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Forms and Symbols: The Roots of Behavior

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FORMS, SYMBOLS, AND THE STRUCTURE OF THE BRAIN

by

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1. INTRODUCTION

The human organism has a boundary of skin with many portals of entry open to the surrounding environment. Food and liquids may be injested, the air may be inhaled, and a wide variety of stimuli impinge on our senses. The outside world , however, does not penetrate intact within our biological intimacy: the oxygen must be combined with the hemoglobin to be transported by the blood. A beautiful apple will be smashed during the process of mastication and digested into a rather unattractive pulp which travels through the intestines. A flower cannot penetrate our eyes. Only a few optic components may travel through the dioptric system and stimulate some cones and rods, starting a chain of chemical and electrical reactions which will be propogated through the central nervous system. The flower will not reach our visual cortex, located in the occipital lobe: only its symbolic representation will be coded and transported through neuronal networks.

Understanding of the information received from our environment requires transduction and codification of stimuli at the sensory receptors, transmission through different material carriers, decodification of the information at specialized sites in the central nervous system, and perception of the subcodes as personal sensation. Although our comprehension of these complex processes is still limited, recent investigations have revealed some of the mechanisms involved in cerebral identification of the received coded symbols.

Since matter is cohesive, objects may be clearly characterized in terms of their boundaries represented by edges, corners, and angles which form the spatial layout of a stimulus object (Werner, 1974). The combination or pattern of these contours form the <u>features</u> which allow unambiguous recognition of an object. The features may be stationary or may have motion. The combination of spatio-temporal features provides information about stimulus identification including its motion.

2. THE MEANING OF SYMBOLS MUST BE LEARNED

The visual systems of frogs, cats, monkeys, and other animals possess specialized feature-extracting neurons which respond in a preferential way to determined stimuli, allowing them to deal with their visual environment with economy and effectiveness. The frog's retina, for example, has special detectors for bugs, edges, and dimming light. The visual cortex of monkeys has orientation-detecting neurons able to perceive the stereoscopic distance of a stimulus (Hubel and Wiesel, 1962, 1970; see also Barlow , 1967).

How are these information processing mechanisms organized ? What are the essential elements in the neurology of feature detection ? We could ask whether there is a genetic determination in this neuronal specialization or if the visual system must learn and adapt to the real world around the individual. Answers to these questions are fundamental. If processing of information is genetically established, the subject will have an established system for interpretation of its environment. This means that human beings would have inborn characteristics which must be repected to preserve their personal identity. On the contrary, if neurons must learn the meaning of received signals, if this process takes place after birth, and in particular if the neuronal structure and functions are shaped by the actual reception of stimuli, then the mechanisms for interpretation of reality are not given from the inside but are molded by gradually acquired experience. If the latter is true, then the brain may be molded and is receptive to the quality and quantity of messages from the perceptible world. Meaning of symbols must be provided from the outside, by culture. In this case, when the environment evolves and changes, the brain structures follow this evolution, adapting to new situations.

Experimental evidence demonstrates that early visual experience is decisive for determining the feature-detecting properties of neurons in the visual cortex of the cat (see a good summary in Blakemore, 1974). By comparing the results in adult cats and young kittens, we may conclude that some elemental neuronal properties are built in while others are not present at birth. We may then wonder whether the missing properties may appear spontaneously and depend only on a process of maturation, or whether visual stimuli are essential for the establishment of normal neuronal functions.

Kittens usually open their eyes about ten days after birth, but we may keep their eyes closed for several weeks and thus prevent the kittens from receiving visual experiences, in order to investigate the evolution of the visual cortex. Results show that in kittens with closed eyes, visual neurons remain undeveloped and a large number are totally unresponsive to subsequent visual stimuli. Visual experience is vital for the establi shment of normal feature-detecting properties in visual cortex neurons: maturation is not enough.

In other experiments, only one of the kitten's eyes was closed. Results showed that after monocular deprivation, only the eye with normal visual experience could evoke electrical responses in the cortical neurons. The good eye was totally dominant over the unused eye. Further testing showed that the establishment of dominance occurred during a short period of development: a few days of monocular deprivation during the fourth week after birth produced total dominance by the other eye, while covering one eye before the third week or after the fourth month did not affect ocular dominance.

After birth, there are short periods critical for the establishment of specific functional differentiation of the cerebral neurons. The guidance of sensory information is essential for this differentiation, for the learning of symbolism, and for the anatomical and physiological structuring of the brain.

3. SLOW BIRTH OF THE HUMAN MIND

The birth of a human baby traditionally arouses the expectation that this new member of the family will provide continuity of name and perhaps of activities and customs. All parental thoughts, however, are only hopes - not realities - because fulfillment of these dreams requires many elements which may evolve but which do not yet exist. The emergence of the qualities that characterize human beings does not coincide with the moment of birth. One by one the many functions and manifestations may slowly appear. We may ask how many and how much of each should be considered necessary to transform a mindless newborn baby into a being able to function adequately as a human being. This question must be answered without committing the error of potentiality. The answer is rather difficult because it depends on the definition of a human being, thus distinguishing man from other living creatures. Selection of the properties essential for identification of man does not depend on experimental investigations but on conceptual agreements. We can certainly state that the new born baby does not and cannot speak and will not be able to do so in the early weeks or months. Shall we deprive the new born of the qualification of "human" because he cannot talk and also lacks most of the other manifestations of mental activities ?

It is preferable to try to clarify - and to test - (a) what is present and absent at different chronological stages; (b) which are the genetic, anatomical, physiological, and environmental elements necessary for the onset, evolution, and preservation of each of the considered qualities; (c) which are the individual (and social) consequences of the beginning and presence of each quality; and (d) which are the possibilities and means to increase or diminish the existence and development of characteristics considered beneficial or harmful. In this last question we enter into the controversial problem of ethics and manipulation of people by other human beings and as we will discuss later, the present state of science and technology make manipulation unavoidable.

Human babies are born with very immature brains (Conel, 1947). In the primary sensory areas, motor cortex, and in other cerebral structures, many characteristics including myelinization, cortical width, number, size, and branching of cells are in embryonic states. Studies performed with radio tracers have revealed that in the hippocampus, olfactory bulb and cerebellar cortex of mammals, about 80 to 90% of the neurons are formed after the animal is born (Altman, 1967). These anatomical facts represent unsurmountable functional limitations of the human new born who is absolutely incapable of acquiring his own food, choosing his environment, and selecting sensory inputs and information which are the decisive elements shaping his brain structure and functions. The new born is also unable (a) to understand symbolic communication; (b) to use any language or even to learn any word; (c) to recognize his environment; (d) to solve any problem; (e) to exhibit purposeful movements; (f) to plan future actions; or (g) to show signs of the possible existence of most mental functions.

As suggested earlier, we must avoid the error of potentiality (Lange, 1873) which assumes that, at an early stage, the baby possesses hidden properties which will automatically be revealed at a later age. In reality these properties such as coordination, vision, the capacity for abstract thought and many others depend on programmed genetic development plus experiential learning. It must be clearly stated that due to neuronal immaturity and lack of experience, most mental activities cannot emerge immediately or spontaneously. A healthy new born baby's mental development depends on many elements located in his surroundings which will affect his genetic potential.

The learning process which determines individual structuring may be blocked, modified, or disturbed by many circumstances including food intake and sensory inputs. The baby can learn to talk, but not until his brain develops

with adequate neuronal and dentritic complexity, and not until he is exposed to language.

A baby's little hands do not suddenly grow to adult size or acquire skills. The learning process will take years. The same slow growth is characteristic of every part of the body. Changes in size, structure, and functions proceed very slowly with many intermediary stages and without drastic changes.

A new born baby, therefore, is full of future possibilities which should not be confused with the very limited amount of immediate realities. The set of genetic determinants and the brief biological history as a fetal being are not sufficient to ensure development of a normal body, to structure a normal brain,or to assure the appearance of mental functions or the establishment of personal identity. Two other sets are totally necessary: namely, the supply from the exterior of (1) physical elements including air, water, and food which are essential for cellular multiplication and for the organization and growth of body structures; and (2) sensory information which is also essential for anatomical and physiological organization of the central nervous system, being also decisive for the structuring of the frames of reference which are basic for personal identity and mental functions.

Ancient beliefs about the existence in the germinal cell of a compressed "homunculus" with microscopic eyes, arms, legs, and an unveiled but preformed mind have been disproven by experimental embryology. Chromosomes do not contain a heart, brain, or any other organ. They carry only a set of architectonic plans able to direct the organization of the building elements formed by proteins, fats, carbohydrates, and other components supplied from the outside via the maternal placenta. These materials will be shaped into new sets of instructions and into multiplying cells that initiate the formation of organs and functional systems.

It should be emphasized that an architect's plans are only instructions, not real buildings. They are only a promise without bricks, cement, steel, and other building materials. A germinal cell and even the embryo are only possibilities, not realities of human beings. Genetic plans are unfulfilled for millions of sexual cells and countless miscarried embryos.

In spite of these facts, many respected authors believe that the fertilized ovum contains the primordia of "what we later call mind" (Rainer, 1962), and as Sherrington (1941) suggested, "The appearance of recognizable mind in the soma would then be not a reaction de novo but a development of mind from unrecognizable ito recognizable."

The controversy between heredity and environment (nature and nurture) as determiants of mental functions and personali ty is classical in the literature. The importance of the prenatal period for future behavior chrystallized in the concept of ontogenetic zero (Gesell, 1928) and is accepted by most child psychologists (Carmichael, 1960). At present the debate over nature versus nurture and its dichotomy of percentages (50% - 50 % ?) in the structuring of human beings is losing interest. Research and evaluation of data are directed toward analysis of the specific roles of the many intervening elements and the study of their mutual relations. Each element is essential although many substitutions are possible and we should consider the consequences of each element as it influences the structuring of human cerebral functions.

The set of chromosomes, and therefore the genetic characteristics of each individual, derive from paternal and maternal sexual cells linked together by pure chance, without the intervention of human intelligence and without consideration for parental desires. They are given automatically to the embryo without its consent and without concern for that individual's future success or failure. Under the guidance of genetic organizers, using the available materials provided by the maternal placenta, and with suitable or unsatisfactory adjustments to possible alimentary deprivations, the new being will be structured according to preestablished rules and mechanisms, developing to term in the uterus, and finally being born and detached from the umbilical cord.

Partners may be chosen for their physical aspect, cultural background, and personal qualities, but there is no way of selecting and encouraging a specific spermatozoa to win the swimming competition inside the fallopian tubes. We are ignorant of the wonderful possibilities and tragic handicaps hidden in the genetic codes carried by innumerable parental cells. Fecundation is a lottery and even in artificial insemination the genetic characteristics of individual spermatazoa are unknown.

In summary, plans for the structural and functional beginning of individual life are established by chance, without intellligent choice of the parents and obviously without intervention of the new being who is in a state of creation and lacks cerebral mechanisms for knowing or choosing.

The question whether, in the new born brain, there is a coexisting mind, is difficult to answer because it depends on our concept of mind. The possibility of conscious experience in the fetus was a classical philosophical and psychological problem (see, for example, Locke, 1931; Peterson and Rainey, 1910). Modern studies indicate, however, that immersed in the night of amniotic fluid, without visual, auditory, olfactory, or gustatory sensations, the possibility of fetal awareness is extremely limited.

To clarify discussion, instead of referring to the vagaries of an undefined mind it is preferable to focus attention on the appearance of specific qualities accepted as specifically mental, such as purposeful motor activity, comprehension of sensory inputs, language, substitutive or symbolic behavior, and intelligent choice.

At birth, a baby cannot have upright posture or purposeful motor activity because of the absence of a myelinated pyramidal tract, the lack of branching dendrites in the basal ganglia, the development of only a small fraction of future synaptic connections in the cerebellum, and the absence of ideokinetic formulas in the brain.

It is not true that motor skills are dormant somewhere in the brain, waiting only to be unveiled. The new born brain does not have the anatomical support, functional mechanisms, or experiential background for skillful mobility. Each of these three elements is essential for motor skills to appear. The crucial fact is that anatomical and functional development of the brain proceed by genetic determination but under the guidance of sensory experience. Learning leaves material traces in the neuronal flesh, influencing synaptic anatomy, enzymatic activity, functional selectivity of pathways, and chemical composition of the neurons.

Initial learning will modify brain structures and transmitting systems, making possible further and more complex learning. At birth, the brain is so immature that its learning capacity is very limited. Skills are not unveiled: their mechanisms must be constructed inside the brain. The cerebral areas which organize hand movements may have the potential to learn the ideokinetic formulas necessary for playing musical instruments, but these abilities do not exist in the naive brain, nor will they be acquired without training. Motor coordination and skillful performance do not emerge from the brain but must be absorbed through the experience provided by sensory inputs entering the central nervous system and by trial and error learning. The received information which imprints neurons and creates feedbacks and correlations will later be expressed by the functioning brain.

In a similar way, the speech areas are undeveloped at birth and it is impossible for a new born infant to communicate verbally. Languages are not dormant somewhere in the brain. A baby must undergo many months of training before it learns, very slowly at first, to parrot some words and then to comprehend their meanings and start constructing phrases. Early sensory experience is decisive for the physiological organization of speech areas.

One of the important differences between animals and human beings is that the instinctive repertoire of lambs and calves, for example, permits them to walk as soon as they are born. This initial advantage, however, represents a neuronal rigidity which prevents significant influence of the environment on their development. In the human species, each individual must learn a multiplicity of non instinctive behavioral responses, thus enriching the personal brain by the cultural acquisition of millenniums of human existence. Genes do provide the initial neuronal mechanisms of learning but <u>not the information to be learned</u> which necessarily originates in the environment and must be introduced into the brain through sensory inputs.

Molecules carrying information have two fundamental characteristics: (1) the message; and (2) a specific address. Peptides, steroids, prostaglandins, and other substances acting as messengers may be compared to orders sent in closed envelopes with well marked destinations. The material substratum is within each organism, but the coded messages originate outside and are received as sensory inputs. These messages will trigger the established mechanisms into action.

Codes are recognizable patterns of material substratum, where the material element is accessory and does not carry information <u>per se</u>. For example, we may write "I love you" on a piece of paper, on a tree, or in the sand, without changing its meaning. Experimental neurophysiology may provide data with which we can understand the correlations between information (including values) and matter, and between brain and mind.

At birth the baby does not recognize the face of his mother, does not talk, does not understand sensory inputs, and is certainly unable to behave intelligently. We must conclude that at that moment the most fundamental mental properties do not yet exist.

It should be made clear that action potentials and the release of neurohumors act as material carriers of coded information in a comparable manner to paper, tree bark, or sand. The meaning of a message will be lost to scientific recording instruments because the meaning is related to frames of reference stored with past personal experience. Memory traces are made by modifications of the neurochemical and synaptic structure of neuronal pools in specific cerebral areas. In this way, the non material aspect of information (its symbolic meaning) is materialized and shapes the anatomy and chemistry of neuronal structures (Lynch, 1985). The reverse is also true: because of the material bases of memory storage in the brain, electrical and neurochemical carriers may be elicited by sensory inputs, triggering the non material manifestations of language and behavior. Ofcourse the evaluation of messages as "non material" is a question of interpretation and the important aspect is the possibility of investigating the molecular and neuronal phenomena necessary for the reception, elaboration, and expression of information (Delgado, 1979). In any case, the process of interconversion between codes and neuronal substance may provide decisive clues for the understanding of relations between brain and mind. At least we may approach both subjects experimentally and study the properties of their relations and intertransformations.

The mind does not appear suddenly or synchronously in all its manifestations but evolves as a multifactorial entity with its many elements at different stages of existence and refinement. Most of these elements are acquired slowly, step by step. Harlow and Harlow (1949) demonstrated that both monkeys and children must learn how to learn. Comprehension of reality, correlation of information, retention and recollection, power of abstraction - all must be learned. Solving one problem facilitates the finding of solutions to other problems.

Development of the capacity to learn and other signs of mental activity are related to the anatomical and functional stages of individual evolution. We know that all young mammals have a period of rapid cellular increase which has been called the "brain growth spurt". There is an initial phase of enormous multiplication of glial cells followed by a process of rapid myelinization which, in the rat, starts at birth and ends at about the twenty fifth day after birth, and which in humans starts at midgestation and ends at about three to four post-natal years. During this time, there is also a major increase in dentritic complexity accompanied by the establishment of synaptic connectivity. Most of this human brain growth spurt (at least 5/6) is post-natal, and this is a delicate period of vulnerability when environmental conditions, including food supply and sensory information, may influence brain development and synaptic connections decisively.

The central nervous system does not develop suddenly (Dobbing and Smart, 1974) or simultaneously in all its different structures. During the brain growth spurt, the human cerebellumm has a more rapid development resulting in a period of greater vulnerability to nutritional restrictions and to Xray irradiation, with a possible association of clumsiness of movements. The brain structures develop at variable rates at each post-natal time. The great variety of mental and behavioral manifestations will be initiated slowly and will progress with different chronology and speeds depending to a large extent on the maturation of their respective neuronal mechanisms. Many of the biosynthetic activities of the brain are only present during the phase of growth spurt and after this period several of the chemical mechanisms are lost forever. For example, synthesis of cholesterol represents an important pathway during the suckling period, while the mature brain tissue cannot synthetize cholesterol _in vivo_ or _in vitro_. Apparently there is a genetically determined brain growth program which must develop at a fixed chronological age. Nutritional deficits or other experimental manipulations may affect the growth but will not change the setting of the chronological program (Dobbing and Sands, 1970). Composition, structure and functions of the adult brain may be permanently handicapped by comparatively mild alterations imposed during the brain growth spurt, contrasting with the negligible effects of severe starvation which will not disturb the well established adult brain (Dobbing, 1976). Since brain growth spurt occurs before that of the whole body, this is the most critical and vulnerable period, representing the once in a lifetime opportunity to build the brain correctly.

There is abundant data demonstrating that, during this early post-natal period, sensory information received from the environment is as essential as the food supply for normal structuring of the brain. As shown by the Berkeley group (Bennett et al., 1964; Krech et al., 1966; Rosenzweig, 1968), baby rats exposed for 8 days to enriched sensory environment had "better brains" than litter mates kept in an impoverished setting. The enriched animals had significant increases in (a) weight of the cerebral cortex; (b) total activity of the cerebral enzyme acetylcholine esterase; (c) cortical activity of cholinesterase; (d) thickness and vascularization of the cerebral cortex. In our laboratory we also observed that keeping baby rats in isolation or in groups which provided multisensorial stimuli caused chemical differences in the brain with the grouped rats showing a significant cerebral increase in GABA and in other brain chemicals (Delgado and DeFeudis, 1977).

As shown by Hyden (1961), early deprivation of sight or hearing in animals results in neurochemical deficits of the corresponding neurons of the sensory cerebral system and their inside looked like empty bags impoverished in both RNA and proteins.

The work of Brattgard (1952) is also in agreement with the decisive importance of sensory inputs for post-natal neurochemical maturation. Animals receiving normal light stimulation during the early post-natal period showed 100% increase in the cellular mass of the retinal ganglion cells, while animals deprived of light did not show this change.

In summary, on the basis of these observations, the following statements are proposed which can be used as working hypotheses for further research (Delgado, 1969):

1. At birth, the human brain is so immature that it does not have the anatomical, chemical or functional mechanisms for mental activities such as language, understanding of sensory inputs, intelligent analysis of information, knowledge and identification of the environment, decision making, awareness of the future, planning of behavior, and other functions. For these reasons, at birth the human mind does not and cannot exist.

2. The moment of <u>legal birth</u> does not coincide with the presence of mental qualities which evolve slowly. The stage of "brain growth spurt" from midgestation until 3 or 4 years of age is the most important period.

3. Identification of a being as human depends on arbitrary agreement about the number and quantity of mental qualities needed. In reality and legally it takes about 18 years to reach full responsibility for individual behavior, indicating the slow development of the human mind.

4. Mechanisms for and existence of many mental functions require as building blocks sensory information provided by the environment which will modify physically and chemically the shape and functions of specific areas of the brain.

5. Since neuronal malleability changes considerably, timing is essential for exposure of the brain to different elements.

4. GIVING PURPOSE TO HUMAN EXISTENCE

Giving purpose to the existence of any inanimate or living entity is not an automatic biological function like respiration, or even a dormant quality of the human brain which may emerge during the process of neuronal maturation. Giving purpose is a personal, sophisticated decision involving interpretation of reality and consequent modification of the (a) processing of information; (b) perception of the received information; (c) establishment of memory traces in the brain; (d) triggering of feelings and emotional reactivity; (e) behavioral output including intellectual and motor expression; and (f) feedback of correlations between the individual and his medium.

Giving purpose to reality is a human activity, not shared with other species, which requires a degree of neuronal compexity, intelligence, and sensitivity.

To evaluate the cerebral processes related to mental activities in general and to "giving purpose" in particular, we may consider the following statements in order to develop suitable working hypotheses:

1. We are discovering the composition, structure, and functioning of existing matter and living creatures, from atomic particles to galaxies, from DNA and viruses to human beings. We are learning the laws and mechanisms of Nature.

2. These discoveries create a new, conscious awareness of existence. Because of the functional properties of the human brain, the cosmos has begun to be aware of itself. This capacity is typically human; it did not exist one or two million years ago before the appearance of man and it is not shared by inanimate objects or by animals.

3. These discoveries promote the use of available resources for the benefit of human beings. Knowing natural laws we can predict - and intervene - in natural events. Agriculture and domestication of animals began in ancient times, liberating man from the uncertainties of food gathering and hunting.

4. These discoveries promoted the invention and manufacturing of tools and their use to control natural conditions: levers to move huge boulders; bows and arrows for hunting and fighting; utensils for cooking; adornments to beautify human existence. The use of tools permits the increasing intervention of human intelligence to modify the natural habitat. An ever increasing human purpose, both creative and destructive, has been imposed on Nature.

5. Scientific findings are ethically neutral. We discover only structures and mechanisms. Interpretations of the purposes of existence are not scientific but philosophical. The scientist may - and probably should - enter into this evaluation to distinguish findings clearly from interpretations. While it should not be assumed, as in ancient cultures, that the world's resources are here to serve us, we are indeed learning to use them, for better or for worse, according to our intelligence. Elements around us have no given purpose in relation to us. Mosquitos do not consciously try to bother humans: they need to suck blood in order to survive. Likewise, cancer cells invade and destroy human tissues because of their abnormal cellular growth. Mosquitoes, cancer cells, and many other organisms may be detrimental to man and therefore we must try to control their proliferation. The same holds true for the rivers which may be controlled with dams and canals. These examples, which may be multiplied "ad infinitum," indicate the reality that we are giving a human purpose to the surrounding world.

6. Although all knowledge may be cosidered ethically neutral, since ethics reflect contemporary human evaluation according to evolving standards and pressures, the consequences of its actual and potential uses are not neutral. The scientist should recognize responsibility for his initial discoveries. Obviously he cannot control their subsequent use or misuse, but he may be expected to take a moral position, considering the individual, social, and

environmental implications of his work in an attempt to direct an appropriate development of his accomplishments.

An amoral position in science signifies a withdrawal from ethics which should not be tolerated by society. Scientists cannot be expected to function as mercenaries for the government or agencies subsidizing their studies. Like all other citizens, they should have the freedom as well as the obligation to formulate and express their social conscience, and their voice is of paramount importance since they are the elite in their respective fields.

7. The basic laws of Nature cannot be changed: we must use them intelligently for human purposes. On earth it is rather difficult to escape from gravity or to remove the air from our surroundings. We have learned that birds fly because their wings create a force uplifting their weight against gravity. Birds fly in agreement with and not in defiance of natural laws. For centuries sailors have known how to employ the prevailing winds to sail in any desired direction, skillfully managing vectorial forces that only recently have been mathematically explained. Modern air transportation offers a most intelligent solution to difficult problems of aerodynamics, jet streams, electronics, and many other complex elements, all of them working together in agreement with, not against, natural laws.

If a person believes that he has suddenly acquired special powers to fly like a bird and jumps out of a window to prove it, he is behaving against natural laws and will crash tragically onto the pavement, as unfortunately has happened a few times to individuals under the influence of drugs. If we learn more about the biological laws of rationality, we may avoid many painful and unnecessary personal clashes against the realities of human life.

8. Scientific knowledge is presently expanding at such a prodigious speed that the human brain is incapable of handling the huge amount of accumulated information and accessory electronic brains including computers, micro-

electronics, and the science of informatics and artificial intelligence have been created to store, retrieve, and process data. We must remember that the inventor, the provider of programs and inputs, and the final user of the processed results is the human brain. Machines have only increased man's efficiency and his responsibility to make intelligent choices.

9. Rapidly accumulating knowledge and technology renders decision making increasingly difficult for the individual. Executives, leaders in politics, business and science are presently being replaced by teams of thinkers and doers who are expert in specific areas.

10. In the past, the ideas, desires and even the capricious behavior of a leader had limited consequences because of his relatively small sphere of influence. Today, however, a political or economic decision may affect all mankind. The formation of OPEP and the subsequent sharp increase in oil prices precipitated a worldwide crisis. The present struggle between two superpowers, with their spheres of influence and accumulation of atomic weapons, has created a balance of terror which is affecting the intellectual, moral, and behavioral attitudes of most countries.

11. Advances in science and technology have adversely affected the lives of many individuals. Automation and the microelectronic revolution should increase production and liberate man from needless labor, but they have not been properly anticipated or controlled and, as many jobs become obsolete, significant sections of the population in industrialized societies are jobless and untrained for novel skills. Future generations must be educated to cope with a highly technical society instead of being left behind. Discoveries must work for, not against man.

12. We cannot ignore the present. We cannot go back in time complaining about today's "artificial" society and fantasizing about yesterday's "natural" world. The privileges of health, material possessions, cultural enrichment, travel, and a longer life span in which to be creative are even today enjoyed by only a minority of the people alive.

With intelligent organization of resources, international cooperation, and leaders who are both efficient and ethical, goals of improving the quality of human life all over the world may be realized. All these aims involve the use of the natural environment with a human purpose. This possibility is unique in the history of the earth because it depends on the appearance of the only organ capable of awareness, superior intelligence, and future planning. The human brain was not invented by man. It is a product of natural evolution lilke the wings of a bird. Nature has created and man is just learning to use this source of power, determined by intelligent efforts of the collective minds of the species.

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