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ABSTRACT

Man's long period of cerebral growth has important implications for education. The brain goes through major developmental changes after birth, and researchers have suggested that this growth process presents an opportunity for fostering the plasticity of genetically determined connections. Animal studies show that postnatal growth of the brain is influenced by increasing the sensory input from the environment. This influence is manifested in terms of increased interconnectivity of nerve cells and microneuron development. It is proposed that, in the human learner, two dimensions of environmental enrichment are necessary: interaction with objects and interpersonal interaction. Implications are discussed for teaching the disadvantaged child and for helping to establish creative modes of thought. Development of better measurement techniques for ascertaining the microneuronal growth pattern and its behavioral correlates should precede further research. (Author/NH)

IMPLICATIONS OF POST-NATAL CORTICAL DEVELOPMENT FOR CREATIVITY RESEARCH [1]

by

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When one thinks of creativity as a cognitive process, three basic factors seem to be of importance: 1) the storage of concrete or abstract conceptions of the environment, that is images, meanings or ideas, 2) a variety of interconnections among these concepts and 3) some means of flexible inhibition and excitation of these interconnections among concepts in response to a situation or problem. These three factors seem to be <u>basic</u> requirements for creativity.

Assuming that information is stored in nerve cells, questions arise as to how connections among these cells are established, how these connections are inhibited or excited during creative thinking and how we as educators can influence this interconnectivity in the brain.

According to current theory, connectivity is a function of the synapse, which is the point at which the axon or dendrite of one neuron comes in functional contact with the cell body of another neuron. It is generally accepted that alteration in the synapse is one factor involved in learning. But a more primary question is what determines which neurons are in synaptic contact with each other. Why does one idea or action follow another? I'd like to discuss these questions in the context of post-natal growth of the brain; growth, that from birth to the age of four has gone from a brain of 335 gm. to 1300 gm. (Altman, 1967). From data available it appears that man has the most prolonged period of cerebral growth, a factor that, as will be pointed out, has important implications for education.

Based on recent studies in neurophysiology it seems that we must consider at least two categories of brain cells. First there is the familiar category of cells that form the motor or sensory relays. These extend from surface receptors to the brain, or from the brain to muscles or glands. Also in this category are the cells that interconnect different parts of the brain. The organization of these connections develops in a specific manner under genetic control, that is they are determined at birth and do not divide or differentiate after birth. These are called macroneurons; they do not divide or change their major connections, although they do increase their dendritic processes, thereby increasing their territory of influence. In addition after birth their axons develop a type of insulation called myelin which increases their speed of conduction. In motor tracts myelinization is correlated with beginning development of coordination at the age of about two years and is manifested as increased skill in walking and fine movements. Carmichael (1954) states that the myelinization of higher associative areas, such as those involved in cognitive processes, continues into puberty and adulthood. Perhaps this is one factor influencing the observed stages of cognitive development.

The second category of cells that undergo post-natal development are most interesting from an educational viewpoint. These are called microneurons and are cells that multiply and migrate within areas of the brain after birth. The peak period appears to be from birth to one and one-half years (see Figure 1). A number of authors suggest that these may be responsible for the plasticity or flexibility of the human central nervous system (Altman, 1967). Table I lists predominant characteristics of microneurons derived from research, and the inferences made by investigators.

If microneurons establish connections under the influence of post-natal interaction with the environment through learning - and, if microneurons play a role in plasticity or flexibility of information processing, - the inferential leap is not too great toward suggesting that creative or imaginative patterns of thinking may be established in early years depending on environmental interaction. Dacey and others (1969) review

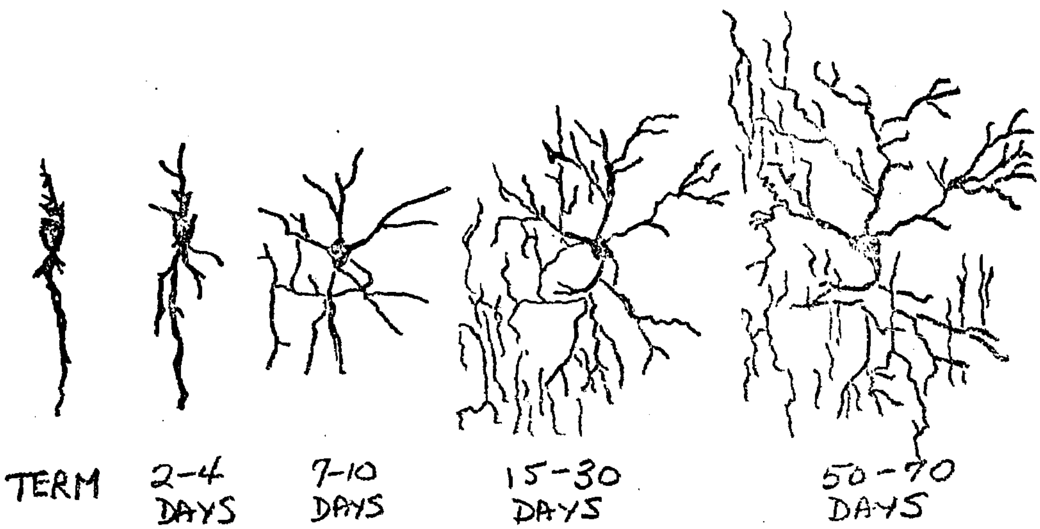

FIGURE 1. DEVELOPMENT OF DENDRITIC PROCESSES OF A MICRONEURON IN THE CORTEX OF KITTENS AT VARIOUS AGES.

TABLE I

CHARACTERISTICS OF POST-NATALLY DEVELOPED MICRONEURONS

RESEARCH FINDINGS	IMPLICATIONS
1. THEY ARE NOT INVOLVED IN TRANSMITTING MESSAGES: ONLY LOCAL OUTPUT. (ALTMAN, 1967)	1. THEY AFFECT TRANSMISSION OF INFORMATION IN OTHER NERVE CELLS. (ALTMAN, 1967)
2. THEY ARE FOUND IN SENSORY AREAS, ASSOCIATION AREAS, AREAS CONCERNED WITH MOTOR COORDINATION AND AREAS PROBABLY INVOLVED IN MEMORY. (ALTMAN, 1967)	2. THEY CHANNEL INFORMATION THROUGH INHIBITING OR EXCITING OTHER NERVE CELLS.
3. THEY MULTIPLY AND MIGRATE WITHIN AREAS OF THE BRAIN AFTER BIRTH. IN SOME AREAS GROWTH CONTINUES INTO PUBERTY AND YOUNG ADULTHOOD. (ALTMAN, 1967)	3A. CONDITIONED LEARNING MAY BE DEPENDENT ON THEIR MATURATION (KONORSKI, 1967) 3B. BECAUSE OF POST-NATAL DEVELOPMENT THEIR ROLE COULD BE TO ADJUST GENETICALLY SPECIFIED CONNECTIONS IN ACCORDANCE WITH ENVIRONMENTAL CONDITIONS. (ALTMAN)
4. THEIR NUMBER IS THE MAJOR DIFFERENCE BETWEEN THE CORTEX OF MAN AND ANIMALS (STELLATE TYPE). (BERITOFF, 1965)	4. THEY MAY BE ONE OF THE STRUCTURES RESPONSIBLE FOR THE PLASTICITY AND ADAPTABILITY OF HUMAN BEHAVIOR. (ALTMAN)
5. AN ENRICHED ENVIRONMENT INCREASES THE MULTIPLICATION OF MICRONEURONS AND INCREASES THE NUMBER OF SYNAPSES (CONNECTIONS) IN RATS. DIFFERENCES DUE TO THE ENVIRONMENT WERE FOUND IN BOTH MATURE AND YOUNG ANIMALS. (ROSENZWEIG, 1964)	5. DEVELOPMENT OF MICRONEURONS IS PROBABLY CONTINGENT ON SENSORY INPUT AND FEEDBACK, WHILE THE ORGANISM INTERACTS WITH THE ENVIRONMENT. (ALTMAN, 1967)

a number of authors (e.g. Deutsch, 1960; Rank, 1945) who suggest that there may be a critical period, the early years, in which modes of thinking are more easily established. This is not to say that after this point determinism operates but rather, that different modes may be more difficult to acquire.

Generally, then, microneurons and the connections they establish in the brain seem to exert some control over information processing. One example of this has been found. At the spinal level microneurons can inhibit, or exert a focusing or sculpturing action, on the intake of information. Inadequate post-natal development of these and higher connections may be one of the causes of perceptual and information processing difficulties, as found in environmental restriction studies.

The behaviors observed under environmental deprivation, such as the studies on institutionalized children, can be contrasted with the descriptions of creative individuals. The contrast is evident in Table II. It would appear that the information intake and processing capabilities are quite different. The problem is to isolate what makes this difference. Does interaction with a rich environment effect the interconnectivity of the brain, as the previously discussed data suggests? We have always assumed that a rich environment will lead to greater information intake and therefore, a greater amount of knowledge about the environment stored in the brain. Does it also lead to more varied modes of thinking or information processing? It would seem that just variation in the environment would not affect modes of thinking. In addition the human learner needs to try out different modes of information processing. He learns these primarily through interpersonal interaction with significant others, who encourage him to deal with information in an exploratory manner.

TABLE II

Descriptions from Deprivation Studies

Failure to attend selectively to environmental stimuli

Fewer cognitive structures

Lack of sustained attention

High arousal with stimulation

Information intake capabilities

Less ability to imagine consequences of actions

Decreased problem solving ability and planning ability

Failure to inhibit irrelevant response patterns, impulsivity

Stereotyped response patterns

Information processing capabilities

DESCRIPTIONS OF CREATIVE INDIVIDUALS

Tolerance of ambiguity, inconsistency

Tolerance of ambivalence

Greater number of alternative dimensions or categories for judging stimuli

Greater category breadth

Perceptual curiousity

Information intake capabilities

Desire for conceptual conflict

Deals with inconsistent information

Searches for inner states or mediating concepts to explain observations

Sensitivity to discrepancy between consistent and inconsistent information in the environment

Information processing capabilities

It seems to us that improved measurement of these factors within the first year and one half of life will have sweeping effects on creativity theory. What is needed is an acceptable technique for determining the degree of multiplication, migration and interconnectivity of the microneurons in infants. One such technique is now being used successfully with higher primates (Woodbury and Esplin, 1959). It employs the measurement of cortical excitability as an index of brain development utilizing the Maximal Electroshock Seizure technique (Woodbury and Esplin, 1959). Another technique currently being employed in Czechoslovakia is the selective destruction of particular cells or areas of the brain by antibodies; this could be adapted to the study of microneurons.

It may well turn out, however, that behavioral measures which are found to be caused by or at least highly correlated to growth in the microneuron system will be the most convenient method of assessing growth patterns of the system. When this is more fully developed, teams of neurophysiologists and behavioral scientists should be able to answer many important questions having to do with the prediction, causation and facilitation of creativity.

On this last question, facilitation, J. McV. Hunt's response to Arthur Jensen's allegation that compensatory education has failed is of interest (Hunt, 1969). Hunt argues that projects like Head Start may be failures because the attempt to make an impact on the child's development comes too late. He says that "...mankind has not yet developed and deployed a form of early childhood education (from birth to age five) to permit him to achieve his full genotypic potential" (p. 292). He argues that even if the genetic factors within a particular group do make for lower intelligence, there is reason to believe that appropriate environmental stimulation could improve those factors over a relatively short period of time. He cites the increase in height of Western man of an average of one foot within a two century time span as evidence of the responsiveness of genetic structures to the environment. Changes in neurological factors (microneurons, mainly) influencing intelligence and creativity might be brought about not only through educational stimuli (e.g., creative playthings, etc.), but also through neuro-surgery and chemical and eldctronic stimulation (Quarton, 1967).

In summary, the brain goes through major developmental changes after birth. It has been suggested that this is an opportunity for fostering the plasticity of genetically determined connections. Animal studies show that post-natal growth of the brain is influenced by increasing the sensory input from the environment. This influence is manifested in terms of increased interconnectivity of nerve cells and microneuron development. It was proposed that, in the human learner, two dimensions of environmental enrichment are necessary: interaction with objects and interpersonal interaction. Before this vital research can take place, much better measurement techniques for ascertaining the microneuronal growth pattern and its behavioral correlates will be necessary.

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