WOMEN: A MORE BALANCED BRAIN?

by Paul D. MacLean

Abstract. On the basis of knowledge prior to 1988, Ashbrook pointed out that whereas most men are primarily dependent on the left cerebral hemisphere ("dominant hemisphere") for verbally related functions, women show a greater hemispheric balance in this respect. For men, he argues, their possession of a "speaking" and a "non-speaking hemisphere" results in a positive-negative, bipolar way of thinking that may be characterized as dualistic and dialectically hierarchical. In contrast, the greater balance of hemispheric function in women appears to promote greater generalization and synthesis in their thinking.

In this article I cite more recent neuroanatomical and brain imaging studies that provide further evidence of disparities in structure and function of the brains of men and women. As background for an attempt to explain these differences, I give a brief review of the triune evolution of the mammalian brain leading up to the human cerebrum. It is of major significance that the female has played a central role in mammalian evolution for more than 180 million years and that the evolutionary transition from reptilian therapsids to mammals is characterized by the development of (1) nursing, conjoined with maternal care; (2) audiovocal communication for aiding mother-offspring contact; and (3) play. In human beings, the infant-carrying hypothesis suggests one means by which, over generations, certain parts of a woman's right hemisphere could undergo functional and eventual anatomical expansion. The mother-infant communication of basic mammalian sounds with vowel and consonant components suggests a basis for the origination of speech.

Finally, in an expansion of Ashbrook's original thesis, we arrive at the provocative consideration that, unlike men, with their dialectical reasoning, women, with their more balanced brain, are provided with a *trialectial* ladder for climbing to achieve knowledge. In terms of quantum mechanics, the particle and wave would correspond to the substance and strength of the sides of the ladder, and the derived psychic information (which is neither matter nor energy) would compare to the rungs in between.

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In his book *The Brain and Belief*, James Ashbrook (1988) specifies two main questions of central interest. The first is concerned with "differences in the beliefs people hold" and the second is "differences in men and women." It is because of what he discusses in regard to differences in men and women that I have chosen to deal with the question, Do women have a more balanced brain than men? In doing so, I will draw upon findings of continuing research that provide both anatomical and functional evidence that the minds of women sail in a vessel less tilted to the left than do those of men. I will consider the findings in light of the recognition that for more than 180 million years, the female has played the central role in mammalian evolution.

Pointing out that in 1861 the French physician Paul Broca (1861) provided the first scientific evidence that the capacity for speech is represented in the left hemisphere (see figure 1), Ashbrook (1988) proceeds to cite a number of "dialectic," cultural consequences. First of all, the "talking hemisphere" became known as the "major" or "dominant" hemisphere, whereas the silent right hemisphere was looked upon as "minor" or "nondominant" and "thereby of lesser value." Referring to Anne Harrington's book *Medicine, Mind, and the Double Brain* (1987), he notes how she contends that "brain science, instead of being objective, has reflected 'individual, cultural, and philosophical prejudices.' At their worst, she ties those biases to 'an ideology of white male supremacy'"(1988, 85). Having already reviewed evidence suggesting that men are more left brained than women, Ashbrook concludes that male scientists were inclined to the view that "their half of humanity was the norm against which all deviants (including women) might be measured" (1988, 85).

As will be discussed below, women may have been more instrumental than men in the development of language (MacLean 1990 [hereafter cited as TBE], 544–45). I should also point out here that clinical observations have demonstrated that the dominant hemisphere accounts for movements on the right side of the body, including the favored use of the right hand (e.g., Broca 1865; Jackson 1874). An accumulation of reports indicate that about 95 percent of the population is right-handed (TBE, 541). Although cultural practices have favored the use of the right hand, there is evidence that handedness itself has a genetic basis.

With respect to male-female differences, it has long been recognized that on the average the hemispheres of men are larger than those of women, a finding usually attributed to inequality of body size. But here again other factors come into play (see Witelson 1991, 135). In 1880,

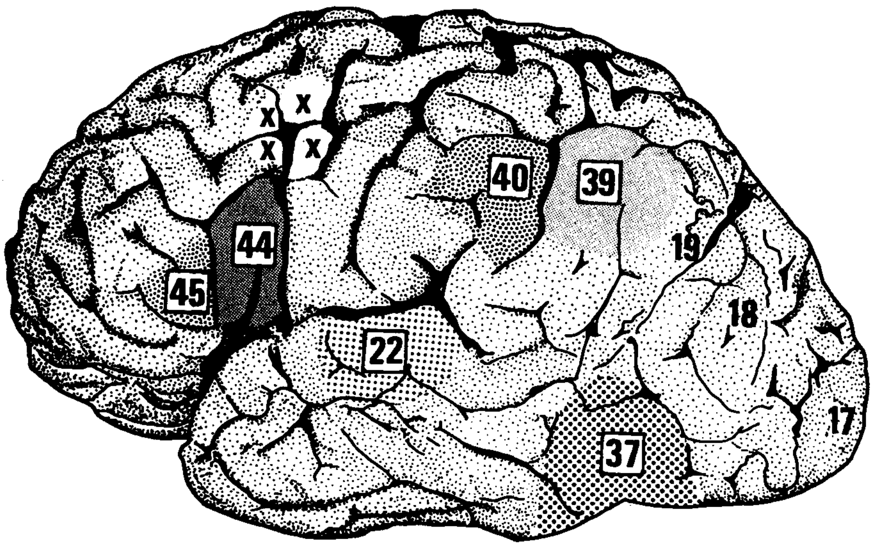

Fig. 1. Side view of left hemisphere of human brain, with cortical areas involved in linguistic functions identified by numbered shaded areas. (Numbering adheres to Brodmann's scheme for labeling distinctive types of cortex [1908]). Areas 45 and 44 overlap part of the inferior frontal gyrus known as "Broca's convolution"after the physician who first demonstrated that damage to this region resulted in disruption of "expressive speech" (see text). Lesions in region above it (marked with X's) interfere with writing. Area 22, including *planum temporale* (see text), is regarded as "auditory association" cortex because lesions affect comprehension of spoken words. Damage to area 39 (angular gyrus) in inferior parietal area results in loss of ability to reed (note its proximity to the visual cortex of the occipital lobe (areas 17, 18, 19]). Area 37 is involved in verbal, visual-auditory associations. With lesions of area 40 (marginal gyrus) involving the cortex and underlying association bundles, a person may be incapable of any verbal grasp.
Source: redrawn after figure 335 in Crosby, Humphrey, and Lauer, 1962, 515.

James Crichton-Browne pointed out that "it would appear that the tendency to symmetry in the two halves of the cerebrum is stronger in women than in men" (cited by McGlone 1980, 250). Such a symmetry is beautifully demonstrated by James W. Papez (1927) in a special article on the brain of Helen H. Gardener from the Burt G. Wilder brain collection at Cornell. On the basis of a comparative study of her brain and those of twenty male and twenty female brains from the same collection (and making allowance for an estimated 6–9 percent male:

female difference in brain size), Papez concluded that the surface area of the precuneus located on the medial wall is about 13 percent greater in the left hemisphere of men than in women. Except for a number of such isolated observations, little attention appears to have been focused on demonstrating male:female differences in the size and configuration of the brain, to say nothing of functional differences.

CLINICAL FINDINGS SINCE THE 1960S

It was at the National Institutes of Health in the early 1960s that I first recall hearing an interest expressed in differences between men and women in hemispheric function. This was after Herbert Lansdell, a psychologist at the National Institutes of Health (NIH), published a paper in *Nature* entitled "A Sex Difference in the Effect of Temporal Lobe Neurosurgery on Design Preference" (1962). Granted that the number of cases was insufficient for statistical analysis, the report seemed to serve as a general alert to investigators to be on the lookout for male:female differences in hemispheric functions.

Although there have been several psychological studies showing certain differences in aptitudes of women and men, I cite only those that have been shown by one technique or another to be hemisphere related. Then after a brief neurobehavioral review of the evolution of the forebrain, I consider the possible significance of the findings from the standpoint of the special role of the female in the evolution of mammals and their distinctive family way of life.

Two Canadian workers, Sandra Witelson and Jeannette McGlone, have been active since the 1970s in research on the differences between women and men in brain function and have written reviews of work in this field up to the early 1990s (e.g. McGlone 1980; Witelson 1991). Since in this account I discuss only male:female anatomical and functional differences in certain hemispheric cortical areas, I call attention to their reviews as a place to learn more about the well-known anatomical differences of certain structures of the hypothalamus in men and women and their respective significance in regard to sexual and psychological functions. Although genetic and hormonal actions must be considered factors inducing male-female differences in cortical development, there is no evidence of lopsidedness of the hypothalamic structures in question.

In an extension of Lansdell's study of 1962, Lansdell and Urbach (1965) reported that following left temporal lobectomy, men were relatively impaired in verbal as opposed to nonverbal skills. The reverse of this condition resulted from right temporal lobectomy. Female patients, however, showed no imbalance in these respects. In a study confined to right-handed patients with strokes or tumors involving either the left or right hemisphere, McGlone (1980) found the same kind of differences of verbal/nonverbal performance in men and in women. In her words, such studies "support the hypothesis of greater hemispheric specialization in males than in females." A brain-imaging study (Azari et al. 1995) combining magnetic resonance imaging (MRI) with positron emission tomography (PET) utilizing glucose metabolism for the display of cerebral blood flow has proved compatible with such a hypothesis: Whereas women showed stronger crisscrossed function between hemispheres, men had stronger back-and-forth activity within the dominant hemisphere.

Aphasia is a clinical condition resulting from damage to certain cerebral regions that affects the expression or comprehension of speech. Derived from the Greek word meaning "without the ability to speak," the term may also refer to the inability to write or comprehend written language. Regardless of handedness, women have been observed to be less subject to derangement of function than men upon damage to either hemisphere. Men, on the contrary, because of the unilateral representation of handedness and speech in the dominant left hemisphere, are more severely affected than women when that hemisphere is damaged in the critical areas. Here again, a brain-imaging study employing echoplanar functional magnetic resonance (Shaywitz et al. 1995) revealed changes compatible with the clinical findings: During phonological tasks, brain activation in men was found to be lateralized in the left inferior frontal gyrus (see figure 1, areas 45 and 44), while in women, activation was observed in both the left and right inferior frontal gyri.

Witelson (1991) has pointed out that gross anatomical differences in the cortex of women and men are most apparent in the temperoparietal region. One such area that has attracted attention is the superior plane of the superior temporal gyrus (the so-called *planum temporale* [PT])—a part of area 22 that lies largely hidden in the Sylvian fissure caudal to the primary receptive auditory area (Heschl's gyrus) (see area 22, figure 1). It is shown in textbooks as forming part of Wernicke's area and is believed to be involved in verbal associations linked to hearing. In 1968, Norman Geschwind and Walter Levitsky reported that in their study of 100 "normal" brains, including those of both men and women, the planum was significantly larger in the left hemisphere. Their study did not take sexual differences into consideration. Subsequently, J. A. Wada et al. (1975) examined "speech zones" in 100 adult and 50 infant brains. In the adult brains, they noted that PT in women was more likely to be larger in the right hemisphere. Jennifer Kulynych et al. (1994) have applied their new MRI method for three-dimensional surface rendering of brains to measure the area of PT in normal subjects. Unlike in a number of previous studies, they used a protocol that is highly reliable for the assessment of handedness. Their subjects were twelve normal women and twelve normal men matched for age (between twenty and thirty-five years) and selected for "strong right handedness." The thrust of their findings was that for the twelve men, the area of PT was significantly greater in the left hemisphere of ten, symmetrical in one, and greater on the right side in one. For the twelve women, in contrast, the area of PT was greater in the right hemisphere in six, greater on the left in five, and symmetrical in one.

Comment. The foregoing illustrations provide combined anatomical and functional evidence in support of the introductory argument that there is a greater balance in the structure and function of the two hemispheres in women than in men. But what do these differences mean? And why and how have they evolved? In order to tackle these questions and to introduce some new brain imaging and other material, we must outline the evolutionary development of mammals. I show the central role of the female in mammalian evolution and suggest that perhaps women were more instrumental than men in the evolution of handedness and speech.

OUTLINE OF THE EVOLUTION OF THE FOREBRAIN

At this point I give a brief outline of the evolution of the forebrain of mammals. In all three classes of terrestrial vertebrates (i.e., reptiles, birds, and mammals) the forebrain consists of the entire cerebral hemispheres above the level of the midbrain. Since in all three classes the forebrain accounts for all psychologically directed behavior (TBE, 19–23), I refer to it informally as the *psychencephalon* (1982). The fossil record and comparative neurological findings indicate that in its evolution, the forebrain of human beings and other advanced mammals retains anatomical and chemical characteristics that reflect a relationship to reptiles, early mammals, and late mammals (see fig. 2). In computer language, this triune assembly would amount to an interconnection of three biological computers, each with its special programs.

For comparative neurobehavioral investigations it is essential to be as familiar as possible with the behavioral program of the type of animal under study (TBE, 93–123). Since all three classes of land vertebrates are derived from reptilian stock, it is not surprising that they share more than twenty-five forms of behavior that are basic to all. All such behavior falls into two main categories. In one category are all the forms of behavior that comprise the daily master routine as well as ad hoc subroutines. In the other category are four main displays used in social communication and identified in lizards as signature displays, greeting displays, aggressive displays, and courtship displays. All of the basic forms of behavior involved in the various routines and displays may be charac-

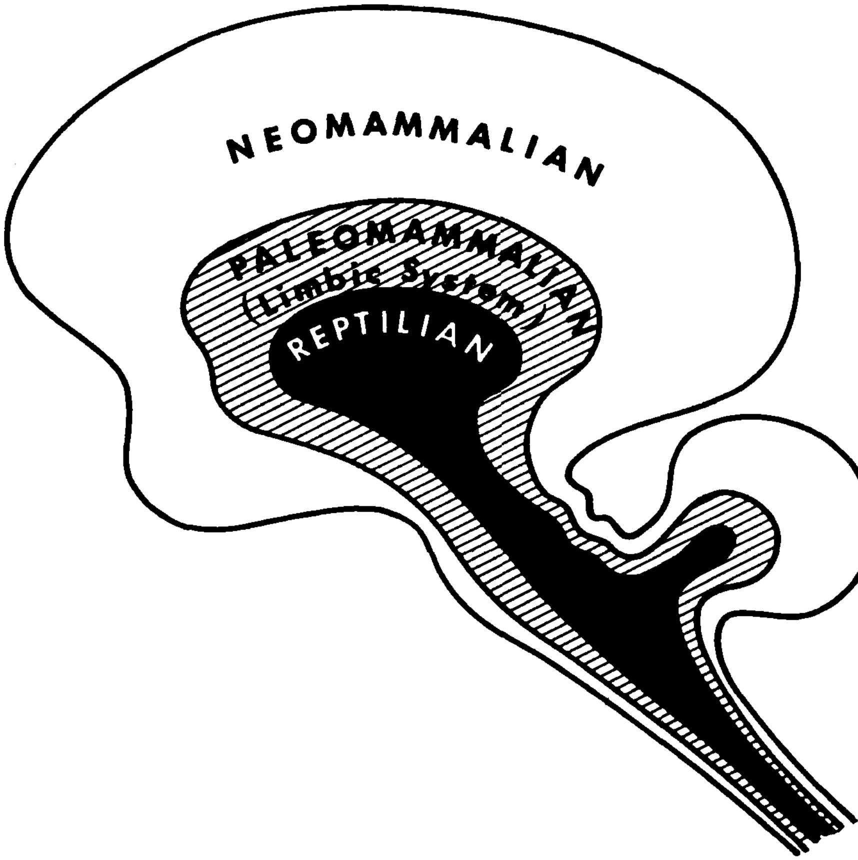

Fig. 2. Symbolic representation of triune evolution of three main neural assemblies leading to the forebrain of human beings and other advanced mammals. Labeling is placed at the level of the forebrain where each assembly, respectively, reflects anatomical and biochemical commonalities with reptiles, early mammals, and late mammals.
Source: MacLean 1967, 327.

terized as "innate," "inborn," or "instinctive." In all three classes of land vertebrates there are indications that such behavior is programmed by the counterpart of the reptilian ganglia of the forebrain that, for short, I refer to as the *R-complex* (TBE, 15–16).

No existing reptiles are in a direct line with mammals. Consequently, in our comparative research we have used lizards, because they have a skeleton and earbones that are very similar to those of the primitive mammal-like reptiles (therapsids) believed to have given rise to the advanced therapsids and transitional mammals. The fossil bones of the latter two forms are so similar that the most reliable distinction is the presence of two bones in the reptilian jaw joint that migrate to become the malleus and incus of the mammalian middle ear. It may be inferred, therefore, that like lizards, the therapsids were hard of hearing and did not vocalize. And also like lizards, they probably reproduced by laying eggs.

In the evolutionary transition from reptiles to mammals, three cardinal developments were (1) nursing conjoined with maternal care; (2) audiovocal communication for maintaining mother-offspring contact; and (3) playful behavior. Contrast the maternal behavior of mammals with that of lizards. Female lizards usually lay their eggs and then leave them to hatch on their own. After hatching, the young of some species, such as the rainbow lizard, must hide in the deep underbrush to avoid being eaten by their parents or other adult lizards. The offspring of the giant Komodo dragon must take to the trees for the first year of life to avoid being cannibalized (TBE, 123). The absence of audiovocal communication in lizards also helps to assure the survival of the young because if, like mammals, they were to make a separation cry, the adults might search them out and eat them.

As we will consider next, the new family-related behavioral triad of mammals seems to have depended on the development of the paleomammalian brain. In terms of our computer metaphor, the cortex (layering of nerve cells) of each of three main formations of the triune brain can be likened to the screen of a computer. In early mammals, there is a great expansion and refinement of the small, rudimentary reptilian screen. It completely envelops a large cerebral convolution which Broca (1878) called the great limbic lobe because it surrounds the brainstem. He also made the notable contribution of providing evidence that it forms a common denominator in the mammalian brain.

Because of its strong connections with the olfactory apparatus, the great limbic lobe of Broca became known as the rhinencephalon (i.e., smell brain). It received little attention because human olfaction was considered of little importance. In 1937, however, the noted anatomist Papez wrote an article calling attention to evidence that the rhinencephalon played an important role in the experience and expression of emotion (1937). Accumulating evidence since then has progressively added support to the Papez thesis. As a means of reducing the emphasis of the term *rhinencephalon* on olfactory functions, I reverted to the use of Broca's descriptive word *limbic*. In a *modular* sense I referred to the limbic cortex and its primary connections with the brainstem as *the limbic system* (1952).

As illustrated in figure 3, the limbic system can be subdivided into three main cortico-subcortical subdivisions. In terms of evolution, the two oldest divisions comprise cortical areas which respectively are mainly connected with the amygdaloid and septal nuclei identified by the numbers 1 and 2. The amygdaloid division is primarily involved in self-preservation as it pertains to feeding and the fighting and self-protection that may be called upon in the search for food. The septal division, on the contrary, appears to be primarily implicated in procreation as it pertains to primal sexual functions and the behavior conducive to mating and copulation.

Over the past forty years it has begun to appear that the third and newest subdivision of the limbic system has been the primary neural substrate for the development of the distinctive family-related behavioral triad in mammals (TBE, chap. 21). Figure 3 shows that the major neural pathways to and from this so-called thalamocingulate division bypass the olfactory apparatus. Stamm in 1954 was the first to report the important role of this cortex in various aspects of maternal behavior, including nest building (TBE, 391). Later Slotnick confirmed and extended Stamm's findings. We also confirmed the findings in a different kind of experiment in which we made ablations in newborn hamsters and then observed their behavior throughout their development. We found that in those animals in which the neocortex failed to develop, all forms of hamster-typical behavior made their appearance at the expected time (TBE, 393–96).

Since reptiles do not play, it was of especial interest that in those hamsters in which the cingulate cortex was absent, play did not occur at the expected time or thereafter. For the purposes of nursing, warmth, and protection there are advantages to keeping baby mammals in the nest. As they grow, their increasing activity and greater use of their sharp little teeth could lead them to fight and escape from the nest. I have suggested that play may have originally developed in mammals to promote harmony and contentment in the nest, and then later on, it served to encourage affiliation among social groups and the other advantages attributed to play.

Suggesting reasons why certain behaviors develop presupposes that one can say nothing about the underlying genetics. It has been suggested that audiovocal communication for maintaining mother-offspring contact increased the chances of survival of the first tiny mammals seeking protection from predators by living in the dark floor of the forest. The separation cry has been suggested as being perhaps the most primitive and basic mammalian vocalization. Relatively few attempts have been made to learn the cerebral representation of the separation cry. Newman and I used squirrel monkeys for this purpose, because even as adults they emit the cry when they are isolated for a time from other monkeys. We

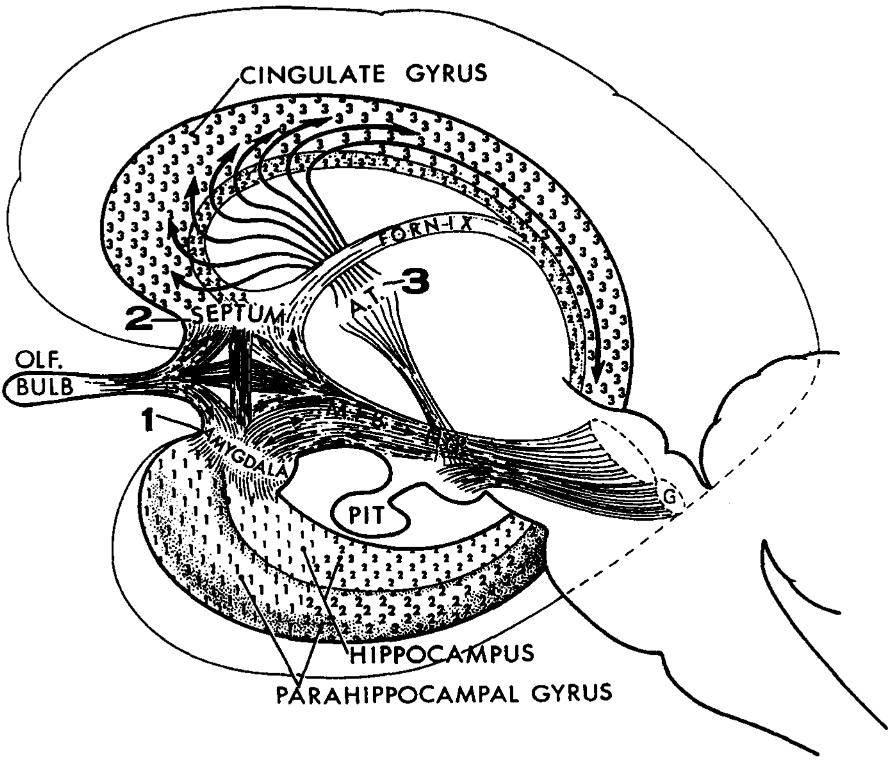

Fig. 3. Three main subdivisions of the limbic system. Large numerals 1, 2, and 3 identify nuclear groups that are nodal, respectively, for the amygdalar, septal, and thalamocingulate divisions. Small numerals overlie limbic cortical areas primarily associated with these nuclear groups; the numbers over archicortical areas are somewhat smaller than those on surrounding mesocortex. See text regarding functions. Abbreviations: AT, anterior thalamic nuclei; G, dorsal and ventral tegmental nuclei of Gudden; HYP, hypothalamus; M, mammillary bodies; MFB, medial forebrain bundle; PIT, pituitary; OLF, olfactory.
Source: MacLean 1990, 315.

found that spontaneous emission of the cry failed to occur when we ablated the rostral cingulate cortex and conducted systematic testing in an isolation chamber over a period of several months (TBE, 401–9).

Comment. It is said that a condition that makes being a mammal so painful is separation from its own kind. The pain expressed by the separation cry is perhaps traceable to the fatal consequences of a baby mammal's becoming separated from a nursing mother. Significantly in regard to pain, the cortical area involved in the separation cry receives part of its innervation from thalamic nuclei involved in the perception of pain. It is also notable in this respect that the cingulate cortex is rich in opioid receptors, and that small doses of morphine eliminate the cry. Morphine is also reported to interfere with maternal behavior.

A just-published brain imaging study by Mark S. George et al. (1995) sheds light on the cortical localization of the call. They found that a volunteer group of eleven women with an average age of thirty-three showed a lighting up of the anterior cingulate cortex when experiencing feelings of sadness. The area overlaps the cortical region implicated in the production of the separation cry in monkeys. (See also a comparative study on men: George et al., in press).

THE QUESTION OF THE ORIGIN AND SIGNIFICANCE OF MALE:FEMALE DIFFERENCES

We are now in a position to enlarge on a discussion regarding Ashbrook's question about "differences in men and women." We focus first on my introductory suggestion that women may have been more instrumental than men in the origin of speech. As background for this discussion I first consider one of the favored hypotheses why men became right-handed, as opposed to other mammals, which are ambidextrous or show a chance favoring of one upper extremity. Here I simply outline the main points of the argument that I have presented elsewhere (TBE, 541–44).

Although bone, twine, hide, and other materials also could have served for the production of tools, the human fabrication of stone instruments presents the best evidence of the primary use of the right hand in making them. On the basis of the examination of tools and flakes found at Lake Turkana, Toth has presented evidence that the favored use of the right hand has existed for at least 2 million years (TBE, 542). Other kinds of evidence for the favored use of the right hand can be deduced from cave paintings, bronze weaponry, and so on.

But why did humans favor using the right hand? The old warrior hypothesis advanced by Carlyle and others was that when men took to fighting with penetrating weapons, they used the left arm as a shield for the heart and thereby had a better chance of surviving and reproducing themselves. The custom of driving on the left side of the road in England is attributed to the practice in the days of knighthood when men on horseback carried the shield on the left and the sword or spear on the right. In our country the practice seems to have become switched, with the steering wheel on the left, where it gives greater protection while driving on the right side of the road. The two-sided survival value under these conditions is well illustrated by the young man whose sports car went off the road in horse country; he survived the penetration of his right chest by a fence board.

But how is one to explain the fact that midline structures such as the tongue and pharynx that are involved in speech also are represented in the dominant hemisphere? Here again priority has been given to the male as a hunter-gatherer in the development of language. As neurological background, it may be noted that when the cerebral cortex in the monkey is electrically stimulated, only excitation of certain limbic areas is effective in eliciting vocalization. Observations indicate that the vocalizations of monkeys compare to the human expletives; they convey emotional states but no precise information. In human beings, however, vocalization can also be elicited by stimulating certain parts of the neocortex. It is a justifiable inference that the neocortex is more educable than the limbic cortex and is capable of communicating more precise information. Although expletives would be sufficient for sounding an alert, they would be inadequate to signal to a fellow hunter the direction of a surprise situation.

The lifesaving capacity of rapid, precise communication leads to a consideration of the advantages of having midline structures involved in vocalization under the unified command of the dominant hemisphere accounting for handedness. If each side of the midline were controlled by the opposite hemisphere, slight differences in the timing of neural conduction could result in the unclarity of slurred speech or stammering. It has been shown neurosurgically in patients that stimulation of the motor neocortex always evokes movement of muscles on the opposite side except for structures such as the tongue and pharynx that straddle the midline (TBE, 543–44).

THE INFANT-CARRYING HYPOTHESIS

On the basis of comparative studies, I proposed in 1990 (TBE, 544) that women might also be considered responsible for the development of handedness and speech. The argument began with the observation of Lee Salk that most women carry their babies with their left arm so that the infant's head lies against the left breast. Left-handed women show the same inclination. In seeking an explanation, he undertook studies that suggested that they unwittingly held the baby this way because the sound of the beating heart had a soothing effect on the infant (TBE, 544). But as opposed to the explanation of the weapon hypothesis, Salk did not consider the survival value of the maternal inclination, nor did he have the anatomical and brain imaging studies referred to above to use in discussing the influence of this practice on the maternal brain. In regard to handedness, one can see how with the baby cradled in the left arm, the mother's right hand would be free to perform ongoing tasks. But how would this practice have a genetic selective survival value for right-handed persons? One might imagine conditions under which absolute silence would be essential for prevention of detection by a human enemy or a dangerous predator. A soothed and quiet baby might mean the difference between life and death, not only for the baby itself and its mother, but also for any affiliated members of a group hiding with them.

Influence on the Maternal Brain. How might the manner of carrying an infant influence over generations the neural organization and synaptology of the maternal brain?[1] For example, proprioceptive brain stimulation from movements caused by the baby's breathing, wiggling, crying, coughing, and the like would be expected to excite predominantly the right postcentral and parietal regions. Moreover, auditory stimulation from the sounds of the baby's breathing, sniffling, whimpering, crying, cooing, babbling, and so on might be expected to be conveyed more strongly by the left ear to the right primary auditory area and the adjoining region of the temporal association cortex, including the *planum temporale* (PT) that, as stated above, occupied a greater area on the right side in over half of the female subjects examined. (It will be recalled that the same area was greater in the left hemisphere in 80 percent of the same number of male subjects). In a recent study (Witelson, Glezer, and Kigar, 1995), PT also was found in female subjects to have a greater density of cells in layers II and IV than in the male brain.

Thus far in brain imaging studies, the parietal neocortex has seemed to be more silent in giving functional clues than the neocortex of other lobes. Information provided by strokes (McGlone 1980) and operative separation of the hemispheres for the treatment of epilepsy (Sperry 1982) has indicated that the parietal cortex on the right side plays an important role in attention and visuospatial function. At this point it is of special interest that there is greater expansion of the dorsal parietal areas on the right side than on the left. David Eidelberg and Albert Galaburda (1984) have given emphasis to the "tight" connections of this region with the limbic cingulate cortex and have suggested that this may account for parietal alerting and attention functions. But if it turns out that the human cingulate cortex, as in animals, plays an important role in the nurturing and care of offspring, the functions of the superior parietal connections could be far more extensive. For example, Paul Horton (1995), in testing his hypothesis that the right parietal cortex is involved in feelings of "wanting-to-give-comfort," has shown in experiments using models that women (significantly more often than men) favor going to the left and using the left arm in extending comfort to one of two identical teddy bears placed in opposite corners and said to be in distress.

Relevance to Speech. The inferior parietal cortex, including the so-called angular gyrus (area 39 of Brodmann; see figure 1) and receiving polymodal connections, has long been known to be crucially involved in language functions. This raises the question of how the infant-carrying hypothesis would apply to the inferred role of the inferior parietal cortex in the development of language and speech. Here again I cover the main points of what I have said elsewhere (TBE, 545). Certain comparative considerations, I noted, suggest that the beginnings of language may have had origins in mother-infant relationships, and if so, the refinement of language meant, as in the case of the weapon hypothesis, a linkup of lingual and manual mechanisms in the same hemisphere as the one issuing commands to the favored hand. It is said that among human infants (regardless of race, ethnicity, or geographic location) spontaneous babbling involving vowel-consonant combinations begins to occur at the age of about eight weeks. On the basis of my personal inquiries of workers observing anthropoid apes, I understand that such babbling does not occur among the young of these animals. How might babbling—a presumed harbinger of speech—have developed? In this respect it is tempting to consider the separation cry and the so-called chuck as prototypes of vowels and consonants, respectively. The separation cry of primates has the character of a slowly changing tone that in the human has the vowel sound *aaah*.[2] It is an innate sound that results from what can be one of the most painful of mammalian conditions, namely, separation. Hence it is a sound associated with great motivation to communicate.

A second basic sound is one made during nursing that is characterized as chucklike. The sound compares to that heard when the sucking lips of the infant break contact with the nipple (tsik). Its consonantal quality is self-evident. It is otherwise familiar as the sound that someone makes when encouraging a horse to get moving. Its use in mother-offspring communication is illustrated by the squirrel monkey. When the sound is make by the mother, it is an encouragement to the infant to resume nursing, whereas the infant makes the sound when searching for the nipple. Later on, when the little one becomes big enough to wander afield, the mother emits a few chucks as a means of calling it back. One might speculate that the separation cry and the chuck are two basic sounds that are later incorporated as vowels and consonants in speech (Newman and MacLean 1985[3]). Given this mother-offspring background for the possible origin of phonemes used in speech, we have an additional or alternative suggestion to the hunting hypothesis in regard to both handedness and speech. Finally, it should be remembered that play between mother and child has been regarded as an important factor in the development of speech.

Concluding Discussion

As I said earlier, Ashbrook (1988) speculates that the greater specialization of the dominant hemisphere in men leads to a positive-negative polarity in their way of thinking that results in a dichotomous cultural view of the world. In such fields as religion, ethics, law, logic, science, and so on, this manner of thinking is reflected as a kind of dualism. In philosophy this would be illustrated by the Kantian antinomies or the Hegelian dialectical ladder. In physics one might picture the wave and particle of quantum mechanics as a kind of parallel to the Cartesian dualistic mind-body concept: The wave would be analogous to the immaterial mind and the particle to body substance. But let me emphasize that the subjective derivatives of the functioning brain represent information, and as Norbert Wiener reminds us, *information is information, being neither energy nor matter* (TBE, 570–79). In contrast to immaterial information, immaterial waves can be physically measured in regard to wavelength and energy. For example, quantum mechanics would provide an explanation of how the visual system could be excited so as to activate structures involved in producing the subjective impression of various colors. But the quanta for a particular color do not exist in the entire universe—there are, say, no quanta for the color green (see Cooney 1991). Any grand "theory of everything" that does not take into account an explanation of subjectivity might as well be called a theory of nothing.

It would seem, therefore, that psychologically a greater balance of cerebral function could provide a kind of three-way situation, with information derived from matter and energy forming part of a trialectical ladder in our climb to achieve knowledge. Contrasting male and female cerebration, Ashbrook comments that whereas the strong lateralization of the male brain results in "approaches to Reality [that] are . . . dualistic and covertly hierarchical, . . . female brains tend to exhibit generalization of function. Bilaterality makes for a more distributed process involving both hemispheres, with the result that . . . approaches to Reality are invariably relational, contextual, and egalitarian" (Ashbrook 1988, 85).

His remarks about the bilaterality of the woman's brain recall what I said above regarding the infant-carrying hypothesis and its possible role in bringing about a greater balance of neuroanatomical function. In considering the neural connectivity that I described, we can imagine how for the mother the experience during pregnancy of the formless life within, could become after birth a sense of exteriorization and extension of the self that physiologically derives to a large extent from the right hemisphere and could conceivably contribute to a greater balance of function of the woman's brain. At the very least, we can say that the conditions the woman experiences could never be duplicated in a man's world. This is a matter that has implications regarding the differences in the degree of parental feeling and attachment felt by members of the two sexes, as well as their capacity for empathic identification with people generally.

As I pointed out, the so-called tight connections of the superior parietal cortex with the cingulate gyrus may prove to be of special interest because of the evidence in animals of the important role of this part of the limbic system in the evolution of mammalian family-related behavior. Parts of the cingulate cortex are closely geared in with the prefrontal neocortex which is known to be requisite for anticipation, planning, altruistic feelings, and empathy. Through its connections with its large, midline, egg-shaped nucleus, it is the only neocortex that receives a strong innervation from the viscera. A sense of personal identity depends upon an integration of information from internal and external sensory systems. I have speculated that through its strong visceral connections, the prefrontal cortex receives the insight that is necessary for the foresight to plan for the good of others as well as the self. Through its cingulate connections the superior parietal cortex would be interrelated with the prefrontal cortex. Although sex-related differences are not known, it is of interest in the light of the hypothesis that the superior parietal covers a greater expanse in the right hemisphere than in the left. In any case, it is a matter worth pondering with respect to the question about differences in the degree that men and women experience *empathy*—a word coined by Lipps to mean feeling one's way into another individual's situation.

This said, we are reminded that as is true for all subjective experience, we are making a statement about unmeasurable values. Yet a consideration of brain function at all levels is enough to convince us that values are a form of information and offer as much reliance as any other. This is because the brain has no yardstick of its own, and we can never get outside of its special substance or reconstitute it to take anything but relative measurements (TBE, 571). Logicians, using the logic of their most advanced neocortex, would say Gödel-wise that no logical system of any complexity can be cleared of contradictions. Or as Bronowski would add in an attempt at further clarification, it is primarily a problem of self-reference as illustrated by "an endless hall of mirrors" (TBE, 571).

But even if an all-embracing theory of cosmology were to include the most important question of all and offer an explanation of subjectivity, we would still have to submit it to the court of final appeal: our subjective self, which includes a very decisive jurist who cannot read or write and is recognized as the embodiment of the limbic system. The clinical study of limbic epilepsy has provided more knowledge about the localization of brain structures involved in subjective experience than any other condition. The subjective feelings are typically affective (emotional) in nature, adding up in one case or another to a thesaurus of feelings that guide behavior in self-preservation and procreation. If the epileptic storm spreads to both sides of the limbic system, its lights go out, as it were. During such periods some patients are capable of performing complicated cognitive forms of behavior, with absolutely no memory afterwards of what they did. It was as though without a functioning limbic system providing combined information from both the inside and outside world, it was impossible to have a sense of personal identity providing a place to store the memory of ongoing experience. Moreover, it is of the utmost importance to emphasize that the affective feelings experienced at the beginning of an aura are usually out of context and free-floating, being unattached to any particular thing, person, or idea. Most relevant to our discussion is that some patients have strong feelings of conviction and belief that what is being experienced at the moment is of the utmost importance or is expressive of the absolute truth. Such feelings are free-floating and do not apply to anything in particular, but clinical findings indicate that they are generated in the nonlingual limbic brain and are of the kind that we attach to our beliefs regardless of whether they are true or false.

This discussion is a reminder of the other theme of Ashbrook's book that we mentioned: differences in the beliefs people hold. Although what has been said would indicate that there is nothing we can believe in except our own subjective experience, we can derive subjective satisfaction from believing in our unmeasurable subjective human values. And one of the most highly esteemed of these values must apply to a remarkable outcome relevant to the topic of this article. The female has had a central role in a mammalian evolution for at least 180 million years. We may imagine that a sense of responsibility began to evolve with her maternal instinct to feed her young and that with the ascendancy to humanness, such a sense generalized psychologically to include others and became what we call "conscience." We have considered conditions that may have especially honed feelings of attachment, empathy, and altruism in the woman's brain. As a prime value consolation for the inability to achieve certitude of knowledge, we can reflect on the realization that, thanks in large part to the attitudes of women, we are witnessing for the first time in evolutionary history the development of beings with a concern for the suffering and dying not only of their own kind but also of all living things.

NOTES

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Isaacson, Professor and Head of the Department of Psychology, Binghamton University. Dr. and Mrs. Christopher Bever called my attention to the Bernstein citation and put his book in my hands.

1. Since I wrote this article, an article on another topic has appeared that suggests a quasi-Lamarckian mechanism that over time might explain how the manner of carrying infants would lead to an expansion of certain activated cortical areas of the right hemisphere. Elbert et al. (1995) describe a brain-imaging study using magnetic resonance imaging in which the cortical representation of the fingers of the left hand was larger in string players than in controls.
2. It is of interest that before he could have been aware of the evolutionary and ethological significance of this sound, Leonard Bernstein singled it out as the key to the origin of music and the harmonic series (Bernstein 1976, 17).
3. Unpublished; see MacLean 1985.

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