sensory images (e.g., frames of a movie film) into their spectral representations and patching these microrepresentations into orderly spatial arrangements that represent the original temporal order of successive images (see Bracewell, 1989, for an excellent brief review). When such conversions are linear (as, e.g., when they employ the Fourier transform) they can readily be reconverted (e.g., by the inverse Fourier transform) into moving sensory images. The spectral domain is peculiar in that information in the Gabor sense becomes both distributed over the extent of each receptive field (each quantum) and enfolded within it. Thus sensory-image reconstruction can occur from any part of the total aggregate of receptive fields. This is what gives the aggregate its holographic, holistic aspect. All input becomes distributed and enfolded, including the dimensions of space and time and therefore causality.

This timeless/spaceless/causeless aspect of processing is instigated by frontolimbic excitation that practically eliminates the inhibitory surrounds of receptive fields in the sensory systems (Spinelli and Pribram 1967; Pribram *et al.*, 1981), allowing these systems to function holistically. It is this holistic type of processing that is responsible for the apparent extrasensory dimensions of experience that characterize the esoteric traditions: because of their enfolded property these processes tend to swamp the ordinary distinctions such as the difference between corporeal and extracorporeal reality.

The ordinary distinctions result from an enhancement of the inhibitory surrounds of the receptive fields when the systems of the posterior cortical convexity become activated (Pribram *et al.*, 1981). As a consequence, the sensory system becomes an information-processing system in Shannon's sense: choices among alternatives become possible. This is comparable to the process called the "collapse of the wave function" in quantum physics. By contrast, in the esoteric traditions, consciousness is not limited to choices among alternatives.

Instead, this type of conscious experience shares with unconscious states the attribute of infinity suggested by Matte Blanco (1975). An intriguing and related development (because it deals with the specification of a more encompassing, "cosmic" order) has occurred in quantum physics. Over the past 50 years it has become evident that there is a limit to the accuracy with which certain measurements can be made when others are being taken. This limit is expressed as an indeterminacy. Gabor, in his description of a quantum of information, showed that a similar indeterminacy describes communication. This leads to a unit of minimum uncertainty, a maximum amount of information that can be packed for processing. Thus there is a convergence of our understanding of the microstructure of communication—and therefore of observation—and the microstructure of matter. The necessity of specifying the observations that lead to inferring these minute properties of matter has led noted physicists to write a representation of the observer into this description. Some of these physicists have noted the similarity of this specification to the esoteric transcendental descriptions of consciousness. Books with such titles as *The Tao of Physics* (Capra, 1975) and *The Dance of the Wu Li Masters* (Zukav, 1971) have resulted.

Laszlo's Quantum-Vacuum Field theory (1995, 1996) fits into this tradition. As with physicists, he acknowledges the critical role of observation in all scientific investigation. Observation is a *conscious* "trying" at understanding, as indicated in the introduction to this chapter. Thus many physicists, as well as Laszlo, have embraced a broader definition of "consciousness" than just our experience of "it." These scientists, therefore, take our transformative, holographic-like experience that transcends the space–time coordinates of ordinary appearances as further evidence for such a cosmic unifying field.

There is, therefore, in the making a real revolution in Western thought. The scientific and esoteric traditions have been clearly at odds since the time of Galileo. Each new scientific discovery and the theory developed from it has, up until now, resulted in the widening of the rift between objective science and the spiritual aspects of human nature. The rift reached a maximum toward the end of the 19th century. We were asked to choose between God and Darwin, and heaven and hell were shown by Freud to reside within us and not in our relationship to the natural universe. The discoveries of 20th-century science briefly noted here, but reviewed extensively elsewhere (Pribram, 1986, 1991), do not fit this mold. For once the recent findings of science and the spiritual experiences of humankind are consonant. This augurs well for the upcoming new millennium—a science that comes to terms with the spiritual nature of humankind may well outstrip the technological science of the immediate past in its contribution to human welfare.

Note

1. There is thus a large element of behavior in animals as well as humans that falls under this definition of unconscious. Only to the degree to which nonhumans show intentionality, thus the ability to discriminate themselves from their environment, would we infer that they are "conscious." In addition, as I have claimed, there is a "cuddliness criterion" to be applied (Pribram 1976), by which, as more elegantly stated by Searle (1992), we mean to take into consideration the form of the embodiment of the creature to whom we attribute "consciousness."

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