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Emotions, the Higher Cerebral Processes, and the SELF

Some Are Born to Sweet Delight, Some Are Born to Endless Night

> The mind of man seems so far removed from anything known in other animals and the animal mind seems so inaccessible to us that those who approach the problem from this side seem prone to seek a way out through metaphysics or mysticism, though relief of this sort is obtained only at the expense of profound narcosis of critical and scientific method.
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> C. Judson Herrick, *Neurological Foundations of Animal Behavior* (1924)

CENTRAL THEME

Although primal emotional feelings arise from the subcortical systems of the animal brain, their consequences ramify widely within the unique conscious abilities of the human mind, as well as the social fabric of our cultures. For 15 chapters I have focused on the former, but now I will turn to the latter. The critical issue that I have avoided until now is the nature of consciousness and the self. Emotional feelings cannot be fully understood without understanding these matters. Do animals have a spontaneous sense of themselves as active creatures in the world? Descartes suggested that animals, unlike humans, did not have a sentient self—that they were closer to reflex automatons than feeling creatures. Many scholars have recently chosen to disagree with this cold view of animal nature, but to be scientifically useful such alternative perspectives need to probe the neuroevolutionary roots of consciousness. I have constructed a brain perspective that acknowledges the existence of internal feelings in other animals. The indirect evidence seems overwhelming that other mammals do have basic forms of affective consciousness, not unlike our own (which is not meant to imply that they can have the same cognitive contents in their consciousness as we have in ours). All mammals appear to experience pain, anger, fear, and many other raw feelings, but they do not seem able to cognitively reflect upon such feelings as we do. They do not appear to extend feelings in time, as we can with our rich imaginations. If the existence of such feelings is not an illusion but a substantive part of nature, we cannot understand their brains, or ours for that matter, without fully confronting the neural nature of that undefinable attribute of mind that we commonly call our sense of self, our ego—the feeling of "will" or "I-ness" by which we come to represent ourselves and our self-interests within the world. Here I will develop the idea that a neural principle of self-representation emerged early in brain evolution, and that it became rooted first in brain areas as low as those situated in ancient midbrain regions where primitive neural systems for motor maps (i.e., body schema), sensory maps (world schema), and emotional maps (value schema) first intermixed. Although this neuropsychic function emerged early in brain evolution, it did not remain primitive. It continued to evolve as brains became increasingly encephalized, which allows us more behavioral flexibility and the ability to have complex thoughts and internal images. Thus, with the evolution of higher brain functions in humans (such as the ability to reflect on our own reflections, as commonly occurs in writing and reading, not to mention our penchant for narcissistic gazing into mirrors), a multidimensional conscious sense of self came to be greatly expanded in the human brain/mind. Although higher forms of human consciousness (namely, awareness of events and our role in them) surely emerge from the cortex and higher reaches of the limbic system, they are not independent of the lower reaches of the brain, which generate our basic emotions, feelings, and other instinctual tendencies. Although our higher cerebral functions have led to the great achievements of humankind, including the construction of civilizations via cultural evolution, they have also generated the illusory half-truth that humans are rational creatures above all else. Despite the appeal of this rational fallacy, our higher brain areas are not immune to the subcortical influences we share with other creatures. Of course, the interchange between cognitive and emotional processes is one of reciprocal control, but the flow of traffic remains balanced only in nonstressful circumstances. In emotional turmoil, the upward influences of subcortical emotional circuits on the higher reaches of the brain are stronger than the top-down controls. Although humans can strengthen and empower the downward controls through emotional education and self-mastery, few can ride the whirlwind of unbridled emotions with great skill.

Appraisals and Higher Brain Mechanisms in Emotions

For every investigator studying the brain substrates of emotions, there are dozens focusing on sociocultural issues. Because of the massive development of the human cortex, many investigators presently see human emotionality as being constituted largely from higher appraisal functions of the human mind that evaluate various situational complexities—ranging from the subtleties of perceptual interpretations to the many intricacies of learning and planning strategies. The human cognitive apparatus dwells easily on the various emotional issues that the world offers for our consideration. By examining the higher sociocultural perspectives, we can pursue many issues that cannot be tackled thoroughly at the neurological level. For instance, many human emotions—from avarice to xenophobia—are almost impossible to study in the brain even with modern brain-imaging technologies, not to mention in animal models.

We humans can experience guilt, shame, embarrassment, jealousy, hate, and contempt, as well as pride and loyalty. However, in some yet undetermined manner, these secondary, cognitive-type emotions may also be linked critically to the more primitive affective substrates that we have discussed so far. Perhaps they emerge largely from social-labeling processes, whereby we experience slightly differing patterns of primitive feelings in various social contexts and come to accept them as distinct entities. Perhaps they reflect intermixtures of several basic emotions, even though no one has yet specified the proportions in the various recipes. However, they may also reflect newly evolved neural functions that have developed within the higher areas of the human brain. Perhaps human brain evolution yielded some totally new forms of affective-cognitive feelings, making us the complex creatures of history and culture that we are. No one really knows for sure, but it seems unlikely that those affective proclivities will ever be clarified at a neurological level, at least until the more primal passions are understood. I do not believe that distinct neurochemical systems will ever be found for such higher feelings, even though they may certainly have emerged from the evolutionary engraving of some additional paths of emotional epistemology within our general-purpose cerebral functions.

It is reasonable to view the evolution of higher cortical processes as a way for nature to provide ever more effective ways for organisms to cope with their intrinsic biological values—to seek resources and reproduce more effectively and to find better ways to avoid dangers. Once special-purpose mechanisms, such as the emotional systems we have discussed, became less adaptive, evolution created ever more sophisticated general-purpose learning mechanisms to provide systems that could cope with the increasing variability of animate nature. The higher reaches of the human brain now contain layers of complexity of such proportions that some investigators find it difficult to accept that many of our psychological processes are still controlled by the basic systems that have been the focus of this book. Such a view, I believe, ignores the evidence. Still, the intricacies of our cerebral abilities pose many conceptual dilemmas for our minds. Our lives, our values, and our aspirations are remarkably complex.

When the mushrooming of the cortex *opened* up the relatively *closed* circuits of our old mammalian and reptilian brains, we started to entertain alternatives of our own rather than of nature's making. We can choose to enjoy fear. We can choose to make art out of our loneliness. We can even exert some degree of control over our sexual orientations. Most other animals have no such options. Affectively, we can choose to be angels or devils, and we can construct and deconstruct ideas at will. We can choose to present ourselves in ways that are different from the ways we truly feel. We can be warm or acerbic, supportive or sarcastic at will. Animals cannot. These are options that the blossoming of the human cerebral mantle now offers for our consideration.

I believe the basic emotional messages that have been summarized here will still be quite clear and evident in any population analysis of human values and behaviors, but they will always be embedded in innumerable complexities that characterize human life. We rarely see human emotional systems in action except as they are refracted through higher cerebral mechanisms. However, we can still see the underlying brain structures and functions reasonably clearly through animal brain research. These lower levels of understanding are essential for clarifying the foundations of our higher thoughts, feelings, and actions. Affective neuroscience aspires to provide answers to such questions, but to do so with any sense of completeness, we must now probe deeper into the very nature of affective consciousness. Only when we begin to understand how primitive subjective feelings are created within the brain will we be able to understand the nature of the values that are stitched together by our more recently evolved cognitive apparatus.

A Prospectus

Thus, this book ends where many books on emotions begin—with a consideration of emotions in conscious experience. But even here I will need to go below the surface glimmer of experience to the deeper causal issues. Because there is less substantive knowledge at this level, this chapter must be more speculative than the rest. To shed new light on the "hard questions" concerning human and animal consciousness,[1] namely, to clarify the brain sources of subjective experience, we must be willing to entertain novel ideas that will lead to new lines of research. Only when there are substantive, testable conjectures on the table will we be able to crawl toward a causal neurodynamic resolution of the mind-body problem (see Appendix C). In pursuing such a path, there will be inevitable mistakes, but hopefully they can be corrected through successive empirical approximations.

By appreciating how the brain is organized, we may gradually outgrow the illusory sense that we are creatures of two distinct realms, of mind and matter, and come to monistically accept that we are simply ultracomplex creatures of the world—with complex feelings, thoughts, and motor abilities that have arisen from the dynamic interaction of our brains with environments, both past and present. So far, I have focused more on the aspects of emotionality that evolved from ancestral challenges of such importance that they became genetically coded into the circuits of the brains we inherit. These ancient structures now constitute the neural substrates from which our primary-process affective consciousness—our "raw feels"—arise. The power of these systems was presumably pulled along during the subsequent mushrooming of the cerebral mass. It is likely that our more subtle feelings are a consequence of this neural expansion, but it is unlikely that those feelings could exist without the basic neural scaffolding we have so far explored.

An image that can serve us well here is that of a tree: Most full-grown trees have a remarkable canopy of branches and leaves that interact dynamically with the environment. However, the spreading branches cannot function or survive without the nourishment and support they receive from the roots and trunk. We may appreciate the tree for its spreading leaves, but our understanding must begin with the seed, the roots, and the emerging trunk. The same metaphor applies to the many neuronal "trees" that mediate emotions. It is certainly likely that the dynamic changes in our moods and feelings can arise from the perceptual capacities of our cerebral canopies, but all that could not exist without the emotional trunk lines.

In any event, the precise manner in which subjective experiences of primitive emotional feelings emerge from neural interactions remains a mystery, but because of the neuroscience revolution, it is fast becoming a scientifically workable problem. An understanding of such fundamental issues as primitive forms of consciousness will prepare us to address the nature of the more recent forms (see Figure 2.6), such as our ability to conjure images and to think about our perceptions and feelings. In other words, the more recent forms of consciousness may be linked critically to the rich neural "soil" that originally allowed our mammalian ancestors to experience primary-process affective states.

Trying to analyze consciousness coherently is difficult enough when we just consider the human mind, to which we have some introspective access, but the enterprise becomes increasingly treacherous when we try to understand the animal mind. However, from a formal scientific/experimental perspective, it should be no more difficult to understand the basic conscious abilities of other animals than our own. Indeed, it is possible that a careful study of animal behavior may take us to valid general principles more quickly than the study of the complex behaviors of humans. Obviously, we can only proceed experimentally if we accept objective animal and human behaviors as accurate indices of inner states (see Figure 2.3). It is unlikely that human verbal reports will provide the *only* inroad to the analysis of conscious experience. Our exquisite ability to transcribe experience into verbal symbols may be a lens that distorts reality as readily as it reveals it. Evolutionarily, the brain mechanisms for language were designed for social interactions, not for the conduct of science (see Appendix B).

Indeed, words give us a special ability to deceive each other. There are many reasons to believe that animal behavior will lie to us less than human words. This dilemma is especially acute when it comes to our hidden feelings that we normally share only through complex personal and cultural display rules. In addition, it now appears that our two cerebral hemispheres have such different cognitive and emotional perspectives on the world that the linguistic approach may delude us as readily as inform. Medical research in which the nonspeaking right hemisphere has been selectively anesthetized indicates that people express very different feelings when their whole brain is operating than when just the left hemisphere is voicing its views.[2] In short, our left hemisphere—the one that typically speaks to others—may be more adept at lying and constructing a social masquerade rather than revealing deep, intimate emotional secrets. If this is so, an indeterminate amount of information that has been collected with questionnaires and other linguistic output devices may be tainted by social-desirability factors, making the data next to useless for resolving basic issues. However, if we accept the reality of the psychological forces that have been long accepted in folk psychology—our ability to feel happy, sad, mad, and scared—and include a careful study of comparable emotional behaviors in animals and their brain substrates, the issue of affective consciousness should be resolvable.

Although emotionality has typically been deemed among the most difficult psychological issues to tackle scientifically, contrary to a traditional assumption of cognitive psychology,[3] the basic emotions we share with other animals may actually be easier to understand in neural terms than are their cognitive representations. As emphasized throughout this book, a consideration of the relevant details in the animal brain may offer an especially robust empirical way to shed definitive light on the neural nature of such forms of consciousness in humans. Moreover, affective feelings are clearly very important forms of consciousness to understand in their own right. Such knowledge has the real potential to improve human existence (by the development of new medications for psychiatric problems) and to reveal the fundamental nature of our core values. It follows that such knowledge should also have profound implications for scientific psychology—one that is not simply an experimental discipline describing surface appearances but also based on a causal, neurobiological understanding of fundamental principles.

If we could come to understand affective experience in neural terms, it could provide the fragmented discipline of psychology with a new unity that often appears unimaginable.[4] At present, there is still one enormous missing piece in scientific psychology. Clearly, we are not just behavioral creatures, as one old school of psychology, by no means dead, continues to assert. Nor are we merely mental creatures, as the prevailing cognitive paradigms would have us believe. We are also deeply feeling and deeply biological creatures who possess values handed down to us not simply through our sociocultural environments but also by the genetic heritage derived from our ancestral past. It is this last dimension, so lacking in modern psychology until quite recently, that has the strength to serve as a foundation for many higher concepts.

We are ultimately creatures whose capacity to feel is based on inherited brain representations of times past. Although the *details* of each individual's mental and behavioral life are constructed by living in the here-and-now world, our values remain critically linked to those encoded in our ancient modes of affective consciousness. Just as most people have always believed, our thoughts and actions are probably guided by our internal feelings—feelings that initially, in our youth, were completely biological and affective but which, through innumerable sensory-perceptual interactions with our environments, become inextricably mixed with learning and world events.

Once we accept the need for such deep evolutionary views, we will eventually have to come to terms with many unconventional premises. For instance, in this chapter I will argue that human and animal affective consciousness is based fundamentally on motor processes that generate self-consciousness by being closely linked to body image representations. I will try to show how an acceptance of such a seemingly incorrect premise—that the fundamental nature of consciousness is constructed as much from motor as from sensory processes—may help us resolve some key conceptual sticking points concerning the nature of consciousness, such as its apparent psychological coherence and unity (i.e., or the "binding problem," as it is traditionally called). Consciousness is not simply a sensory-perceptual affair, a matter of mental imagery, as the contents of our mind would have us believe. It is deeply enmeshed with the brain mechanisms that automatically promote various forms of action readiness. If this nontraditional view is on the right track, it may allow us to come to terms with our deepest nature in a nondualistic way.

If one accepts the importance of consciousness in understanding many psychological issues, the ultimate questions are: How can a brain feel its ancestral emotions and motivations? How are the intrinsic emotional processes generated by brain tissue and intermixed with representations of specific life activities? And how can we construct a third-person consensual science that is intimately linked to first-person subjective experiences?

On the Nature of Affective Consciousness

So far I have argued that the fundamental executive substrates for a large number of affective processes are coded into mammalian brains as a birthright—as cross-species, genetically provided neural functions that are experientially refined through maturation within the developing functional architecture of the brain. The basic emotional systems serve adaptive functions that emerged during the evolutionary history of mammals. They help organize and integrate physiological, behavioral, and psychological changes in the organism to yield various forms of action readiness. The emergence of emotional circuits, and hence emotional states, provided powerful brain attractors for synchronizing various neural events so as to coordinate specific cognitive and behavioral tendencies in response to archetypal survival problems: to approach when SEEKING, to escape from FEAR, to attack when in RAGE, to seek social support and nurturance when in PANIC, to enjoy PLAY and LUST and dominance, and so forth. Each of these systems is affectively valenced, yielding feelings that are either positive or negative, desirable or undesirable, but there are probably several distinct forms of each of these general types of affective experiences. Considerable evolutionary diversity has been added by species-typical specializations in higher brain areas as well as lower sensory and motor systems, but as we have seen, the basic affective value systems, deep within ancient recesses of the brain, appear to be reasonably well conserved across mammalian species.

These systems provide a solid foundation of biological values for the emergence of more complex abilities. Without a consideration of the types of underlying brain functions, it will probably be impossible to provide definitive *inclusion* and *exclusion criteria* for what constitutes the various emotional processes and how one emotional process might be distinguished from another. Such issues are solvable, in principle, when one begins to anchor his or her thinking about basic issues in neural terms. The ultimate inclusion and exclusion criteria for basic emotional processes must be found within the intrinsic potentials of the brain as opposed to the peripheral physiological and expressive changes of the body. Obviously, they cannot be based simply on our "feelings" or on psychological appraisal processes. For instance, the inclusion criteria for one type of fear are the properties of a specific neural circuit that extends from the lateral and central amygdaloid areas to the central/periventricular gray (see Figure 11.1) The exclusion criteria are the properties of many other nearby emotional and motivational systems. Furthermore, the properties of these brain systems can, I believe, be linked credibly to our deepest human concerns.[5]

Affective neuroscience seeks to provide conceptual bridges that can link our understanding of basic neural circuits for the emotions with straightforward *cognitive* and *folk-psychological* views of the human mind and, most important, its emotional disorders. This interdisciplinary approach would have little chance of working were it not for the simple fact that we humans do have some introspective-linguistic access to our subjective feelings.[6] Because of that small psychological window, and because the key emotional circuits are conserved in the brains of all mammals, the two can be linked in such a way that we can finally understand the neurobiological underpinnings of our human feelings. Conversely, and equally important, our introspective access to primitive feelings may also provide a credible scientific view, albeit indirect, on the minds of other animals.[7] This conceptual bridge can yield clear empirical predictions in both directions, from animal to human and from human to animal, and it can serve as an intellectual highway for productive commerce between the psychosocial and neurobiological sciences, at least as far as the basic, genetically dictated foundations of our natures are concerned.

The present era is an opportune time for such views: Brain research, because of its abundant factual riches, is finally ready to deal with some subtle integrative issues. Also, there is now increasing agreement that humans do have some universal psychological traits,[8] a possibility that was long viewed skeptically because no unambiguous methodologies existed to resolve the inevitable debates. Until recently, the most compelling evidence came from studies of identical twins separated at birth and cross-cultural ethological analyses of behavior patterns, such as facial, vocal, postural, and other behavioral expressions.[9] Now, however, there is an additional and remarkably robust strategy: the comparative neurological study of homologous psychobehavioral functions across mammalian species. Our neuroscientific knowledge allows us to probe below the surface details, to recognize the deep emotional and motivational homologies that guide animals in the use of their different toolboxes of sensory and motor skills. For instance, there is little doubt that the 24-hour biological clock of the suprachiasmatic nucleus guides the distribution of behaviors in all vertebrate species, or that the neuronal regulators of sleep are conserved in essentially all mammals, or that our urges to eat, drink, and make merry (i.e., play) are strikingly similar.

Currently, an increasing number of psychologists and other social scientists are beginning to develop an enthusiasm for the brain sciences, largely because of the great advances in clinical psychopharmacology and the spectacular advances in our ability to image brain functions in humans. Still, we should recognize that detailed animal brain research will be essential for us to make progress on the details of every one of the mechanistic issues. Such work has the best chance of filling in anatomical, neurophysiological, and neurochemical details for the basic psychological concepts derived from higher levels of analysis.[10] Indeed, for those who believe the new brain-imaging technologies will soon answer all the important brain questions, I simply note, once more, that they are not terribly precise in highlighting many of the subcortical neural circuits and chemistries involved in governing basic psychological processes, partly because multiple interacting systems are so incredibly tightly intermeshed in the brain stem.[11]

In any event, because of the many emotional homologies that have been revealed across species, we must also now seriously consider that other animals possess a conscious appreciation, rudimentary though it may be, of their own personal circumstances in the world. Of course, a great deal of their perceptual consciousness as well as ours is sensory, but there are good reasons to conclude that they also can feel internal affective states in ways that are not remote from our own. A rabbit trying to evade a mountain lion may subjectively experience an emotional state of fear embedded within a cognitive context of having perceived and identified a threat, and it may have some automatized awareness of its behavioral options. The rabbit's consciousness is surely much more tightly constrained to the present than is ours because of the animal's comparatively modest frontal lobes. When a rabbit is in the midst of danger, it probably has little thought about the past and future. It is dealing with its present circumstances on a moment-to-moment basis. It is precisely those here-and-now states of consciousness that we must seek to understand before we can grasp how they come to be extended in time, as they are within the human mind through our frontal cortical time-extending and planning abilities.[12]

I will propose a conceptual scheme of how the brain may generate subjective feelings through the neural mechanisms of self-representation at a primitive motor and sensory level. As I have reflected on the current, rapidly expanding literature on the nature of consciousness, it seems that this view is still a novel one. It may also be closer to the truth than many of the others, or as remote as any of them. The only thing we can be confident about with regard to this difficult topic is that our doubts must still outweigh certainties, and that our ideas should be cast in ways that can lead to empirical tests.

We should also recognize that many dedicated investigators remain doubtful that there can be any credible science of consciousness. Many psychologists, neuroscientists, and philosophers believe that the transmogrification of brain processes into subjective experience may be inexplicable on the basis of first principles: There is simply no way to understand mental states that we all experience firsthand by applying the consensual observational approaches of our third-person scientific methodologies. Such concerns are profound and appropriate, and they can only be skirted by the development of new and indirect strategies such as the one advocated throughout this text. If one assumes or can demonstrate that the affective neuroscience approach simply cannot work, then the task is, most assuredly, undoable at least for emotional consciousness. I believe the skeptical views are wrong and counterproductive; the powerful lessons of 20th century particle physics suggest that a comparable highly theoretical but empirically constrained strategy might succeed in psychology and neuroscience. Only because of the advances in behavioral brain research is this matter now an empirical issue that must be resolved on the basis of the predictions that can be made.

A growing number of investigators[13] believe that the solution to the mind-body problem—namely, the *fundamental* nature of consciousness—can emerge only when we begin to theoretically blend "first-person" insights concerning primitive states of consciousness that we humans share with the other animals with "third-person" empirical observations that can be made in the behavioral brain research laboratory. I believe that if we deploy the full flexibility of empiricially guided theoretical inference (i.e., the so-called hypothetico-deductive method of traditional science), there is no unbridgeable chasm between the nature of subjective experience and relevant brain and behavioral facts that can be gathered through traditional scientific modes of inquiry. Before I proceed into the center of the hornet's nest of primary-process consciousness, let me dwell briefly on a few examples of the problems that arise when we begin to address such ephemeral matters scientifically.

Common Mistakes in Conceptualizing Psychological Functions in the Brain

In our continuing quest to reveal the natural order of brain processes (or, as the popular saying goes, "trying to carve nature at its joints"), will the search for affective consciousness in the brain of other mammals help reveal human realities, or will it take us down a misguided path of postulating brain functions that do not exist? Many examples of such mistakes come to mind from the history of the physical sciences—including "the ether," a nonexistent substance that was postulated to transport light in space, and "phlogiston," which was thought to do the same for heat. The history of functional brain research, rooted as it is in the phrenological tradition of postulating organs for mental faculties, still makes many of us shudder with shame for some of the gross oversimplifications of our predecessors.[14] Such mistakes remind us of the empty concepts that litter the history of science. Such "empty categories" and "block diagrams" are even easier to create in the psychological sciences, partly because of the complexity of the matters we seek to understand and partly because of the social nature of language, which, from an evolutionary vantage, was surely not designed for scientific discourse (see Appendix B). In any event, serious investigators of the brain are loathe to contribute more verbal rubbish to existing confusions so they are prone to remain silent on such matters.

Let me share one minor but instructive example of a conceptual mistake that has assumed the status of accepted fact in the popular imagination—the observation of "sexual cannibalism" in certain insects. On occasion, female praying mantises have been observed to consume the head parts of males that have pounced on them with copulatory intent (all presumably done unconsciously, of course). A functional evolutionary story has been generated that this type of "sexual cannibalism" emerged to release the natural sexual reserves of the male. By removing higher sources of inhibition, the female supposedly promotes (unconsciously again) unbridled copulation in her headless suitor. This type of beheading has been widely assumed to be an evolved behavioral strategy that helps ensure reproductive success.

Many even believe that evolution coaxed the male to offer his life (or, more accurately, his bodily energy) to help assure the female's ability to rear the next generation successfully. Are such tendencies toward "self-sacrifice" and "sexual cannibalism" real *sexual* repertoires of male and female mantises, or simply a myth created by scientists awed by the predatory rapaciousness of these creatures? Careful evaluation of the evidence now suggests that mantises are simply very predatory creatures and that cannibalistic tendencies are amplified by limitations imposed on their opportunity to hunt in captivity. Perhaps only because of certain experimental procedures (i.e., the use of isolation housing that precludes predation) do sexually eager males unwittingly come to gratify the female in more ways than one. There may, in fact, be no evolutionary connection between the two acts. The females merely grasp their opportunity to express predatory urges when males are copulating close at fang.[15] Thus, there may be no neural mechanism for sexual cannibalism or self-sacrifice within the nervous systems of female and male preying mantises.

It is certainly possible that other animals, despite their many emotional behaviors, have no internal experience of any ongoing emotional states. As asserted by René Descartes, who formally introduced dualism into our sciences almost 400 years ago, the other animals of the world may be more akin to reflexive robots than to the feeling creatures some of us believe them to be.[16] If this is so, a search for mechanisms of affective consciousness in the animal brain will be futile. However, it does *seem* self-evident to most observers that animals experience emotional states. Not only is this apparent in their outward behaviors, but it has now repeatedly been indexed by their motivation to exhibit various conditioned approach and avoidance behaviors. Other compelling lines of evidence come from psychopharmacology, where behavioral changes in animals can predict human clinical and subjective responses, and from brain stimulation studies, where the subjective responses of humans and the corresponding behavioral responses of animals are remarkably similar. Indeed, on a related topic, formal analysis of rat behavior has led to the conclusion that such creatures do exhibit some true intentionality.[17]

Hence, it seems likely that the pursuit of the underlying mechanisms of affective consciousness in the animal brain may help reveal the nature of homologous processes in the human brain/mind. If so, the eventual knowledge we may achieve by pursuing this path of reasoning may be more worthwhile than the rather sterile views promoted by the strict paths of logical positivism and skepticism (i.e., that only the consensual evidence arising from our visual system is to be believed in science). Instead, we should come to respect a new and more powerful criterion: Our ability to predict new observations should serve as the only credibility discriminator for various competing lines of thought.

A Rapprochement between Logical Positivism and Folk Psychology

It is obvious that the concepts we choose to guide our experimental inquiries must be as flexible and profound as the functional processes that actually exist in nature. The recent neuroscience revolution has finally provided the necessary tools and findings for a major rapprochement between the internally situated emotional powers long recognized in folk psychology and the subcortical neural controls that can be detailed through animal brain research. We can finally seek the neurobiological wellsprings, albeit not the diverse cultural consequences, of human emotionality by studying the neural mechanisms for affective experiences in other animals. Their emotions will surely not resemble the cognitively detailed and emotionally subtle experiences that fill our minds. But they may resemble the deeply felt, visceral emotions of children, which some adults again experience when they succumb to psychiatric disorders.

So how shall we ever understand how felt experience actually emerges from brain matter? Let me suggest a new brain process—one that is not as controversial in developmental psychology as it is in neuroscience: To really understand the basic affective states of consciousness, we may have to understand the primal nature of "the self." We need to fathom how humans and animals naturally come to experience themselves as active, feeling creatures in the world. To do so, we must learn to conceptualize subtle brain processes such as "the self" in neuroscientific terms. Such a neural entity, in its primordial form, may constitute the preconscious foundations for all other forms of consciousness—it may be the essential object of mature consciousness without which higher levels of consciousness could never have emerged. However, before I tackle this thorny issue, let me first dwell on several "higher types" of conscious awareness of which the human brain/mind is capable. This may ease our difficult journey into this central mystery of the animal mind—the nature of primary-process affective consciousness.

Obviously, within the human cortex, there is not just a single form of consciousness but various types of awareness, as indicated by changes that can result from damage to specific parts of the brain. The higher levels of consciousness give us awareness of the almost infinite regress of self-reflection: We can be conscious of being conscious of being conscious, and so on.[18] An initial consideration of these levels may help us distinguish the lower forms of consciousness. That will help us understand how emotional feelings are actually encoded within the intrinsic potentials of brain dynamics.

Higher Levels of Human Consciousness

There is great appeal in trying to find the keys to conscious activities within the higher sensory-perceptual reaches of the human brain. However, the functions of most higher brain areas may be more closely related to the neural computations required for specific skills—namely, the various "tools of consciousness"—as opposed to the construction of primary-process consciousness itself. For instance, although we are getting close to understanding the conscious experience of vision, few are tempted to argue that elimination of visual abilities or any other single sensory system markedly impairs primary-process consciousness.[19]

The most discrete disruptions of perceptual awareness occur as a result of various forms of cortical damage. One of the most striking is the loss of consciously appreciated vision following damage to the occipital cortex. Although individuals with these impairments report being completely blind, they can accurately identify the locations of moving objects in their visual fields. This "blindsight" has perplexed students of consciousness, for it highlights how wrong our conscious understanding of our behavioral abilities can be. It seems likely that blindsight is mediated by our ancient frog-type visual abilities, seated in the superior colliculi of the midbrain. That ancient visual system allows all animals to identify *where* objects are in visual space without being able to decode *what* they are. Our higher levels of conscious awareness are no longer well tuned to movement information in the absence of object information. Such blindsight leaves only a vague feeling of something having happened.[20]

Comparable types of effects have been found with the loss of face-recognition abilities, or *prosapagnosia*, following damage to the bottom surface of the temporal lobes and the neglect of personal space following damage to the parietal lobe, especially when these forms of damage are situated in the right hemisphere. Such *agnosias* clearly tell us how important specific types of cortical information are for constructing a detailed awareness of our world. Not only are afflicted individuals still able to identify others by their tone of voice and by the clothes they wear, they can still process incoming facial information at a preconscious level. For instance, people with prosapagnosia still selectively exhibit galvanic skin responses to familiar faces, indicating that their autonomic nervous systems remain in touch with the facial features of the people they have known.[21] We do not know whether this type of autonomic information is simply unable to be represented in consciousness, or whether it has come to be neglected during development because of the power of the more salient types of visual information—namely, it became a "preconscious" ability. I would assume that the latter is true, and that such alternative channels of information can be made more salient within affective consciousness through emotional education (i.e., by training people to get in closer touch with their feelings).

Phenomena such as blindsight and prosapagnosia highlight how powerfully preconscious perceptual processes may control our behavior. Such findings have generally led to the widespread view that the contents of consciousness are mediated by very specific neocortical functions. As a consequence, it is now commonly believed that most subcortical processes operate unconsciously. However, this is far from true. By comparison to cortical damage, very small lesions of subcortical areas can severely compromise human consciousness, and electrical and chemical stimulation at many subcortical sites can have effects on affective consciousness that cannot be matched by any form of cortical stimulation.[22] Still, because of such examples, we should obviously remain cautious in trying to understand conscious awareness in animals by simply interpreting their outward behaviors. Special behavioral assays need to be conducted before such conclusions are warranted. When we do use procedures such as conditioned place preference and avoidance, a mass of data from animals as well as humans suggests that the fundamental sources for affective and intentional consciousness are subcortical, but they are also represented in higher regions.

Split-Brain Data and the Subcortical Sources of Consciousness

A subcortical location for the essential mechanisms of consciousness can be derived from the many fascinating studies of "split-brain" individuals in whom the corpus callosum has been severed, eliminating the main communication channels between the two cerebral hemispheres. Although such data are more commonly used to argue that human conscious awareness is cortically elaborated, the continued unity of primary-process consciousness and a primal form of behavioral intentionality following the splitting of the human brain are also striking.

Although each hemisphere can have independent realms of perceptual awareness, cogitate independently, and have distinct emotional communication styles, careful behavioral observation of split-brain individuals yields an additional overriding conclusion: Despite massive hemispheric disconnection, the deep and essential coherence of each person's personality and his or her sense of unity appears to remain intact. Most forms of intentionality and deep emotional feelings are not split in any obvious way by a parting of the hemispheres. Only the cognitive interpretations of specific events are affected. For instance, when one side of the brain is exposed to a sexually arousing visual stimulus, the other side feels the arousal but is not able to interpret the precipitating event correctly and often dissembles and rationalizes.[23] The unity of an underlying form of consciousness in split-brain individuals, perhaps their fundamental sense of self, is affirmed by the fact that the disconnected hemispheres can no more easily execute two cognitive tasks simultaneously than can the brains of normal individuals.[24] The inability to distribute attention simultaneously to two tasks is a characteristic feature of a unified consciousness in neurologically intact individuals. In split-brain people, a central workshop of consciousness,[25] which simultaneously influences both hemispheres, continues to limit distribution of attentional resources.

Only with special procedures can we demonstrate distinct types of cognitive and affective styles, as well as perceptions and information-processing strengths within each hemisphere.[26] To put it simply, the left hemisphere is generally more socially communicative and seemingly happier than the right hemisphere, while the right side is more reserved and prone to feel intense negative emotions and to become depressed.[27] Even though it is clear that the right and left hemispheres have different affective styles, this does not mean that the affect they help weave can be generated without subcortical inputs. It is possible that the distinct affective abilities of the hemispheres arise from how they handle ascending emotional messages from subcortical circuits. This possibility has been explored in some detail.[28] It is also noteworthy that in day-to-day activities, the longitudinally severed hemispheres of split-brain people rarely meddle with each other's affairs. For instance, when a split-brain individual dives into a swimming pool, there are no behavioral signs, such as one side of the body flailing, to suggest that half of the brain has been taken by surprise. Thus, the most impressive message is that despite a massive division of the major toolboxes of human consciousness, split-brain individuals still operate as coherent wholes in the affective, intentional, and motor conduct of their daily lives. Thus, the foundations for our subjectively experienced core of being must lie deeper within the brain than the cerebral hemispheres. Indeed, there are many subcortical channels for interhemispheric communication of information that could sustain coherence between the two hemispheres.

A similar conclusion is evident from the study of animals that have been decorticated early in life: They sustain a remarkably strong level of behavioral coherence and spontaneity. Indeed, as mentioned in the previous chapter, college students asked to observe two animals, one normal and one decorticate, typically mistake one for the other. This arises from the fact that decorticates are generally more active, while the normal animals appear more timid. Students tend to believe that the energized affective behavior is an indication of normality. The ability of such decorticate animals to compete effectively with normal animals during bouts of rough-and-tumble play is further testimony to the likelihood that internal self-coherence is subcortically organized.[29]

Such diverse lines of evidence, taken together, suggest that the essential "core of being" is subcortical. In my estimation, it was first elaborated in brain evolution within central motor–type regions of the midbrain—in periventricular and surrounding areas of the midbrain and diencephalon that are richly connected with higher limbic and paleocortical zones. These brain areas appear to be the most likely sources for the primal neural mechanisms that generate affective states of consciousness. It will be argued that those primordial circuits may elaborate a fundamental sense of "self" within the brain. Although this is not a very skilled and intelligent self and its pervasive influence may often seem preconscious (especially when higher forms of consciousness have matured during ontogenetic development), it ultimately allows animals to develop into the intentional, volitional, and cognitively selective creatures that they are.[30] It may do this in part by providing a basic body image that can control primitive attentional and intentional focus. I will assume that such archaic brain functions provide a fundamental reference point for the development of more sophisticated levels of competence throughout the rest of the nervous system.

If, as John Milton suggested, "The child is father of the man," a primordial sense of self may ultimately be mother to all higher forms of consciousness. This is not to imply that higher forms of conscious awareness do not require higher brain mechanisms, only that the elaboration of conscious abilities in the brain germinates and sprouts from a primal neural field that intrinsically represents a basic body image within the brain stem. This mechanism is shared by all mammals, and it is presumably grounded in various intrinsic circuits that exhibit spontaneous types of oscillatory activity. Because of the different paths of cortical evolution in different species, and distinct forms of higher epigenetically derived paths of cognitive development among different individuals of a species, these primal mechanisms come to be manifested in many ways. To simplify my analysis, I will focus, once more, on essential evolutionary sources rather than on their ultimate manifestations.

Obviously, humans can have contents within their conscious awareness that other animals never have, and vice versa. Simply consider the importance of language for the temporal extension and deepening of human thought, the sophisticated olfactory abilities of the rat and the ability of bats to represent the world in auditory coordinates. It is as unlikely that classical speech areas of the brain mediate the elemental infrastructure of primary-process consciousness in humans as it is that the auditory cortex or olfactory bulbs do so for bats and rats. Many of us know individuals with left hemisphere strokes who in most realms act as do unimpaired individuals, even though they can no longer use language effectively. In short, one can damage many higher parts of the brain, eliminating specific cognitive abilities, but the organism's internally sustained neural representation of itself as a coherent creature remains intact. Likewise, following damage to higher motor areas, people can be paralyzed while sustaining the internal experience that they are not. Just ask a hemiplegic person, paralyzed on one side because of a stroke to the opposite side of the brain. Such individuals typically retain the internal feeling that they can still move the impaired limb. This is a motor counterpart to the common feeling of amputees that they still have their missing body parts (i.e., the experience of "phantom limbs").[31]

In sum, following many forms of higher brain damage, an individual's "center of being" or "sense of self" appears to be intact. Is there, in fact, such a center of being within the brain, or is it a mere mythical entity?

No one knows for sure, but here I will develop the position, probably uncontroversial to most neuroscientists, that a variety of key processes centered in the ancient circuits of the brain stem are absolutely essential for the creation of consciousness within the brain. For instance, there is general agreement that the extended ascending reticular activating system, including thalamic reticular nuclei, is necessary for normal waking and attentional activities.[32] However, I think we have almost totally ignored one of the ancient foundation processes—a neurosymbolic affective representation of I-ness or "the self" that may be critically linked to a primitive motor representation within the brain stem. It is easy to overlook this motor foundation for consciousness when we are continually entranced by the seemingly endless forms of sensory-perceptual awareness. However, I would suggest that the self-referential coherence provided by ancient and stable motor coordinates may be the very foundation for the unity of all higher forms of consciousness.

A Proposal concerning the Fundamentally Affective Nature of Primal Consciousness

No matter how one views it, discussions of consciousness resemble the heads of Hydra—from each severed observer, many others can sprout. To use this slightly mixed metaphor, each observer gazes at the others, wondering if there is some more powerful observer who can see all the rest, leaving all to ponder the infinite regress of who is observing the observer, and so forth. Is there a primal monitoring function within the brain, one that observes but is not observed? Many, including myself, believe there is no such entity.[33] In anticipation of the main point of this chapter, I will suggest just the reverse—that there is a coherent foundational process, or "self-representation," that does not observe in the conventional sense but is observed or at least strongly "intermeshed" with various higher perceptual processes. In other words, the self-schema provides input into many sensory analyzers, and it is also strongly influenced by the primal emotional circuits discussed in the previous chapters. These interactions may constitute affective consciousness. This foundation process—the primordial self-schema—was first laid out in stable motor coordinates within the brain stem. It not only helps guide many higher perceptual processes, by promoting attentional focus and perceptual sensitivity, but also may provide a fundamental stability for the psychological "binding" that is characteristic of our perceptual field. Presumably, this foundation process is not *directly* influenced by higher contents of consciousness, although it may be strongly and automatically modified by various other influences—by conditioned emotional "triggers," by meditation, by music, dance, and probably a variety of other rhythmic sensory-motor inputs and activities.

To facilitate discussion, I shall henceforth refer to this "it" as the SELF—a Simple Ego-type Life Form—deep within the brain. At present, our knowledge about this brain function is so rudimentary that we can only generate "best guesses" as to its nature. I will advance one proposal with some confidence, since it squares with known facts and yields testable hypotheses. I will advocate the view that the SELF first arises during early development from a coherently organized motor process in the midbrain, even though it surely comes to be rerepresented in widely distributed ways through higher regions of the brain as a function of neural and psychological maturation. Not only does this archaic SELF-representation network control motor tone and some simple orienting responses, its intrinsic rhythms can be transiently modulated by a wide array of regulatory inputs, and it is highly interactive with all the basic emotional circuits discussed in this book. Feelings may emerge when *endogenous sensory* and *emotional systems* within the brain that receive direct inputs from the outside world as well as the neurodynamics of the SELF begin to reverberate with each other's changing neuronal firing rhythms.

By directly modifying the intrinsic neurodynamics of the SELF, emotional circuits establish the conditions by which the essential neural conditions for affective consciousness are created. Here I will argue that the changing neurodynamics of the extended representation of SELF networks are essential for generating subjective emotional feelings in all mammalian brains. Thereby, the neurodynamic ripples of various affective codes may spread widely through the brain. The interaction of these neurodynamics with the sensory analyzers of the thalamus and cortex and the motor systems they regulate allows organisms the possibility of various species-typical modes of emotional SELF-expression and SELF-regulation. The ensuing affective states may be the internally experienced regulatory value signals around which much of animal behavioral and cognitive activity revolves. Organisms aspire to maximize certain states of the system and to minimize others.

Considering this possibility, I would argue that basic affective states, which initially arise from the changing neurodynamics of a SELF-representation mechanism, may provide an essential psychic scaffolding for all other forms of consciousness. Thus, a primitive affective awareness may have been an evolutionary prerequisite for the emergence of perceptual-cognitive awareness. If so, computational and sensory-perceptual approaches to consciousness must take affective bodily representations into account if their higher extrapolations are to be correct. From such a vantage, Descartes's faith in his assertion "I think, therefore I am" may be superseded by a more primitive affirmation that is part of the genetic makeup of all mammals: "I feel, therefore I am."[34]

Evolutionary Relations between Primary-Process and Secondary Forms of Consciousness

To get at the root of primary-process consciousness empirically, one will surely need to distinguish between the varieties and sources of distinct conscious abilities in different species and the shared neural foundations across species. For instance, other animals obviously do not have linguistic consciousness, although they no doubt have some complex ideas that emerge from the association cortices that eventually led to the evolution of linguistic abilities in humans. The emergence of a multimodal association cortex capable of constructing ideas by intermixing information from various senses surely preceded the ability of such tissues to represent those ideas in concrete symbols such as grunts and eventually words.[35] Thus, while the mental activity that emerges from multimodal association cortex in humans can now focus on the detailed meanings of words, the integration of information in similar brain regions of other animals may create comparatively simple holistic perceptions and appraisals. For instance, the apparent sound or smell of a predator at a certain location means that danger may be nearby, perhaps leading to the automatic evocation of wariness—fearful internal feelings and images of potential predators along with some simple strategies to avoid them. In other words, the cognitive and affective contents of consciousness may become inextricably intertwined within the highest forms of neural symbolization that can be created by the animal's cortex.

Presumably, some of the neural connections that instantiate such internal images arise from neural computations that occur in rapid eye movement (REM) sleep (see Chapter 7). Unfortunately, such cognitive issues are horrendously difficult to analyze neuroscientifically. Short of someone identifying neurophysiological or chemical markers for the animal's internal representations, such issues are scientifically unworkable.[36] Such difficulties help highlight why the study of spatiotemporal abilities, as opposed to internal images, is such a popular topic of study in the field of animal cognitions. It is comparatively easy to determine how animals use cognitive strategies with reference to measurable events in the outside world.[37] Although the various brain-imaging technologies are now providing a glimmer of the higher cognitive-emotional interactions in human brains, it would be premature to conclude that these representations actually reflect the fundamental affective substrates in action.[38] Most of the affect-related brain changes observed so far may be more closely aligned with the cognitive contents of different affective states rather than with the primary-process affective states themselves. The types of work that are needed to reveal the latter are direct chemical and electrical stimulation procedures that arouse emotional states unconditionally—work that is best done in animals.

Conceptualizations of SELF-Consciousness

For the present purposes, primary-process consciousness will not be conceptualized simply as the "awareness of external events in the world" but rather as *that ineffable feeling of experiencing oneself as an active agent in the perceived events of the world.* Such a primitive SELF-representation presumably consists of an intrinsically reverberating neural network linked to basic body tone and gross axial movement generators. It may provide a coherent matrix in which a variety of sensory stimuli become hedonically valenced. In other words, primary-process consciousness is probably rooted in fairly low-level brain circuits that first represented the body as an intrinsic and coherent whole. When other incoming stimuli, both internal and external, interact with this body schema and establish new kinds of reafferent reverberations,[39] the potential for an internal state of affective awareness is created. Obviously, for such an entity to have adaptive value, it must be able to control certain basic motor and attentional processes.[40]

This type of analysis suggests that the brain substrate of "the SELF," and hence primary-process consciousness, has certain explicit attributes. Contrary to some traditional religious and philosophical thought on the matter (i.e., concerning the nature of the soul), the SELF has concrete neuroanatomical, neurochemical, and neurophysiological characteristics. First, it should be ancient in brain evolution and hence situated near the core of the brain. Also, one would expect that it would be richly connected to the rest of the brain, both higher and lower areas, presumably more richly than any other area of the brain stem.[41] It would be highly multimodal, allowing for rerepresentation at many levels of the neuroaxis during ontogenetic development. With the emergence of such rerepresentations, a variety of recursive observers and observers of observers seems to emerge within the maturing fabric of the brain. Presumably such higher SELF reverberations would typically operate in coordinated fashion with the lower substrates, but the possibility of semi-independent action may also emerge.

According to such a view, emotional feelings, as well as the unique character of various emotional behaviors, may arise from the ways in which the basic emotional command circuits modulate neuronal reverberations or resonances within these extended representations of the SELF. FEAR circuits may push the SELF-schema into an "up-tight," shivery state of tension. RAGE circuits may pressure it into an invigorated cycle of forceful actions, and so on. These changes in the ongoing neurodynamics of the SELF would set the stage for a variety of discrete emotional behaviors and mood-congruent forms of information processing. It would also establish a homeostatic "set point" or "settling point" (see Chapter 8) whereby various emotional self-regulatory strategies could be established.

In sharing this viewpoint about the sources of consciousness, I am affirming a truism of 20th century behavioral science: Evolution can mold brain functions only by inducing changes that modify the efficacy of behaviors. Affective representations promote certain classes of behavior patterns, and with the additional evolution of various highly differentiated sensory and motor tools, affective states may increasingly provide an internal reference point for more complex abilities. Thus, in complex organisms such as human adults, affective feelings may arise from a build-up of reverberations in the extending SELF-schema, which is experienced as a mounting sense of "force" or "pressure" to behave in a certain way. With psychological development, organisms may develop a variety of counterregulatory strategies, ranging from various cognitive-perceptual reorientations to the withholding of behavior patterns. In other words, since the basic emotions provide fairly simpleminded solutions to problems, it would be adaptive for organisms to be able to generate alternative plans. Still, such newly evolved brain abilities may continue to be referenced to the affectively experienced neurodynamic status of the primal SELF. To put it quite simply: Animals may adjust their behaviors by the way the behaviors make them feel.

We cannot be confident of the predominant anatomical source of the primal SELF in the brain, but two areas recommend themselves—the deep cerebellar nuclei, which receive a great deal of primitive sensory and emotional information and control body movements, especially those guided by sensory feedback, and the centromedial areas of the midbrain, including the deep layers of the colliculi and the periventricular gray, which do the same. Many believe these areas are too low in the neuroaxis to create consciously perceived affect, but this is certainly not so during infancy and early childhood. Because removal of the cerebellum does not severely compromise consciousness, I favor the option that the centromedial zones of the midbrain are the very epicenter of the primordial SELF (see Figure 16.1).[42]

A SELF-Referencing Mechanism in the Brain: A Foundation for Primary-Process Affective Consciousness?

Recently, and without much data to bear on the issue, it has become fashionable to question the existence of central agencies within the brain that permit conscious awareness. Many claim that there is no coherent neural referent for the pronoun "I." Contrary to that trend, I would advocate the position that such a central processor (albeit perhaps not an observer) does exist within the "Cartesian theater"—a current philosophical catchphrase for the neural work space of consciousness within the brain.[43] Thus, a key element in the present conception of primary-process consciousness is the SELF—an ancient neural process for the generation of spontaneous emotional actions that *is observed* within the Cartesian theater by a series of more recently evolved "monitors" or sensory-perceptul processors. It is assumed that with the aid of such a primal SELF-referencing mechanism, deviations from a resting state came to be represented as states of action readiness and as affective feelings. Further, this central faculty may have served as a critical neural vector for the evolution of a variety of higher forms of consciousness that humans spill out so casually with phrases such as "I felt this" and "I felt that."

As already mentioned, traditional contemplations about the nature of conscious awareness have led thinkers to envision an infinite regress of sensory homunculi observing each other ad infinitum. It is obviously quite difficult to contemplate how an ultimate observer could ever have evolved. The existence of an archaic SELF-network, especially one that is referenced in motor coordinates, can help solve this dilemma and others as well: All higher monitors are entranced by a central process that itself does not observe but exists in the very center of the Cartesian theater as the primordial neurosymbolic representation of the core of each individual existence. The SELF does not have thoughts or clearly defined perceptions, but it does help elaborate primitive feelings, and it serves as an anchor that stabilizes or "binds" many other brain processes.

At a practical neurobiological level, the postulated existence of a primitive motor-action homunculus that is the primal representation of the SELF allows us to envision ways in which primary-process consciousness can begin to be empirically studied. In its essential state, I assume the SELF provides the first executive mechanism for behavioral coherence and bodily awareness. In neural representational terms, the SELF may be topographically like a body of quite primordial shape. Perhaps an image of a stingray may serve as an approximate metaphor here. While it is reasonable to assume that the SELF is not unchanging but becomes more sophisticated in the course of both ontogeny and phylogeny, this is more likely due to the addition of new layers of neural control as opposed to a reshaping of the original form.

The intrinsic neurodynamics of the archaic SELF may be a primary influence in guiding the neurodevelopmental maturation of higher levels of consciousness, perhaps through various iterative bootstrapping processes, whereby closely interconnected brain areas begin to resonate with the inherent neurodynamics of the lower substrates. Also, the existence of use-dependent neuronal growth factors (see Chapter 6), which guide the development of certain patterns of brain interconnectivities, may contribute to the neuronal maturation of the SELF through higher regions of the neuroaxis. Such spreading epigenetic interactions may help make certain higher brain circuits more permeable to lower influences, leading to a sense of SELF and a feeling of internal coherence or discoherence that are represented ever more widely in the brain as organisms develop and mature. Thus the developmental reflections of the SELF may eventually come to reside in many brain areas, in individualized ways, thereby providing higher brain circuits a concrete value focus for their complex deliberations about the external world. Presumably this immigration would at least initially be controlled by the richness of intrinsic, genetically and epigenetically guided connectivities of the basic SELF circuits with higher brain areas.[44]

This, I believe, is the type of primitive but developmentally flexible and intrinsically dynamic substrate of consciousness that we should be seeking deep within the brain stem—not the final observer, not the ultimate perceptual monitor in the Cartesian theater, but a spontaneously active "stage manager" that helps create a neuropsychic focus of existence for a multitude of higher observers that emerge as the SELF-process migrates through higher regions of the brain, especially the frontal, temporal, and cingulate regions of the cortex.[45] Thus, fully developed consciousness is reflected in hierarchical but recursive sets of neural processors, all still rooted in some primal aspects of SELF ontogenesis.

I will now elaborate the idea that the primary template or "seed" of the SELF process, and hence the roots of primary-process consciousness, reside deep within medial zones of the brain stem. In one sense this is an uncontroversial issue, since the reticular formation of the brain stem, with extensions into the thalamus and hypothalamus, has long been considered an essential substrate for conscious, attentional activities (see Chapter 7). However, in another sense, what I suggest here is significantly different from, albeit complementary with, that view. Rather than focusing on the basic waking and attentional systems of the ascending reticular activating system (ARAS), which certainly allow higher brain areas to work efficiently, I will now develop the idea that the deep layers of the colliculi and underlying circuits of the periaqueductal gray (PAG) are the neuroanatomical focus of the intrinsic motor SELF (Figure 16.1).

A remarkable amount of neuropsychological and neurobehavioral evidence is consistent with such a possibility. The deeper layers of the colliculi constitute a basic motor mapping system of the body, which interacts not only with visual, auditory, vestibular, and somatosensory sytems but also with nearby emotional circuits of the PAG. The PAG elaborates a different, visceral-type map of the body along with basic neural representations of pain, fear, anger, separation distress, sexual, and maternal behavior systems (as summarized throughout this text). Adjacent to the PAG is the mesencephalic locomotor region, which is capable of instigating neural patterns that would have to be an essential substrate for setting up various coherent action tendencies.[46] If one had to select between these functions (the motor or sensory zones of the tectum) as the very focus of the SELF process, I am inclined to envision the motor map as being more central to the SELF than the incoming somatosensory processes. This is based partly on evolutionary considerations: A level of motor coherence had to exist before there would be utility for sensory guidance. Neurophysiological evidence also indicates that the somatomotor, eye-movement map that borders the PAG is intrinsically a more stable tectal circuit than are the overlying sensory maps of the superior colliculi. While the superficial layers of the su-

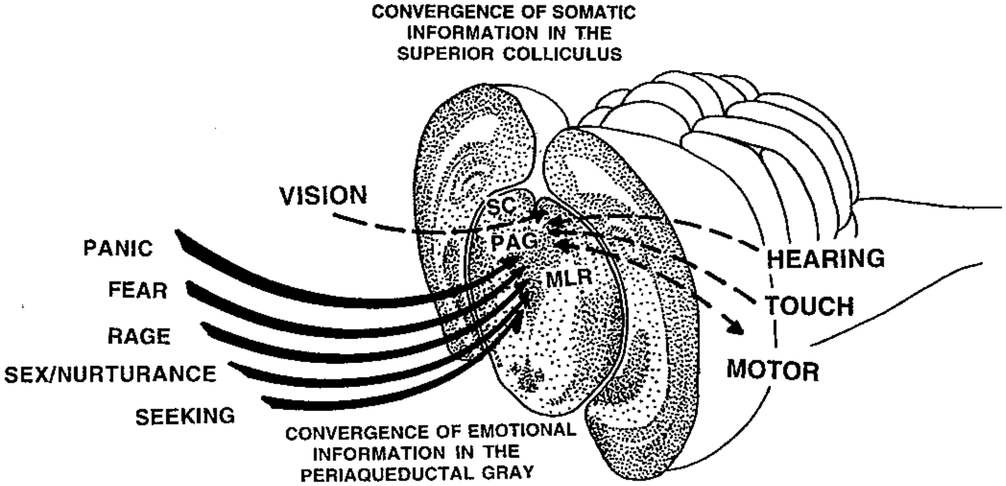

Figure 16.1. Overview of mesencephalic organization of convergent somatic and emotional processes in the interface area of the periaqueductal gray (PAG) and the superior colliculi (SC) of the tectum. The adjacent mesencephalic locomotor region (MLR) can generate coherent forward locomotion.

perior colliculi flexibly harvest information about the location of visual stimuli, the underlying motor system generates appropriate orienting movements using what appears to be a remarkably stable set of action coordinates. In other words, the sensory maps of the tectum appear to shift markedly in reference to stable motor coordinates when the motor map initiates specific actions.[47] I take this stability of the somatomotor system to indicate that it has primacy in the evolution of the psychobehavioral coherence that this system spontaneously generates. In addition, the underlying PAG tissues, which contain representations of all emotional processes, may constitute an even deeper and more primitive visceral SELF. To keep things relatively simple, for the present purposes the somatic and visceral components will be considered as an interactive unity.

The mesencephalic roots of the SELF, through its many neural connections with higher brain areas, help us envision, albeit dimly, the emergence of higher forms of self-consciousness. The deep tectal and underlying PAG zones are more richly connected with frontal motor areas, where plans and intentions are generated, than with posterior sensory areas, where perceptions are constructed. Again, in selecting one or the other of these large cortical regions of the brain—sensory or motor—as being more closely linked with primal consciousness, the frontal cortex clearly has a great deal to commend it. To establish behavioral priorities in time, the frontal cortex needs to *actively* retrieve perceptual information from sensory cortices. It is also significant that more powerful personality changes result from frontal cortical damage than from comparable damage to posterior sensory areas.[48]

It should be recalled that the frontal areas are the motor association or planning cortex. Thus, even though the exteroceptive contents of consciousness are obviously created by sensory zones, those zones must send massive outputs into the motor areas in order for coherent behavior to occur. I suspect this has led many thinkers to mistake sensory awareness for consciousness itself, as opposed to the toolbox of consciousness that it really is. In sum, I would suggest that a careful consideration of all issues indicates that primary-process affective and intentional consciousness is more critically linked to motor than to sensory cortices. This is not to deny the importance of sensory-perceptual processes in the guidance of behavior, but to make a distinction between the essential foundations of consciousness and the contents of consciousness. The contents of consciousness (which I would consider a secondary or derivative form of consciousness) are obviously created from the various sensory-perceptual processes—visual, auditory, somatosensory, olfactory, gustatory, vestibular, and kinesthetic—to which may be added the various thinking and cognitive operations that allow these systems to be interrelated. I assume that primary-process consciousness is more than that, and it resides in the intrinsic action-readiness of the system. I assume the action-readiness system provides a massive stability for the perceptual apparatus, and that it is essential for the retrieval of information from those toolboxes of consciousness. Changes in the neural activities of primary-process SELF-schema, I assume, constitute the changing nature of affective consciousness.

A Putative Neuroanatomical Roots for Primary-Process Consciousness

The massive and unparalleled convergence of information onto a simple and ancient body representation makes the centromedial areas of the midbrain an excellent candidate for the basic integrative framework that provided a neural scaffolding for a primitive neurodynamic of emotional SELF-awareness. As mentioned, this may have been achieved by the ability of the SELF-map to establish a characteristic resting tone within the somatic and visceral musculatures. The establishment of such a tone throughout the body and brain, along with a variety of reafferent processes, may have provided each organism with the feeling of individuality—of "I-ness." Upward influences into higher parts of the brain may have been achieved through the control of certain neural rhythms (e.g., delta, theta, alpha, beta, and gamma) that appear to have general properties in the control of exteroceptive information processing.[49]

This postulated SELF-schema presumably can trigger basic forms of bodily orientation and promote the extraction of values from the interaction of the internal milieu with environmental incentive stimuli. It may not be exceedingly difficult to imagine how such a system might generate intrinsic biological meaning structures within the organism. For instance, brain hormone detectors that instigate sexual urges may do so partly by promoting a natural copulatory LUST-type neurorhythm within the SELF-schema. This rhythm would reverberate through the body and, at a cultural level, find representation in the varieties of dance. Hence, certain types of music, such as the pulsing rhythms of rock and roll, may help simulate a sexual neural reverberation in the brain, promoting energetic forms of dance with strong pelvic movements. Other rhythms may promote the expression of other affects that can be expressed in dance, or simply felt. For instance, the "chills" discussed in the "Afterthought" of Chapter 14 may reflect a local sound-induced isolation-type change within the neural representation of the primal SELF. If various emotional and regulatory inputs modulate the SELF-schema in distinct ways (each with a characteristic neurodynamic and neurochemical signature), the internal result may be a large number of subjectively experienced feeling states.

Although one might fault this schema by noting its failure to specify the exact manner in which subjective experience emerges from neurodynamics, that shortcoming may reflect our human inability to verbally symbolize the operations of complex, intrinsically active neural systems in action. At such levels of ultracomplexity, where our human imagination does not reach, we have to rely on the power of predictions. For instance, from the preceding analyses, I would suggest that the emotional power of music may arise from auditory inputs from the inferior colliculi invading the underlying emotional circuits of the PAG. Also, if this hypothesis is essentially correct, extensive damage to the PAG should have disastrous effects on all forms of conscious activity, while more modest damage should dampen many affective tendencies.

Indeed, extensive PAG damage does produce a spectacular deterioration of all conscious activities, but to achieve that, the damage must extend along the whole length of the PAG. For instance, early studies in which lesioning electrodes were threaded from the fourth ventricle up the aqueduct to the caudal edge of the diencephalon yielded striking deficits in consciousness in cats and monkeys as operationalized by their failure to exhibit any apparent intentional behavior and their global lack of responsivity to emotional stimuli.[50] While forms of damage to many other higher areas of the brain can damage the "tools of consciousness," they typically do not impair the foundation of intentionality itself. PAG lesions do this with the smallest absolute destruction of brain tissue.[51] Moreover, lower intensities of electrical stimulation in this brain zone will arouse animals to a greater variety of coordinated emotional actions than stimulation at any other brain location. Accordingly, as a provisional hypothesis, I would suggest that the foundation of the most basic form of conscious activity, the generation of SELF-representation along with various basic affective states, arises from the intrinsic neurodynamics of the PAG, as well as the direct extensions of this tissue upward in the brain to intralaminar and midline thalamic areas, to widespread hypothalamic areas, and to various branches of the cerebral canopy.

Although it may seem unlikely that PAG tissue is sufficiently high along the neuroaxis to elaborate conscious awareness and intentionality, this doubt may be based more on our human pride in our extensive neocortical perceptual skills than on a critical evaluation of the empirical evidence and a consideration of what the foundation of consciousness must be like. Although high-level cognitive awareness is certainly not a local property of the PAG, such functions do emerge from the many higher brain areas that are especially closely linked to the PAG, including the frontal cortex.[52] As we have seen in so many of the preceding chapters, many affective processes seems to be intimately linked to networks that are interconnected with the PAG. To the best of our knowledge, this tissue is the most primal source of the anguished pain and suffering that suffuse consciousness during stressful circumstances. It is here that all forms of pain leave strong neuronal footprints, as indicated by *cfos* and Fos neuronal labeling. It is the PAG that allows creatures to first cry out in distress and pleasure.[53] It is largely here that pain arouses the unconditional state of fearfulness,[54] even though learning allows many other inputs, especially those from the amygdala and hippocampus, to also access the SELF.[55] All this is consistent with the postulate that our basic biological values, essential ingredients for a sense of self, are inextricably intertwined with the local properties of PAG tissue.

In sum, I doubt if we can explain secondary or higher contents of consciousness without first coming to terms with primitive SELF-representations and the ancient attentional work spaces with which they interact. Without the activities that transpire at the lower levels, the higher cerebral "observers" probably could not function efficiently, and if they could, they would probably suffer major deficits[56] as they stared into empty psychoaffective space. If all of the preceding is on the right track, we may eventually be able to measure the affective consciousness of animals in action by using modern electrophysiological and neurochemical techniques, especially when our probes are properly situated within the mesencephalic substrates of the SELF.[57] It is unfortunate that these brain areas are so inaccessible for analysis in humans, but neurochemical knowledge may eventually yield insights that can be evaluated using pharmacological probes.

The Neurochemistry of Consciousness

The primordial SELF is most probably organized around universally important, rapidly acting amino acid transmitter circuits such as glutamate. The closely related ARAS attentional networks, on the other hand, appear to have acetylcholine and norepinephrine at their core.[58] In addition, the SELF network may receive feedback concerning affective states via the many converging neuropeptide systems discussed throughout this book. Each separate emotional input may modify the reverberatory activity of the SELF in characteristic ways. Such changes in neural activity may ultimately be experienced as different emotional states of being. Obviously, the SELF mechanism also must have powerful outputs to control various higher brain activities as well as behaviors. The presence of nearby ascending serotonin, norepinephrine, and acetylcholine circuits provides such generalized neural substrates. Each of these systems has powerful and coherent effects on higher brain activities, yielding several ways in which all brain activity can be molded and controlled. For instance, cholinergic influences in the thalamus sustain processing in all sensory channels of the cortex and thereby control the flow of information that generates the perceptual contents of consciousness. Indeed, specific nuclei of the thalamus, the intralaminar nuclei and most especially the nucleus reticularis, may be critical for controlling the informational work space through which the specific contents of consciousness are created.[59] Although acetylcholine and GABA are key players in such thalamic functions, there are bound to be others. As we have seen in previous chapters, it is through specific neurochemical theories that most testable ideas concerning the nature of emotions, and thereby of primary-process affective consciousness, will be forged in the foreseeable future.

Although many neurochemical systems can modulate affective processes,[60] a key issue is whether disruptions of any single system will compromise all forms of affective consciousness without impairing general perceptual awareness. No such item is known at present, suggesting the two may be tightly linked. It seems certain that glutamate transmission is essential for both, for the simple reason that glutamate antagonists provoke such remarkable changes in the quality of consciousness. Drugs such as phencyclidine (PCP, street name "angel dust") dissociate sensory and motor processes to the point where cognitive coherence disintegrates.[61] Mild doses can cause panic attacks, while at high doses waking consciousness is so impaired that treated animals can undergo surgery without further anesthetic. Likewise, a study of the brain sites and mechanisms by which general anesthetics operate should provide key insights into the neurochemical nature of consciousness.[62]

Advances in clinical medicine have brought us many anesthetic agents that can completely compromise conscious activities. If we could identify the major brain circuits that such manipulations act upon, we would have the beginnings of a substantive neuroanatomy of consciousness. Unfortunately, critical sites in the brain remain to be identified, but judging by the evidence offered here concerning the nature of the SELF, I would predict that consciousness would be compromised most when such agents are placed into the PAG tissues of the midbrain and closely connected reticular areas of the diencephalon, perhaps all the way up to the front of the neural tube at the septal area.

Anesthetics have been used in novel ways to highlight the nature of consciousness in the human brain. In the study of epilepsy, neurologists have developed what is now called the *Wada test*, whereby short-acting barbiturate anesthetics are injected into one or the other carotid artery (see Figure 4.6), leading to a brief anesthetization of one whole cerebral mantle. Since much of the injection enters the anterior and lateral cerebral arteries, it is generally assumed that most of the effects are cortically as opposed to subcortically mediated. When one selectively "knocks out" the right cerebral hemisphere in this way, patients usually express little emotional concern about the matter, claiming everything is just fine; when the anesthetic wears off, they change their minds rapidly, making statements of their displeasure with the manipulation. This has led to the idea that each of the cerebral hemispheres can have distinct emotional feelings, which, if true, will tell us much about the higher nature of affective consciousness.[63]

In this vein, it is important to emphasize that scientists typically only respect theories that can be empirically evaluated, and those who are interested in the nature of consciousness should be willing to provide paradigmatic experiments that would highlight the workings of their theories. For me, the most telling experiments will be those that attempt to reveal the brain sites and neural mechanisms by which anesthetics operate and the study of the brain mechanisms that mediate affective experiences such as simple gustatory pleasures and aversion, as well as various forms of pain.[64] However, such primitive affective functions must link up with higher sensory-perceptual analyzers of the cortex.

Reflections of Emotions in the Higher Reaches of the Brain

Although the basic emotional "energies" arise from subcortical processes, the external details of emotional experiences are obviously encoded in the neural representations of time and space at higher cerebral levels. Usually, we do not just love, we love *someone.* We are not simply angry (a subcortical process), we are angry at something (a cortical process). We are not angry and in love for just a moment but for as long as our memories and relevant neurochemistries are aroused to sustain the neurodynamics of anger and love. Thus, affective and cognitive processes are inextricably intertwined in higher brain areas, such as the frontal and temporal cortices, which allows our brains to extend psychological events in time and space. Whether emotions in these higher brain systems also operate via the same neurochemical codes as in the lower reaches of the brain remains unknown. For instance, there are some corticotrophin releasing factor (CRF) cells in the cortex, as well as abundant CRF receptors, and it may well be that various stressful experiences are imbued with stressful affect in part by local cortical CRF dynamics.

Although emotions derive their rich cognitive resolution from interactions with higher brain functions, they can also be triggered at various levels of the neuroaxis by minimal stimuli as a function of conditioning—from the briefest glance to a nuance in someone's tone of voice. Once emotional systems are aroused, a variety of higher brain functions (from subtle appraisals to self-serving plans) are energized. Such cognition-emotion interactions constitute the details of people's lives, and we are more likely to recall specific events related to emotional episodes rather than reexperience the intensity of the aroused emotions themselves. The actual affective intensity that promoted the flow of action during emotional episodes seems to be easily forgotten. Only when the right "buttons" (i.e., the conditioned stimuli) are pushed again do the feelings return once more.

I will not dwell on cognitive details here, but it is important to consider how basic emotional systems might modify the higher cerebral processes that allow us to be the sophisticated, affectively cognitive creatures that we are. Indeed, it may well be that specific higher brain areas are specialized to help elaborate the cognitive contents of different types of affective processes (Figure 16.2). Thus, one general way to view many higher cortical functions is as providing ever more flexible ways for animals to deal with basic survival issues. One of the most important of these functions is the ability to utilize past experiences to inform future plans. The ability to extend action tendencies in time and space provides humans with remarkable advantages over animals that cannot gauge the passage of events as well.

It is generally accepted that the frontal lobes are capable of anticipating events and generating expectancies and foresights about the world. People with frontal lobe damage typically perseverate on old strategies and do not plan ahead effectively. They are susceptible to living within the present moment, in a more animal-like state of existence.[65] Because of rich cortical connections, the SEEKING system is especially strongly related to frontal cortical functions.[66] On the other hand, social-emotional sensitivities and feelings related to the PANIC system—namely, the affective dynamics of both positive and negative social interactions—appear to find a stronger focus of control within the cingulate cortex. For instance, the psychic tension that leads to panic disorders and agoraphobia is markedly diminished following cingulate cortex damage in humans, and changes in the arousability of this brain region have recently been implicated in the genesis of depression.[67] Neural computations that can activate FEAR, RAGE, and LUST appear to be especially well represented in the temporal lobes; indeed, the arousal of such emotions is based on perceptions that are processed in temporal cortical areas that have strong connections to specific regions of the amygdala.[68] People with damage to anterior temporal areas are often emotionally placid (the Klüver-Bucy syndrome); it is difficult to arouse such laid-back individuals to the point of irritability, anxiety, or lust. Indeed, it has recently been shown that people with amygdala lesions exhibit deficits in fearful memories, as has long been evident from animal brain research.[69]

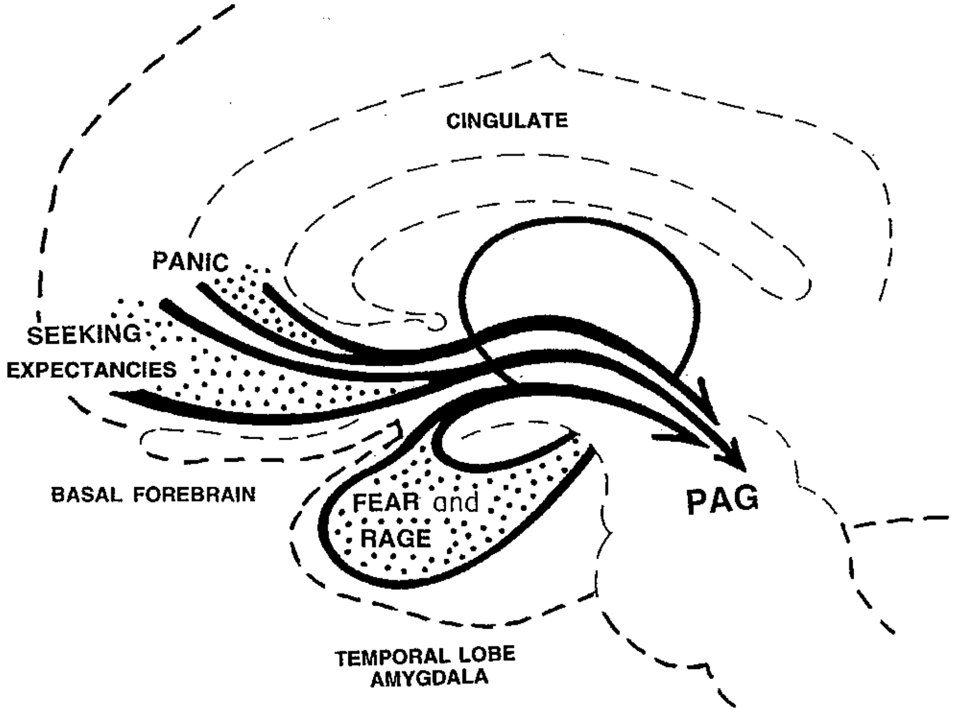

Figure 16.2. Overview of forebrain zones that are devoted to elaborating higher manifestations of basic emotional processes. Each of the emotional systems has higher spheres of influence, with FEAR and RAGE concentrated in the lateral and medial temporal lobes, SEEKING in the ventromedial frontal lobes, and various social emotional processes such as separation distress or PANIC in the anterior cingulate. All of these systems converge on the emotional and SELF representation zones of the midbrain. (Adapted from Panksepp, 1989; see n. 80.)

Although it is certain that the amygdala and nearby hippocampus are very important in processing cognitions and memories that can arouse various emotional responses, it is probably a mistake to believe that the affective entirety of such emotions as fear, anger, and sexuality is mediated locally just within medial temporal lobe structures. For instance, although it might be reasonable to expect that in males the sexually arousing effects of erotic images would be dramatically reduced by severing the pathways that transmit well-processed visual information from the occipital lobes into the temporal lobes, such brain damage should have much less of an effect on sexual arousal induced by touch, where the key connections are bound to be subcortical. Thus, even though it is likely that many conditional stimuli derive their emotional impact from local interactions within the amygdala, many other unconditional sensory inputs to the same functional systems may derive their affective impact by interacting with lower aspects of the emotional command systems (see Figures 10.1 and 16.1).

The main reason the amygdala may appear to be so important in generating affect may arise largely from the fact that most emotional episodes in adult animals are closely linked to learning and cognitive appraisals. These are the types of emotional stimuli that converge on the amygdala. Accordingly, the amygdala may gradually become a strong interface between higher information processing and emotional arousal as a function of development and various concrete life experiences,[70] but there is presently no clear evidence that the amygdala can generate emotional energy without the arousal of the lower functions situated in the hypothalamus, the PAG, and the rest of the periventricular gray. As we saw in Chapter 10, rage elicited from the amygdala is critically dependent on the integrity of the systems in the hypothalamus and the PAG (see Figure 10.4). Of course, it may well be that during ontogenetic development the higher functions assume such a prominent role in conscious life that the lower functions tend to become increasingly subconscious as organisms mature. Clearly, a great deal of work is needed before we will understand these processes with any assurance. Recent brain-imaging studies do suggest that only higher brain areas are aroused during emotional episodes, but, as indicated earlier, these techniques are quite likely to generate false-negatives as far as the lower brain stem areas are concerned. For simple anatomical reasons, such as the massive overlap of antagonistic circuits, the lower limbs and trunks of each emotional "tree" are less likely to "light up" than the more widely distributed branches.

One of the most intriguing findings is that positive emotional feelings are associated with EEG arousal of the frontal areas of the left hemisphere, while negative and depressive moods are associated with frontal arousal within the right hemisphere. These types of patterns also prevail in the resting EEGs of individuals with different temperaments—people who are depressed, or simply susceptible to depression, exhibit more right frontal arousal, while those who feel positive about life exhibit more left arousal.[71] These types of asymmetries are already evident in babies, with extroverted ones having more left arousal and inhibited ones having more right arousal.[72]

More recently, PET scanning studies have also provided glimmers of happiness and sadness in the brain; perhaps not surprisingly, sadness produces more arousal, while happiness produces neuronal relaxation.[73] This is not unexpected, since during sadness we have more cognitive problems to dwell on.[74] However, the laterality effects are not totally congruent with the electroencephalographic (EEG) data. Acute sadness leads to left frontal arousal, while depression has the opposite effect; only this latter effect is congruent with the EEG data, indicating left frontal underactivity in depression.

Considerable neuropsychological evidence indicates that characteristic emotional changes also result from damage to higher brain areas. In agreement with the aforementioned EEG data, the most robust finding is that damage to the left cerebral hemisphere (especially left frontal areas) appears to reduce positive affective tone, while similar damage to the right hemisphere does not.[75] Thus, following strokes to the right hemisphere, which is generally the sadder side of the brain, it is not uncommon for patients to deny that anything bad has happened; comparable damage to left cortical areas, the seemingly happier side, can promote feelings of catastrophic despair.[76]

Congruent effects during brain activation have been obtained with new techniques called rapid transcranial magnetic stimulation (rTMS). Preliminary results suggest that rTMS of the left frontal cortex can evoke feelings of sadness, while right stimulation enhances happiness. Of course, this is outwardly inconsistent with the aforementioned EEG data; however, the complexity of the underlying neural changes precludes definitive interpretation. It is certainly possible that the rTMS disrupts normal neural activity, causing a diminution of normal functions. In support of this possibility, the longer-term effect of right prefrontal stimulation was an increase in anxiety and worsening of mood in depressed individuals, while left stimulation provoked remarkable improvements in mood, even in medication-resistant individuals.[77]

It is generally believed that in addition to such positive and negative affective distinctions, the right hemisphere is more of a specialist for deep emotional communication as compared with the linguistically competent left hemisphere (see Appendix B), which is more focused on social niceties. While left hemisphere damage typically leads to deficits in understanding and expressing thoughts, right hemisphere damage disrupts one's ability to express and understand emotional inflections.[78] Although there are a great number of theories as to why the two hemispheres have different emotional specializations, as yet there is no clear evidence for any of them. One good idea is that the left hemisphere is more skillful in serial processing of information, as required for linear thinking such as math and language, while the right hemisphere provides more of an affective background for various experiences. Another intriguing possibility is that the left hemisphere specializes in the communication of socially constructed emotions, while the right hemisphere is more closely attuned to primal-process emotionality.[79]

Although a great deal of work has been devoted to differentiating how right and left hemispheres participate in various emotional functions, the idea that different cortical regions modulate specific emotions deserves greater attention in the future. It presently seems reasonable to suppose that in a mature organism the two hemispheres have different emotional strengths. However, it may be that these differences arise largely from learning, rather than from any deep and intrinsic differences in emotional competence.[80] For instance, the left hemisphere may appear more happy only as a secondary consequence of its linguistic functions, which are at least partly designed to reinforce the appearance of a positive "social front." This may leave the right hemisphere to dwell on the emotional realities that emerge from subcortical dynamics.

In addition, it also remains possible that various areas of the neocortex can be devoted to different emotions in relatively idiosyncratic ways, just as core memory space is devoted to software files in modern computers. Thus, there may be a great deal of variability in the higher representations of emotions among different individuals. In this context, it should again be emphasized that the new brain-scanning technologies are not as well suited for picking up distinct brain stem functions as they are for detecting differences in higher brain areas. In addition to concerns voiced earlier, most mood-induction procedures used for generating feelings in brain-imaging studies tend to employ mental imagery of one kind or another, which would automatically lead to better differentiation of higher rather than lower brain processes. To the best of our knowledge, the higher areas of the brain would remain emotionally cold without the psychological energies that emerge from the subcortical circuits described in this book. In other words, a distinction between higher cognitive/rational processes and the more primitive affective/passionate processes is essential if we are going to make sense of how the brain generates affective experiences and spontaneous emotional behaviors. Such a distinction is further affirmed by the ability of higher forms of brain damage in humans to impair voluntary facial expressions of emotions, while the more spontaneous emotionally driven expressions remain intact.[81]

How Does a Cognition Provoke Feelings?

Perhaps the most obvious experience of emotions that we humans have is that environmental events cause our feelings. As we have now seen, this is largely an illusion: Such events only activate intrinsic affective potentials of the nervous system. However, now that I have completed this provisional analysis of the deep nature of affective experience in the brain, we are in a better position to address the question: What does it mean, in brain terms, to experience the illusion that appraisals cause emotions?

I would suggest that this question boils down to how cognitive representations of the world get enmeshed within the extended neurodynamic process that we call affective states. If affective mood states are ultimately constituted of distinct reverberatory neural patterns within the extended SELF-representation networks of the brain, it is possible that each type of mood can be set in motion by a variety of inputs into the system. When the primitive emotional command circuits arouse the whole extended neural network, we have full-blown emotional states. On the other hand, when cognitive inputs, both conditioned and unconditioned attributions, initiate weaker types of reverberation in the system, we have mood states. Thus, because of our past experiences and history of conditioning, cognitions can come to reevoke strong feelings.

However, once a weak type of reverberation has been established, it can proceed along several paths. It has the potential to become a full-blown emotion if the reverberation recruits full arousal of the primitive emotional command systems. This is probably the path of least resistance in the brain, because of our many mood-congruent memory processes that can add fuel to each emotional fire. However, the reverberation also has the potential to fade rapidly, if one can divert cognitive resources to other points of view. This, I believe, is the main aim of various forms of self-discipline, including assisted ones such as cognitive behavior therapy. Thus, in adult humans, cognitive processes have the option of becoming enmeshed, ever further, within ongoing emotional dynamics, or they can extract themselves from any oncoming neural maelstrom. Emotional self-regulation is presumably made possible through our higher cerebral endowments. Our symbol systems are especially effective in allowing us to negotiate such rough terrain. Language allows us to regulate our emotions.

Conflicts between Cognitions and Emotions

If emotions and cognitions—or passion and reason, as they used to be called—are differentially, albeit interactively, organized in the brain, there are bound to be conflicts between the influences of the two systems. The dictates of emotional systems are bound to be more egocentric and unconditionally affective than those of cognitive systems, even though, as emphasized recently by proponents of evolutionary psychology, the goal of cognitive processes is to provide more subtle solutions to problems posed by states of emotional arousal.[82] Indeed, the evolution of certain higher symbolic abilities in hominids may have provided ways for organisms to solve conflicts that are simply too difficult from a simpleminded emotional perspective. For instance, explicit spoken or written contracts between humans help minimize disputes that would easily emerge if one merely followed the dictates of one's immediate wants and desires.

The ability for symbol systems to mediate conflict resolution has even been observed in chimpanzees. When confronted by a seemingly simple pointing task, where their desires are put in conflict with outcomes, chimps find it impossible to exhibit subtle self-serving cognitive strategies in the immediate presence of a desired reward. However, such tasks are mastered when an alternative symbol system is employed. Let me clarify: In one study, animals were confronted by a simple choice; two plates holding tasty food items were presented, each with a different number of treats. If the animal pointed to the plate having more treats, it would immediately be given to a fellow chimp in an adjacent cage, and the flustered subject would receive the smaller amount. After hundreds and hundreds of trials, these chimps could not learn to withhold pointing to the larger reward, even though it always resulted in the same undesired consequence of receiving the smaller of the desired alternatives. Although this outcome was commonly accompanied by howling and complaining, the task was simply too difficult for them to solve. However, these same chimps had already been taught the symbolic concept of simple numbers; when those numbers were placed on the plates as a substitute for the actual rewards, the chimps promptly learned to point to the smaller numbers first, thereby commandeering the larger rewards for themselves.[83]

In other words, in the immediate presence of a treat, chimps could not withhold their apparent self-referential desire for the bigger reward, but once a more affectively neutral numerical symbol system was introduced, they restrained themselves to achieve successfully selfish ends. The extent to which our various symbol systems, ranging from paper money to contracts, allow us to capitalize on our own selfish desires appears to be an unstudied dimension of human motivation. Obviously, money is equivalent to having the ability to make more choices in the world, and it is remarkable that even among chimpanzees a numerical symbol system was a more effective tool for acquisitiveness than the immediacy of their own wants when actually confronted by available rewards. Seemingly, the acquisition of numerical symbols expanded the options available for the chimp's higher levels of consciousness. Such work should make us suspect that human reason may still be inextricably intertwined with our self-centered animal needs.

If one is willing to dichotomize between cognitive functions and emotional functions—between reason and the passions (as many are no longer inclined to do in the present intellectual climate)[84]—then one can ask whether the downward cognitive controls or the upward emotional controls are stronger. If one looks at the question anatomically and neurochemically, the evidence seems overwhelming. The upward controls are more abundant and electrophysiologically more insistent; hence, one might expect that they would prevail if push came to shove. Of course, with the increasing influence of cortical functions as humans develop, along with the pressures for social conformity, the influences of the cognitive forces increase steadily during maturation. We can eventually experience emotions without sharing them with others. We can also easily put on false faces, which can make the facial analysis of emotions in real-life situations a remarkably troublesome business.[85]

Although we can employ our emotions with gradients of subtlety that other creatures simply cannot match, even using them for aesthetic or manipulative purposes, we would probably feel very little without the ancient subcortical source processes. And when those ancient sources become truly aroused, our cognitive apparatus shifts into fairly narrow grooves of obsessive ideation.[86]

In Sum

Although I have tried to clarify the neural foundations of affective experience in mammals, the actual manifestations of the neural circuits within living brains are so complex that many centuries of work will be needed to reveal how emotional systems really operate. In pursuing such matters empirically, we may find that there is a great deal more variability, plasticity, and flexibility in the underlying systems than I have suggested here. Many molecular underpinnings for neuronal plasticity have already been revealed (see Chapter 6), but no growth factor or gene has yet been identified that is specific to the growth and development of emotional systems. I suspect such molecules will be discovered, which may eventually open up a totally new area of psychiatric medicine.

Since we finally do have some precise knowledge concerning the neural substrates of a few emotional systems, we can begin to ask how these circuits change both structurally and functionally in response to various environmental events.[87] Ongoing work on electrical and psychostimulant sensitization (see "Afterthoughts," Chapters 5, 6, and 8) has already confirmed what William James surmised a long time ago when he wrote: "We are spinning our own fates, good or evil, and never to be undone. . . . The drunken Rip Van Winkle, in Jefferson's play, excuses himself for every fresh dereliction by saying, 'I won't count this time!' Well! he may not count it, and a kind Heaven may not count it; but it is being counted none the less. Down among his nerve cells and fibres the molecules are counting it, registering and storing it up to be used against him when the next temptation comes."[88]

We are spinning our own fates not only in our personal lives but also in our body politic. Until now, I have only alluded to the implications of this type of biological knowledge for cultural issues. A psychobiology text is not the most fitting place for such intellectual exercises, but I will take this final opportunity to share a few thoughts on the potential societal ramifications of emotional matters. I would emphasize, in closing, the obvious fact that our lives are outwardly swayed more by cultural issues than by biological ones. But even as we reside within the complexities of cultural structures and processes, our internal feelings will always be guided by powerful psychobiological tethers—our deep affective reactions to events in the world. Although such biological constraints on the human spirit have been denied by generations of scholars who prefer to think in terms of personal life histories rather than evolutionary terms, the evidence that such tethers exist is definitive. But the societal implications are not.

AFTERTHOUGHT: The Role of Brain Emotional Systems in the Construction of Social Systems

What consequences might a deeper understanding of emotions have on modes of thought in the humanities and social sciences? Can new information from psychobiology clarify issues in fields as distant as social, economic, and political thought? Hopefully they can. Although we remain remote from understanding the many interactions among brain circuits that govern the real-life flow of psychological responses in either animals or humans, our provisional knowledge allows us to explore some new lines of thought, hopefully without falling into the pit of *naturalistic fallacies*.[89] In this final "Afterthought," I will briefly probe the possible implications of the emerging psychobiological knowledge for the construction of social systems.[90]

To understand how affective processes are related to cultural institutions, we need to discuss how each emotional system of the brain might be related to existing social structures. This is a daunting task. Although we have many emotional systems in common with other mammals because of the long evolutionary journey we have shared, our cultural self-conceptions are not governed or constrained by our animal past. Nonetheless, they may be substantively clarified through the inclusion of affective dimensions in our discussions. For instance, the failure to fully recognize certain internal "forces" in human children may have already led to some very unusual societal practices in the United States.

Consider one troublesome example from our present educational practices—the widespread pathologization of rough-and-tumble play in the American school system. The widespread medical treatment of attention deficit, hyperactivity disorders, or hyperkinesis, as it used to be called, does not reflect an increased incidence of a neurological disorder in American children but an increased intolerance for childhood impulsivity. The use of drugs to control such symptoms in American schoolchildren has risen dramatically in the past few decades, to the point where many believe it has become a national scandal. The neuroscience data clearly indicate that psychostimulants such as methylphenidate and amphetamine can increase synaptic levels of catecholamines in the brain, and it is understandable why facilitation of noradrenergic tone in the cortex would increase attention spans in the classroom. The normal neurobiological function of this chemical system is to facilitate attentional processes, and the maturation of such systems during childhood is slow. This is one of the reasons young children are so impulsive and playful.

Obviously, these systems will mature more gradually in some children than in others, and psychostimulants certainly can increase attention span miraculously in children whose neurochemical development is slow. However, such drugs have many other effects on the brain. For instance, they markedly decrease playfulness—an effect that is well documented in animal studies (see Chapter 15). Are excessively playful children now being medicated to reduce their natural desire to play, on the pretext that they have some type of impulse-control disorder? This seems to be the case for at least some of the children who are being medicated. If so, it is unconscionable to give them antiplay drugs such as methylphenidate instead of providing substantial opportunities for rough-and-tumble play at the appropriate times of day, such as early in the morning when such urges are especially high. Even more frightening is the fact that the nervous system becomes sensitized to psychostimulants, and animal research indicates that such modifications of the nervous system can be permanent.[91] Are we now permanently altering the nervous systems of children with psychostimulant medications? Might we not actually be retarding the natural growth of the brain by reducing the normal influence of playful behaviors on central nervous system development?[92]

I believe that such effects are, in fact, occurring as a result of our present social policies, but the growing ethical debate on such matters is not yet being premised on our knowledge of the brain. The other basic emotional systems have equally important implications for our social practices, but they are also not being addressed because, as a society, we have yet to come to terms with the evolutionary epistemology of the nervous system.

As we have seen, the subcortical areas of the brain contain a large number of emotional systems that govern our moods and values. However, our cortical abilities have played a greater role in constructing social institutions than have our limbic circuits. The uniquely human neocortex, which allows our brains to elaborate complex ideas about the world, such as humanistic, scientific, and economic concepts, has evolved largely from sensory and attentional systems that harvest information from our external senses rather than from those that generate our internal feelings. Considering the likelihood that the evolution of human neocortical/cognitive processes was only partly constrained by the dictates of ancient limbic circuits, let me briefly explore the general impact on social institutions of our emerging understanding of subcortical emotional systems.

The human brain, like all other mammalian brains, has circuits that are designed to seek out positive rewards in the environment; this innate tendency can promote excessive materialism and greed (see Chapter 8). The brain also has systems that can induce anger toward perceived offenders to our liberties and freedom, which can lead to deep animosities among groups forced to compete for common resources (see Chapter 10). The brain mediates fear to detect those agents of change that threaten our safety and comfort; this can lead to xenophobia and the stigmatization of groups that do not appear to share our interests (see Chapter 11). We have brain systems that aspire for social pride and dominance, leading to the types of power politics that have been the hallmark of human history down through the ages.

Our mammalian brain also has systems that mediate social and sexual bonds, including parental nurturance (see Chapter 13) and the despair of being isolated from our fellows (see Chapter 14). As humans with sophisticated social sensitivities, we can also be overwhelmed with grief, shame, and embarrassment when we feel we have offended the strictures of our social contracts. Social systems that fail to recognize the importance and natural dynamics of these intrinsic urges are bound to make graver mistakes than those that do. The brain also elaborates hungers (see Chapter 9) and passions (see Chapter 12), and social systems that do not aspire to distribute necessary resources relatively evenly must tolerate increasing social chaos. The brain also contains circuits for social play and dominance (see Chapter 15), and no successful social system has stifled the dictates of those circuits. Emotional systems add immeasurably to the variety, chaos, meaning, and value of our lives. Without them, the cortex would have little to talk about and little to be excited about. Indeed, some deem it a moral imperative to live a passionate life. But our passions have no unambiguous power to dictate outcomes within complex social systems. Our feelings only encourage us to consider the options that are available to us.

There have already been too many political structures in human history that have promoted fear and aggression, but it should be possible to develop distinct social systems based on each of the emotions. If such social engineering is possible, the next question might be: At our present stage of cultural evolution, should a single system have priority in our deliberations about the future? Does one system have the intrinsic "right" or "worth" or "power" to predominate over the others? Many of us might agree that the social-emotional systems that allow us to be caring and giving, that promote deep sympathies for each other, have intrinsic worth, although they do not seem to have intrinsic power. Perhaps they could gradually recruit the necessary power by being more widely and realistically recognized within our cultural matrix, but there is no assurance that such values could prevail within the intrinsic emotional tendencies of the neurobiological mind. The urges for power and greed are probably as insistent in the brain circuits of the human species as the urges for nurturance.[93] But since we can now conceptualize the roles of the basic emotional systems more clearly, we are left with more choices.

It would be most interesting to imagine what form our society could eventually take if it chose to foster the feminine forces of nurturance and incentive-based altruism as opposed to materialism and male dominance. But how shall we construct stable and balanced economies that are not fueled by the self-serving forces of greed and materialism? Most prefer a bigger and bigger piece of the pie. How do we learn to divide the bounty of mother earth more equitably around the world so all her children can be reasonably satisfied? Perhaps a legislated cap on individual greed would be a move in the right direction, but to do so effectively, we may need to allow new and creative expressions for our dominance urges. As already exists in sports, we may have to widen compensatory doors for self-expression in the arts, humanities, and social services. These are psychobiological options that mammalian brain evolution offers for our consideration.

Although a full understanding of emotional systems may provide better alternatives for conceptualizing and creating new and better social institutions, our ancient emotional circuits cannot dictate the future. The neocortex, with its cognitive riches, shall remain the uneasy and pretentious master of the external realm, while emotions will remain the masters of our inner lives. Still, it is reasonable to suppose that new social systems will prosper only to the extent that they harmonize with the positive emotions of the greatest number, and will flounder to the extent that they do not. Social systems will flourish if they minimize the impact of negative emotions on the members of a society, and they will fail to the extent that they do not. However, within these constraints, there are all too many options to consider, including, as always, the dream of reason that creates monsters.[94]

This may be the most important overall message to take away from our consideration of the many emotional systems that exist within our human brain. These ancient neural systems, which constitute the foundations of our deeply felt personal values and standards of conduct, only give us options to consider in our social worlds. The relative importance we give to various emotional factors in each social equation will be determined as much by historical and ecological forces as by neurobiological ones. Environments where one must battle for resources will promote different social solutions than environments where circumstances are more generous and forgiving. This, of course, makes the study of cross-cultural differences in emotionality a remarkably difficult area of inquiry. Even though the different branches of the human family may have slightly different patterns of emotional responsivity, for both genetic and cultural reasons, it is now clear that we also share the same fundamental feelings. The same goes for the various genders.

What should scare us most is the 20th century recognition of the layers of deviousness that evolution may have bred within our intermediate cognitive systems (those areas of the higher limbic brain that intrinsically interface between primitive emotional systems and higher cognitive realms). Understanding human nature is surely not as simple as understanding the nature of the subcortical emotional systems we share with other mammals, even if they are the ancient centers of gravity for our affective value systems. On top of these systems we also have strong intrinsic potentials for Machiavellian deceit. The brain of "the lizard" still broadcasts its selfish messages widely throughout our brains. We have layers of human nature that sociobiologists and evolutionary psychologists are only beginning to decipher with the conceptual tools of inclusive fitness and game theories.

If we take their evolutionary stories to heart,[95] we can begin to grasp the nature of the psychopathic and sociopathic personalities that can sprout from the varieties of human SELVES. At some point in human evolution, it was probably adaptive for a certain number of individuals in each human society to have warrior temperaments—individuals who were highly pugnacious and relatively insensitive to the pain of others. If such adaptations thrived during human evolution, these traits probably remain with us, all too well prepared by our evolutionary heritage to wreak havoc and violence in social life, even during times of peace.[96] To some extent such urges may be rechanneled into sports and other forms of competition, or perhaps even modified by new social and pharmacological strategies.[97] However, if we see the cortex as a neuronal playground where multiple, evolutionarily adaptive strategies, some of them quite unseemly, can be played out, we have only modest reason for optimism and solace. It is sad to note that our sense of sympathy may be intrinsically weaker than our sense of retribution.

There are reasons to believe that cold reason, unfettered by the impulses of social emotions, can yield personalities that are egotistic, selfish, and willing to hurt others for their own gratification (as long as the perceived costs to themselves are not too high). There is no intrinsic reason that such personalities could not present themselves as highly extroverted and sensitive while seeking to skillfully take advantage of others in social and economic encounters. The existence of the social emotions within the human brain provides no shield against the existence and future evolution of cutthroat, self-serving individuals who have no desire to advance cooperative altruistic behavioral tendencies in human societies. It is troubling to contemplate that such individuals may be especially highly motivated to aspire to positions of political and economic power. The massive growth of the human neocortex now provides options such as these for the human spirit.

To grow fruitfully into the future, society must learn how to recognize and benignly discourage and shun those who have no wish or ability to practice and promote stable and honest cooperative strategies. It remains possible that some individuals pursue such avenues of life because of atypical responsivities of their basic emotional systems, while others pursue asocial life activities because of more personal choices. We may eventually be able to detect such personality traits at an early age, using sophisticated brain measurement procedures, a troublesome possibility that is almost at our doorstep.[98] It is hard to imagine how we might seek to measure and modify such emotional strengths and weaknesses of individuals without infringing on basic human rights and liberties.

It is a blessing that a modest sense of fair play has already been built into the value structures of our human brains. As game-theory analysis has affirmed, the most effective trading strategy is fairness: to punish your trading partners only if they have cheated, but then to forgive rapidly. This "tit-for-tat" strategy is also ingrained in our best social traditions such as "honesty is the best policy." Unfortunately, this strategy appears to be most effective in small groups where everyone knows each other and where shame can still motivate behaviors. In our anonymous megasocieties, the ancient stricture—*do unto others as you would have them do unto you*—may be gradually losing force. Wherever long-term social relationships are not stable, our commitments to traditional social contracts appear to weaken.[99] Since we are now so remote from the original evolutionarily adaptive environments where our brains were constructed, our best option may be to understand as honestly as possible the varieties of nature that can be nurtured within human minds.

Perhaps early emotional education could counter our potential for evil, but to do so, our school systems may need to cultivate new perspectives that explicitly recognize the nature and importance of *all* the basic emotions of our lives.[100] We should be willing to clearly and unambiguously teach future generations about the true nature of the affective forces that reside with-in the ancient structures of our brains. Public forums such as television, movies, and popular music can be increasingly coaxed and molded to uplift our spirits rather than to provide more and more shallow limbic and reptilian entertainment. We must learn to emotionally educate the whole brain. To do that well, we must come to terms with the biological sources of the human spirit.

Joy and woe are woven fine,
A clothing for the soul divine;
Under every grief and pine
Runs a joy with silken twine.
It is right it should be so;
Man was made for joy and woe;
And, when this we rightly know,
Safely through the world we go.

William Blake,
"Auguries of Innocence" (1863)

Suggested Readings

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