T-223

Indeed, the diagnosis of dissociative amnesia can be difficult to ›stantiate and may be met with skepticism by hospital staff. Often, clinical picture remains unclear until the amnesia clears. In some ses dissociative amnesia has been observed to clear after a period days, but in other cases it has persisted as a potentially permanent ature of the personality.

UGGESTED CROSS-REFERENCES

Functional neuroanatomy is discussed in Section 1.2; delirium, mentia, and amnestic and other cognitive disorders is discussed Chapter 10; dissociative amnesia is discussed in Section 18.1; oad issue of neuropsychological and intellectual assessment of cogtive functions is covered in Sections 7.4 through 7.6; false memory ndrome is discussed in Section 3.4.

REFERENCES

Baddeley AD, Wilson FA, Watts N, editors: *Handbook of Memory Disorders.* Wiley, Chichester, UK, 1995.
Bailey CH, Bartsch D, Kandel ER: Toward a molecular definition of long-term memory storage. Proc Natl Acad Sci USA *93:*13445, 1996.
Buckner RL, Tulving E: Neuroimaging studies of memory: Theory and recent PET results. In *Handbook of Neuropsychology,* vol 10, F Boller, J Grafman, editors, Elsevier, Amsterdam, 1995.
Cabeza R, Nyberg L: Imaging cognition: An empirical review of PET studies with normal subjects. J Cognitive Neurosci *9:*1, 1997.
Desimone R: Neural mechanisms for visual memory and their role in attention. Proc Natl Acad Sci USA *93:*13494, 1996.
Fuster JM: *Memory in the Cerebral Cortex: An Empirical Approach to Neural Networks in the Human and Nonhuman Primate.* MIT Press, Cambridge, MA, 1995.
Heiss W-D, Pawlik G, Holthoff V, Kessler J, Szelies B: PET correlates of normal and impaired memory functions. Cerebrovascular and Brain Metabolism Reviews *4:*1, 1992.
Kapur N: Focal retrograde amnesia in neurological disease: A critical review. Cortex *29:*217, 1993.
Kopelman MD: The Korsakoff syndrome. Br J Psychiatry *166:*154, 1995.
Lashley KS: *Brain Mechanisms and Intelligence: A Quantitative Study of Injuries to the Brain.* Chicago University Press, Chicago, 1929.
LeDoux JE: *The Emotional Brain.* Simon & Schuster, New York, 1996.
Lezak MD: *Neuropsychological Assessment,* ed 2. Oxford University Press, New York, 1983.
Mayford M, Abel T, Kandel RT: Transgenic approaches to cognition. Curr Opin Neurobiol *5:*141, 1995.
Mishkin M: A memory system in the monkey. Philos Trans R Soc Lond B Biol Sci *298:*83, 1982.
Paller KA: Consolidating dispersed neocortical memories. The missing link in amnesia. Memory *5:*73, 1997.
•Ranganath C, Paller KA: Frontal brain potentials during recognition are modulated by requirements to retrieve perceptual detail. Neuron *22:*605, 1999.
Raymond JL, Lisberger SG, Mauk MD: The cerebellum: A neuronal learning machine? Science *272:*1126, 1996.
Rugg MD: Event-related potential studies of human memory. In *The Cognitive Neurosciences,* MS Gazzaniga, editor. MIT Press, Cambridge, MA, 1995.
Schacter DL, Tulving E, editors: *Memory Systems 1994.* MIT Press, Cambridge, MA, 1994.
•Schacter DL, editor: Memory distortion: How minds, brains, and societies reconstruct the past. Harvard University Press, Cambridge, MA, 1995.
Shimamura AP: Memory and frontal lobe function. In *The Cognitive Neurosciences,* MS Gazzaniga, editor. MIT Press, Cambridge, MA, 1995.
•Squire LR: *Memory and Brain.* Oxford University Press, New York, 1987.
Squire LR: Memory and the hippocampus: A synthesis of findings with rats, monkeys, and humans. Psychol Rev *99:*195, 1992.
Squire LR, Butters N, editors: *Neuropsychology of Memory,* ed 2. Guilford, New York, 1992.
•Squire LR, Kandel ER: *Memory: From Mind to Molecule.* Freeman, New York, 1999.
Squire LR, Knowlton B, Musen G: The structure and organization of memory. Annu Rev Psychol *44:*453, 1993.
•Squire LR, Zola SM: Structure and function of declarative and nondeclarative memory systems. Proc Natl Acad Sci USA *93:*13515, 1996.
Squire LR, Zouzounis JA: Self-ratings of memory dysfunction: Different findings in depression and amnesia. J Clin Exp Neuropsychol *10:*727, 1988.
Thompson RF, Kim JJ: Memory systems in the brain and localization of a memory. Proc Natl Acad Sci USA *93:*13438, 1996.
•Ungerleider LG: Functional brain imaging studies of cortical mechanisms for memory. Science *270:*769, 1995.
Weiler IJ, Hawrylak N, Greenough WT: Morphogenesis in memory formation: Synaptic and cellular mechanisms. Behav Brain Res *66:*1, 1995.
Zola-Morgan S, Squire LR: The primate hippocampal formation: Evidence for a time-limited role in memory storage. Science *250:*288, 1990.

▲ 3.5 Brain Models of Mind

KARL H. PRIBRAM, M.D., PH.D.

For two centuries brain models of mind have fascinated scientist and the lay public alike. This intense interest began with Francis J. Gall's pioneering correlations between brain pathology and characteristic personality histories of patients. As with every major advance in understanding the mind-brain relationship, Gall's demonstrations became a popular fad in the form of reading bumps on the skull, *phrenology.* Today a similar fad is evident in the application of the findings regarding hemispheric specialization: educators and politicians alike recommend using the right brain more lest the human race fall forever into damnation.

Brain models of mind have shown a remarkable coherence over the nineteenth and twentieth centuries despite the often acrimonious emphasis on this or that phenomenon to the exclusion of a comprehensive analysis. Further, when carefully considered, each of the often opposing views captures important aspects of the issues and that reconciliation devolves on making distinctive definitions and reading the proposals in their original form with these definitions in mind.

One definition of mind was provided by Gilbert Ryle: Mind comes from minding, paying attention. In old English the word is *gemynd,* akin to *remind,* which was derived from terms that meant *to warn* and *to intend.* The Sanskrit word *mynas* means to think.

As a whole, the human brain is critical to minding; one case history highlights the obvious. A 14-year-old-girl who had fallen out of a rapidly moving automobile had sustained a head injury with multiple scalp lacerations. Transporting her to a hospital several hundred miles away was thought to be too risky to an already traumatized head. Her head was swathed in bandages through which some blood had oozed, making them appear bright red; in contrast, the girl looked green. When addressed: "Hello Cathy, you look like a Christmas package all dolled up in your bandages," the girl smiled and said, "Hello, doctor." It was evident that this girl's brain was intact. She minded, and even had a sense of humor. A thorough examination revealed a broken rib with a puncture to one lung, thus her green color. Bandages and a brief time in an oxygen tent quickly allowed healing to commence.

The diagnosis rested on the truism that scrambled brains result in scrambled minds. However, because of its pervasive validity, this truism can blind us to the more subtle aspects of the mind-brain relationship. For instance, the close association of mind to brain might lead us to suspect uncritically that mind and brain are the same, which would be as absurd as stating that the islands of Langerhans of the pancreas are the same as insulin regulation of glucose metabolism. Minding is a function of the entire organism interacting with its environment (just as glucose metabolism is a function of the organism metabolizing environmentally derived nutrients). What is common to brain and mind is their organization, much as what is common to a computer's hardware and the various levels of programming software is the *in*formation (the form within) being processed.

Thus, although the special relation between brain and conscious experience is widely acknowledged, the subtleties inherent in the nature of the relation remain debatable. In this respect apparently no progress has been made in the past two millennia.

The time is ripe for an advance in understanding. Each of the philosophical stances toward the mind-brain relationship has merit as long as it is restricted to the database that defines the stance. The set of problems that characterize the special relation between brain and the variety of mental processes is closely related and the mind-brain analysis must be anchored in an ontological neutral monism. What is ontologically neutral to the material brain and mental (psychological) processes is *order*—order as measured scientifically in terms of energy, entropy, and information.

With respect to the special relation between brain and the variety of mental processes, this ontological neutrality is expressed by showing that conscious (and unconscious) processes are coordinate with identifiable brain processes occurring in identifiable brain systems, that is, at some level the descriptions of brain processes and descriptions of mental processes become homomorphic.

An example from computer science illustrates what is meant by *homomorphic:* the computer is used as a word processor when English words and sentences are typed into it. The word processing system, by virtue of an operating system converts the keyboard input to binary, which is the language of the computer. Nothing in the description of English and of binary machine language appears to be similar, yet by virtue of the various transformations produced in the encoding and decoding operations of the various stages leading from typescript to binary, the information in the typescript is preserved in the binary language of the operation of the computing machine.

In a similar fashion, little in conscious experience resembles the operations of the neural apparatus with which it has such a special relation. However, when the various transformations, the transfer functions, the codes that intervene between experience and neural operations are sufficiently detailed, a level of description is reached in which the *transformations* of experience are homomorphic with the language used by the brain. This language is the language of the operations of a microprocess taking place in synaptodendritic fields, a mathematical language similar to that which describes processes in microphysics that is, subatomic physics.

At this microprocessing level an identity describes the relation between brain and mental processes. At more remote processing levels, encompassing larger event structures (assemblers, operating systems, or their counterparts in brain systems), pluralism, and eventually, at the level of natural language, dualism characterizes the relationship. The special relation between brain and mental processes is thus not identical, except in implementation at the microprocessing level. At the neuronal and even at the neural system level several types of relationship with psychological processes can be discerned.

First, there are neurochemical states operating in the synaptodendritic processing web that determine states of consciousness. The very active field of psychoneuropharmacology is replete with evidence of relations between catechol and indole amines acting in specified brain locations to produce states of consciousness such as wakefulness and sleep, depression, and elation, and perhaps even dissociated states such as those seen in schizophrenia. The relations between relative concentrations of blood glucose and osmolarity and hunger and thirst; between sex hormones and sexually characteristic behaviors; and between peptides such as the endorphins and enkephalins and the experiences of pain and stress are all well documented.

Second, there are detailed descriptions of the relations between the sensory systems of the brain and the sensory aspects of perception: the contents of consciousness.

States of consciousness often determine contents and as often, are determined by them. When hungry one tends to notice restaurant signs; walking past the fresh aromas emanating from a bakery whets the appetite. This connection between states and the contents of c sciousness is mediated by the process ordinarily called *attention* (control of sensory input), by *intention* (the control of motor outp and *thought* (the control of remembering). The understanding of th processes of minding is critical to understanding the special relat between brain states and the contents of conscious experience.

VARIETIES OF BRAIN ORGANIZATION

Localization and Distribution of Function S models of brain organization are crucial for determining the organ tion of minding. First is the issue of localization of function. Fra Gall brought this issue to the foreground by correlating diffe local brain pathologies to the histories of the cadavers he autops Although often wrong in detail, he was correct in the method carefully detailed. He was naïve in delineating the faculties of r for which he sought localization, but systematic classificatio mental functions continues to be elusive despite a half-centur operational behaviorism. Today, it is popular to discuss the mod ity of mind and component systems of the brain and relate them in the clinic and in the laboratory by crafting experimental de and behavioral and verbal testing procedures. The use of these niques traces its heritage directly to Gall's enterprise.

The excesses of phrenology raised the question of which system brought the various faculties together into a conscious The unity of being, the soul of mankind, was challenged when m tion was subdivided into a mere collection of faculties. Further experimental evidence accrued to demonstrate a relation bet impairments in complex behaviors and verbally reported experi and the amount of brain tissue destroyed irrespective of locatic the recent past, Karl Lashley has been an exponent of this action view.

However, in a letter to Fred Mettler, Lashley once state exasperation at being misinterpreted: "Of course I know the of the brain does something different from the back. The sensory input terminates in the occipital lobes. Electrical stimul of the pre-Rolandic areas elicit movements and the front par more enigmatic in their functions. But this is not the issue." where he states the issue clearly: ". . . certain coordinated acti known to be dependent upon definite cortical areas, can be c out by any part (within undefined limits) of the whole area."

What Lashley emphasized was that certain selected mental tions appeared to be related to brain processes that are distri For instance, he pointed out that sensory and motor equiva could not be accounted for even by a duplication of brain path "Once an associated reaction has been established (e.g., a p reaction to a visual pattern), the same reaction will be elici the excitation of sensory cells which were never stimulated way during training. Similarly, motor acts (e.g., opening a latc once acquired, may be executed immediately with motor which were not associated with the act during training."

The following is example of motor equivalence: a dog was tioned to raise his right hind leg to the sound of a tone. Aft conditioned response was well established, his right motor (which controls the left side of the body) was exposed. Then the performance of the conditioned reaction a patty of strych filter paper (which chemically excited the cortical tissue) was on the area that controls the left forepaw. Immediately t switched the responding leg: he now raised his left forepaw conditioned signal. A temporary dominant focus of excitati been established in the cortex by the chemical stimulation.

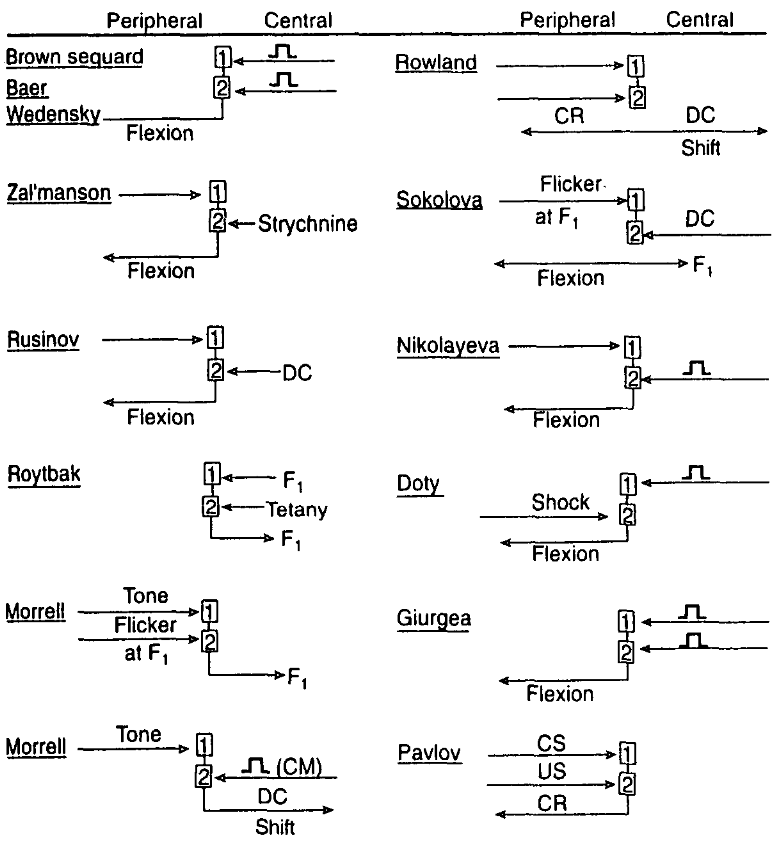

FIGURE 3.5-1 Methods of conditioning that have been used by various investigators to establish and produce shifts in cerebral dominant foci. The example in the text refers to Zal'manson's experiment. (Reprinted with permission from Pribram K: *Languages of the Brain: Experimental Paradoxes and Principles in Neuropsychology*. Random House, New York, 1971.)

John summarizes the experiments that demonstrate such shifts in cerebral dominant foci in Figure 3.5-1.

The distributed aspect of brain function becomes most evident in memory storage. Even after large deletions of brain tissue such as those resulting from strokes or tumor resections, specific memories, *engrams*, are seldom lost. When amnesias do occur they are apt to be spotty and difficult to classify, which suggests that memory is stored in a distributed fashion. The storage process dismembers the input, which is then re-membered on occasions that necessitate recognition and recall. In contrast to storage, the retrieval processes are localized, at least within systems such as those that are sensory specific. When such systems are damaged, sensory-specific and even category-specific agnosias may result. Thus with regard to memory, both distributed and localized processes can be identified depending on which property of the process is being considered. This principle of analyzing a mental process to identify specific aspects will be useful in other contexts as well.

Systems in the Control of Attention and Intention

Brain systems serve as controls on the processes intrinsic to minding in detail. William James noted that the delineation of minding, or consciousness, devolves on processes usually referred to as *attention* and *intention or volition.* Controls on attention determine the span of sensory processing, those on intention determine the span over which action becomes effective, and controls on thought determine the span of memories being considered.

Two decades of investigation into the neural processes involved in the control of attention discerned three such mechanisms: one deals with short phasic response to an input *(arousal)*, a second relates to prolonged tonic readiness of the organism to respond selectively *(activation)*, and a third *(effort)* acts to coordinate the phasic *(arousal)* and tonic *(activation)* processes. Separate neural and neurochemical systems are involved in the phasic (arousal) and tonic (activation) processes: the phasic process centers on the amygdala and the tonic process centers on the basal ganglia of the forebrain. The coordinating system (effort) critically involves the hippocampus, a phylogenetically ancient part of the neural apparatus.

Evidence 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 a more basic process centered on the dorsal thalamus, the waystation 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 brainstem (tectal region), which in turn influence 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 also regulated by input from the system centered on the amygdala—the arousal system. When stimulated, this system produces an effect on the "gate" opposite to that of the activation system.

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 brainstem. At this juncture the relation of attention to intention, that is, to volition or will, comes into focus. Again, William James had already pointed out that a good deal of what is called voluntary effort is the maintaining of attention or the repeated returning of attention to a problem until it yields solution.

William James had apposed will to emotion and motivation (which he called *instinct*). Beginning with Walter Cannon's experimentally based critique of James, followed by Karl Lashley's critique of Cannon, to the anatomically based suggestions of James Papez and their more current versions by Paul MacLean, brain scientists have been deeply concerned with the processes that organize emotional and motivational experience and expression. Two major discoveries have placed the earlier more speculative accounts into better perspective. One such discovery has been of the role of the reticular formation of the brainstem and its chemical systems of brain amines that regulate states of alertness and mood. Donald Lindsley proposed an activation mechanism of emotion and motivation on the basis of the initial discovery and has more recently detailed the pathways by which such activation can exert control over brain processes. The other discovery is of the system of brain tracts that when electrically excited results in *reinforcement* (i.e., an increase in the probability of recurrence of the behavior that has produced the electrical brain stimulation) or *deterrence* (i.e., a decrease in the probability that such behavior will recur) by James Olds and Peter Milner.

To organize these discoveries and other data that relate brain mechanisms to emotion, it is necessary to distinguish clearly between data that refer to experience (feelings) and those that refer to expression, and further to distinguish emotion from motivation. Thus, feelings were found to encompass both emotional and motivational experience, emotional as affective and motivation as centered on a readiness processes. Not surprisingly, the affective process of emotion was found to be based on the process of arousal, the ability to make phasic responses to input that "stop" the motivational processes of activation that maintain selective readiness. Thus, feelings were found to be based on neurochemical states (predispositions or moods) that become organized by appetitive (motivation, "go") and affective (emotional, "stop") processes. Feelings of effort often are experienced as anxiety.

A wealth of new data had spawned these insights and made it fruitful to reexamine the Jamesian position with regard to his visceral theory of emotions. James is almost universally misinterpreted as holding a peripheral theory of emotion and mind. Through his writings he emphasizes the effect that peripheral stimuli (including those of visceral origin) exert on brain processes. Nowhere, however, does he identify emotions with bodily processes; emotions are always the resultant effect on brain states. What James failed to take into account is the role of expectations (the representational role of the organization of familiarity and novelty) in the organization of emotions. It is these "neuronal models" of prior experience that were found to entail the functions of the hippocampus and of the basal ganglia, including the amygdala.

Nonetheless, James is explicit 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. Both possibilities have been realized: parts of the frontolimbic forebrain (especially the amygdala and related systems) process visceroautonomic bodily inputs, and the results of processing become distributed via brainstem systems that diffusely influence the perceptual systems. Additionally, James clearly defines the difference between emotions and motivations (which he calls instincts): emotional processes take place primarily within the organism whereas motivations reach beyond into the organism's environment. James perhaps overemphasized the visceral determination of emotional experience, but he did occasionally include attitudinal factors as depending on sensory feedback from the somatic musculature.

The distinction between the brain mechanisms of motivation and will are less clearly enunciated by James. He grapples with the problem and establishes the questions that must be answered. These questions remained unanswered until the late 1960s when several theorists 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 mechanisms depend on error processing and are therefore sensitive to perturbations; programs, unless completely stopped, run themselves off to completion irrespective of obstacles placed in their way.

Clinical neurology had classically distinguished the mechanisms involved in voluntary behavior from those involved in involuntary behavior. The distinction rests on the observation that lesions of the cerebellar hemispheres impair intentional (voluntary) behavior whereas basal ganglia lesions result in disturbances of involuntary movements. Damage to the cerebellar circuits are involved in a feedforward rather than a feedback mechanism. Recent microelectrode analyses suggest that the cerebellar hemispheres perform calculations in fast-time, (i.e., 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.

Just as the cerebellar circuit has been shown to serve intentional behavior, the basal ganglia have been shown to be important to involuntary processes. These structures are also involved 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 that these disturbances result from interference by the lesion of the normal feedback relationships between basal ganglia and cerebral cortex. Surgical removal of motor cortex has 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 basal ganglia diseases.

Massively Parallel Distributed Processes Two closely related issues concerning the organization of brain function are often confounded: (1) localization versus distribution of function within each system and (2) whether processing proceeds among different localizable systems in a hierarchical fashion or whether processing proceeds in parallel and thus heterarchically.

The fact that a temporary dominant focus in the cerebral cortex can take control of the expression of a learned behavior indicates that hierarchical control operates in the central nervous system. Equally persuasive is the evidence for control over spinal cord activity by the brainstem and forebrain. Neuronal activity in the spinal cord displays an extremely high rate of spontaneous impulse generation. These generators are modulated by inhibitory local circuit neurons in such a way that the resultant activity can be modeled in terms of coupled ensembles of limit cycle oscillatory processes. In turn, these ensembles of oscillators become organized by brainstem systems that consist of cholinergic and adrenergic neurons. The cholinergic set regulates the frequency of a wide range of tonic rhythmic activities such as those involved in locomotion, respiration, cardiovascular responses, and sleep. This cholinergic system is coupled to an adrenergic set of neurons that segment the rhythmic activities into episodes. Both systems are subject to further hierarchical control by the dopaminergic system of the basal ganglia. Clinically, loss of this hierarchical control is expressed as an exaggeration of the normally present, almost subliminal tremors that under extreme conditions lead to spastic paralysis, hyperreflexia, and uncontrollable fits of oscillatory muscular spasm.

However, the evidence from the experiments that demonstrated temporary dominant foci can be viewed from the perspective: that the flexibility demonstrated by the shift from one controlling locus to another shows the organization of the cortical system to be heterarchial. Any locus within the system can become dominant if sufficiently excited. The following story, attributed to Warren McCulloch, illustrates the nature of heterarchial organization:

> After the battle of Jutland in which the British Navy took a beating, both the British and American navies reorganized to change from hierarchical to heterarchical control. Thus, battleships no longer had to await orders from a central command source to engage in defensive maneuvers. During World War II the Fifth Fleet was stationed in an only slightly dispersed mode of operation somewhere in the Pacific Ocean when it was attacked from two directions by separate air squadrons. Sightings of the attackers were made from different locations in the fleet by observers on the ships closest to one or the other of the attacking planes. The sailor who made the sighting became a dominant focus and his ship and those in his proximity took off to defend against the attackers. However, because the attack came from two different directions, two dominant foci were created, each commanding parts of the fleet to steam away in different directions. This left the ship at the center of the fleet that housed its admiral haplessly unprotected and, since no sightings were made by his ship, at a momentary loss as to what to do. Fortunately, both attacking squadrons were defeated and turned back without any damage accruing to the Fifth Fleet.

There is thus a possible penalty to be paid for the flexibility achieved by temporary dominance over processing as any person who has ever been of two minds knows well.

Ordinarily hierarchical control is conceived of as a serial process. This is because when control is direct, there is a causal connection between the controller and the controlled. Causality implies that the origination of the control signal precedes its effect on the system being controlled. Seriality remains when there are feedback loops. However, when feedforward operations are inserted into the process, seriality is no longer as clearcut. For example, lower the temperature or blood sugar on a thermostat or homeostat and the sensor responds, closes a circuit, and the effector responds; this is a serial process. Now place a control dial or other bias on the process and there are two or more ways for the sensor to become adjusted. The temperature falls, but because the heating bill was too high last month the dial is reset and warmer clothes are worn. There are parallel inputs to the sensor. Herman von Helmholtz is credited with pointing out that voluntary processes such as those by which we move our eyes are constituted of such parallel feedforward corollary discharges to the effectors. Control can be hierarchical yet dependent on a parallel process.

Processing in the cerebral cortex is massively parallel. Simulations of these parallel cortical processes have since the late 1980s become implemented on personal computers to such an extent that the endeavors have been dubbed a cottage industry. These simulations of neural networks are capable of pattern recognition, of language learning, and of decision-making that is remarkably true to life. Single-layered simulations have given way to three-layered computations that involve an input layer, an output layer, and a hidden layer. All the elements of the network are interconnected to one another. In several such simulations the input is fed forward through the net and the output is compared with one that is desired; the difference between the actual and the desired is fed back to the net. The process is repeated until the desired output is achieved. Variations on this theme abound, each variation being better adapted than its alternates for a particular purpose.

One of the most fascinating attributes of these neural networks is that the information contained in the input becomes fragmented and distributed in the elements of the layers. The simulations are therefore said to be massively *parallel distributed processes* (PDP), which makes them akin to optical information processing systems such as holography and tomography from which they were in fact derived.

Cerebral Dominance and the Unity of Consciousness

Surrounding the major fissures of the primate cerebral cortex lie the terminations of the sensory and motor projection systems. These systems have been termed *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 called *epicritic processing* takes place. These extrinsic sensory-motor projection systems are organized such that movement allows the organism to project the results of processing away from the sensory and muscular surfaces where the interactions take place, out into the world external to the organism. Thus, processing within these extrinsic systems constructs an objective reality for the organism.

Between the perifissural extrinsic regions of cortex lie other regions of cortex variously named *association cortex, uncommitted cortex*, or *intrinsic cortex*. These names reflect the fact that there are few, if any, direct connections between peripheral structures and these regions of cortex that make up most of the convexity of the cerebrum. Thus, on the brain's convexity a three-tiered arrangement for these systems can be discerned. Each major sensory apparatus has a fairly direct input to areas in the cortex. Immediately surrounding these areas are others, which when electrically stimulated originate movements of the musculature associated with each of the sense organs (e.g., eye muscles for vision, ear muscles for hearing, and body muscles for somatic sensations). These areas are extrinsically connected to organs in the periphery of the body and therefore provide perspectives relating the body to the world beyond.

Surrounding these extrinsic areas are sensory-specific areas that are primarily connected intrinsically to other brain structures. These areas provide perspectives that are intrinsic to the entities perceived, perspectives such as those provided by color and object constancy. Finally, other areas operate on inputs from a variety of senses and relate their perspectives to each other. All these areas and the brain systems that they represent are involved in organizing phenomenal perceptions or the sensory-driven aspects of perception. Another set of systems, more noumenal in their function, are located frontally and on the limbic medial border of the brain's hemispheres.

Three important discoveries have fueled the current interest in hemispheric lateralization. One of these was actually a rediscovery during the latter half of the nineteenth century of the fact that the speech of most righthanded individuals is usually controlled by the left hemisphere. Hippocrates already knew this and may well have learned it from the Egyptians. Running from back to front, comprehension, grammar, and fluency (*semantics, syntactics,* and *pragmatics*) are affected by lesions centering on the sylvian fissure. However, dominance is not as complete in females as it is in males, nor is it as pervasive in cultures that do not use phonemic writing. It is now known that the non–speech-dominant hemisphere has its own characteristic modes of processing. With the left hemispheres of right-handed persons being taken over by an aural-oral dimension, the right hemisphere is left free to process visual-spatial relations.

A third and most pervasive and persistent focus of interest has been that of the unity of consciousness. When the corpus callosum was severed in patients who had suffered severe unilateral epileptic seizures in order to prevent involvement of the healthy hemisphere, testing revealed that what was sensed by the right hemisphere could only be expressed nonverbally by that hemisphere. The left verbal hemisphere appeared to be ignorant of what had transpired. It seemed as if consciousness had been split when the hemispheres were sundered. The assumption that there is ordinarily a unity to consciousness was bolstered precisely because this unity had been ruptured.

Taken together with the facts of hemispheric specialization and the "dominance" of the left hemisphere for language, these observations were broadened to the conception that human civilization suffered from left brain dominance and that training for greater brain balance would restore balance to civilization. However, innumerable studies have demonstrated that all but the most rudimentary processing involves both hemispheres. Even in language, the appreciation and expression of emotional communication involves the right hemisphere, and extreme specialization is limited to right-handed males raised in a phonemic literary environment.

Although the popular overgeneralization about hemispheric lateralization is to be deplored there was renewed interest in the question of whether consciousness could be divided. Sir John Eccles argued that consciousness is tied to language, an argument also made by Freud, and that therefore the right, speechless, hemisphere was to all intents and purposes essentially unconscious. However, the right hemisphere clearly communicated with left-handed, nonverbal instrumental responses that it had processed the input presented to it: the nonverbal hemisphere obviously had a mind of its own. Conscious minding is of two sorts: *instrumental* and *intentional*; thus, Eccles' proposal is tenable if what is meant is intentional consciousness. Brain facts as they relate to behavior, mind, and consciousness often spring surprises on the unwary.

VARIETIES OF CONSCIOUS EXPERIENCE

Cerebral Cortex and Reflective Consciousness

The distinction between the systems that control intentional behavior and those that control involuntary behavior extends to the control of sensory input and the processing of memory. With regard to sensory input, the distinction between the contents of awareness and the person who is aware was delineated by Franz Brentano and called *intentional inexistence.* This dualism of a minding self and objective matter (e.g., brain) was already present in the writings of René Descartes. 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. John von Neumann and Julian Jaynes have suggested that a change in consciousness (i.e., in distinguishing an aware self from what the self is aware of) occurs somewhere during the eighth century BC between the time of the Iliad and the Odyssey, which links it to the invention and promulgation of phonemically based writing. Prehistory was transmitted orally and aurally; written history is visual and verbal. In an oral and 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 personally to guide individual man.

This process of ever-clearer distinctions between personal and extrapersonal objective realities culminates in Brentano's intentional inexistence, which was shortened by Edmund 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.

A few years ago during a seminar, the author noted that the left arm of a graduate student was moving somewhat awkwardly while arranging papers on a table in front of us. The author asked the student, Ms. C., if she was alright, while pointing to her left arm. She replied, "Oh, that's just Alice; she doesn't live here anymore." At the end of the semester, Ms. C. presented a detailed account of her experiences with Alice.

Ms. C. experienced devastations to her locational *integrity.* Other patients, after injuries to their occipital lobes, demonstrate "blindsight," the ability to visually identify objects in the "blind" field despite the fact that they fail to be consciously aware of these objects. Patients such as those who are blindsighted and Ms. C. who might be considered to have a tactile and kinesthetic blindsight both have damage to the cortex of the posterior convexity of their brains. Thus, they suffer disruption of their egocentric (essentially tactile and kinesthetic) and allocentric (essentially visual and auditory) organization. This is a disruption of "objective" awareness because it relates patients to their impairment as if it were a relationship among objects. The relationship is "intentional" in Brentano's sense of an ability to differentiate the perceiver from the perceived. Note also that the narrative abilities of such patients do not suffer.

In contrast is the case of a boy who was *unable* to recount his experiences. Thus, the case histories present two distinct modes of coping that are disrupted by injury to distinctly different brain systems: one articulates the organism in egocentric space and locates it allocentrically in its environment; the other evaluates and monitors experience.

According to Ms. C.:

I was doing laundry about midmorning when I had a migraine. I felt a sharp pain in my left temple and my left arm felt funny. I finished my laundry towards mid-afternoon and called my neurologist. He told me to go to the emergency room. I packed a few things and drove about 85 miles to the hospital where he is on staff (the nearest was 15 minutes away). In the E.R. the same thing happened again. And again, the next morning after I was hospitalized, only it was worse. The diagnosis of a stroke came as a complete surprise to me because I felt fine, and I didn't notice anything different about myself. I remember having no emotional response to the news. I felt annoyed and more concerned about getting home, because I was in the process of moving.

Not until several days later while I was in rehabilitation did I notice strange things happening to me. I was not frightened, angry, or annoyed. I didn't feel anything—nothing at all. Fourteen days after I was admitted to the hospital, I became extremely dizzy, and I felt I was falling out of my wheelchair. The floor was tilting to my left and the wheelchair was sliding off the floor. Any stimulus on my left side or repetitive movement with my left arm caused a disturbance in my relationship with my environment. For instance, the room would tilt down to the left, and I felt my wheelchair sliding downhill off the floor, and I was falling out of my chair. I would become disoriented, could hardly speak, and my whole being seemed to enter a new dimension. When my left side was placed next to a wall or away from any stimuli, this disturbance would gradually disappear. During this period, my left hand would contract, and the arm would draw up next to my body. It didn't feel or look like it belonged to me. Harrison moved the left arm repeatedly with the same movement, and a similar behavior occurred, except I started crying. He asked me what was I feeling, and I said anger. In another test he started giving me a hard time until the same episode began to occur, and I began to cry. He asked me what I was feeling, and I said anger. Actually I didn't feel the anger inside but in my head when I began to cry. Not until I went back to school did I become aware of having no internal physical feelings. . . .

. . . I call that arm *Alice* (Alice doesn't live here anymore)—the arm I don't like. It doesn't look like my arm and doesn't feel like my arm. I think it's ugly, and I wish it would go away. Whenever things go wrong, I'll slap it and say, "Bad Alice" or "It's Alice's fault." I never know what it's doing or where it is in space unless I am looking at it. I can use it, but I never do consciously because I'm unaware of having a left arm. I don't neglect my left side, just Alice. Whatever it does, it does on its own, and most of the time, I don't know it's doing it. I'll be doing homework and then I'll take a sip of coffee. The cup will be empty. I was drinking coffee with that hand and didn't know it. Yet I take classical guitar lessons. I don't feel the strings or frets. I don't know where my fingers are nor what they are doing, but still I play. . . .

How do I live with an illness I'm not aware of having? How do I function when I'm not aware that I have deficits? How do I stay safe when I'm not aware of being in danger? . . .

Ms. C. is an obviously intelligent, widowed woman in her mid-50s enrolled in adult education classes and majoring in clinical psychology. She gets around splendidly despite "Alice" and despite a history of a temporary left hemiparesis. The diagnosis was damage of the right temporal-parietal cortex confirmed by an abnormal EEG recorded from that location. The damage was not sufficiently extensive to show up in a PET scan.

Contrast Mrs. C.'s story with the following observations made on an 8-year-old boy:

T.J. had an agenesis of the corpus callosum with a midline cyst at birth. During the first 6 months of his life, two surgical procedures were carried out to drain the cyst. Recently performed magnetic resonance imaging showed considerable enlargement of the frontal horns of the lateral ventricle, somewhat more pronounced on the right. The orbital part of the frontal lobes appeared shrunken as did the medial surface of the temporal pole. . . .

T.J. appears to have no ability to quantify the passage of time and no experiential appreciation of the meaning of time units. For example, a few minutes after tutoring begins, he cannot say, even remotely, how long it has been since the session started. He is as apt to answer this question in years as in minutes. He does always use one of seven terms of time quantification (seconds, minutes, hours, days, weeks, months, or years) when asked to estimate the duration of an episode but uses them randomly. He can put these terms in order, but does not have any sense of their meaning or their numerical relationships to one another.

When T.J. returned from a trip to the Bahamas he did recall that he had been on the trip; however, the details he could recount about the trip numbered fewer than five. His estimates of how long it had been since his trip were typical in that they were inaccurate and wildly inconsistent on repeated trials. Also, on the first five tutoring sessions since his return he stated that he had not been tutored since his trip. He seems unable to place in sequence those few past events that he can recall. Nonetheless, he can answer questions correctly based on his application of general knowledge about development (e.g., he knows he was a baby before he could talk because "everyone starts as a baby"). However, one day he asked his tutor if he knew him when he was a kid, indicating his incomprehension of the duration of each of these developmental periods and his unawareness of what events constituted such a period for him.

T.J. is aware that he has a past, that events have happened to him but he cannot recollect those events. He also spontaneously speaks of events in his future such as driving an automobile and dating and growing a beard. He has playacted on separate occasions his own old age and death. He is capable of excitement about the immediate future. On the very day that he was going to the Bahamas he was very excited as he exclaimed repeatedly: "I'm going to the Bahamas." But when his tutor asked him when, he said blankly: "I don't know." He also displayed keen anticipation when he saw a helicopter preparing to take off from the hospital. The helicopter engines revved approximately 13 minutes before it took off and T.J. became increasingly more vocal and motorically active, laughing as he repeated "When's it going to take off?" He also anticipates future punishment when he is "bad." He is aware, on some level of the immediate future in his constant question "What's next?" which he asks his mother at the end of each activity. . . .

There are a variety of other occasions on which he demonstrated this capacity regarding tempo (as opposed to evaluating the duration of an experience). There have been several breaks in his usual thrice-weekly tutoring schedule. Each of four times this schedule has been interrupted, he has run to meet his tutor when he approached rather than waiting inside as he usually does. Also, on these occasions he has typically asked if his tutor missed him. However, he states he does not know how long it has been since his last session, and there is no evidence that he knew it had been longer than usual. . . .

T.J. can compare who walks faster or who draws faster. He has a basic sense of sequencing as when he says "I'll take a turn and then you take a turn." He also uses terms like "soon" and "quick" correctly in conversation. For example, when he wanted to do a drawing at the beginning of a session, and his tutor said that they needed begin to work, T.J. countered with "This will be quick." Unsurprisingly, he finished his drawing at his normal pace. He somehow seems to use such terms correctly without any experiential appreciation of them.

These two case histories illuminate two very important dimensions of self. One dimension, portrayed by Mrs. C., *locates* an objective "me" in the world and with respect to the configural integrity of the body. The other dimension, highlighted by T.J. *monitors* an individual's experience. Without such monitoring, the events comprising the experience fail to be relevant and are not evaluated with respect to an autobiographical self, a narrative "I." Kempen and van Loon have provided an excellent history of differentiating an objective "me" from a hermaeuentic "I."

Location is akin to but more primitive than a spatial dimension; monitoring is akin to but more basic than a temporal dimension. However, the locational dimension includes clock time, what the Greeks called *chronos* and Albert Einstein among others related to space. A moving organism is always located in space-time. Monitoring entails not only the experiencing of duration but also the decisive moment; what the Greeks referred to as *kairos*. The dictionary defines *monitor* as a device to record or control a process; to check for significant content.

Unconscious Processing Freud had training both in medical practice and in philosophy. When he emphasized the importance of unconscious processes, was he implying the medical definition or the philosophical one? Most interpretations of Freud suggest that unconscious processes operate without one's 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 processes with repression operating to push memory-motive structures into deeper layers where they no longer access awareness. Still in his "Project for a Scientific Psychology" memory-motive structures are neural programs that are located in the core portions of the brain that access awareness by their connections to cortex, which determine whether a memory-motivated wish comes to consciousness. 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, it is possible to know two languages but at any one time connect only one to cortex and thus the other remains unconscious and voluntarily unexpressed.

The thrust of most recent psychoanalytical thinking as well as that of experimentalists such as Jack Hilgard is in the direction of interpreting the distinction between the conscious and unconscious in the philosophical sense. For instance, Matte Blanco 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. In 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 defined unconscious processes as those that involve feelings.

Bringing the wellsprings of behavior and experience to consciousness means making distinctions, providing alternatives, making choices, becoming informed in Claude Shannon's sense of reduction of uncertainty (Shannon noted that every binary decision reduced uncertainty by half; thus, each such decision provided one bit of information). Clarity regarding the details of how such distinctions are achieved did not come until the late 1960s when several theorists 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 mechanisms depend on error processing and are therefore sensitive to perturbations. Programs, unless completely stopped, run themselves off to completion irrespective of obstacles placed in their way. The difference between feedback and feed-forward processing turns out to be the same as the difference Freud drew between primary and secondary processes.

However, unconscious processes as defined by psychoanalysis are not completely "submerged" and unavailable to experience. Rather, unconscious processes produce feelings that are difficult to localize in time or in space and difficult to identify correctly. Unconscious processes construct the emotional dispositions and motivational context within which extrapersonal and personal realities are constructed. As research has shown, feelings are to a large extent undifferentiated, and are recognized and labeled according to the circumstances in which they become manifested.

It is in this sense that behavior is under the control of the unconscious processes. During angry outbursts, individuals are certainly aware of having lost their temper and of the effects of their anger on others. Despite this awareness, the anger may be uncontrolled. Only when the events leading to the anger become clearly separated into alternative or harmoniously related distinctions is the unconscious control converted into conscious control. A person with an obsession or compulsion is not unaware, in the instrumental sense, of his or her experience or behavior. The patient is very aware of it and feels awful; however, without help, he or she cannot differentiate between controls on the behavior generated by feelings.

Consequential Processing As is well known, frontal lesions were produced surgically in order to relieve intractable suffering, compulsions, obsessions, and endogenous depressions. When effective in relieving pain and depression, these psychosurgical procedures established the functional relation between frontal intrinsic cortex and the limbic forebrain in nonhuman primates. Further, frontal lesions can lead either to perseverative, compulsive behavior or to distractibility in monkeys and humans. A failure to be guided by the outcomes, that is, the consequences of behavior, can account for this effect; the opposite—the alleviation of obsessive-compulsive behavior—can also occur. Extreme forms of distractibility and obsession are caused by a lack of sensitivity of the activation (readiness) process to feedback from consequences. The results of experiments with monkeys as well as clinical observations attest to the fact that subjects with frontal lesions, whether surgical, traumatic, or neoplastic, fail to be guided by consequences.

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*, meaning *outcome*), outcomes that guide action and thereby attain predictive value (as determined by confidence estimates).

Confidence implies familiarity. Experiments on humans have shown that repeated arousal to an orienting stimulus results in habituation, that is, the orienting reaction gives way to familiarization. Familiarization is disrupted by limbic (amygdala) and frontal lesions. Ordinarily, familiarization allows continued activation of readiness; disruption of familiarization (orienting) leads to repeated distraction and thus a failure to allow consequences to form. When the process of familiarization is disrupted, the outcomes of behavior become inconsequential. When the process of familiarization is intact, it 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; particular outcomes only *guide* competent performance, they no longer *produce* orienting reactions.

This cascade, which characterizes episodic processing, leads ultimately to considerable autonomy of the committed competence. Envisioned events are woven into coherent subjectivity, a story, a narrative, the myth by which the "I" lives. 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 (temporary) stability in the face of a staggering range of options.

Consciousness is manifest (by verbal report) when familiarization is perturbed and an episode is updated and incorporated into a larger contextual scheme (the narrative) that includes both the familiar and novel episodes. Consciousness becomes attenuated when actions and their guides cohere—actions become skilled, graceful, and automatic.

Transcendental Consciousness The contents of consciousness are not exhaustively described by feelings of familiarity and novelty that are the basis for episodic and narrative consciousness, nor by those of extracorporeal allocentric and corporeal egocentric consciousness. 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. Experiences are described as *oceanic*, a merging of corporeal and extracorporeal reality or as *out-of-body*—that is, corporeal and extracorporeal realities continue to be clearly distinguished but are experienced by still another reality: a *meta-me* alternatively, the "I" becomes transparent, a throughput experiencing everything everywhere; there is no longer any segmentation into episodes nor do events become enmeshed in a narrative structure.

All these experiences have in common a transcendental relationship between ordinary experience and some more encompassing organizing principle. This relationship is ordinarily termed "spiritual." 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 that characterizes cortical receptive fields in the sensory extrinsic systems (involved in the construction of objective reality).

In addition to the gross topological correspondence between cortical receptive fields 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 receptive field comes into play. This internal organization of receptive fields embodies, among other characteristics, a spectral domain: receptive fields of neurons in the extrinsic cortex are tuned to limited bandwidths of frequencies of radiant energy (vision), sound, and tactile vibration.

The most dramatic of these data are those that 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 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 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 of spatial frequency. This frequency-selective microprocess operates in a holographiclike manner.

Processing can thus be conceived to operate 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 microorganization of the cortical neurons in the extrinsic systems resembles the organization of a multiplex hologram. A multiplex hologram is characterized by a Gabor elementary function, which Dennis Gabor called a *quantum of information.* A Gaussian envelope constrains the otherwise unlimited sinusoid described by the Fourier transform to make up the Gabor function. Experiments have shown that electrical excitation of frontal and limbic structures relaxes the Gaussian constraints that are manifested as inhibitory surround or flanks in the receptive field architecture. When this occurs during ordinary excitation of the frontolimbic systems of the forebrain, processing leads to narrative construction. 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. When such conversions are linear (e.g., when they employ the Fourier transform) they can readily be reconverted (e.g., by the inverse Fourier transform) into moving (i.e., successive) sensory images. The spectral domain is peculiar in that information (in the Gabor sense) becomes both distributed over the extent of each receptive field or 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, of causality. It is this apparently timeless-spaceless-causeless aspect of processing instigated by overwhelming frontolimbic excitation that is responsible for the extrasensory dimensions of experience that characterize the esoteric traditions. Because of their enfolded property these processes tend to swamp distinctions, such as between corporeal and extracorporeal reality. In the esoteric traditions, consciousness is not limited to this type of reality.

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 clear that there is a limit to the accuracy with which certain measurements can be made; this limit is expressed as an indeterminacy. In his description of a quantum of information, Gabor showed that a similar indeterminacy describes communication; leads to a unit of minimum uncertainty, the maximum amount of information that can be packed for processing. Thus, there is a convergence of the understanding of the microstructure of communication—and therefore of observation—and the microstructure of matter. The need to specify the observations that lead to inferring the properties of matter has led noted physicists to write representations of the observer into descriptions of the observable. Some physicists have noted the similarity of this specification to the esoteric descriptions of consciousness.

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 thus far resulted in the widening of the rift between objective science and the subjective spiritual aspects of man's nature. The rift reached a maximum toward the end of the nineteenth century: mankind was asked to choose between God and Charles Darwin; Freud showed that heaven and hell resided within people and not in their relationship to the natural universe. However, the discoveries of twentieth-century science do not fit this mold. For once, the recent findings of science and the spiritual experiences of mankind are consonant. This augurs well for the upcoming new millennium because a science that comes to terms with the spiritual nature of mankind may well outstrip the technological science of the immediate past in its contribution to human welfare.

SUGGESTED CROSS-REFERENCES

Neuroanatomy is discussed in Sections 1.2 and 1.3, electrophysiology in Section 1.9, perception and cognition in Section 3.1, psychoanalysis in Section 6.1, and psychosurgery in Section 31.32.

REFERENCES

Ashby WR: *Design for a Brain: The Origin of Adaptive Behavior*, ed 2. Wiley, New York, 1960.
*Avi G, Amir B: Brain organization and psychodynamics. J Psychother Pract Res *8:* 24, 1999.
Bekesy Von G: *Sensory Inhibition*. Princeton University Press, New Jersey, 1967.
Bogen JE, Bogen GM: The other side of the brain III: The corpus callosum and creativity. Bull Los Ang Neurol Soc *34:*191, 1969.
Bracewell RN: The Fourier transform. Sci Am *260:*86, 1989.
Brentano F: *Psychologie vom empirischen Standpunkt, vol III, Vom sinnlichen und noetischen Bewusstsein*, ed 2, Franziska Mayer-Hillebrand, editor. Felix Meiner, Hamburg, 1968.
Bucy PC: *The Precentral Motor Cortex*. University of Illinois Press, Chicago, 1944.
Cannon WB: The James-Lange theory of emotions: A critical examination and an alternative theory. Am J Psychol *32:*106, 1927.
Efron R: *The Decline and Fall of Hemispheric Specialization*. Erlbaum, New York, 1989.
Gabor D: Theory of communication. J Inst Elect Eng *93:*429, 1946.
Gall FJ, Spurtzheim G: Research on the nervous system in general and on that of the brain in particular. In *Brain and Behavior*, KH Pribram, editor. Penguin, Middlesex, England, 1969.
Gazzaniga MS: *The Social Brain: Discovering the Network of the Mind*. Basic Books, New York, 1985.
Hermans HJM, Kempen HJG, van Loon RJP: The dialogical self: Beyond individualism and rationalism. Am Psychol *47:*23, 1992.
Hilgard ER: Divided consciousness: Multiple controls in human thought and action. Wiley, New York, 1977.
Hinton GE, Anderson JA: Parallel models of associative memory. Erlbaum, Hillsdale, NJ, 1981.
Jaynes J: The origin of consciousness in the breakdown of the bicameral mind. Houghton-Mifflin, Boston, 1990.
John ER: *Mechanisms of Memory*. Academic, New York, 1967.
Kelso JAS, Saltzman EL: Motor control: Which themes do we orchestrate? Behav Brain Sci *5:*554, 1982.
Lashley D: The thalamus and emotion. In *The Neuropsychology of Lashley*, FA Beach, DO Hebb, CT Morgan, HW Nissen, editors. McGraw-Hill, New York, 1960.
Matte Blanco I: *The Unconscious as Infinite Sets*. Gerald Duckworth Ltd, London, 1975.
McFarland DJ: *Feedback Mechanisms in Animal Behavior*. Academic Press, London, 1971.
Miller GA, Galanter A, Pribram KH: *Plans and the Structure of Behavior*. Henry Holt, New York, 1960.
Neumann E: *The Origins and History of Consciousness*. Princeton University Press, Princeton, NJ, 1954.
Olds J, Milner P: Positive reinforcement produced by electrical stimulation of septal area and other regions of rat brain. J Comp Physiol Psychol *47:*419, 1954.
Peirce CS: *Pragmatism and Pragmaticism: Collected Papers*, vol 5. Harvard University Press, Cambridge, MA, 1934.
Pribram KH: *Brain and Perception: Holonomy and Structure in Figural Processing*. Erlbaum, New York, 1991.
Pribram KH: The intrinsic systems of the forebrain. In *Handbook of Physiology, Neurophysiology*. Field, HW Mogoan, VE Hall, editors. American Psychological Society, Washington, DC, 1960.
Pribram KH: The deep and surface structure of memory and conscious learning: Toward a 21st century model. In *Mind and Brain Sciences in the 21st Century*, RL Solso, editor. MIT Press, Cambridge, MA, 1997.
Pribram KH: How is it that sensing so much we can do so little? In *Central Processing of Sensory Input*, FO Schmitt, FLG Worden, editors. MIT Press, Cambridge, MA, 1974.
Pribram KH: *Languages of the Brain: Experimental Paradoxes and Principles in Neuropsychology*. Prentice-Hall, Englewood Cliffs, NJ, 1971.
Pribram KH: Limbic system. In *Electrical Stimulation of the Brain*, DE Sheer, editor. University of Texas Press, Austin, TX, 1961.
Pribram KH: Localization and distribution of function in the brain. In *Neuropsychology After Lashley*, J Orbach, editor. Erlbaum Associates, Hillsdale, NJ, 1982.
*Pribram KH: The Composition of Conscious Experience. J Conscious Studies *6:*20, 1999.
*Pribram KH: The primary of conscious experience. In *Science and the Primacy of Consciousness*, RL Amoroso, R Antunes, C Coelho, M Farias, A Leite, P Soares, editors. Noetic, Orinda, CA, 1999.
Pribram KH: What is mind that the brain may order it. In *Proceedings of the Norbert Weiner Centenary Congress, 1994*, V Mandreka, PR Masani, editors. American Mathematical Society, Providence, RI, 1997.
Pribram KH, Gill M: *Freud's "Project" Reassessed*. Basic Books, New York, 1976.
Pribram KH, McGuinness D: Arousal activation and effort in the control of attention. Psychol Rev *82:*116, 1975.
Pribram KH, Reitz S, McNeil M, Spevack AA: The effect of amygdalectomy on orienting and classical conditioning in monkeys. Pavlov J *14:*203, 1979.
Rumelhart DE, McClelland JL, and the PDP Research Group: *Parallel Distributed Processing*, vols 1 and 2. MIT Press, Cambridge, MA, 1986.
Schachter S, Singer TE: Cognitive, social and physiological determinants of emotional state. Psychol Rev *69:*379, 1962.
Searle JR: *The Mystery of Consciousness*. New York Review of Books, New York, 1997.
Thatcher RW, John ER: *Functional Neuroscience*, vol 1. Erlbaum, Hillsdale, NJ, 1977.
Weiskrantz L: *Blindsight: A Case Study and Implications*. Clarendon Press, Oxford, 1986.

3.6 Emotional Intelligence

DANIEL GOLEMAN, PH.D.

To be *emotionally intelligent* is to have the personal skills that characterize a rich and balanced personality. Emotional intelligence includes, as Aristotle put it, the rare ability "to be angry with the right person, to the right degree, at the right time, for the right purpose, and in the right way." Emotional intelligence is distinct from intelligence quotient (I.Q.), which is the ability to perform cognitive tasks adeptly; each of these kinds of intelligence is based in differing but interlinked neural circuitry, with emotional intelligence largely mediated by limbic and prefrontal areas and I.Q. by neocortical zones alone. Emotional intelligence and I.Q. are not opposing competencies, but discrete and synergistic ones.

The theory of emotional intelligence offers a new psychological framework for primary prevention in psychiatry that integrates recent discoveries in cognitive science, neurological science, and child development. The competencies of emotional intelligence are crucial for the self-management of emotion and for the skillful handling of relationships. These abilities are learned throughout life, with primary learning occurring during childhood. Such learning shapes the underlying neurological circuitry, which continues to mature into adolescence. Emotional intelligence can be enhanced through the systematic offering of beneficial learning experiences as children grow, and deficits can be repaired through remedial learning and coaching.

Those who fail to master the competencies of emotional intelligence face a spectrum of heightened psychiatric risks, such as mood and anxiety disorders, eating disorders, and substance abuse. Because these skills of emotional intelligence are teachable, offering children and adolescents opportunities to strengthen these competencies can act as an inoculation against a spectrum of social and psychiatric risks.

COMPONENTS OF EMOTIONAL INTELLIGENCE

One commonly used version of Peter Salovey and John Mayer's 1990 definition of emotional intelligence includes abilities in five main areas:

1. *Self-awareness:* Recognizing one's feelings as they occur is the linchpin of emotional intelligence. The ability to monitor feelings from moment to moment is key to psychological insight and self-understanding. Being aware of one's emotions makes one more