RAGNAR ROKR: THE EFFECTS OF CONSCIOUS PURPOSE ON HUMAN ADAPTATION [211]

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Warren McCulloch

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Introduction

Once upon a time the whole event, rolled in one for us, our universe, began. Small atoms formed and in their coalescence made the stars, fusing their atoms to make larger ones and radi-ating energy. There is a mainline of their evolution, a way of becoming that makes for their longevity. From this our Sun has strayed. It has lived more than half its life. It will flair as a red giant and evaporate our Earth.

Even of atoms the same is true, for there are several ways of making most of them that are unstable. Even the stable isotopes get hit by cosmic rays and are disintegrated. Now we have learned the tricks to smash them, and, with them, make Earth unlivable.

But if man goes on as he is going now we need not wait for the end of the eternal firmament or the fission of the unsmashable atom. Heinz von Foerster's calculated doomsday of population explosion will be met by children now alive. And Dian Hitchcock's data on our thirtyfold consumption of power per capita, our liberation of poisons from fossil fuels, our devastation of forests, our efficient destruction of most forms of life, and our pollution of lakes, rivers, and the very ocean allot us a much shorter span. We may be left with no meat, fowl or fish and only those plants that would die without our husbandry. Clearly, our culture in the literal sense has developed in a way to make life more precarious. Economic competition can only hurry us along. Even if man is as old as Leakey thinks, the killer ape has upset evolution in a short epoch. Evolution progressed by producing the requisite variety of species to fill every environmental niche. Ubiquitous Man has broken up the niches and exterminated the species. Where did evolution go wrong in producing us or our ancestors? Long before man appeared, the main line of mammals had an aberrant branch, whose brains grew bigger than is normal for their size.

This is true of some of the little ones with smoother brains, like the lemurs and spectral tarsiers. A surprisingly large portion of their cortex is a visual analyzer and an associative cortex for vision, and, secondly, a very large area devoted to sensory input and motor control, and the associational areas for each of them. These areas make for increased visual recognitions and for the acquisition of motor skills that fit them well to their forest homes. In the true monkeys the cortex has become so large that it has to be regularly folded to fit into their heads. The frontal pole, the temporal lobes and the parietal region are enlarged and more of the volume of the cortex is utilized to provide richer connections. The brain is more immature at birth: They learn more and are more inquisitive. Gibbon, chimpanzee, orangutan, and gorilla are still more like us, with proportionate increases in the same areas and richer connections of associative types. They are more skillful, more inquisitive, and, by any ordinary test, more capable of solving problems and of playing games, even just for the fun of it. The primary regular folding of their cortices remains, but I have never seen two chimpanzees with the same secondary folding, and none with folding exactly alike on the two sides of any one. The variations are greatest in the very areas in which I am most interested, the frontal pole and the parietotemporal area. Without stimulation and recording it was often difficult to identify these regions and these were, under the conditions of experiment, the so-called "silent areas". They yielded no sign of response to sensory input and no motor response to electrical stimulation. They cannot be identified by exclusion, only by mapping their connection to other cortical areas by the local application of strychnine and the recording of an almost simultaneous spiking of electrical activity which can be recorded in any cortical area to which axons come from the strychninized area. With the joyous team play of anatomists, physiologists, and neurosurgeons, I have mapped these connections in the brains of some 30 chimpanzees. I have known a single experiment to last 3 days and nights and produce several miles of records. I was particularly eager to locate two silent areas, precursors of those required for human language. One lies in man in front of the motor area controlling face and tongue, and the other at the end of the fissure of Sylvius that divides the temporal from the parietal areas, concerned with other aspects of language, spoken or written, heard or seen. This is the last part of the brain to evolve and the slowest to mature, and, unfortunately, so variously folded that it would be impossible to identify it in a cast of a man's brain. Fortunately, as brains grow the growing bones conform, and this does make it possible to make a cast of the lower frontal part of a hominoid brain wherein to seek for signs of the convolution controlling motor speech. The great comparative anatomist of the nervous system, Ariens Kappers, did just that to all of the skulls of our precursors then known to science. There was no sign of such a convolution in the skulls of men of the old Stone Age. He then studied their tools, most of which fit either hand, and those that fit one better than the other are as equally likely to fit the left or right. When we come to the age of polished tools, things like scrapers that show handedness are 19 times out of 20 made for the right hand, which is the ratio of handedness today. The corresponding skulls show a well-developed convolution for control of motor speech. Since speech and handedness in living man are both controlled by the

dominant hemisphere, usually the left, Kappers concluded that there is no evidence that the Neanderthal could speak, but that the Cro-Magnon spoke. After all, his brain was as much greater than that of the Athenian patrician as his is greater than that of the European of our day.

Man's upright posture has clearly freed his hands for making and using tools, but no one realized its relation to motor speech until Lloyd DuBrul began to analyze it. In the normal quadrupedal posture the weight of a large and powerful lower jaw has to be carried by massive muscles, and the windpipe defended by a strong hyoid structure with elaborate muscles. As we move toward the vertical, the targets of the evolutionary changes are in the centers from which we develop the bony structures of the base of the skull and of the jaw. The brain bulges upward, kinking the brain stem. As the jaw recedes, the muscles become smaller, but the nerve cells that control them remain as numerous as ever. They are then free to indulge in finer control – ending in song and speech. It happens in birds, as well as in the monkey tribe, including man. Since we can grind our corn and cook our meat, it does not matter too much that we are losing our teeth – and we do talk.

To explain the function of that parietotemporal cortex of man, which is commonly called the *Angular Gyrus*, is more difficult, for it requires more detailed knowledge of the functions of other structures: So forgive what may seem a digression.

What little cortex a frog has receives signals in all of his sensory modalities, and signals from the reticular core that decides to which of his incompatible modes of behavior he should commit himself entirely. These functions are retained through the life of the vertebrates but that old forebrain, notably the hypocampus, becomes deeply buried as the new cortex grows. It was, and is, some sort of analyzer of the total environment, including the rest of animals. But its role in learning is best seen in bigger brains. When it is destroyed bilaterally in man, while his old memories persist, he can form no new traces. We see the same thing — but not so clearly — in lower forms of life. It differs from the rest of the brain chemically, structurally, and in the fan-out of its connections to the rest of the brain, but we do not know which of these differences is important, or how, in the laying down of traces elsewhere in the brain. For present purposes, it is enough to remember that it is part of the limbic system which is primarily concerned with feeling, affection, and emotion, but that the traces of learning it engenders are not in it. The greatest recent work on it is by Paul MacLean, done chiefly on the squirrel monkey. He, most excellently, has taught us its anatomy and its role in instinctive acts and in social behavior.

When we turn from this to the rest of the cortex, we find it a great analyzer of sensory inputs, with the ability to perceive shape regardless of size, chord regardless of key, and so on. For each sensory receptive field there is an adjacent field that controls the motor apparatus for its specific receptors, and an associative field for the perceptual elaboration of its specific modality. In the parietal lobe this is for somesthesia; in the occipital region for vision; in the temporal region for audition; and down in the Sylvian fissure for gustatory affairs, including taste. Thus in the primate brain there is the possibility of establishing conditional reflexes of high-level analysis and elaboration of each of the sensory modalities by way of coupling each of these with the affective components of the old limbic system. What I could not find in primates was any cortical area to which came axons for all of the associational cortices. In man it is the Angular Gyrus that serves this role. Without it the anatomical substrate for carrying over from a shape seen to that same shape felt is wanting. There is no place for an engram of the same thing heard, felt, seen, and so forth, and no carry-over of learning from one modality to another in primates below man — and none in the human infant until the connections to this area develop! I do not mean that a baby cannot learn to respond in the same way to a breast seen and a breast felt. He can; but he learns them separately, each by its affective component releasing adversión and sucking. He cannot have the general object, breast, because he has no cortical connections to engender the notion. When these develop he can have that notion, and there is nothing to stop him from learning its name of Mama. Among mammals only the monkey tribe has certainly color vision. Mothers come to me saying, "My child is color-blind. He knows the names of all of the colors but uses them at random." The answer is, "Wait." Normally, until it is 3 years old the tract from the visual associative cortex has not yet myelinated, but it will, and in a matter of days the colors will be named correctly. If he could have felt or heard a color, then that color would have been a thing for him, like a dolly or a whistle. All this presupposes that the babe is a free-moving infant in a normal world and a mammal in a family. If premature, immobilized in an incubator, gazing at a white ceiling lighted day and night, fed and changed by a nurse with a mask, the babe upon maturing may never show a social smile, never speak, and never treat a human being differently from an inanimate thing. Salk's work on this is most impressive. But mere sensory inputs are not enough. As Sechenov correctly surmised, a motor component is necessary for learning. Held has demonstrated this beautifully. Speech and writing play this role for the word heard and printed.

Apart from these, there are hereditary disorders called dyslexias, in which, according to Ertle's work, there is a wrong temporal phase shift between the impulses recorded from the temporal lobes. These are fairly common disorders. The Danes, who have studied it most thoroughly, estimate that it occurs in about one in ten of their population. We still do not know its anatomical substrate, but we do know that it is unduly frequent in the left-handed, and may therefore be related to cerebral dominance. It is not related to intelligence but proves an increasing difficulty in our culture, which depends evermore on the printed word and number. These cases account for perhaps one-third of the 30% of our children who are hampered by difficulty in reading and writing. Many of the rest are syndromes of disconnection in the cortex caused by injuries, frequently at birth. Those that occur later in life, when brains have ceased to grow, produce apraxias, aphasias, agnosias, and so on, which have been best analyzed by Norman Geschwind, and on many of these we do know the anatomical lesion.

The point I want to make is that in all of them there remains a human give-and-take by the more fundamental forms of relating to our fellows. The social harmony may remain when the cultural score of our symphony is obliterated. Society rests securely upon

thinking and feeling in natural terms which we share with the beasts. Our culture requires thinking in conventional terms, enjoyed by man alone.

Sometimes, to save his patient, the surgeon must destroy a cerebral tissue or its connections. In the case of uncontrollable convulsions beginning in one hemisphere and spreading to the other, endangering the life of the patient, the connections between them have to be severed, so that they operate independently. The right visual field of both eyes communicates to the left hemisphere, and vice versa. Hence we can test them separately. The dominant hemisphere can then read, write, and speak. The nondominant cannot. The spoken word reaches them both — but only the dominant comprehends by any verbal test thus far attempted. The nondominant can perform many skilled acts, sometimes better than the dominant. Of the half dozen such patients now alive, I have seen only two. In both, both half-brains were alert, friendly, interested, sociable, even when their respective hands got at cross purposes.

Let me summarize here and now how a neurologist may look at the brain as the substrate of behavior. The primitive core of the nervous system, sampling all inputs, listening to and directing all other structures, commits the whole organism to sleep, making love, eating, fighting, running away, investigating or taking another look. The brain stem, or central cephalic structures, determine our state of vigilance, our alertness, our awareness, and our level of attention: the oldest part of the cortex, sampling all modalities, and constrained by the reticular system, determines what we shall remember; the limbic system handles affection, feeling and emotion; the rest of the cortex makes a model of the world, including the body, for each modality separately; the Angular Gyrus conjoins these yielding those objects that we identify when they are given by any one or more of several modalities of sensation. Given these, the Angular Gyrus of the dominant hemisphere creates words and sentences, spoken or written, heard or seen. It is able to bear witness in conventional terms about what happened when and where, and if it agrees with a second witness is legally, forensically, conscious of that event with that other witness. We can be aware, affected, responsive without it — even sociable. With it we can have culture. Just as each of the structures mentioned depends upon the one I mentioned earlier for its proper function, so culture depends on society and it on the family without whose suckling and rearing every mammal is lost to this world.

Man, born with the most immature brain, matures most slowly, and is most affected by environment, chiefly his fellow man, so that by the time he is sexually mature, he is so shot through and through with socially determined relations that he scarcely seems to have an instinct of his own. Language so permeates this structure that thought, to many men, seems little more than an internal speech.

This is surely an exaggeration. In the state of nature we, like all marsupials and mammals, are born sucklings or we die. As soon as we can follow objects with our eyes, we follow faces in preference to other forms, and in the early months of life, smile when we see them. From birth to death we are startled by loud sounds and flashes of light, and are terrified by falling. In such matters we remain instinctive; as we become, in matters sexual, as we mature. In such basic things, words cannot save us if we lack the instinct. We can be thwarted, for in living things there is a time for an imprinting and a necessary sequence in our learning, each new acquisition becoming only a modification of what went before, each in its proper time. Most of this happens when we have no words for them, and often we lack words for them, the bases for our words. Our thoughts arise from them, though they, the primitives of thought, to thought seem nebulous. The artist, painter, poet, and musician coax us back to their intrinsic powers. When these sway people toward a feeling for the whole of man, not just his artifacts, there is a wholesome breath of life in a society. When they deceive us we are sick indeed. The difficulty is the want of clarity, the lack of those very tests by which we can, with propositions, sharpen our ideas and put them to the test of logic and the science of observables. Without them, our culture is unthinkable, with them alone it were unlivable.

I am no romantic to decry that “false secondary faculty whereby we multiply distinctions,” call it “reason” if you will, or simply *Logos*. It is the culmination of our evolution. There is no way back. Equally, there is no excuse for letting that afterthought of Nature, the Angular Gyrus, sweep the whole of mankind into activities at variance with the rest of his new cortex, his limbic cortex, his hypocampus, his brain stem or his reticular core.

No more would I go along with Plato in exiling the poets, who play on the limbic cortex. Not even they are powerful enough to evoke the whole of man. If we are to survive our own destruction of our world and of ourselves by our advance of culture we had better learn soon to modify our genes to make us more intelligent. It is our last chance, that by increasing our diversity we may be able to make some sort of man that can survive without an ecological niche on this our Earth. We have made houses, clothes, ships, planes, and rockets. We may be able to live in gas masks and eat algae and distill the ocean. I doubt that we have time enough.

We are, I think, nearing the end of a course that left the main line of evolution to overspecialize in brain to its own undoing. Time will tell.