BRAIN SCIENCE AND THE HUMAN SPIRIT

by Colwyn Trevarthen

Abstract. In recent decades of its brief history, brain science has shed light on the source of motives. We review the chemistry and anatomy of the neural core of human motivation; it seems to penetrate the hemispheric cognitive fields asymmetrically, subjecting them to differing evaluations by self-organizing states of mind. The brain core generates and responds to the rhythm and color of emotions, giving moral control to relationships and setting values and meanings in communication. The newborn human mind is ready to share transcendent states with an empathic partner. Fantasy-making play of a child in friendships presages adult rituals. Mystic rites and mythic symbols express feelings essential to time- and space-defying cooperation within the ancestral culture.

The great variety of myths and rituals cannot conceal that there are underlying feelings and motives that all religions serve—motives that spring directly from the unchanging life processes of the human spirit with power to question existence, holding believers to values and feelings of good and evil that transform ordinary practical objects and tasks, affirming a zest for belief. Believers obey intrinsic passions that seek sympathetic response in a community of minds, and they reject disbelief with fear or anger, even with hatred.[1]

We have few options to explain aesthetic, moral, and religious universals in human inspiration. For the associationist they penetrate from outside into a receptive mind fabric, born a blank state in each generation. But are they merely accumulated experience built up over centuries in the memories of individual men and women, knowledge concentrated through the connectedness of the social histories within groups of people or by means of trade between groups across continents and oceans? Could they have been impressed in unquestioning minds from cosmic regularities of the environment that we cannot

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escape? Are they advice received from an all-knowing deity resembling a supremely powerful parent or teacher? Or are they actively conceived, manifestations of genetic rules that govern the outward growth of millions of nerve cells according to a psychogenetic strategy for place-seeking and pattern-forming that absorbs the chance experiences of individuals into brain functions that were validated through natural selection in the evolutionary past of our species?

Victor Turner (1983a) believed that inherent forms of brain activity give rise to deep universals of culture. He proposed that anthropologists should take note of recent brain research in order to better understand the form of rituals and content of myth. He courageously put his mind to the task of absorbing evidence from comparative and experimental brain science, neuropsychology and psychiatry, and built up a persuasive explanation why humans in very different situations are attracted to parallel images, legends, and ceremonials. He sought to define the inner satisfactions that customs bring to people by identifying anatomical and chemical categories of neuronal process that work together in each and every human being, presumably in consequence of self-organizing and genetically constrained growth processes that link up and diversify the actions of nerve cells as they multiply and spread into the tracts and nuclei of the brain.

In responding to Turner's theory, it will not be sufficient to detail what we know of the complexity of information-receiving or movement-coordinating mechanisms in the brain. We will need, as Turner perceived, to interpret the deeply rooted, motivating, choosing, and evaluating systems that evolution has fashioned at the source of mental activity—the motive structures that mediate advantageous transactions between a unified knowing, imagining, and remembering self, its body, and the world.

Turner raises a question about how the inner working of the brain, with ancient evolutionary origins, might relate to spiritual vision and to the ritualistic forms that human individuals in their communities look to for support and confirmation, and by which they break free from the impositions of reality. He promulgates a belief in motivator mechanisms of the brain that mix action and reflection, power and self-reward, anger and love, joy and despair, and faith and fear. He accepts the principle that patterns of social signaling have evolved to promote a community of beings that gain advantage in life by interacting cooperatively—linking themselves mentally. Turner follows Eugene d'Aquili (1983) in extending the concept of an heritable structure of antithetical drives (such as ethologists attribute to animals and use to explain their "rituals" of courtship and mating, parental care, territorial fighting, etc.) to include the human cognitive modes of the hemispheres, viewed as being balanced in opposition—the energetic, pragmatic, and effective on the left side and the reflective, dreaming, and restoring on the right.[2] The brain division so described recalls Carl Jung's archetypal division of the mind and spirit into *animus* and *anima* (Turner 1983a, 238-39). Turner cites modern psychiatric, physiological, and pharmacological evidence as well as interpretations of the split brain and effects of unilateral cerebral lesions. This analysis he applies not so much to the ethnography and psychology of human techniques and artifacts as to more spiritual concerns and their celebration.

Turner's knowledge of African mythology inspired him to give a special role to "the Trickster" of play, an elusive force for jovial teasing and absurd rule-breaking, defiant of established routines and factual explanations. He saw playfulness as mixing up the ergic, reality-bound and the trophic, self-protecting, the animus and the anima, and the rational and the emotional in borderline "liminal" states of mind, pitting rival brain systems in a creative conflict that cracks the monopoly of concrete reality (Turner 1983a; 1983b). I am fascinated by this insight because it is plain to me now, after a decade and a half watching spontaneous communicating between mother and infant, or toddler and toddler, that joking, teasing and imaginative, fantastical, rule-breaking play is the well-spring of energy for healthy mental growth and the promoter of learning in affectionate relationships. Its absence in a young child is an infallible sign of motivational pathology and a forewarning of retarded mental development.[3]

Can we hope to bring all these exciting ideas of Turner's together in a theory of human cerebral nature and innate motivations for social cooperation and celebration as he recommends us to do? It is a grand challenge.

Doubts may be felt that our scientific traditions are well suited to this enquiry. Confronted with consciousness and the complex antithetical purposes and values that it serves, our theories appear hidebound in rational objectivity or lost in a dualistic set of thinking that, by irrevocably separating the material from the spiritual, blocks the path to an understanding of motivations. As long as scientists believe that the only testable truth is in an uninterrupted physical reality outside the special psychological reality of minds, there is no way of conceiving either the inside springs of animal spirit or the fabric of human understanding that has evolved from them. Brain science is in the unique position of studying the only part of physical reality that has the design to contain or generate inner mental processes. Grasping this requires a shift in scientific attitudes, not just an extension of past physical models. Moreover, before we jump to the conclusion (perhaps encouraged by the rapidity of recent advances and the abundance of new findings that fill the journals and receive increasing attention in public media) that the task of making a brain science of spiritual, mental, or emotional matters will be no more awkward than any other physical analysis that science has attempted—merely a replacing of inaccurate superstitions with substantial and reliable data on brain matter and its chemistry, and with some more complex models of the causal machinery—it is well to remind ourselves just how little we know and how recently it is, and in what climate of thinking, that we have opened the Pandora's box of the brain to glimpse a little of what is inside. The history outlined below reveals a clear bias towards simplistic mechanical models that leave the creative power of motives obscure.

I believe, in spite of obvious difficulties, that Turner's audacious challenge comes at the time to facilitate a new understanding. Brain science knows much more about the inner workings of the brain than it did just two decades ago. Now it can offer guidance concerning the origins of significant human motives. Psychology, too, is certainly more sophisticated today than over most of the past half century about the intrinsic, self-sustaining processes of mentation, including those that motivate and regulate both learning and social behavior. It is less reluctant to tackle the mysteries of cognitive, volitional, and emotional processes that taunt scientific efforts at reduction to the supposedly greater certainties of physics and chemistry. Scientific theories attempting to integrate cerebral facts at the level of psychological functioning are getting new confidence and credibility. They are beginning to find explanations for the human state of mind.

The Evolutionary Continuum of Brains and of Behaviors

At the origin of the scientific view of ourselves is the Darwinian concept of evolution. A modern biologist expects human intelligence to resemble that of animals closest in the evolutionary scheme. In 1861 Thomas Huxley, lecturing to working men in London, took battle in support of *The Origin of Species*, recently published by his friend Charles Darwin (Darwin 1859). The lectures appeared in a best-seller entitled *Evidences as to Man's Place in Nature* (Huxley [1863] 1913). Huxley confronted those whose religious beliefs concerning creation forbad them to see humankind as related in form or function to any animal species. Eloquently, and with painstaking accuracy, he recited the evidence from comparative anatomy and embryology, paying particular attention to the latest information from dissection of preserved brains of monkeys, apes, and humans. He sifted evidence from reports of traveling naturalists and his own wide knowledge of human societies to show that behaviors of all tribes of human beings could be compared to behaviors of monkeys and apes. Huxley could have but gross knowledge of the brain and virtually no awareness of its inner histology or physiology. He concludes, "So far as cerebral structure goes, Man differs less from the Chimpanzee or the Orang than these do even from the Monkeys" (Huxley [1863] 1913, 69); but he goes on, "It must not be overlooked, however, that there is a very striking difference in the absolute mass and weight between the lowest human brain and that of the highest ape. . . . This is a very noteworthy circumstance, and doubtless will one day help to furnish an explanation of the great gulf which intervenes between the lowest man and the highest ape in intellectual power. . . . It is no doubt perfectly true, in a certain sense, that all difference of function is a result of difference of structure; or, in other words, of difference in the combination of the primary molecular forces of living substance" (Huxley [1863] 1913, 70).

Huxley thought that inconspicuous differences in brain mechanism combined with new peripheral organs, such as those of throat and mouth for speech, could produce great transformations in psychology and intellect. Here we see the gifted prophet of natural history to be mistaken. Brain science now knows real and large-scale evolutionary transformations, not in "the combination of the primary molecular forces of living substance," but in the design and function of cell communities of the brain. In essence, however, it was not the anatomy but the psychological subtleties of the human mind that eluded Huxley, who was too preoccupied with a search for "structures." Without some theory of the mental events that conceive the world and act upon it with choice we cannot begin to look for the brain mechanisms behind mental differences that separate humans from apes. Since Huxley's day, our thinking on brain and mind has been transformed.

A brief glance back over the history of brain science will suffice to warn us of the risks that lie in any attempt to bridge the gap between human communal mind and the human brain. Scientific materialism will make the grade to explain deeper psychological events only with great difficulty. But one has no right to make the traditional response of a dualist; we must not turn away and deny that these problems are tractable.

Discovery of the Brain

It is barely 300 years since an Oxford professor of medicine Thomas Willis argued that scientists should look for mind processes in the solid matter of the brain.[4] Before that the cerebral processes of the mind and mental illness were utterly obscure, and brain science was nonexistent. The ancient Greeks, Hippocrates of the fifth century B.C. greatest among them, had brilliant insights into brain activity and the effects of wounds or epilepsy, but these informed guesses were forgotten as centuries of savants since Galen, court physician to emperor Marcus Aurelius in second-century Rome, imagined the spirits of cold reason mingled with hot emotion in the ventricular cavities of the brain. In the seventeenth century René Descartes' doctrine of reflexes, "mindless motor acts in man and animals" (Sherrington 1940, 161) could only provide an argument for placing mind, and also God, outside the machine of the body.

As Darwin was working on *The Descent of Man* in the mid-nineteenth century (Darwin 1871),[5] the best an expert on the brain could do was ponder a mystery of bulbous masses and a tangle of white strands, but great strides were made in the space of a few decades. At the end of the century Sigmund Freud ([1895] 1954) was bold among neurologists to accept the intuition of the great Spanish anatomist Ramon y Cajal that the brain was a tissue of separate nerve cells that communicated through discrete contacts, perhaps by chemicals (Freud [1895] 1954; Pribram 1969; Konner 1982, vii). Beautiful global brain anatomies, full of intricate histological detail, were published at that time (see fig. 1A), but the physiology of integrative neural action was virtually unknown.[6]

Charting of the cortex to locate different psychological functions began with the development of accurate experimental surgery and delicate electrical stimulation a little over 100 years ago. Gustav Fritsch and Eduard Hitzig, Hermann Munk, David Ferrier, and Friedrich Goltz identified sensory perception territories for each of the modalities and defined a map of the motor organs of the body and limbs.[7] Psychic integrations of differing kinds were observed to have a systematic relation to the locus of cortical damage in humans when neurologists could localize lesions and when they had learned to analyze psychological reactions. These practices, too, were perfected in the latter decades of the last century. Tragically, the human brain maps became clearer with the invention of high velocity rifles for war use and explosive shells that projected shrapnel with sufficient velocity to cut discrete pieces from the surface mantle of the brain. Through all this advance in knowledge of the cortex there was uncertainty and bitter controversy over how local territories, with different relation to peripheral sensory or motor organs, could contribute to integrated consciousness and voluntary movement. Some thought mental operations could never be localized, that they were diffuse properties of a brain that could function only as a whole.

Concerning the special human form of mind, the greatest breakthrough was the discovery in the 1870s that language, for many scholars the defining feature of human intelligence, could be selectively impaired by either a lateral-frontal or a posterior-temporo-parietal lesion restricted to the left cerebral hemisphere (Broca 1865; Wernicke

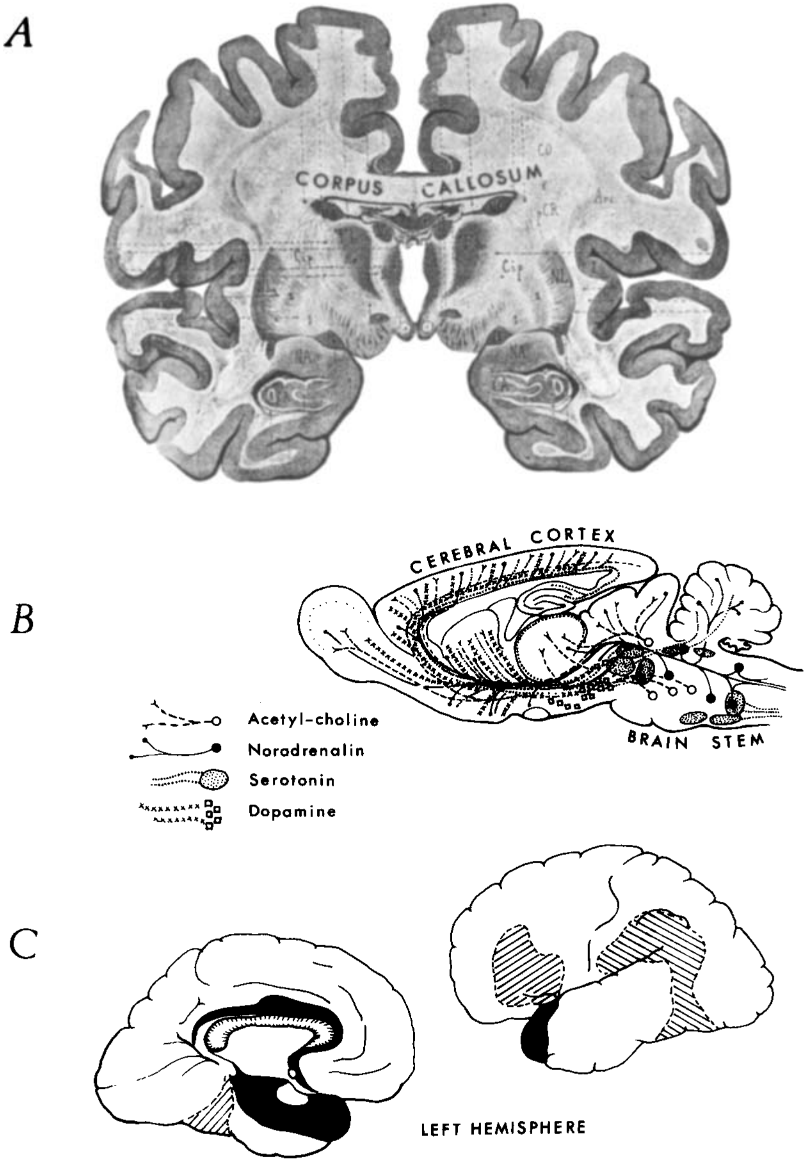

FIG. 1.—A: Cross-section of a human brain from Dejerine ([1895-1901] 1980) showing the corpus callosum, limbic structures (in black) and a portion of the late maturing "cultural" cortex (marked by a dashed line). B: Section of a rat brain indicating approximate distribution of the brain-core transmitter systems important in motivation (based on McGeer, Eccles, and McGeer 1978; Ungerstedt 1971). C: Diagrams of the human cortex showing limbic tissue in black and "tissues of culture," Brodmann's territories numbers 37, 39, 40, 44-46, cross-hatched (original).

1874; Freud 1953; Penfield & Roberts 1959; Blakemore 1977, 141-44; Trevarthen 1984a, 1159-60). The one-sided lesions that destroyed speech or comprehension of speech were in an anatomical *terra incognita* outside the primary sensory or motor areas. Their discovery inspired lively speculation on the anatomy of higher mental processes. It was soon observed that skillful coordinations of moving and perceiving to read, to perform significant gestures, or to formulate purposeful performance of a task could be disrupted by a lesion that disconnected areas of the cerebral hemispheres and separated sensory and motor territories from integrative command centers placed one-sided in the brain. However, until Roger Sperry's work in the 1960s the function of the corpus callosum bridging the gap between the hemispheres was a matter of speculation (Sperry 1967). This is the biggest mass of nerve fibers in the brain, now estimated to contain 800 to 1,000 million fibers in one head, as many as the population of China. Inborn, visible anatomical differences between the cerebral hemispheres have been generally believed important in human psychology only since the mid 1970s.[8]

A golden age of anatomical research began about 1870 when the method of staining single nerve cells black with silver deposits was discovered, and by the 1900s the fabric of the primary receptor territories, and many other cortical tissue types with uncertain function, had been distinguished. Paul Flechsig demonstrated in 1901 that the primary sensory and motor cortices matured quickly after birth in a baby's brain but that other territories took many years of childhood to complete differentiation.[9] The Australian Elliot Smith showed that the amount of neocortex, the territory in most immediate contact with receptors and motor organs and capable of refined sensory and motor discriminations in mastery of the external environment, increased relative to older archicortex and paleocortex from primitive to advanced mammals (Smith 1910). Evolution seemed to be building up the neocortex with increase of intelligent awareness and learning, older forebrain regions being most involved in automatic, instinctive orienting reactions close to satisfaction of vital needs.

Charles Sherrington defined in 1906 how nerve fibers made contact with nerve cell bodies at junction points he called synapses, but the fine structure of the synapse was perceived only 60 to 70 years later.[10] At Oxford in the first decades of this century scientists in Sherrington's school worked out reflex integrations of the spinal cord by controlled stimulation of receptors in various intensities and combinations and by precise measurement of elicited response movements. They experimented with these basic sensory motor coordinations in animals which had their brains removed or disconnected from the cord—not the ideal procedure to elucidate higher mental functions. Ivan Petrovich Pavlov in Russia, inheritor of the materialistic tradition for interpreting brain functions of Emil du Bois-Reymond, Hermann von Helmholtz, and Ivan Michailovich Sechenov, founded his conditioned reflex theory of learning on early investigations of sensory and motor maps in the cortex of animals exposed to rough tissue removals and simple behavioral tests (Pavlov [1927] 1960; Fearing [1930] 1970). Sherrington, who refers to Pavlov as a reflexologist and Descartes' greatest successor, admired his experiments but rejected his materialist explanation of the fabrication of the mind (Sherrington 1940).

The idea of chemical transmitters that carried excitation across the minute synaptic gaps between neurones and at nerve-muscle junctions was developed after 1914 by Henry Dale, Otto Loewi, and others. A physical model of how nerve impulses are started and how they travel down the nerve membrane, along with proof of the integrative blending of excitatory and inhibitory currents in postsynaptic cell bodies, came in the 1940s with the invention of microelectrodes, fine probes that could pick up electrical currents passing through the membranes of nerve cells.[11] Without these basic physiological facts it was impossible to even begin to conceive how nerve-cell circuits, seen clearly by anatomists since the 1870s, could process excitations and coordinate an animal's movements with perceptions of the outside world.

Up to this time nearly every scientist thought of the brain as a circuitry that had energy put into it from stimuli, even though the level of electrical activity in the brain fluctuated spontaneously in the sleep-wake cycle. Then, forty years ago, important psychological functions of the reticular core of the brain, regulating arousal of attention against sleep, were demonstrated by Horace Magoun and John French (Magoun 1958). This opened the way for new ideas on how the integrative activities of the cortex responsible for perceptual discrimination and learned guidance of movements could be sensitized or changed by the activity of brain-stem systems that also controlled vital body states.

At present new theories about cerebral functions come so fast—from brain scans, clinical neuropsychology, neurophramacology, histochemistry of neurones, experimental embryology of the brain, brain grafts, and so on—the picture we have must, at best, be provisional. And yet there are already findings that are enlightening for psychology and not unfriendly to traditional wisdom about the inspirations and maladies of the human spirit.

The Neurobiology of Motives

Adjustments within the core of the brain can select the physically insignificant for awareness from among a plethora of distinguishable elements in stimuli, can concentrate and aim the "searchlight" of attention and seek for goals, and can choose to forget the large and permanently retain the very slight and rare. The complexity of these systems has become clearer in the last decade (Scheibel 1984).

In the past century emotions have been identified by physiologists with sensory systems that monitor vital body functions, maintain tissue integrity, and ensure reproduction of the species. Autonomic control systems that balance visceral against somatic; restorative and sustaining against energy-expending, effortful, and depleting; rest against action; pleasure against pain; flight against fight have been taken as the basis for explanations of emotion and emotional illness (McGeer, Eccles & McGeer 1978, 465-80; Konner 1982, 137-42; Pribram 1984). Drives of hunger and sex, triggered by events in gut and gonads, have been perceived as primary.

But transactions of the brain with physical nature outside the body are controlled by independent nerve action in the brain core.[12] Spontaneous changes in arousal, attention, or curiosity gate perceptions of the external world and give pattern to motor action and learning. Consciousness, though capable of reacting precisely to sensory stimulation, is under the control of systems that balance exploration against knowing, seeking against choosing, taking against rejecting, and remembering against forgetting. Movement is made effective by these motivations for perception of useful information. Its voluntary control depends on active and selective absorption of stimulus energy from the environment into images of events in a space/time field for acting that has been generated spontaneously in the brain. These "programs" of the brain for its own information-seeking purposes, that coordinate both perception of objects and movements, can be identified with cognitive processing. But there is one kind of motivation, essential to the development of cultures, that transcends both the autonomic and the cognitive.

Mind states of a human being, whether to keep the body intact or to further consciousness and intended action, are made into information for other minds. Human motives can be intimately shared through the expressions of the face, the voice, or gesture. These actions bring, through subtle regulation of mutual attention, a fusion of purposes between individuals and a collective awareness of reality.[13] Here, at length, we reach a level of brain work directly related to Turner's quest; we begin an enquiry into the neurology of his *communitas*.[14]

Melvin Konner has described how, about 1890, before leaving objective brain research behind him to explore the subjectivities of psychoanalysis, Freud worked out a remarkable theory to explain how neural emotional systems regulate neocortical transactions with reality

(Freud 1953; Konner 1982, 130-33). As a young neurologist and neuroanatomist of great promise, he confronted the new and exciting but simplistic view of language centers and one-way links between the word-hearing area of Carl Wernicke and the word-speaking area of Paul Broca, with a theory of processes for comprehending the meanings of words or for synthesizing ideas to be put into words. In his early papers, Freud was giving anatomical plausibility to notions that later, when he had given up attempting to formulate a neural model, became his metaphorical entities of id, ego, and superego. His informed speculations on the brain mechanisms of motivation at the dawn of psychoanalysis carry much sense to this day (Pribram 1969).

Paul MacLean followed the same tradition.[15] He took up the idea of James Papez that a circuit of structures in the inner rim of the hemispheres and penetrating basal ganglia, thalamus, and hypothalamus was the seat of emotions. He brought anatomy and physiology back to Freud's theory by direct examination with electrical stimulation of the centers in a monkey's brain that seem to command urges to sexual display, or the excitement of perceiving it. Taking a term invented by Broca, he names Papez's emotional system "limbic," that is, "on the fringe" of the cognitive neocortex.

MacLean noted that his squirrel monkey subjects displayed their genitals for the visual appreciation of social partners and also moved their faces to coordinate impulses to fight or mate. He perceived great significance in the ability of these animals to make social engagements by means of posturing, grimacing, and simple calls over a distance. He emphasized that the monkeys use an emotional code to regulate the compelling attractions and rivalries of sex. He expanded the concept beyond experiment to explain how humans, through expressions of love in partnership, find satisfaction for the drive to plan a safe and prosperous future for a family; and he guessed that the brain parts that carry monkeys into mating and generate social bonds must be homologous with those, much enlarged, that make it possible for humans to form lasting affectionate relationships. He proposed that enlargement of the motives of social and interpersonal life must involve projections from the limbic system into the prefrontal cortex, and such an anatomy was confirmed by Walle Nauta (1971). The regulation of emotional signals that can touch another mind is a mental necessity for humankind. The work of Freud, Papez, MacLean, Nauta, and many others since has helped identification of parts of the brain that form the essential crucible of the human spirit (McGeer, Eccles & McGeer 1978, 469-76; Pribram 1984).

MacLean's plan of a three component, "triune" brain is full of rich insights and is supported by careful research. Nevertheless, his idea that automatic reptilian and emotional early mammalian brains form separate, sometimes anarchic strata inside the human mind does not bear critical examination (Damasio & Van Hoesen 1983, 87). Every layer of the brain has been radically reworked by evolution, and new components have been added at the places where functional systems border one another, to make novel systems from their overlapping. All brain components are transformed in the making of human mentality which manifests itself in their interactions. At the same time, the fundamental relationships between instinctive motor patterns, autonomic emotional states, and cognitive processes that learn may be detected in a humble fish or a tiger salamander.[16] New human cerebral organization elaborates the whole plan.

The inner generated spontaneity of motivation, making curiosity for experience and will for actions, plus the emotional linking together of motives between separate beings, are complementary to the building of cognitive, rational, and realistic faculties. Reason and emotion differ not as alternatives or mutually exclusive levels but as mutually dependent causes and explanations of mental life. This is being clarified by remarkable discoveries of different interlocking and balanced mechanisms within the reticular core of the brain. Here research on the tough ingenious rat, long a servant of behaviorists attempting to measure formation of conditioned reflexes, is in the forefront of the new scientific campaign to explore the many-colored motive networks in the periventricular core of the brain stem and to understand their extensive penetration into the cognitive circuits of the cortex that receive sensory information or command motor action (Ungerstedt 1971; see fig. 1B). It is impossible to comprehend this kind of neural machinery without going into the recently discovered chemistry of the brain.

Chemistry of Emotional State and Human Empathy

Nerve cells interact by chemical substances that excite receptor gateways on the surface membranes of other nerve cells (McGeer, Eccles & McGeer 1978). Neurohormones or transmitters emitted from the nerve endings, or brought via blood capillaries from endocrine glands into the nervous system, have complex effects on nerve cell transmissions. Some chemicals instantaneously trigger the cell membrane to a discharge of impulses that travel in thousandths of a second from cell to cell down the network. Others have long-lasting, even permanent, effects on the chemistry and excitability inside the cell body. Some can regulate the chemistry of the receiver cell's cytoplasm to the extent of modifying gene transcription and protein synthesis and cell development.

In the motivational core of the brain there are intermingled cell clusters and a forest of cell communication lines that have a multiplicity of roles to play in balancing environment-sensitive perception against emotion, activity and effort against passive self-nurturance, fight against flight, and pleasure against pain. The whole dynamic multicellular federation integrates the antithetical states of a psycholgoical subject and consolidates awareness of a "self"; it regulates the rate and intensity or force of motor output, focuses and aims a dozen different types of attention to sensory input, repairs diseased or disordered tissues, including the motivating tissues themselves, and reaches out to communicate with other organisms that mirror the excitements of the self and react with complementary messages or actions.

The chemical code of nerve cell communication in the brain stem has been discovered in the last fifty years (McGeer, Eccles & McGeer 1978). Adrenaline and acetylcholine in the peripheral autonomic nervous system, readying the body for intense effort and resisting pain, or settling it for sleep and recuperation, were detected about the turn of the century; however, transmitters in the brain itself were found in the 1930s, and the main quick-acting excitatory and inhibitory *ionotropic* agents of refined sensory and motor coordination were not discovered until the 1950s.

Slow *metabotropic* regulators of nerve cell activity and excitatory state act by releasing intracellular "second messenger" substances that give energy to chemical reactions of protoplasm, including protein synthesis. They are secreted by a scattering of neurone groups in the brain stem that have been known for less than thirty years. While about one million in number, less than one-50,000th of the total population of neurones in a human cortex, regulator neurones have axons penetrating into all brain networks, perhaps five million endings arising from a single cell. They influence perception, learning, remembering, and motor programming by changing the state of cells in many deep nuclei of the brain and in the cerebral cortex. They are the telegraphic system of instinctive readiness in the nerve networks, capable of setting the balance of nerve energy in innate patterns and driving the rituals of social engagements, including those between the sexes or between parents and their offspring. These substances, acting in counterbalanced combinations to modulate all cerebral integrations, play a crucial role in altered states of consciousness and mental illness, in the day-to-day regulation of mood and personality, and in the moment-by-moment changes of emotion.

Historic experiments on the effects of electrical stimulations in the brain were carried out in the 1930s by Walter Hess. Hess described opposing systems. One produced arousal, increased muscle strength, active psychic alertness, and exploration; he called this *ergotropic* and identified it with stimulation of the posterior hypothalamus. The other induced behaviors promoting rest, recuperation, low body activity but high visceral processing, apathy, relaxation, and sleep; he named this system *trophotropic* and linked it to anterior hypothalamic stimulation. Later work by Hess, Heinrich Kluver and Paul Bucy, MacLean, and James Olds implicated an extensive system of brain stem and limbic cortex in this same regulation of motivations, appetites, and sexuality (Hess 1954; 1964; Olds 1962; Valenstein 1973). The evidence from cases of accidental injury to mesofrontal cortex, to the hippocampus, amygdala and limbic tissue, and to the hypothalamus and areas of the midline or ventral brain stem in humans is in agreement. Activation or suppression of these systems is associated with changes in vitality and alertness or sleepiness and confusion, and with pleasurable elation and warm floating feelings or irritability, anxiety, fear, and rage. They are involved in the symbolic effusions and "pressure of words" in schizophrenia, or in the withdrawn silence of the depressed or autistic individual. Sexual feelings and urges as well as visceral states are also altered by excitation or removal of these parts of the brain.[17]

In 1959 dopamine, abundant in the corpus striatum (key component of MacLean's reptilian brain), was implicated in Parkinsonism, a disorder of movement accompanied by a characteristic depression of motivation. At this time Bernard Brodie had the idea that noradrenaline is a central ergotropic agent while serotonin, first found in the early 1950s and concentrated in the hypothalamus and limbic system (MacLean's emotional brain of mammals), is the central trophotropic substance. Thus began a great era in discovery and synthesis of chemicals that could tranquilize, elevate mood, stimulate, and reduce psychotic symptoms, and of drugs that could create psychotic states of euphoria and hallucination. The most active substances, including reserpine, chlorpromazine, iproniazid, amphetamine, and lysergic acid, caused changes in the availability or action of serotonin, dopamine, noradrenaline, and adrenaline, or they mimicked the action of these substances. Hope for cures of mental illness drove researchers to untangle an immensely complex system, but unfortunately the antipsychotic drugs usually cause unpleasant Parkinson-like motor problems and agitation or depression.

In the 1960s and 1970s, ways were found to stain selectively natural transmitter chemicals in cell groups and fiber projection pathways, and at nerve cell endings where mental states and moods are regulated, making the transmitters easily visible under the microscope. The extensive penetration of these neurochemical systems into the classical sensory, motor, and associative tissues and the intricate convergence of their endings on integrator cells of cortex and brain stem were made vividly apparent. Then, in the mid 1970s, a new group of central transmitters was found regulating both the experience of pleasure and pain and the secretion of anterior pituitary hormones of growth and healing. Minute quantities of natural opiates could produce the effects of addictive opiate drugs like morphine: euphoria, sedation, relaxation of muscles, and relief from pain. The discovery of the enkephalins and related endorphines explained how traditional meditative or hypnotic techniques, or manipulations such as acupuncture, were effective in controlling the physical origin of pain; they caused the brain to produce its own analgesic (Marsden 1979). Secretory neurones of this type were found in the peripheral pain pathways and in the brain stem reticular formation and basal ganglia. They are probably involved in the whole range of appetitive drives for food, water, and sex, as well as in maternal behavior and transitory affective states of the limbic system.

The chemical systems of motivation are concentrated in the same brain structures as have been identified with emotions by clinical studies of temporal lobe epileptics, who experience depersonalized states and powerful emotional auras, and by electrical recording and stimulations with awake animals or in a few unhappy human patients who suffer uncontrollable aggression, fear or pain, or disturbing involuntary movements (Heilman & Satz 1983).

Brain science and clinical neuropsychology, linked to psychiatry and neurology, show up a bewildering variety of normal and broken-down states of personality that give evidence of the shape of the motivating fabric in human brains and how it is built up and maintained. Pharmacological drugs block or mimic the action of natural neurotransmitters, giving rise to abnormal impulses to move, whipping up storms of joy, anger or despair, perverting attention and blotting out remembering, and evoking psychotic fantasies with aimless outpourings of verbal and gestural symbols. Their evil as addictive drugs misused socially arises from their power to destroy the very basis of human affection, making expressions to others untrustworthy and driving creativity crazily inwards so it burns itself out in circular logic and narcissistic chains of association. Epileptic discharges focused in limbic and association cortices, or in the deep nuclei with which these cortices communicate, likewise make false motives, inappropriate emotions, and illusory perceptions. Tumors in these places leave holes in consciousness or the patterns of voluntary purpose, or they change personality, sometimes leading to profound indifference, depression, or uncontrolled anger. Psychic defects caused by local injury in the limbic and deep parts of the brain display a bewildering spectrum, mixing cognitive and emotional effects (Heilman & Satz 1983).

MacLean has emphasized the discovery of the motivating mechanisms by locating epileptic discharges, applying electrical stimulation and surgery, and manipulating brain chemistry has left obscure how they can be excited by stimuli in normal life. One proven input to them is from hormones in the blood. Thyroid hormone in excess causes emotional instability, and apathy or depression if depleted. Sex hormones cause changes in aggressivity or gentleness as well as in erotic excitement. They are taken up by hypothalamus, septum, and amygdala, regions where Hess showed, in the 1930s, that instinctive sex behavior patterns could be triggered by electrical stimulation in hens and cats (Hess 1954; McGeer, Eccles & McGeer 1978, 468). But for consciousness a more significant input is the one through eyes and ears or through touch, taste, or smell which detect the organism's relationship with external conditions and events and assist in adjusting the state of the body to its circumstances. We can include the detectors of food and water, and the detectors of a safe, warm, and comfortable situation for rest and recuperation. These are of primary importance when an animal learns how to make the best of an environment that can be perceived by distance receptors.

The motivating core of the human brain is supremely sensitive to signals from the environment, especially the human environment, but it is full of spontaneously generated nerve activity and acts as source of excitatory and neurochemical signals for the rest of the brain. The anatomy of the brain core defines a coherent, multimodal space-time field of behavior. Orientations of attending in all modalities and movements of all body members are held together by associative systems of interneurones of the motivating system. Rhythmic measures of time and the tempo of movements, too, are created in pacemakers of the reticular network that can synchronize all parts of the body in cyclical expressive effusions that need bear no immediate relation to the timing of events in the outside world. The unified configurations and rhythms of expressive behavior constitute a common code for interpersonal attunement. By this code we share motivation, through imitating the forms of actions and the rhythms of movement of our partners. The messages of motivation are carried from a patterned and integrated emitter in one brain to tuned and matching receivers in other brains. In a sense, the cadences and shapes of movement that are caused by different fluctuating states of interneuronal chemistry in one brain stem can be the cause of matching or complementary patterns of chemistry in another brain stem.

The power of learned associations and of symbolic formulae to act as languages for communicating human feelings and experiences must be derived from these empathic mechanisms that attune emotions between individuals directly. Both experiences of reality and symbols are given values derived from emotional referencing between human beings who match their evaluations. That is why meanings of objects and symbols have universal dimensions in psychic space and time, such as rate and rhythm of movement, brightness or darkness, color values, warmth or cold, and loving and trusting or fearfulness—all qualities differently labeled in the chemistry and anatomy of the emotional brain core. It is barely a quarter of a century since the outlines of this inner evaluative council of the brain became known. Clearly we have much to learn about its vital workings.

Motivation for Learning

One persistent mechanistic view of brain physiology and of reductionist psychology that turns to physiology for explanations is that the neocortex is a retentive fabric without prejudice, a network that starts its postnatal maturation with no functional design, in which associations of experience are made in response to patterns of chance in encounters with the outside world. This cortex stores or encodes the history of stimuli traced *a posteriori*. An adult human mind so built is thought of as essentially pragmatic or rational and logically deterministic, ruled by a truth-telling propositional language that transmits cognitive structures into the brains of children. They learn practical tasks by practice and how to deal with facts and the logic of combinations of facts by absorbing reason in language. Rules of inference acquired in school lead to progressively more powerful propositions about truth in both practical and social worlds.

This analysis flatters text-proud and physicalistic European philosophies that place motives and values in a dependent relation to practical and realistic necessities. It is favored by empiricist doctrines of education such as that advocated by John Locke,[18] and it is congenial to the contemporary physicalism of the computer-minded. But, in the eye of an evolutionary or developmental biologist the child's brain is less passive and less empty of values than conceived by these philosophies. It is a strategy-planning controller of a vital and self-regulating being. It is the organ that represents in its genetically transmitted self-fabricating design a set of adaptive purposes for behavior that physical and logical programs so far created by systems engineers can imitate only in caricature. Activity patterns and responsive settings generated within the brain before birth are independent of outside facts at that stage of development, and after the brain is born into perception of an outside world it gains desired forms of acting by reference to categories of perceiving and moving and to states of motivation and emotion created *a priori*. As the educators Comenius and Friedrich Froebel taught, children learn largely by development of their natural impulses to share knowledge.[19]

In the last five years it has become clearly apparent that brains never solidify into the static nerve cell networks they seem to be in anatomical pictures or physiological tests of reflex integration. They retain a lifelong embryogenic dynamism and develop perpetually (Trevarthen 1980a). In a spontaneously active cerebral federation the activities, growth, and indeed the survival of every nerve cell depend upon the balance of excitation it receives from other nerve cells. Growing neurones cooperate and compete in vast assemblies. Moving and changing populations interact to generate flowerings of structure where fusions and destructions of elements occur, and competing activities stabilize in elaborate equilibria. Damage is repaired, sometimes with novel rewirings. From time to time parts of the developing brain undergo catastrophic fall or upheaval with death of vast numbers of cells. Throughout the life cycle within an overall organization that resists deformation, neurones are uniting in new functional teams—not just drilled by patterns in stimuli but also under the regulation of rewarding and punishing patterns of motivation that the brain generates in itself.[20]

Tissues that Learn Culture

A striking anatomical feature in maps for human brain functions is a large, slow-maturing zone of cortex where limbic inward-directed and neocortical outward-directed tissues meet and intensively interact (see fig. 1C). This zone appears to have evolved in humans to carry out the cooperative learning activities that make culture possible (Trevarthen 1983a; 1984a). It is the area of greatest difference between ape and human brain, and lesions in it cause the most bizarre cognitive disorders: the aphasias, which lead to failures in the use of language to communicate and to think; the apraxias, which affect the planning of intricate, and arbitrary, serial motor skills; neglect syndromes, which leave a patient unable to generate and use an awareness of one side of his or her body, of the space around, or of objects in it; and the specific agnosias, where a class of objects important in normal intelligent life is not comprehended and is poorly perceived. Prosopagnosia, for example, is an extraordinary loss of the ability to recognize people by their appearance; of course it is socially incapacitating. The lesions that cause these defects either disconnect tissues by breaking nerve tracts that allow motives to integrate with perceptions or actions, or they demolish an integrative center where motives are elaborated. In every case they change the functions of primary sensory and/or motor projections known for more than 100 years and also of the still poorly understood reticular and limbic projections of the brain core. This component of the human cortex seems to be both source and pinnacle of remembering, where experiences are represented in forms that have the most concentrated meaning for the subject.

I see these tissues as receiving the best of information from both inner-directed and outer-directed cerebral worlds. On the one hand they are most finely tuned to the affective states engendered by self-awareness and to that peculiar innate awareness of people that causes imitation and sympathy. On the other hand they receive the most synthetic, most abstract forms of association between experiences, as well as the most sifted and densely correlated resultant memories, and their rationalized overworkings. They also include areas, such as the supplementary motor cortex, that can initiate actions. Furthermore, this part of the cortex integrates a link between the unconscious motor plan of the cerebellum, which predicts kinetics of body action and delicately tunes them to feedback from sensors of force in body members and round their joints, and the space and object perceiving images of the projection zones of the cerebral cortex. The latter images give propulsive and prehensile movements their precise and appropriate targets in the outside world. In short, the learning processes in this ultra-neo, hyperlimbic cortex tissue at the junction of the main cerebral lobes are the ones that give meanings form. They generate actions and experiences that have been validated by shared emotions and common experience in an instinctively, and sometimes stormily, cooperative community of human minds.

It is to the motivation and emotion side of this critical mind apparatus, not to the rational inferential side, that we must turn to get clarification of religious, artistic, theatrical, or playful experiences. The senses of holiness, of morality, of beauty, and of humor project the attitudes that people have towards experience. They arise because people need to and want to communicate evaluations of experience and because they must test their motives for comprehension and cooperation to the limit. The grasp of reality is precarious in the sacred, the ethical, the aesthetic, or the playful or tragic dramatic events; but it is also most powerful in significance, which explains why parables of tradition compel attention and why they are so instructive. They show ways that all manner of new experiences may be interpreted in terms of universal feelings compatible with an ancient human lore.

Modes of Consciousness and Learning in Split Brains

Pioneering split-brain experiments of Ronald Myers and Roger Sperry in the 1950s proved that the great interhemispheric bridge, the corpus callosum, could transmit details of learned consciousness from one cerebral hemisphere to the other (Sperry 1961). Their tests showed that each half of a cat's brain separated from its partner could direct behavior of all the cat's body.

I used learning experiments with split-brain monkeys to demonstrate that perceiving and remembering are not just an automatic consequence of the cortex being aimed at and receiving any stimulus that might be suitable to direct the actions that the animal is set to perform (Trevarthen 1965). The two anatomically equal halves of the divided monkey brain could be getting identical stimuli, but only one side, the one engaged in directing a hand to push a lever for a peanut, would learn. The other half brain, which was not involved in responding, seemed unconscious and retained nothing. The obvious conclusion was that a cerebral cortex has to be readied inwardly for awareness and learning to occur. Perceiving required wanting to act or an active interest in the consequences of action as well as an input of relevant sensory experience.

In the 1960s a few epileptic patients whose sickness was not responding well to drugs were relieved of seizures by commissurotomy. Disconnection of the hemispheres prevented spread of electrical discharges. The now famous psychological tests performed in Sperry's laboratory at Caltech (Sperry 1967) revealed that in these human beings a readiness to know and learn with one hemisphere at a time was part of a strategy to act with a particular kind of problem-solving program. Their left and right minds were different. While the cerebral hemispheres of a monkey are almost equal alternative systems of consciousness and learning, human hemispheres were revealed to be specialized for complementary domains of awareness. They perceive different meanings in identical stimuli and each solves best its own kind of mental problem. This conclusion accords well with a century of observations of people with injury in one or the other side of the brain and with many recent experiments in which normal people have been tested with stimuli routed to one hemisphere at a time (Bradshaw & Nettleton 1983; Trevarthen 1984a). Most people, we now believe, have different concepts of experience, different aptitudes for learning, and different creative strategies for using experience to guide thoughts and actions in their two cerebral hemispheres.[21]

By analysis of the dynamics of perceiving in commissurotomy patients, Jerre Levy and I were able to show that adjustments in the whole brain, including brain-stem circuits that operate below consciousness, could turn on or off all or part of high-level processes in the cerebral cortex of one hemisphere (Levy and Trevarthen 1976). Both awareness and ability to move could be adjusted by this channeling of internal facilitation or activation into one or the other half of the divided forebrain. We called this "meta-control" of consciousness. It qualifies the permanent differences in functional capacity of the separated hemispheres. Indeed, the common pattern of differences between the two human cerebral hemispheres may turn out to be related to alternative ways in which the motivating and orienting mechanisms of the brain stem can be set to deal with the outside world.

The right hemisphere appears to have a more diffuse and more coherent representation of all the body and its parts, and of the space that radiates out from the body as the field into which attentions and actions are projected. The left hemisphere has a more crisply differentiated representation, more focused on just the right hand and just the right side of body-centered space as this is represented in visual, auditory, and tactile spheres. In consequence of this asymmetry, injury to the right posterior cortex often leads to an unawareness or neglect of the left of the body or the left of space, but such indifference to one side of reality is not produced by a left-hemisphere lesion of the same size. The right hemisphere, because it has more complete representation of space round the body, appears to be better equipped for the primary organizing of attention to stimuli. In addition, this hemisphere is better at recognizing faces and bodies and at making drawings or arranging elements to make patterns or schematic diagrams. Geometric puzzles are used with brain injured patients as tests for failure of predominantly right-sided abilities.

Of course the most dramatic difference between the human hemispheres, vividly demonstrated in the early experiments of Sperry and Michael Gazzaniga (1967), is that when each is on its own, lacking connections to its partner, only the left one can speak. Since the days of Broca and Wernicke over a century ago, it has been thought that all language functions are much more strongly represented in the left hemisphere. But exploration of language function in commissurotomy patients soon revealed that the surface effects are misleading. In fact the right hemisphere contributes much to the understanding and conceiving of language, even when it has been disconnected from the speaking partner (Hughlings Jackson 1932, 129-45; Trevarthen 1984a). Its poor perception of fine features of speech, its failure in rhyming when it has to imagine the sounds of speech, and its inability to emit any articulatory movements of speech except very rare fragments may all be consequences of a congenital restriction of a unique part of the speech apparatus to the left hemisphere, a part that performs a final stage of programming to insert the smallest units of speech expression into slots of meaning that the right hemisphere can conceive on its own. The right hemisphere, listening to language, can pick up much of the sense, especially that part of it that translates readily into a scenario of being and acting. It relates words to a pragmatic and emotive world that can be perfectly well seen, heard, felt, and understood without coding into words—a world like that of a young child, remembered directly and not explained by a propositional argument (Ross 1984).

Besides transmitting semantic information about facts and features of an objective world, the structure of language must encode rules for engagement of awareness, feeling, and purpose between conscious subjects. Sentences explain how subjects are acting on objects or on other subjects. The syntax and case inflections define changing motivations and purposeful tendencies. Language must, therefore, involve a cerebral regulation of how the inner situation of one person can reach out and cooperate with what is going on in the feelings of another person.[22] The propositional and informative functions of language ride upon an assertive interpersonal engagement that tries, by appeal to a common expressive code, to make the other mind take something in. These contrast with the self-regulatory, remembering, and thinking functions of language in a private world where messages of speech mingle freely with images and thoughts in wordless form.

Perhaps the partitioning of language functions we observe in human brains is a product of an ancient tendency for the left brain to be outgoing and assertive and the right to be more receptive, accommodating, and self-sustaining. Support for this idea comes from asymmetries favoring the right hemisphere in nonlinguistic areas of mental activity mentioned above, including the private management of action of the body by an integrated self who perceives both the configuration and motions of its body and the relation of the body in time to the geography of surroundings. This difference is reflected in the very mysterious, universal and prehistoric tendency for one hand to be the most public, most expressive and most symbolic one. In a majority of people everywhere it is the right hand, but for some people it is just as definitely the left (Corballis 1983; see fig. 2).

If we direct attention to the emotional and temperamental side of human behavior, an intriguing partitioning of the personality seems to emerge in differences between the hemispheres (Heilman & Satz 1983; Trevarthen 1984a, 1174). Along with their attentional neglect and reduced body scheme, patients with right-sided strokes or other right-brain pathology seem temperamentally brittle in response to experience, extraverted, insensitive to others' emotions, literal in their impressions of phenomena rather than metaphorical, and deficient or inappropriate in sense of humor. People with left-hemisphere lesions tend to be not only impaired in language but also withdrawn and yet

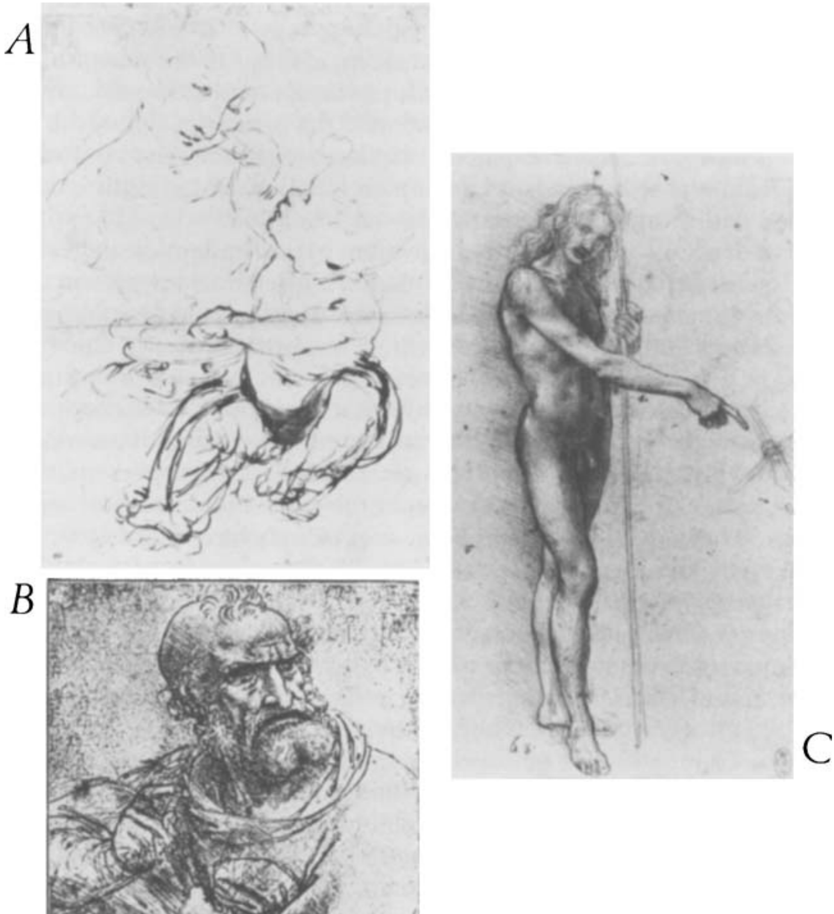

FIG. 2.—Leonardo da Vinci was left-handed, as one can see from the slope of the shading in his drawings, but he drew right-handed models as he saw them and he obeyed the sacred rules for the gestures of religious subjects. A: Madonna and child with bowl of fruit: a one-year-old baby who was to be a right-handed adult would normally prefer the right hand to touch a mother's mouth or to feed her. (With permission of the Louvre Museum, Paris; Copyright "Cliché Musées Nationaux"). B: Apostle with the right hand raised. (With permission of the Albertina Museum, Vienna). C: Study for youthful John the Baptist. (Windsor Library, Copyright reserved. Reproduced by gracious permission of Her Majesty Queen Elizabeth II). Right-handedness for gestures of communication is inherent in about ninety percent of people. The use of the right hand for sacred messages is traditional wisdom, convention giving the living motivation a specific meaning and moral force. (See Hertz 1909; Corballis 1983; Trevarthen 1985b.)

retaining social sensitivity and a metaphorical or poetic imagination that may be revealed in their mistakes with language or in interpretations they make of pictures. The symptoms seem to relate to the subject's way of assimiliating a situation to himself, physically or emotionally, and to constitute a form of primary adaptation to that situation. Thus, the left hemisphere seems to be revealed as having a more active commitment to execute acts on the physical or human world while the right is more private and receptive. The left seems to seek initiative and to express itself in declarative mode. There is evidence from epileptics suggesting that in emotional pathology the left hemisphere tends towards manic, aggressive states while the right is more depressive and submissive (Flor-Henry 1983). These are of course important poles in the emotional balancing of viewpoints between persons who are attempting to share consciousness and transfer information about it or act cooperatively within it. Infusion of feeling into experience makes it communicable and gives meaning to metaphorical and narrative representation. Fantasy always draws richly on metaphor as well as a sense of unfolding drama. The right hemisphere of most of us may have more complete mastery of an essential motivation for this generation of a story in experience.

There is widespread interest now in these indications of differences in the personalities and emotions of the two hemispheres of the human brain. Some believe that the articulate and rational left hemisphere has, in our culture, had unfair hegemony over an intuitive right hemisphere. They appear to be rebelling against our deep-seated Western belief that reason must master emotion and hold it in check, a belief that owes its strength to the rational philosophy that has dominated our Western culture since the seventeenth century. Knowing facts and arguing from them with appeal to truth, objective reality, and necessity, independent of personal feelings, must involve different brain mechanisms from the having and sharing of emotions or the influencing of others by arousing in them imaginary and moving connotations and intuitive evaluations. But communication needs both these kinds of mental strategy. They must work together, as seeking and evaluating do in control of adaptive behaviors of very simple animals. It is difficult to imagine that a human mind could work at all if reason and emotion were separated surgically. There is evidence that commissurotomy patients exhibit an impoverishment of emotion and lowered vigilance in attention, but each of the separated hemispheres can achieve elaborate consciousness and can react with social sensitivity.[23]

We have learned much from the discovery of the contrasting mentalities of our left and right hemispheres, but this is only one way of viewing complementary mental states. First, it fails to recognize that there are other anatomical axes along which one may seek contrasts in motivational process. For example, frontal and posterior parts of both hemispheres differ in their relationship to perception, to generation of motor impulses, to emotions, and to cerebral trophotropic regulations of the body's physiological functioning. There is a mapping across the cortex in each hemisphere, and through its subcortical nuclei, of the same components of mental activity as are used to characterize left and right parts of the brain. Second, given that clear-cut hemispheric differences in mental style and in motivations exist, they certainly normally interact in synchrony and with the closest coordination. Various states of mind may arise not from the separate action of the two hemispheres, but from their joint action. Consider an example: Is the energy of play and ritual the result of left and right hemispheres in dialogue, of basal ganglia and limbic structures interacting with neocortex, or of frontal parts of the cortex engaging with parietal and temporal parts?[24]

Split-brain studies showed how cortical states of consciousness are regulated by the motivation for response. They showed that refined perception and learning were confined to the cortex, and they revealed the power of underlying directives of attention and evaluation from the brain stem. They also gave a new view of complementary cognitive strategies in human consciousness. These too seem now to originate in deeper asymmetries of motives for acting on the world and for communicating. Consistent differences between the cognitive functions of the hemispheres seem to bear a relationship to different motivations for engagement of a person with the outside world or with other persons. Further evidence for this kind of inherent structure in human motives for cooperative awareness comes from recent research on the communicative behavior of infants.

The Human Spirit in Children

About 1970 psychologists began to observe in films and television recordings of mothers and infants playing happily and intimately without interference behaviors of wonderful complexity. Within hours of birth a baby can join in a delicately regulated exchange of feeling with a responsive and loving mother, showing a remarkable precocity in appreciation of the pulse and musicality of human expression. By two months, subtle conversation-like exchanges occur (Trevarthen 1974; 1983b). The new discoveries stimulated experiments which prove that newborn infants are tuned to many signals from the mother's body, that they can identify her from her odor, her voice, and the rhythms of her movements, and that they can imitate her face movements (Field & Fox 1985). Even the most skeptical, and there has been an intellectual resistance to this evidence, have to admit that a human being is born with a capacity to empathize with another who is sought as a trusted and loving caretaker.

I have been studying the development of this human empathy, attempting to discover how the infant regulates the attentions of the mother in play. For me the most important discovery is that the infant, aware of persons before attending to objects that can be manipulated, has a growing interest in learning about the world by sharing experiences and tasks and by tracking what others know and understand through observation of their actions. I see the child working towards a symbolic, cultural understanding well before he or she utters first words in the mother tongue (Trevarthen 1979; 1980b).

The patterns in the behavior of infants give evidence of inborn cerebral organizations that set mental life in motion. They show up universal laws of emotion by which interactions between persons are regulated (Trevarthen 1984a; 1985a). From birth, there is a deep antithesis between the joyful affection that promotes coming together of persons and their joining to share motives harmoniously, and the anger or fear that exploits or withdraws from another and destroys sharing. After three months, play between infant and a trusted caretaker joins affection to that measured aggression called teasing in a dynamic and lively dance across the boundary between dependence and independence of consciousness and will. In a happy relationship it reinforces bonds of trust and confidence (Trevarthen 1983a; 1984a).

Infants display from the beginning a spontaneous integrity of action and expression that corresponds with the ανεμος of the ancient Greeks, an invisible wind that moves, and the *anima* of Latin that became the Judeo-Christian "soul." This stirring spirit (akin to the breadth of life, πνευμα), with insistent beat and subtle rhythmic variations, resists analysis in machine terms. All parts of the baby's body move together to express shades of feeling. The expressive flowing of an infant's emotion is highly responsive. It encourages a mother, deeply moved by the birth of her infant, to feel she is appreciated by another being who is intimately like herself. A new system of two persons—a self-sustaining relationship—is made of their behaving together (Stern 1985).

The practical curiosity about the world that an infant builds up in the first six months is not simply the expression of self-regulated independence of perception and acting. In it interpersonal motives remain strong, so the exploring infant is inherently cooperative and communicative. Play with objects opens the relationship with the mother towards the world they can learn about together (Hubley & Trevarthen 1979). While the infant is striving to understand objects, with intent following of gaze and reaching out with the hands, he or she is intimately sensitive to what others do. The baby soon becomes expert at seeking information about how acts of a trusted partner, recognized as part of a relationship and different from strangers, may extend a project in hand. The will to manipulate and explore is expressed as a message to people, as being shy or showing off, that is, trying to escape attentions of others or trying to cause them to accept the interest or purpose behind any action or novel experience (Trevarthen 1983b; 1985b). Soon familiar playthings and tricks of expression absorb an evaluation not only from the way they reward the feelings of the child directly but, even more powerfully, through the expressions of approval, pleasure, or dislike that others give forth when the child attends to these things or acts that way.

A mother who loves her child is ready to be a pupil to this growing curiosity about the shared world. Her behavior gives pattern and development to infant motives for expression, and this is the basis for an affectionate teaching relationship. Through it the mother becomes a traveling supporting consciousness for the infant's mental differentiation, driven forward by her instinctive impulse to be guided by the infant's signals of curiosity and pleasure. The friendship between mother and infant, though asymmetric in complexity and purpose, is held together by the same emotions as in all other human friendships. It uses the same affective code to establish mutual awareness, the same concordance of motives and regulated variation in dependence and independence of wills (Trevarthen 1984b; Stern 1985).

Developments in the stage called *infant*, a word derived from the Latin meaning "without speech," though related to the child's eventually gaining command of speech, are independent of words. Also, later developments are not a simple consequence of thinking in words; they rely upon the interpersonal and emotional patterns practiced and developed in communication in the first months, at least a year before the first true word. Even a two-month-old can actively contribute utterances and gestures to precise intercoordination of a communication game (Trevarthen 1983b). By six months he or she will show playful, humorous interest in the clashes of purpose that arise in play with the mother. Both enjoy teasing, which is a regulated use of resistive or aggressive moves that test the skill and affection of the other (Trevarthen 1984b). It is a way of challenging that laughs at the efforts of the other to respond.

There is an impulse from early weeks for the infant to express the germ of an idea in gesture and utterance, and this expressiveness has power to become the unique human gift of language (Trevarthen & Marwick 1986). Towards the end of the first year simple word-like sounds and hand signs are imitated by the baby and displayed to gain recognition for others. Called "protolanguage" by Michael Halliday (1975), these signs immediately serve as a common currency in the family to represent shared ideas and to label intentions or designate important experiences or people. This ushers in an ebullient production of fantasies in play that rework all experiences to make them into sociodramatic entities, pieces of a picture or story being created with others, a miniature symbolic world to be lived in with them.

At one year most infants use gestures and vocalizations to engage the interests and attentions of familiar persons, and they understand instructions and want to comply (Trevarthen & Marwick 1986). They watch, gesture, and listen to utterances, fixing gaze on the partner's face to get as much information as possible about the message. In other words, they begin to show that they want cooperative action, hunting for signs that help them to perform tasks in collaboration. Pretending to be someone else, pretending to carry out actions that another will understand, or for the benefit of another, pretending to use banal or meaningless things as tools, consumables, or emblems that are full of meaning and meaningful action—such acts of mental creation appear in the spontaneous repertoire of an eighteen-month-old who has few words (Trevarthen 1985b). The requisite imagining and motivation for this "symbolic" kind of communication arises asymmetrically in the child's brain before language is mastered. It is coupled to a strange unconscious preference to use one hand, usually the right, for such communication (see fig. 2). It does not need words but is clearly of fundamental importance to the understanding and use of words in language, and it can take in spoken messages from adults who are trying to assist. Details of the ways toddlers play with people, especially how three-year-olds develop play with peers in friendships, make it clear that the adaptive function of fantasy is to construct a world of metaphor that is sharable and collectively useable.[25]

The play of animals that so amuses us, like play of humans, contributes to the development of social awareness. The cognitive representations involved in it have to be separable from those that govern what each subject is doing for himself, so they can be presented with clear emotional force for assimilation by another. Just imagine kittens at play: Do they not strut and posture and dodge within the awareness of another being, real or imagined? John Fentress finds that wolf cubs play at the thrust and dodge of a fight even when on their own, but the instinctive moves only make sense in a real combat with a fighting partner (Havkin & Fentress 1985). The actions of play are communications. This is understood in Gregory Bateson's theory of metacommunication (Bateson 1972). Bateson focuses on the paradox of play where every act is different from what it seems to be doing, drawing attention to what it could be. Play biting, hiding, or dodging is not "serious" with a simple purpose for the player alone: it is always combined with an expression of feeling that signals "this is play." In humans metacommunication becomes the generator of meanings and the foundation of rituals that give collective social events significance.[26]

It might be thought outrageous to suggest that we can designate elements of brain activity for such emotional and playful subtleties of spirit in the infant and toddler and for such sensitivities to the spirit of others, especially the mother and friends, but there are signs of how parts of the brain are implicated in the early growth of the human mind (Trevarthen 1983a; 1985a). We have a few pointers to the cerebral growth changes underlying early postnatal developments in motivation for human contact. First, the affective signaling in the primary intersubjective contact of the first two months has much that is homologous with emotional signaling of animals. The cerebral mechanisms of brain stem, midbrain reticular formation, basal ganglia, and limbic system that govern vocal expressions of monkeys certainly will have homologues in humans, and the same applies to movements of facial expression. Detlev Ploog, a pupil of MacLean, suggests that early coos and cries of infants are involuntary and unlearned, closely similar to the calls that he has studied in squirrel monkeys to determine their neuroanatomical basis (Ploog 1979). However, coos of two-month-olds already have morphological characteristics that show they are rudiments of human speech. This does not mean they are produced by the cortical speech areas because even in adults speech still involves processes in subcortical (limbic and thalamic) centers. It seems that the subcortical components, already formed for speech, mature ahead of the neocortical ones.

A wave of cell differentiation and maturation of intercellular contacts spreads across the posterior cerebral cortex of a baby from the occipital pole through the integrative parietal cortices shortly after birth. This correlates with rapid improvements in visual perception in the first six months and with the development of efficient manipulation. Developments in frontal parts of the brain a few months later have been correlated with development in the infant's ability to predict the place of interesting objects in spite of periodic rearrangements and disappearances as the objects are moved about, behind, or inside other objects by an adult (Goldman-Rakic 1984). They may be vital in imitation and observational learning.

One special feature of human communication, present in rudimentary form in monkeys and capable of "cultural" moulding in the apes, is the use of hands to give messages. Ordinary people move their hands to express feelings and ideas in parallel with speech. Most of us use the right hand as the dominant expressor of ideas and the left as a supporting partner that helps lay out the context for what is to be expressed. In deaf people the hands can become transmitters of a full sign language, as rapid as speech and carrying all the subtleties of emotion and reference. Hand gestures of young infants also show asymmetry, expressive responses to maternal speech being most often made by the right hand (Trevarthen 1985b). This second remarkable precocity in human expression, coupled to cooing vocalizations that lead to speech, may also be due to inherent asymmetry in brain parts beneath the neocortex in limbic cortex, basal ganglia, and thalamus (see fig. 2).

Intersubjective mirroring essential to the establishment and progress of normal intellectual development may involve the medio-frontal limbic system and medial cortex in front of the corpus callosum. Damage to these regions in monkeys causes a loss of social skill and an apparent fall in the kinds of motivation that are essential to maintaining a lively and confident position in a group. The poor animals become isolated and withdrawn (Myers 1972). In human beings the same kind of loss of spirit for communication and cooperation is seen when a stroke or infection leads to a lesion in this territory of the brain. Rare cases have been reported where a damage in the meso-limbic cortex or supplementary motor area causes a social apathy and muteness, although the patient is not paralyzed, retains high intelligence, and can still understand what other people refer to when they speak (Damasio & Van Hoesen 1983). There is evidence that defects in the meso-limbic frontal parts of the brain underlie the tragic conditions where infants and toddlers are autistic and fail to develop communication with the human world except in poor and fragile forms.[27]

Autistic toddlers, who avoid direct contact with their caretakers and cannot share the pleasure of play, show mysterious numinous states of joy. They gaze up to the sky opening their hands to a private experience and emit a saint-like smile. Autistic children, typically inclined to intense concentration of their minds or the exploration of sensations and playing seriously with visual, tactual, or auditory effects of their own making, can have remarkable gifts. Cases are known that draw with astonishing artistic maturity, that write sensitive poetry with wonderful imagery, and that make brilliant calculations or beautiful musical sounds. Clearly they retain a sense of beauty and a pleasure in mystical experience that can have symbolic value to others. When observed closely they are seen to be supremely sensitive to others while avoiding eye contact or touching and exhibiting no joy in sharing. I believe these sad children, whose development needs the closest, most sympathetic and perceptive support, reveal to us an antithesis in the human spirit of which we are all secretly aware. They seem to have a lesson to teach us about the austere and lonely origin of religious or artistic inspiration. There is no doubt about the awe such inspiration can command.

Conclusions

"*The Spiritualist and the associationist must both be 'cerebralists,'* to the extent at least of admitting that certain peculiarities in the way of working of their own favorite principles are explicable only by the fact that the brain laws are codeterminant of the result" (James [1890] 1950, 1:4). Since that was written, a mere 100 years ago, some coherent knowledge has been won of the cerebral mechanisms of mind. James reviewed body-imaging maps that respond to sensory input in separate modalities or that excite movements of body segments. In these windows of perception and outlets of will humans and intelligent animals are easily compared. In addition, neurologists have located tissues at the confluence of the main lobes of the left hemisphere in the human brain that are vital for coordinating speech or for comprehending language. Now we know that language areas are one part of a newly evolved cortical zone that contains the power to grow the myriad memories and skills required for participation in the collective enterprise of culture. The "tissues of culture" all tend to asymmetry; in a majority of persons certain ones are stronger in the left brain while others are better served in the right hemisphere. Greater mysteries remain within the deeper motive systems that have decisive control over both the development and the functioning of the reality-oriented and cognitive brain—from the embryo, when neurones are beginning to distribute themselves in brain nuclei and the cortical mantle of the hemispheres, to the failing but experienced and wise networks of the aged adult.

In the last fifteen years a system of fibers has been found penetrating from clusters of neurones in the brain core into every region of the neocortex and into surrounding sensory and motor fields of the brain stem. This core brain is much more differentiated than had been imagined; it creates kaleidoscopic changes in the balances between evaluative and motivating impulses that impinge on every element of the integrative networks of the mind. We find, too, that the cerebral hemispheres with their different cognitive styles and preferences have characteristic emotional and temperamental differences. Perhaps these are due to an asymmetry in the neurochemical activators that direct growth of anatomical patterns in brain systems long before birth and long before their psychological engagement with reality.

The motivating brain is responsible for the patterns of emotion, for the activating or depressing changes of attention or fatigue, in perception, learning, remembering, and acting. It contributes a subjective unity of evaluation to memories and becomes part of the mechanism of their recall. It switches the patterning of movement or readiness to react of the whole organism between energetic, information-seeking vigor of action against the environment and inner-directed withdrawing to sustain or recuperate in a reflective state of rest. When stress, disease, or drugs that mimic or block the natural transmitters interfere with the balance of action between emotional components, they can create abnormal excitement and awareness, illusory experiences, moods of elation or depression, transcendent dream states, joy or terror or rage, and grotesque distortions of communicative expression, many of which may have an erotic aspect.

But these emotional parts of the brain are not just involved in pathological states or instinctive drives. They give vitality to normal living. They must concern not only the psychiatrist or neuropsychologist but every student of the deep processes of the human spirit and their development, and they must be implicated in any scientific examination of religious experience. Their patterned activity is behind the rhythm and drama of music, dance and theater, the aesthetic evaluation of art, and the love or hate that binds human beings in fellowship or that segregates followers of different teachers or political leaders into suspicious, vengeful camps. These parts make up the peace and ecstasy of fulfillment in communication, or the anxiety and pain of suffering in loneliness.

The place of emotion in the growth of human consciousness, grace of moving, and interest for learning is clear from the earliest play between infant and mother and from the games of fantasy that are shared in early childhood friendships. The creative energy of these engagements shows us an innocent human reaching out to learn from others the symbols and roles of an ancient but endlessly renewable way of living and cooperating. In childhood, liking and learning are inseparable. As we perceive the emotions of childhood more clearly, we know better what questions to ask concerning the brain mechanisms that generate the essential feeling and consciousness of being human.

While there is no alternative for the scientist but to study by the best means available the unique mental physics of the brain itself in order to comprehend the human spirt and how the feelings of a child reach out to experience to give it form and value, we must recognize that every symbol, role, and ritual is a product of tradition. In a mature mind the passions of moral, artistic, theatrical, and practical sharing are crystallized in intricate habits of perception, expression, practice, and thought. The underlying motives are there, much stronger than in infancy and still capable of asserting their primordial equilibria and contrasts in the same uncompromising forms with universal human appeal. But they are also specified and disciplined in relation to an historic fabric of belief and conventional action. They are made relevant to elements of a particular reality conquered by ancestors and currently exploited in traditional ways. Different societies use different statements of belief or knowledge that require different cognitive aptitudes and that carry connotations in different material, ethical, and artistic contexts. Consciousness is attracted to the innumerable learned referents that interest shares. Symbols are not exempted from this traditional specifying, even though their power and utility spring from the unconditional principles of motivation by which humans seek comfort, contentment, happiness, inspiration, or excitement and flee their opposites, communicating these feelings to each other. Icons blend the power of directly perceived tempo, symmetry, color, and force of representation with traditional styles and codes of expression that are in no way present in the mind at birth. Archetypes are both innately motivated and conventional; the "inner experience" of religion works within the "protection and guidance of dogma and ritual" (Jung 1938). Their truth comes from this union of inner values and outward facts historically experienced and made explicitly traditional, timeless affordances of nature felt emotionally and made part of culture through learning within "communitas."[28]

If we attempt to break the unity of feeling-with-experience in human consciousness, the analysis ends in confusion. Sociobiology seeks explanations of taboos and prejudices concerning social and interpersonal contracts by reference to the economics of biological inheritance only. When Edward O. Wilson (1980) would find the causes of these feelings and beliefs in scientific materialism and nerve cell biology, he unwittingly gives but lip service to the role of emotions in the life of a community that transmits traditional wisdom as well as its genes. He reduces human motivation to the resemblance of a survival kit of instincts appropriate to a social insect. Gene-culture coevolution theory enlightens us as to the problem of human mental evolution but does not solve it. We might agree that "an understanding of the roots of human nature now seems essential to ethical philosophy" (Wilson 1980, 431). First we must understand the nature of emotions and their service to life of real persons. We need more than concepts of "sensory screening, interneurone coding, memory and other cognitive processes" plus "responsiveness to the behavior of others" (Wilson 1980, 428) to understand how culture is learned.

Veteran brain scientist John Eccles (1979) puts the soul, the "self-conscious mind," quite outside the neuronal machinery. We can accept with Eccles the integrator principle that evaluates and motivates mental life into a unified self, but with Sperry (1985) we look inside the total organization of the brain, not somewhere else, for the evidence on how self-consciousness and its values arise. We look particularly into a component of the brain that is richly and specifically concerned with maintaining "communitas," with gaining self-consciousness through sympathy with the souls of fellow humans.

To understand the caldron of the spirit that brain science brings to light we need a philosophy of mind that unifies Spinozan belief in a self-maintaining vitality of will with a Buberian recognition that truth lies in a personal relationship, one to another. The human spirit defines itself in qualities of fellowship discovered in play and achieves fulfillment in companionship made strong with ritual. Victor Turner has directed us to the right track.

NOTES

1. Robin Fox (1980) discusses theories of anthropologist Claude Lévi-Strauss and sociologist Emile Durkheim concerning universals in human psychology. He points out the difficulties that arise for these authors from dichotomizing intellect from emotion and social from natural. Fox later sketched an illuminating history of sociopolitical philosophy and controversies about the "innate" in human intelligence (Fox 1985). Randall Collins (1984), a sociologist, discussing "the role of emotions in social structure," contends that "interaction rituals" regulate emotions which serve as the driving force for functions of society. Robert Levy (1984), an anthropologist, views emotions in a comparative perspective, claiming a new anthropological orientation that perceives emotions as universal organizers of communication and knowledge. Such ideas give credibility to the "collective unconscious" of Carl Jung (1938). Mary Midgley (1984, 38-39), discussing the "endless trouble" anthropologists go to to explain moral paradoxes between cultures, notes that, "the assumption of shared moral compass-bearings is what makes it possible for us to praise and learn from other cultures, and also to accept criticisms which outsiders pass on our own culture." Furthermore, in assessing Freud's view of culture, "unless we suppose our species to have run an evolutionary course quite contrary to that of other social species, we ought to conclude—that culture is the fruit of exceptionally well-developed social instincts, not that it is a kind of weed-killer put down to control those few we possess" (Midgley 1984, 159).

2. The antithetical temperamental functions that d'Aquili (1983) would separate between the hemispheres have been recognized since T. Ribot (1917) described temperamental types. His distinctions were taken up by William James (1907) who contrasted "tender-minded" and "tough-minded" individuals. These correspond, in turn, with the "introvert" and "extravert" of Jung (1917). E. Kretschmer (1925) described "cyclothymic" and "schizothymic" types as "two great chemical hormone groups." Motivational differences between the cerebral hemispheres are discussed below.

3. Depressed infants do not play (Rosenblatt 1977). Autistic children lack the rapport with others that is essential to participation in joking play, and this affects their learning (Kanner 1943; Richer 1978).

4. Original sources may be found in Richard Jung's history of concepts of sensory systems (Jung 1984). A popular account of theories of mind in the brain is presented by Colin Blakemore (1977). Charles Sherrington gave the Gifford lectures on national theology in Edinburgh in 1937-38. His book, *Man on His Nature* (Sherrington 1940) is a classical appraisal by a physiologist of the mind/brain problem. His pupil Sir John Eccles gave the Gifford lectures in 1977-78 and produced an updated dualistic interpretation from the viewpoint of a leading brain scientist in *The Human Mystery* (Eccles 1979).

5. Darwin published *The Descent of Man* eleven years before his death. He delayed presenting his view of human evolution partly out of respect for the religious beliefs of

his family. His thinking on the matter began over thirty years earlier (see Gruber & Barrett 1974).

6. Exquisite examples of anatomical drawings of the human brain, showing fine details of tissue structure, were published by Dejerine ([1895-1901] 1980).

7. For a contemporary review of the experiments of Fritz and Hitzig, Munk, Ferrier, Goltz, and others, see William James ([1890] 1950, 1:12-80).

8. Interest in anatomical differences between the hemispheres was revived by Norman Geschwind and W. Levitsky (1968). See also Trevarthen (1984a, 1139-44) and Rosen and Galaburda (1985).

9. Flechsig made a pioneering demonstration of how areas of the human cerebral cortex develop at different rates (Flechsig 1901).

10. For a recent account of how the fine structure of synapses was found, see McGeer, Eccles, and McGeer (1978, 7-10).

11. McGeer, Eccles, and McGeer (1978, 141-46, and following chapters) describe transmitters and their discovery.

12. Sherrington (1940, 172) refers to the central place that Baruch Spinoza gave to will, which he described as "a manner of thinking and understanding" that is essential to the mind. Modern ideas on spontaneous cerebral activity behind movement are lucidly presented, with classical articles in original form, by C. R. Gallistel (1980). Michael Arbib (1984) interprets the thinking of the great Russian physiologist of movement Nicholas Bernstein and his argument that self-directed activity is the distinguishing mark of living things.

13. Darwin (1872) pioneered modern research on emotional expressions. The communicative function of emotions has been neglected in psychology (Trevarthen 1984b).

14. In his concept of "communitas" Turner (1974) captured the innate fellowship of feeling that is capable of setting itself in opposition to the conventions of society (societas). As Roy Willis (1985) explains in his obituary for Turner, anthropology has assimilated the concept without full recognition of its importance.

15. The theories of J. W. Papez (1937) and MacLean (1949; 1958) are discussed by A. R. Damasio and G. W. Van Hoesen (1983) who present a modern neuropsychological account of emotional systems.

16. Charles Herrick (1948) in a classic study of the brain of the tiger salamander perceived the evolutionary relationship of the neocortex to core integrator circuits of the brain stem adjacent to the hypothalamus (ventrolateral peduncular neuropil).

17. Stimulation of brain core structures to help direct brain surgery in human patients can produce strong emotional states (Damasio & Van Hoesen 1983, 101-4; Mark & Ervin 1970).

18. John Locke (1632-1704) had perfect trust in truth and reason; he thought the child lacks these at first and acquires them by formation of habits. He compared the young child to "white paper or wax" (Quick 1910).

19. Jan Amos Komensky, known best as Comenius (1592-1670), in contrast to Locke thought of the child as a "reasonable creature" from birth. He emphasized the natural process of learning from adults, as did Friedrich Froebel (1782-1852) who shared Comenius's belief in the importance of early years in a child's mental development (Quick 1910).

20. Wolf Singer (1984) showed that development of the visual cortex in a kitten requires both patterned visual stimulation and activity from the brain core mediated by the neurotransmitters acetylcholine and noradrenaline. The role of limbic structures (amygdala and hippocampus) in recognition memory has been demonstrated by recent research with monkeys (Mishkin 1982). Robert Zajonc (1980; 1984) has performed psychological experiments showing that emotion has a primary organization and that it can regulate cognition.

21. Lesions at different locations in the human brain produce distinct cognitive and emotional effects, and the two cerebral hemispheres differ in both the nature and severity of effects with a lesion of a given size and location (Blakemore 1977; Corballis 1983; Trevarthen 1984).

22. Speech act theory emphasizes the intentional and interpersonal functions of language against the traditional theory that language is propositional and fact stating (Searle 1969).

23. James Henry (1982) contrasts the power-control-agentic with the social status-communion-attachment axes in human personality and social conduct. Competitive tension leads to a denial of feelings and absence of compassion. He cites evidence from Hoppe and Bogen (1977) that commissurotomy patients are alexithymic, that is, they lack mythopoetic skills or the ability to link affectively loaded images into a meaningful story.

24. Victor Turner (1983b) following the lead of Barbara Lex (1979) and d'Aquili and Laughlin (1979) considers whether play may pit the hemispheric temperaments against one another. It is noteworthy that children show playful motivation before six months of age, when cortical structures of the hemispheres are still to undergo elaborate development (Trevarthen 1980a; 1983a). Hemispheric motivational asymmetries probably originate deep in subcortical regions.

25. Fantasy play blossoms in toddlers, though why it does is a mystery (Winner & Gardner 1979). The world of imagination with all its subjective color and emotional complexity appeals strongly to young children who love a fantastical and thrilling story (Bettelheim 1977).

26. Play of children and adult ritual have much in common; both involve participants in temporary sociodramatic roles *vis a vis* others (Turner 1974; Handelman 1977). Play weaves a baffling mixture of equilibrium and disequilibrium; it is an active psychological process in its own right, not derivative of imagination, exploration, construction, or practice (Sutton-Smith & Kelly-Byrne 1984). As play contributes to relationships of child to child or child to adult, so ritual assists the maintenance of "communitas" in a society structured by traditions.

27. Childhood autism was first described with unsurpassed clarity by Kanner (1943). Its consequences for social and cognitive growth are considered by Richer (1978). Damasio and Maurer (1978) propose a neurological explanation.

28. Ernest Renan, the biographer of Jesus, vividly describes how the inspiration of Christianity arose from the religious beliefs current at his time and place and was then transformed by his spirit. "To show that religion founded by Jesus was the natural consequence of that which had gone before, does not diminish its excellence; but only proves that it had a reason for its existence that it was legitimate, that is to say, conformable to the instinct and wants of the heart in a given age" (Renan [1863] 1927, 390). "Jesus is the highest of these pillars which show to man whence he comes and whither he ought to tend. In him was condensed all that is good and elevated in our nature" (Renan [1863] 1927, 392).

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