The Brain's Generation Gap

Some Human Implications

by Paul D. MacLean

There is a saying that something does not exist until you give it a name.[1] There has, of course, always been a gulf between generations, but call it by any other name, none would be more expressive for our times than "the generation gap." As with the familiar spark plug, the word gap implies a critical distance. Too wide or small a gap, and the whole social engine breaks down. The ever-critical need for an evolving and thriving society is just the right gap for sparking constructive ideas. For those of us on the older side, the problem is not just the gap but also the gas mixture. The bright spark of youth is making this increasingly clear. In calling for a cultural tune-up, young people insist that it is primarily pollution from the mixture of out-worn political, social, and commercial ideas that destroys our environment, poisons human relationships, and threatens atomic blistering of the whole world. They also point out that the twentieth-century doctrine that businesses and institutions must either continue to grow or perish no longer makes sense. It is somewhat like saying, "I want a tumor."

At the international level the most explosive issue is the problem of controlling man's reptilian intolerance and reptilian struggle for territory, while at the same time finding a means of regulating our soaring population.

It is my purpose here to call attention to another generation gap that applies to the human brain. It is a gap that is generally unfamiliar to young and old alike. Yet it exists in every one of us, and, adding to countless generations, makes the familiar generation gap seem insignificant by comparison. And it is an extremely critical gap because learning to recognize it, understand it, and live with it may be more crucial than anything else to worthwhile survival.

To understand the brain's generation gap, it is necessary to think in evolutionary terms. Propelled by our imagination which exceeds the speed of light, we will go back 250 million years to the age of reptiles, when animals which never learned to talk began to crawl into the brain of man. In evolution, the primate forebrain expands along the lines of three basic patterns characterized as reptilian, paleomammalian, and neomammalian. The result is the remarkable linkage of three brain types which are radically different in structure and chemistry and which, in an evolutionary sense, are countless generations apart. We possess, so to speak, a hierarchy of three brains in one – a triune brain.[2] Or, stated another way, we have a linkage of three biocomputers, each with its own special kind of intelligence, sense of time, memory, motor, and other functions.

Although my proposed scheme for subdividing the brain may seem simplistic, the fact remains that the three basic formations are there for anyone to see and, thanks to improved anatomical, chemical, and physiological techniques, stand out in clearer detail than ever before. It should be emphasized, however, that the three brain

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types are in no sense separate, autonomous entities, although they are capable of functioning somewhat independently (see diagram on previous page).

Man's Reptilian Brain

In discussing the three brain types we will need only a handful of anatomical terms. Let us deal first with the largest generation gap and look at the reptilian-type brain. In mammals the major counterpart of the reptilian forebrain includes a group of large ganglia which, for short, I will call the "R-complex." In ganglia the nerve cells appear to be in large clumps, whereas in cortex they are arranged in layers. The Koelle stain for cholinesterase brings out a remarkable chemical contrast between the R-complex and the two other brain types.

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At our new Laboratory of Brain Evolution and Behavior we are investigating the role of the R-complex in natural forms of animal behavior. We are testing the hypothesis that it is basic for such genetically constituted behavior as selecting homesite, establishing and defending territory, hunting, homing, mating, forming social hierarchies, and the like. We also hope that this work will shed light on neural mechanisms underlying compulsive, repetitious, ritualistic, deceptive, and imitative forms of behavior.

The British naturalist, Eliot Howard, emphasized that the establishment of territory may be an essential preliminary to mating and breeding.[4] Ethologists have confirmed and extended his observations.[5] Ritualized, aggressive displays are used in establishing and defending territory. All kinds of trappings are used to make an aggressor look big, colorful, and menacing. In a number of species hair tufts are part of the regalia. Some tribal warriors display the hair of the armpit as a threat.[6] According to Hingston, the direction of the hair follicles on a man's shoulders indicates that he once wore a mane, giving him a bulky disguise like that of a football player.[7] All that many of us have left to show for this is gooseflesh.

The aggressive display of some reptiles and lower forms is the same as their display in courtship and mating. We have found a parallel situation in the small South American primate, the squirrel monkey.

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It is a long leap from monkeys to man. Do the comparative observations have any human relevance? There is much suggestive evidence. For example, in primitive cultures in different parts of the world the territorial aggressive implications of genital display are illustrated by houseguards – stone monuments showing an erect phallus – used to mark territorial boundaries. It is as though a visual, urogenital symbol is used as a substitute for olfactory, urinary territorial markings of animals, such as the dog with a well-developed sense of smell. Gajdusek, in an article on Stone Age man,[13] has suggested a parallel between the display behavior of our squirrel monkeys and certain rituals of Melanesian tribes. Is it possible that primitive man may have learned that by covering himself he reduced unpleasant social tensions arising from the archaic aggressive impulse to display and that this, rather than modesty, has led to the civilizing influence of clothing?

The work I have described is relevant to the important question of the neural mechanisms of imitation, about which almost nothing is known. Look through current neurological texts and you will find the topic hardly mentioned. Many forms of imitation, of course, involve learning, but basic to this is a strong natural tendency to imitation. I am reminded again of Gajdusek's observations. He describes an encounter with a Stone Age tribe which had never seen Western man before. He was interested to observe that when he scratched his head or put his hand on his hip, the whole tribe did the same. Such imitation may have some protective value as signifying, "I am like you."

Imitative behavior works in myriad ways to maintain group identity and promote group survival. The case of the autistic child is an example of the devastating effects of an inability to imitate. Is there is anything that marks an autistic child, it is an apparent incapacity for natural imitation.

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Man's Old Mammalian Brain

We turn next to the other great generation gap – the one pertaining to the old mammalian brain. Recalling that reptiles have only a rudimentary cortex, we must presume that in the lost forms between reptiles and mammals there was an expansion and elaboration of the primitive cortex. Reminiscent of the invention of television, this cortex provides the animal a better means for viewing its environment and learning to survive. In both lower and higher mammals the old cortex occupies a large convolution which Broca in 1878 called the "limbic lobe" because it surrounds the brain stem. It forms a common denominator in the brains of all mammals. In 1952, I suggested the term "limbic system" for the limbic cortex and structures of the brain stem with which it has primary connections.[16] The limbic system, let it be emphasized, represents an inheritance from lower mammals. Until thirty years ago, it was believed to be primarily an olfactory brain and hence was called the "rhinencephalon." As I will explain later, evidence has accumulated that this brain derives information in terms of emotional feelings that guide behavior required for self-preservation and preservation of the species.

The Neomammalian Brain

Compared with the limbic cortex, the new cortex is like an expanding numerator. It mushrooms late in evolution, culminating in man to become the brain of reading, writing, and arithmetic. Mother of invention and father of abstract thought, it promotes the preservation and procreation of ideas.

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I have already referred to striking chemical differences of the three brain types. There is brain-wave and other evidence that some of the psychotherapeutic drugs owe their salutary effects to a selective action on the limbic system and the R-complex.

In connection with science and discovery, it is of special interest that limbic discharges may trigger eureka-type feelings expressed by such words as "this is it, the absolute truth; this is what the world is all about."[24] The feeling is free floating, being attached to no specific solution or idea. It has the quality of what most of us feel when we make a discovery or arrive at the solution to a problem. Kepler provides a vivid illustration. He was drawing a figure on the blackboard for his class "when an idea suddenly struck him with such force that he felt he was holding the key to the secret of creation in his hand."[25] Although his inspiration proved to be wrong and lingered as an *idée fixe* the rest of his life,[26] it led to the formulation of his three famous laws. Ironically, it seems that the ancient limbic system provides the ingredients for the strong affective feelings of conviction that we attach to our beliefs, regardless of whether they are true or false!

Before some concluding remarks, I want to emphasize again that the three basic brain types are not to be considered as separate, autonomous entities. They are extensively interconnected, but just how they are connected and function together as a triune brain is a major problem for future investigation.

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Making Three Brains Operate As One

I suggested earlier that the reptilian brain is a neural repository for innate forms of behavior. Other bits of evidence indicate that with the evolution of the old and new mammalian brains, nature economically uses the reptilian brain as a storage mechanism for parroting learned forms of emotional and intellective behavior acquired through limbic and neocortical systems.[27] We are all aware, for example, that having once acquired a verbal or other skill, we can later repeat it, so to speak, almost instinctively. Indeed, if we stop to think how we do it – as, for example, playing a musical piece learned by heart – it may interrupt the continuity of performance. As Plutarch taught us to say, habit is "almost a second nature."

There are clinical indications that the reptilian- and old mammalian-type brains lack the neural machinery for verbal communication with these ancient cerebrotypes; [in other words] there exists in each of us an unbridgeable generation gap – a gap that makes the familiar one seem tame by comparison. But to say that [these ancient brains] lack the power of speech is not to disparage their intelligence. Nor does it mean they can be relegated to the unconscious, when in actuality they may be wide awake. The need for more harmonious survival with our animalistic selves calls for new research approaches in cryptopsychology. Among the challenges are finding better ways for coping with the communication gap and discovering more perceptive measures of human intelligence.

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At the international level, the most explosive issue is the problem of controlling man's reptilian intolerance and reptilian struggle for territory, while at the same time finding a means of regulating our soaring population. Language barriers among nations present great difficulties, but the greatest language barrier lies between man and his animal brains.[28]

Part of the poisonous fallout of today's hurry-up attitudes may be that we are getting out of step with our animalities. It seems that ever since *Sputnik* our educational leaders have been planning our existence as though we had to satisfy only our neocortex. Designed to come up with new ideas, the neocortex appears to thrive on change. With its imagination that exceeds the speed of light, the neocortex may be able to keep up with the present accelerated tempo of life through speedreading, help of computers, and other contrivances; but the two animal brains which are our constant companions move at their own slow pace. They have their own biological clocks and their own sequential, ritualistic ways of doing things that cannot be hurried. Courtship, for example, does not lend itself to the rules of speedreading. The reptilian and limbic brains have survived millions of years of evolution, and it is evident that no genetic tailoring will remove them overnight from the brain of man. Although we now anticipate public transportation at rocket speeds, we will still have to move at a horse-and-buggy pace with our animal brains. Once this is realized, we may achieve a quality of life that will bring greater contentment. Perhaps this is what today's youth have been trying to tell us.

I have not forgotten my reptilian promise to return, in conclusion, to the question of imitation. With worldwide television, the matter of imitation looms more important than ever in human affairs, not only as it applies to fads, fashions, and drug cultures, but, more significantly, to forms of mass hysteria and violence. It has become almost a dictum that "imitation rules the world." There is abundant evidence from animal behavior studies done by Calhoun, Myers, and others, that the conditions of crowding are conducive to aggression and combative behavior.[29] In addition to bringing out aggressiveness, crowding also increases the opportunities for imitation. One may therefore suppose that violent behavior can lead to a kind of vicious circle through the positive feedback of imitation. It is one of the perversities of television that it brings crowding, violence, and imitation right into the living room. It was stated recently that by the age of fourteen the average child will have seen eighteen-thousand murders on television.

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Because of our scientific emphasis on the control of natural phenomena, we tend to regard ourselves as separate from, and even superior to, nature. But the fact remains that we are one of nature's experiments, and we might justly wish that it would share our guilt for the violence that we do to ourselves and the environment. Nature, indeed, sets us a terrible example not only in regard to the violence of storms, earthquakes, disease, and cancerous erosion, but also in exposing us on all sides to trickery, deceit, and treachery. The wonder is that man has ever been able to go straight! Indeed, if we were not part of nature, it could be said that we had surpassed nature in a sense of honesty and altruism. For where else in nature can one look for an example that "honesty is the best policy"? When we are at our best, nothing makes us more unhappy than seeing living things suffer. And nothing brings greater satisfaction than to relieve

suffering or to witness the relief of suffering. Recalling that the word "altruism" was coined as recently as 1853 by Auguste Comte and that the word "empathy" was given to us by Theodor Lipps about 1900, we gain intimations that the humanitarian movement is still in evolution.

Partly on the basis of new information mentioned in this paper, I would suggest that the capacity for empathic identification with others stems from the great developments of the cingulate division of the limbic system and in articulation with a more recent expansion of the human brain, the prefrontal cortex. There are clinical indications that the prefrontal cortex provides foresight in planning for ourselves and others and that it also helps us to gain insight into the feelings of others. In the remarkable development of these structures which seem to be especially geared for promoting the welfare and preservation of the species, we find reason for hope that in the further evolution of man, human love and enlightenment will prevail over the forces of violence and destruction.

For weary mortals looking for relief from the constant drone of dismal news about the state of the world, I would suggest that they take up cerebral astronomy and study the three great galaxies of the triune brain. •

NOTES

[Numbers of notes are those in the original text. Lapses in numbering are due to editing. Copies of the full text are available on request.]

1. Harley C. Shands, "Outline of a General Theory of Human Communication," in *Essays in Semiotics*, ed. J. Krsiteva, J. Rey-Debove, D. J. Umiker (The Hague: Mouton & Co., 1971), pp. 343-81.

2. P. D. MacLean, "The Triune Brain, Emotion, and Scientific Bias," in *The Neurosciences Second Study Program*, ed. F. O. Schmidt (New York: Rockefeller University Press, 1970), pp. 336-49.

4. H. E. Howard, *An Introduction to the Study of Bird Behavior* (Cambridge University Press, 1929), p. 136.

5. For a lively, extensive review see Robert Ardrey, *The Territorial Imperative* (New York: Atheneum Publishers, 1970), p. 405.

6. Desmond Morris called my attention to this observation.

7. Richard W. D. Hingston, *The Meaning of Animal Colour and Adornment* (London: E. Arnold & Co., 1933), p. 411.

13. D. C. Gajdusek, "Physiological and Psychological Characteristics of Stone Age Man" (Symposium on Biological Bases of Human Behavior, California Institute of Technology, Pasadena, April 1970), *Engineering and Science* 33 (1970): 26-33, 56-92.

16. P. D. MacLean, "Some Psychiatric Implications of Physiological Studies on Frontotemporal Portion of the Lymbic System (Visceral Brain)," *Electroencephalography and Clinical Neurophysiology* 4 (1952): 407-18.

23. Ibid.

24. MacLean (in 2 above).

25. A Koestler, *The Sleepwalkers* (New York: Grosset & Dunlap, 1963), p. 624.

26. Ibid.

27. P. D. MacLean, "Cerebral Evolution and Emotional Processes: New Findings on the Striatal Complex," *Annals of the New York Academy of Sciences* 193 (1972): 137-49.

28. P. D. MacLean, "Man and His Animal Brains," *Modern Medicine* 32 (1964): 95-106; "Alternative Neural Pathways to Violence," in *Alternatives to Violence, ed.* L. Ng (New York: Time-Life Books, 1968), pp. 24-34.

29. J. B. Calhoun, "Population Density and Social Pathology," *Scientific American 206* (1962): 136-46; K. Myers, C. S. Hale, R. Mykytowycz, and R. L. Hughes, "The Effects of Varying Density and Space on Sociality and Health in Animals," in *Behavior and Environment*, ed. Aristide H. Esser (New York: Plenum Press, 1971), pp. 148-87.