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Dynamics of learning and recent RX toward improving memory abilities

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THE DYNAMICS OF LEARNING

AND

RECENT RX TOWARD IMPROVING

MEMORY ABILITIES

by

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THE PROBLEM AND ITS SIGNIFICANCE

Statement of the Problem

Memory pervades every sphere of human activity and raises many problems of practical concern, both to the individual and to society at large. Small wonder, then, that the topic of memory has attracted the attention of scientists and of educators since ancient times and has, in the present century, been explored by the various sciences which study man and his activities. A very revealing paragraph follows which proves that memory has been the concern throughout centuries of historical research:

> More than 2,000 years ago the Greeks were already trying to explain how memory works. Aristotle suggested that the senses stored memories in the mind by making imprints on it like those made by a signet ring on wax. The very young and very old stored memories poorly, he said, because their wax was in a state of flux. Plato outflanked the problem by saying all true ideas preexisted in the brain, and that knowledge came from correctly matching sensory input to that basic, innate imprint. The Greeks, in fact, recognized that one kind of sensory memory--our ability to store and recognize--is in many ways more effective than our capacity for handling words and ideas. On the basis of this discovery they developed the "art of memory", using the same trick modern-day memory experts use and recalling verbal information by linking it to more easily remembered images.[1]

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[1]Rick Gore, "The Brain," Part III The Mind in Action, Life Magazine, Volume 71, No. 20 (November, 1971), 70.

Importance of the Study

As an educator among educators, the writer is concerned with the intellectual potential of individuals viewed through their intellectual ability, and, presently, restricted to the function of memory. The writer is also deeply interested with the nature of research in several areas which encompass "memory"--the key to educational improvement.

Throughout the centuries one problem has been to decide what memory is and as possessed by particular individuals. Presently, what we actually think of as our memory is really the combination of at least two systems: sensory memory and verbal memory. Certainly the brain's most essential function is memory and without this miracle function which enables us to store and recall information, the brain's crucial systems for waking and sleeping, for expressing how we feel about our surroundings and for performing complicated acts could do little more than fumble with the sensory inputs of every moment. Without memory, man's extraordinary powers for putting things into groups, for relating likes and unlikes, for generating options and hypotheses, for creating the complicated fabric of his life, simply would not exist. Thus the brain mechanisms which are involved in storage and retrieval of memories are of peculiar interest to mankind because memories are among the ingredients of thought. After thousands of years of theorizing, of reading and misreading his own behavioral quirks, man is just beginning to have some understanding of the mysterious process that permits him to break and store bits of passing time. An understanding of the mystery of memory processes could provide a uniquely intimate insight into the material bases of the human experience.

Today there are many new clearings and older clearings have been enlarged, and these clearings are joining up to form an organized whole.

Learning is the core of human understanding and adjustment. We learn by living and we live by learning. Without our ability to remember past experience, we would be wanderers in a world perpetually new to us. Each encountered situation requires reflexive or random behavior. Therefore, learning is a process which brings about changes in the individual's way of responding as a result of contact with aspects of his environment. What actually takes place during learning is still a mystery, as is the question of whether there is an all-around learning ability because learning does not happen passively. It is an activity which a person does. It is a task which can be attempted in various ways, some of which are more appropriate than others.

Effective learning conditions are expressed by William James as: "Briefly, then, of two men with the same outward experiences and the same amount of mere native tenacity, the one who thinks over his experiences most, and weaves them into systematic relations with each other, will be the one with the best memory."[2] Organizing the task of learning is an activity which must be taught to children. Nevertheless, learning improvement is not guaranteed by the mere giving of "rules" for success. Of itself, practice in learning development techniques offer a constant challenge to interested educators.

A major difficulty in educational research is the inability of students to deal vigorously with the interaction of variables affecting social and mental processes. Many human activities result from complex mental processes that are not easily made directly observable.

The purpose of this research paper is to explore the future of the mind, especially the memory labyrinth which affects the life of man--as glimpses of it are caught in experimental laboratories and trying to foster a better plan to develop the mind in the education of the young.

Scope and Limitations of the Study

The scope of this research paper is merely an amateur's attempt to a survey of older clearings and to supply recent clearings in the broad field of memory and learning discoveries, and also, of supplying psychological guidelines which may serve as directives to interested educators, inasmuch as this study will have to offer. If men of science

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[2] Ivan M. L. Hunter, Memory, 2nd reprint, Great Britain: The Whitefriars Press, Ltd., 1970.

haven't found all the answers, the writer does not intend to solve the "memory" or "learning" problems. Yet, the writer does hope that her limited knowledge will prove her interest in the field of memory and learning improvement; especially in her effort to help individuals to a social adjustment according to the possible development of their native potentials.

CHAPTER II

RECENT RESEARCH ON CURRENT MEMORY EXPERIMENTS

Man has always been challenged by himself. In science, authority comes only from factual evidence derived from systematic, repeatable observation. Ideas that have been accepted for centuries, that have been supported by brilliant and eminent men, must be discarded or revised as new facts emerge. Concepts that seem strange and implausible but which can explain and predict previously unpredictable phenomena are examined and accepted. Science is active, always testing, revising, reformulating, always changing.

Accurate observations of one set of events becomes the basis for predicting future events. Science deals with consistent relationships; the scientist deals with consistencies in behavior. He attempts to find general laws that will enable him to understand and predict behavior.

For years science has nibbled away at the whole area of the brain, "the great raveled knot". Scientists know that answers lay hidden in tortuous pathways that feed into each other. The disentangling will be slow and arduous, but it has begun. Recent experiments will prove that the knot is unraveling through continuous research.

Neonatal Conditioning

Conditioning in the first four weeks of life, the neonatal period, may be significant for later patterns of behavior. But valid research evidence relating early conditioning to later behavior has been difficult to obtain because of the absence of conscious awareness or cognitive recall during the neonatal period.

Psychologist Virginia Johnson of Los Angeles reported at the neuroscience meeting that in an experimental program based on experiential recall a number of subjects were able to recall neonatal experiences. The subjects were given high doses of methylphenidate--a mild brain-stimulating drug. Interviews conducted after the drug was discontinued elicited recall sequences that reflected early conditioning affecting known patterns of later behavior. They were frequently specific with respect to psychopathological symptoms. Johnson says this suggests that neonatal experiences leave permanent memory traces; that such experiences are significant for later behavior and that they are accessible to certain recall techniques.[1]

Geniuses May Come From Placentas

The interesting findings of three scientists, Drs. Stephen Zamenhof, Edith Van Marthens, and Mrs. Ludmila Grauel,

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[1] Behavioral Sciences, Science News, Volume 100, No. 19 (November, 1971), 313.

at the U.C.L.A. Medical School Mental Retardation Center revealed that geniuses may come from large placentas.[2]

In their study of the relationship between placenta and brain size in rabbits they discovered that there was a distinct variation in the size of placentas in normal rabbit litters, and that the larger the placenta, the larger the baby rabbit was at birth. Size of the animal, they reported, correlated with the size and weight of the brain and number of brain cells. This, in turn, they concluded, could result in higher intelligence.

Fetal Brain Waves Recorded

An electrode system that will free nurses from having to listen every fifteen minutes for the fetal heartbeat during labor is being set up at the University of Rochester's Strong Memorial Hospital. It will help physicians learn about causes of brain damage in newborn babies by applying the electrode to the head of the fetus early in labor. This brain wave-measuring system is the first of its kind.

Scientists have not yet discovered which of the many prenatal influences are critical and how they act on the fetus. More than a quarter of a million newborns a year show brain damage or mental retardation.[3]

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[2]Medicine, Science Digest, Volume 69, No. 2 (February, 1971), 7-8.

[3]Medical Sciences, Science News, Volume 95, No. 22 (May 31, 1969), 529.

Malnutrition not a Unique Factor

Tests show that malnutrition in early life permanently impairs the functioning of the nervous system and results in loss of learning ability. According to Dr. Ernesto Pollitt of Yale University School of Medicine, this is an incomplete picture.

The learning ability of the malnourished child should not be judged solely on the basis of nutritional background, he says. When considering malnutrition--protein-calorie deficiency--and poor test performance in children, other factors may well come into play. Dr. Pollitt considers two variables: an appropriate measure of nutritional history is often very difficult to find, and biological and social factors affect the overall development of a malnourished child and it is often difficult separating these from the nutritional components.

When animal studies are undertaken, the results are often incomplete or different from human studies. Dr. Pollitt, in the May-June, 1969, issue of Psychosomatic Medicine, establishes the need for more research in the field--studies involving the use of affected cases as their own controls.[4]

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[4]Behavioral Sciences, Science News, Vol. 96, No. 2 (July 12, 1969), 31.

Effects on the Brain

Malnutrition during periods of rapid brain growth in the fetus and infant produces permanent mental deficits. Dr. Delbert Dayton of the National Institute of Health in Bethesda, Maryland, says the damage occurs during the phases when cells are multiplying.

The brain grows in three phases, including a period when cells multiply, when cells increase both in size and number, and a period when the cells increase in size alone. If malnutrition occurs in either of the first two phases, says Dr. Dayton, it can interfere with cell division, thus resulting in fewer cells in the brain. This could be a permanent effect, he says.

Cell division in the human brain usually occurs during the development in the uterus and the early part of the first year of life. Dr. Dayton cites a study where markedly fewer cells were found in the brains of a small sample of children who died of malnutrition during the first year of life than in the brains of a group of well-nourished children who died in accidents.

Although these studies demonstrate the importance of nutrition during development of the nervous system in these stages, it is not known whether this represents an irreversible change.[5]

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[5]Medical Sciences, Science News, Vol. 97, No. 3 (January 17, 1970), 70.

Memory and Protein Synthesis

Researchers at the University of Pennsylvania have shown tests with mice that memory probably does not depend on continuing synthesis of protein.

Previous research with the antibiotic puromycin--a drug which interrupts protein synthesis--resulted in loss of memory of test animals.[6] This suggested to Dr. Lewis B. Flexner that protein synthesis in the brain was necessary for memory.

Experimenters with other antibiotics brought no memory loss, although they did interrupt protein synthesis. Since these experiments seemed to negate the theory of protein synthesis affecting memory, the investigators are looking for other areas of the brain affected by puromycin.

Although study is not complete, it appears, says Dr. Flexner, that the abnormal molecules created by the puromycin may be the real reason the mice lose their memory. These molecules may somehow interfere with the functioning of the nerve cells in the brain.[7]

More Evidence that Malnutrition Causes Brain Damage has come out of research at the Massachusetts Institute of Technology. Undernourished rats killed a few weeks after birth were proven to have damaged brain neurons. This is further evidence that inadequate protein early in life of a

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[6]Psychbiology, Science News, Vol. 95, No. 1 (January 1, 1966), 3.

[7]Behavioral Sciences, Science News, Vol. 96, No. 2 (July 12, 1969), p. 30.

human baby can interfere with brain development, the ability to learn and general behavior patterns.[8]

The Brain Dictates Our Eating Habits through a sensory network extending from the oral cavity and stomach to the "feeding area" of the brain, studies at U.C.L.A. indicate. Drs. Wanda Wyrwicka and Michael Chase have demonstrated that sensory receptors in the mouth project into the parts of the brain related to feeding. One part stimulates and the other inhibits eating. If the inhibitory section is destroyed in animals, they overeat but if the stimulating part is destroyed they will not eat at all.[9]

Brain Affected by Environment

That the brain is materially affected by experiences engaged with the environment and by the general amount of brain activity has been clearly demonstrated at the University of California in Berkeley. Drs. Edward L. Bennett and Mark Rosenzweig have been subjecting animals to different environments designed to require varying degrees of activity from the animals.

There were basically two experimental groups of animals: Gerbils lived either in isolation--the impoverished condition--or in groups of twelve in a large cage provided

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[8]News in Brief, Science Digest, Vol. 69, No. 5 (May, 1971), 5.

[9]News in Brief, Science Digest, Vol. 67, No. 6 (June, 1970), 6.

with numerous objects to offer varied stimulation--the enriched condition. Following suitable periods of exposure to their environment, the animals were killed and their brains subjected to quantitative measurements and chemical analysis.

Gerbils from the enriched condition exceeded those from the impoverished condition in weight of cerebral cortexes. Chemical analysis showed the animals of the enriched condition with a greater amount of enzyme related to synaptic functioning, a good indication of higher rate of brain activity.[10]

"Kholod" Brain-Cooling Helmet

Professor Victor Bukov of the USSR Institute of Clinical and Experimental Surgery and his associates have developed a brain-cooling helmet, reports the Soviet press. The device will be used in brain, heart and other major operations in which the heart must be disconnected from the blood circulation system which supplies oxygen to the brain. Since the brain can only be deprived of oxgyen for four to five minutes without causing serious and irreversible brain damage, various methods have been devised to alleviate this situation, including the heart and lung machine and the general hypothermy (cooling) method. Soviets claim that

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[10] Life Sciences, Science News, Vol. 95, No. 18 (May 3, 1969), 428.

the "Kholod" brain-cooling helmet has many advantages over the previously used methods since it excludes the possibility of heart fibrillation, provides a five to six times longer period for a surgeon to perform the operation and can be used in emergency cases without the need of prolonged preparation. Automatic cooling of the head is achieved via a special liquid mixture circulating in the apparatus in a closed cycle. Jet streams of the mixture, under pressure, fall upon the patient's head through numerous openings in the helmet, penetrate the hair, and very quickly and effectively lower the temperature of the cortex. Over 50 operations already have been performed with the new method and all have been successful, the Soviets claim.

In the United States, a similar cooling helmet has been developed by Dr. Arthur Cushman and his associates Doctors S. Rouche, G. Austin, and N. Horn of the department of neurosurgery of the Loma Linda School of Medicine in California. Dr. Cushman states that the unit is still in experimental stages but promises to be most effective in surgical applications. He says that a similar helmet was used in the United States for treatment of headaches in the middle of the nineteenth century.[11]

All of Us Are Mentally Retarded to a degree, as a result of slight brain damage at birth. That's the word from

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[11]Medicine, Science Digest, Vol. 69, No. 3 (March, 1971), 21-22.

Dr. Abraham Towbin of Harvard Medical School, reporting in the Journal of the American Medical Association.

"Hypoxic and mechanical injury to the central nervous system, in some measure, is inescapable," says Dr. Towbin. Hypoxia (oxygen starvation) is a major cause of neurologic disorder, the report reveals, and can result in cerebral palsy, epilepsy or mental retardation--from mild to severe. According to Dr. Towbin, more than 3,000,000 American adults and children suffer at least minimal brain dysfunction--which could spell the difference between an average child or genius; or brothers--one a skilled athelete; the other awkward. Brain injury is a particularly iminent threat to premature births, according to the report.[12]

Alpha for Anxiety

A number of researchers in the field, like Dr. Joe Kamiya of San Francisco's Langley Porter Neuropsychiatric Institute are cautious about the claims made for alpha waves. "There is no evidence that alpha does anything to a subject," he notes, "except that some say it helps them get away from anxieties." According to Dr. Thomas Mulholland of the Bedford, Massachusetts, V.A. Hospital, nearly anyone can produce alpha waves simply by closing his eyes in a darkened room. Kamiya wants to define mental states associated with all types

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[12]News in Brief, Science Digest, Vol. 70, No. 5 (November, 1971), 5.

of brain-wave patterns, and Mulholland is devising a way to use discrepancies in the ouput of alpha waves on each side of the brain during biofeedback as a means of diagnosing brain disorders. Dr. Donald B. Lindsley of the University of California at Los Angeles thinks brain-wave studies may help educators define the times when children are most receptive to schoolwork.[13]

L-Dopa a Brain Pill?

The new drug for Parkinson's disease has exceeded expectations as a tremor-reliever as it also appears to be increasing intelligence of patients. Presently, it cannot be regarded as a "brain pill", but tests on goldfish have pointed to the brain-enhancing quality under experimental conditions. Normal fish who are taught to avoid an electric shock learn twice as fast when given L-dopa, a possible brain pill for the future.

However, Dr. Benjamin Boshes, chairman of the neurology department, Northwestern University medical school, says, "it cannot now be regarded as a "brain pill". Yet, there is no question but that L-dopa is enabling us to move into a new era of understanding the chemistry of the brain." There is

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[13]Medicine, "Probing the Brain," Newsweek, Vol. 77, No. 25 (June 21, 1971), 65.

quite a bit of excitement among researchers. The value of L-dopa is expected to go beyond the benefit to Parkinson patients.[14]

Large R N A for X-Ray Study

University of Wisconsin scientists reported they have discovered a large R N A crystal which will lead to further understanding of the mechanisms of protein synthesis in the living cell. A breed of transfer-R N A, the crystal of the nucleic acid is large enough to be studied by X-Ray diffraction.

Knowing the diffraction pattern of the molecule will facilitate understanding of how the transfer action works in picking up amino acids and aligning them for protein synthesis, says Dr. Robert M. Bock, director of the research team of molecular biologists at the Sloan-Kettering Institute for Cancer Research in New York. The crystal is present in the serum of pigs.[15]

According to Baylon College pharmacologist, Dr. George Ungar, a memory chemical which he isolated from the brains of rats trained to fear the dark makes untrained rats fear the dark, too. Called scotophobin, the chemical has been synthesized almost perfectly. When the synthetic scotophobin is

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[14] News in Brief, Science Digest, Vol. 69, No. 2 (February, 1971), 56-57.

[15] Life Sciences, Science News, Vol. 95, No. 18 (May 3, 1969), 428.

given to rats, it induces fear of the dark although higher doses are required than with the natural chemical.

The Hungarian born pharmacologist, thinks his discovery is the first step in decoding the complex chemical language by which the brain processes and learns information. He also notes that this is the first chemical code work to have been identified and by code word he infers that there is a system of signals in the brain by which the information is processed, as in a computer.

In five years, Dr. Ungar predicts, that we may have a glimpse of the general outlines of the code as it applies to the human brain. The first human applications of the research could follow in another five years in the treatment of some kind of mental retardation, senility and brain defects. The first application could be done with retarded children. Simple things like toilet training, walking, and so on could be possible.[16]

Memory Lab Reports Progress

Sasha K., 19 year-old student of one of the Moscow technical institutes, can remember, in less than three minutes, a set of forty-two numbers written in one line. A Tass correspondent has witnessed one of the memory experiments conducted at the laboratory of A. Luriya, the famous Soviet

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[16]Colleges in Action, Science Digest, Vol. 69, No. 4 (April, 1971), [illegible]-82.

psychologist, widely known for his work on the problems of memory. For fifteen seconds, Sasha looks at the set of numbers written on a white sheet. Then, setting the sheet aside for forty-five seconds, he conducts a mental verification of the numbers. After that, both operations are repeated and in two minutes and forty seconds he almost repeats all of the numbers in the set in their proper order. The article claims that Sasha can remember the sets of numbers for a long period and can repeat all of them correctly even as much as ten days after the experiment.[17]

Delgado: Stop the Bull

Yale's Delgado forsees a future society that has become "psycho-civilized", through the application of ESB--Electronic Stimulation of the Brain, and other techniques. Psychologist-philosopher Arthur Koestler argues that the psycho-civilizing process can begin none too soon if man is to be saved from himself. "It's a race against the clock," says Koestler. He specifically advocates biochemical manipulation to insure the dominance of the brain's rational cortex over irrational, animal-like "old cortex". Koestler asks: "Why despair of the possibility of stabilizing people, of harmonizing them without really castrating them, without sterilizing them mentally?

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[17] Russian Press Reports on Soviet Science, Science Digest, Vol. 69, No. 5 (May, 1971), 86-87.

Others take a distinctly gloomy view of the prospects for the future. The question is asked: if human behavior can really be so radically altered by psychosurgery, ESB, biofeedback and genetic tinkering, does it not follow that society itself might some day be governed by the wholly rational supermen with their superbrains whom the brain researchers and their colleagues have created?[18]

'What Makes Me a Unique Being?'

Eccles and his wife, Helena Taborikova, a distinguished neurophysiologist in her own right, sit before a wall of electronic equipment, watching a computer dial and TV monitor and listen intently to crackling sounds emanating from a loudspeaker. A fluffy white cat lies anesthetized on a table nearby with a microelectrode 1/50,000 of an inch in diameter at its tip inserted into its brain. Eccles had been the first to use such electrodes to record the internal electrical impulse of a single nerve cell exactly twenty years ago. Today, he was to be the first to tune in on naturally stimulated neurons of the "roof nucleus" in the cerebellum.

For fifteen hours straight, bolstered only by peanut-butter crackers and the excitement of the hunt, he sticks to the task. "It's like planning a campaign," he remarks. "We're

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[18] Medicine, Newsweek, Vol. 77, No. 25 (June 21, 1971), 67.

still feeling our way. No one has ever looked at these cells this way before." The clicks from the loudspeaker come slowly now as the electrode is advanced micron by micron into the brain. "Why is this cell so sluggish, so lazy?" Eccles muses. Suddenly there is a high-pitched screech from the loudspeaker--the electrode has just pierced a cell and killed it. "It's almost human, isn't it?" says Lady Eccles.

Quest: Finally, there is the sound of lively firing from another neuron and Eccles looks pleased. "It's a good cell," says his wife; and together they record the distinctly different patterns of sound the cell makes as various parts of the cat's body are brushed or touched. I was amazed to find that the clicking language the neuron used when one footpad was tapped bore no resemblance to the sound it produced when another foot was touched. It wasn't even a mirror image. "In this business," Eccles says, "we've learned that everything is possible. We're always learning, learning, learning."

The quest for learning keeps Eccles in his lab until after midnight several nights a week. It is thanks largely to his efforts that the cerebellum, which controls the subtlety and skill of movement, is the best-understood part of the brain. Eccles notes that the cerebellum, with its densely packed clusters of cells, is the organ of the brain that most closely resembles a computer. He adds that it is also superior to any machine conceived by man. "Imagine," he says, " a computer designed to make a robot go through an extra performance of 'Giselle' equivalent to that of Margot Fonteyn's."

"What," I asked Eccles later, "is one of the most important insights that recent research has produced about the brain?" After a moment's reflection, he cited the growing realization that a very large number of nerve cells at the higher level of the brain do not excite other nerve cells to fire, but inhibit them from doing so. Inhibition, he explained, prevents the brain circuits from becoming overloaded with information and keeps the neurons from working at cross-purposes; to flex an arm, for instance, some muscles must be put to rest, even as others are pulled into action. "Now we know that inhibition is at least as important as excitation." Eccles said. "It's like sculpture, what you cut away from a block of stone produces the statue."

<u>Continents</u>: Like many scientists in basic research, Eccles is notably conservative, and he takes a dim view of some of the more highly publicized experiments in brain control. "Anybody can buy a machine and turn it onto the brain and write up the results," he says. "The number of papers being published on the brain is doubling every two or three years, but most aren't worth reading." For Eccles, the search for an understanding of the brain is like charting continents, and each new landmark produces yet another challenge. "The more heights you reach, the more country you see that looks interesting," he says. "There will be no end to this enterprise, at least for centuries."

Despite (or perhaps because of) his half century of experience as an explorer of the physical brain, Eccles steadfastly refuses to accept the notion held by many of his colleagues--that the brain and the mind are one. He still thinks that they are separate and distinct, and ventures into epistemology in explaining himself. "I can explain my body and my brain," he says, "but there's something more. I can't explain my own existence. What makes me a unique being?"

Eccles insists that this line of thinking is not invoking the supernatural, but that it is rather "making a play for honesty." He goes on: "We should not pretend that consciousness is not a mystery. People are looking for packaged answers. There are none." Now and again one hears echoes of Teilhard de Chardin or Jacques Monod. "If we are still essentially automotons," he says, "then all moral judgments are phony. How can Calley be blamed for anything he does? Is there anything more than training? Are we only playthings of chance? This is what I resist."[19]

Learning and Memory Transfer: More Experimental Evidence

Until recently the transfer of learning and memory from one brain to another brain was straight out of science

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[19]Medicine, Newsweek, Vol. 77, No. 25 (June 21, 1971), 66.

fiction. Then in the early 1960's investigators turned fantasy into reality by feeding brains from flatworms trained to respond to light or to navigate a maze to untrained flatworms, and found that the recipients aped the donors' behavior. In 1965, Ejnar Fjerdingstad of the University of Copenhagen took a crucial experimental leap from the worm to a vertebrate, the rat. He trained rats to go to light in order to receive water, then injected the brain material from trained rodents into naive ones. The recipients did not imitate the donors' learned habit right off, but they did acquire it faster than control rats that had not been injected, implying that the injected brain material indeed boosted learning.

There are now some thirty-two laboratories in the United States injecting brain extracts from trained amphibians, fish, mice, and rats into untrained recipients, and the work seems to be achieving ample success in modifying the behavior of the recipients. Most brain transfers are limited to one species, although several labs are transferring brain material from one species to another, with some positive results.

What's more, the first memory molecule has been isolated, characterized and synthesized by George Ungar of Baylor University in Houston and by Wolfgang Par of the University of Houston. They first announced the achievement last December, 1970, and a technical report will appear soon in Nature. What these investigators did was slowly to accumulate several pounds of brains from rats that had been shocked in the dark. They tested different fractions of this brain material for memory transfer ability in recipient rats until they narrowed the material down to what appears to be the actual molecule. It is a protein and dubbed "scolophobin" after the Greek words for "fear of the dark".

Several groups are now working with scotophobin. William Braud, a psychologist at the University of Houston, for example, reported at the first annual meeting of the Society for Neuroscience in Washington that he has been injecting extracts of crude rat brain (which he believes are scotophobin) into fishes' brains. The recipient fish indeed exhibited fear of the dark. The fear lasted up to ten days in some fish, but usually not more than six days and was an on-again phenomenon.

Rodney Bryant at the University of Tennessee confirms this short, transient effect. He reported at the neuroscience conclave that he has injected synthetic rat scotophobin into the brains of hundreds of goldfish. While the fish indeed exhibited fear of the dark and resisted learning to swim into the dark, the fear was of brief duration. "I would not say scotophobin is a memory molecule at this point, but memory linked," he said.

Then Ronald Hoffman, a biophysicist at the University of Houston, reported that after teaching goldfish to swim through a triangle to get food, he injected their brains into other fish. All swam to the triangle without prompting.

Yet here again, instilled learning lasted but a day or two. Hoffman is now working on the isolation and purification of the learning molecule involved. He thinks it is a protein--R N A complex.

Even these vertebrate experiments, though, haven't convinced everyone that learned information can be transferred chemically from one organism to another. Scientists who believe that memory is primarily a function of the neural pathways of the brain, requiring an intact brain, particularly score the possibility that memory is solely a cellular, or biochemical, phenomenon. Nonetheless, those investigators doggedly pursuing biochemical packets of learning and memory avow that they have analyzed their results statistically and that the behavior of recipients is definitely not chance. Those workers tend to agree, though, with William Byrne of the University of Tennessee and author of a book on learning and memory molecules that far more brain material must be obtained, scrutinized and tested before biochemistry's true role in learning and memory can be delineated.[20]

A Pill for French

Many scientists remain highly skeptical at the prospect of an injection or a pill that could impart any kind

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[20] Science News of the Week, Science News, Vol. 100, No. 19 (November 6, 1971), 308.

of learning, including intellectual skills. For the most part, they point out, drugs improve deficient function, but do not boost normal function. "Drugs function at the level of emotion, not cognition," adds MIT's Seymour Kety. "I don't see how you could make one that would teach French."

French pills or no French pills, the fact remains that the day may come when the combined efforts of the brain researchers and the genetic engineers will enable men to alter radically the functioning of the human mind, and while some scientists and philosophers take cheer in the prospect, others find it a somber one, indeed.[21]

Experimental Generalizations

You look up a phone number, close the book and dial. Seconds later the number is forgotten. You may remember the name of your first-grade teacher. Yet the name of the person just introduced at a dance escapes you. Lines of a poem learned long ago flow back easily. But for the life of you, you can't recall that it was apples you were supposed to buy on the way home.

Nearly 10,000 thoughts pass in and out of your mind every day. Luckily, most are forgotten, since they are trivial, useless or irrelevant. How, though, do you remember the ones you retain? What makes one person seem to be a

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[21]Medicine, Newsweek, Vol. 77, No. 25 (June 21, 1971), 67.

walking encyclopedia, another a veritable dunce about past events? Can you do anything to bolster your own memory?

Memory alone won't turn you into a genius. Consider the plight of one 18th century Englishman who could multiply millions by millions in his head, yet who was otherwise so dull that he never rose above day laboring. Even so, most authorities agree that memory and intelligence do generally go together. One measure of the efficiency and degree of both is the size of the vocabulary a person comprehends and uses. Whatever makes one person remember better than another is akin to whatever makes one person brighter than the next.

Fundamentally, memory is learning. How a thing is learned decides just what kind of memory it is. Learning to skate, for example, is a skill. Memorizing the names of the states and repeating them is a verbal response. Learning to fear serious disease is an emotional response. You remember some skills and some verbal and emotional responses for a lifetime, and you forget others. Usually, skills and emotional responses are better remembered than verbal responses.

Memory particularly recollection of recent events, begins to fade with age. Tests comparing people in their sixties with those in their twenties showed the oldsters remembered 40% less of what they had just read than the young people.

There are exceptions, notes gerontologist Dr. Nathan Shock of Baltimore, who finds little or no impairment in oldsters of high accomplishment in life. "Mentally active people seem to keep their memories intact longer," he says.

Memory varies in duration, too. The phone number you forget just after you have dialed it is a short-term memory. But one used over and over is different. You may be able to recall it even if you haven't used it for months. It becomes a long-term memory.

Detecting the differences between the two and identifying mechanisms that cause some short-term memories to become long-term are two main riddles of learning that scientists the world over are trying to solve.

Obviously, a telephone number you carry in your head is only one of the thousands of bits of information you can dredge up to order. Yet, it illustrates four steps of learning and memory we all go through: receiving, filing, retaining and recalling information cue. How is the trick done?

No one knows for sure, but interesting theories are emerging. The human brain, seat of memory and learning, contains an estimated ten billion microscopic nerve cells called neurons, plus another hundred billion of a second kind called glial cells. Electro-chemical interactions take place with the help of a fluid bath in which the cells are suspended.

The neurons receive and transmit impulses of emotions, memories and thoughts. Neurons are irregularly shaped cells with delicate projections called dendrites angling out in many directions. An unusually long branch, called an axon, can measure inches or even feet. Typically, the dendrites of one neuronal cell don't quite touch those of another. The gap between is called a synapse.

When stimulated, a neuron transmits a weak electric impulse along its surface and down its numerous projections. Ordinarily, the impulse would stop at the synaptic gap. When chemical environment at the synapse is just right, however, the energy jumps the gap.

Suppose a new experience is received, which triggers a kind of cycling electrical activity among the network of neurons. Imagine it as a barrage of memory signals. As they jump synaptic junctions, they start chemical changes--maybe the synthesis of new cell material called ribonucleic acid (R N A), possibly the formation of complex molecules of proteins or peptides involved in protein manufacture.

It is thought that chemicals first create a temporary electrical path, or memory trace, and then in hours or days actual changes may occur in the cortex of the brain to "fix" the trace. In time, these physical and chemical alterations become the "soldered wiring" of long-term memory.

When certain chemical substances inside the cell link up with key parts of the master D N A molecule, R N A molecules form. The R N A then apparently directs proteins in the body, according to the pattern provided by the D N A.

Today, some researchers contend that the creation of new R N A and proteins is characteristic of long-term memory and somehow separates it from short-term memory.

Thanks to biochemists who discovered two complex chemical compounds vital to every living cell, we know more about the chemistry of memory than ever. One is deoxyribonucleic acid (D N A), whose molecules form a structure resembling a spiral staircase within the nucleus of the cell . The second, a related substance that develops in single spiral strands, is called ribonucleic acid (R N A).

The forty-six chromosomes in every normal human body cell are made of D N A molecules that constitute the genes, the elements of heredity that parents pass to their children. Arranged in four related but different units, the steps of the D N A molecule form a genetic "blueprint" that causes one person's eyes to be blue, another's brown, and, in effect, directs development and function of the person.

When certain chemical substances inside the cell meet up with key parts of the master D N A molecule, R N A molecules form. The R N A then apparently directs the manufacture of thousands of different proteins in the body, according to the pattern provided by the D N A.

Using exquisitely sensitive instruments, a Swedish neurologist, Dr. Holger Hyden, has learned that when neurons are stimulated, some of the millions of R N A molecules inside them direct glial cells to produce new proteins. The shape and nature of what has been perceived is imprinted on these proteins. Perhaps this is the very basic element of memory. This process can be detected in animals that have been forced to learn new skills. Evidence to this effect has been turned up in a number of laboratories.

In all of his 35,000 year history, Homo Sapiens has found it harder to fathom the depths of his mind than to unlock the secrets of his body. The discoveries of molecular biology may well show the way to a new comprehension: they may make it possible, through genetic engineering, surgery, drug therapy and electrical stimulation, to mold not only the body, but also the mind.

Men cannot wait for natural selection to change him, some scientists warn, because the process is much too slow. Thus, by his own efforts man must sharpen his intellect and curb his aboriginal urges, especially his aggressiveness.

To most laymen, the idea of remaking man's mind is unthinkable: "You can't change human nature," they insist. Yet, many scientists are convinced that the mind can be altered because it really is matter. A physicist by the name of Gerald Feinberg has explained that what sets us apart from inanimate matter is not that we are made of different stuff, or that different physical principles determine our workings. It is rather the greater complexity of our construction and self-awareness that this makes possible.

That self-awareness resides in the brain, the organ about which scientists have the most to learn. The brain's ten billion nerve cells are like an "enchanted loom" with "millions of flashing shuttles". Some brain cells are pre-programmed with "enormous specificity of configuration, chemistry and connection." Some are sensitive only to vertical lines, others only to horizontal or oblique ones. Each of these little creatures does his thing.

In the hope of deciphering the "brain", hundreds of scientists, including molecular biologists, in the United States and abroad, are now turning to extensive brain research. One day in the distant future, their discoveries may help man to improve his already remarkable brain--for despite its dazzling versatility and subtlety, it is not without limitation. To most scientists, the brain, this reference system, or memory, is one of the most important tools of man's intelligence.

Initially, some brain researchers believed that memories were stored in electrical impulses. Scientists could not comprehend how a cranial electrical system, however complex its interconnections, could accommodate the estimated million billion pieces of information that a single brain collects in a lifetime.

Doubts increased when scientists found that a trained animal generally remembered its skills despite attempts to disrupt its cerebral electrical activity by intense cold, drugs, shock or other stress; only short-term memory--of recently learned skills--was impaired. There was an obvious conclusion: while short-term memory may be partly electrical, long-term memory must be carried in something less ephemeral than an electric current.

That something, theorists believed, was chemical. Scientists had long known that chemical as well as electrical activity goes on in brain neurons: these cells carry metabolism and protein synthesis like other body cells. Researchers soon learned that the leap of message-carrying nerve impulses across the gap between one cell and another takes place only with the help of chemical transmitter substances. One of these, acetylcholine, was promptly identified, and investigators began to look for other brain chemicals, specifically for varieties that might contain memories.

Their reasoning was just as D N A carries genetic "memories", so other molecules might encode and carry information plucked from transient electrical impulses. Some early researchers proposed the idea of a separate brain molecule for each memory. The hypothesis of Swedish neurobiologist Holger Hyden of the University of Goteborg was a bit more sophisticated; he thought that R N A was the key to memory formation and was encouraged in his belief by the results of his experiments with rats. When he taught them special tasks, he discovered that the R N A had not only increased in quantity but was different in quality from ordinary R N A. In short, what Hyden did was to lay the groundwork for a molecular theory of memory.

What all this seems to mean is that short-term memory is easily erased and is probably not dependent upon formation of proteins. But for reasons unknown, long-term memory may be.

Like any new research, the study of memory transfer has found its skeptics. In 1966 more than twenty scientists from seven research centers wrote in Science magazine that they failed to achieve similar results when repeating the experiments.

No one has yet found for sure the exact memory molecule. No "smart" pills are available by prescription yet. However, certain chemicals do appear to aid learning and enhance memory.

Memory-enhancing chemicals are being tried experimentally, perhaps advancing the day when science may produce a "memory pill" capable of correcting learning and memory deficiencies in the same way that corrective lenses now correct visual defects.

Perhaps it will be the right of every child to have the opportunity to become a lawyer, doctor, merchant or his own choice according to his desires of achieving success during his lifetime. The social and economic implications of this possibility are enormous--maybe we should begin to give them some thought.

Ways to Improve Memory

It is assumed that science and technology will continue to have a profound influence on the culture which places demands on education, especially in the field of learning relative to memory. Obviously, this requires that speculations on what kind of technologies may be developed in coming decades, and what effects they may have on schools and colleges. According to Francis Keppel, our first task, then, is to define such a "technologically oriented culture" as:

> We take these words to mean the effect on the society of the further development of a variety of technologies, and not alone the technologies that result from the advance of the physical and social sciences. Included in such a longer list, we believe, must be the technologies that will result from medical and biochemical research, and perhaps especially processes involved in inheritance, human growth, human learning and human behavior.[22]

Demands upon education will be expected to take form of more of what has been happening in recent decades at a faster rate. Presently, computer aided instruction, multi-media systems and the various television systems are trying to find their place. In instruction, they may be expected to increase the teacher's span and allow for program enrichment, individualization and "games" that stimulate thought.

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[22] Edgar L. Morphet and David L. Jesser, Designing Education for the Future, no. 6 (New York: Citation Press, 1969).

Yet, if it is assumed that education will have to respond to man's ability to change himself as well as to take advantage of his physical environment, then the demands of the "technologically oriented culture" on education may turn out to present a new set of problems and possibilities. Those who design education for the future may find that the most influential sciences of this and coming decades may be the studies of human and animal behavior--studies which can be divided into two parts: neuro-science or the neural physiological behavior of the individual in the group.

The results of "technologically oriented culture" that seem of particular importance are:

1. An increased knowledge of the operation of the brain and nervous systems.

2. Knowledge of the effect of environmental factors such as nutrition, exercise, and endocrine functions on the development and operation of the central nervous system.

3. The relation between neurophysiology, behavior and emotion. One can speculate that formal institutions of teaching.may be called upon in coming decades to mediate the effects of the advances of these sciences in the handling of future generations. Schools and colleges may have to be responsible, in cooperation with others, for intervening through prescribing physiological--in addition to educational--techniques to affect learning. Education may have to learn

how to apply wholly new technologies at the same time that it absorbs the impact of other and very recent development.

Different brain functions such as memory, recognition, "read out", and information storage appear to develop at different rates for different individuals, and during different periods in an individual's life. Therefore, the good teacher, of course, has always recognized this and by experience has learned to factor these differences into his teaching. It can be expected that a more precise profile of the student, established on the basis of new understandings from the neuro-sciences--when combined with the technological possibilities in the new media--may make individualized programs of instruction rather than rhetorical. A culture which has absorbed the impact of the technology of these "life sciences" may demand that educational learning adjust its aims as well as its procedures.

An example of the influence of applied psychology and sociology is already before us. As society has become more aware of a cultural, physical, and social deprivation of some children, it is requiring that the schools concern themselves with the child at an earlier age. When we learn more about the effects of physical activity and nutrition on the development of the central nervous system, it seems likely that the curriculum for the younger child will both reflect this knowledge and require further changes in our institutional structure.

Possible development in the interaction of physiology with learning ability and emotion lead into the question of how the society is perceived by the individual and how he responds to this perception. As his actions become better understood and his genetic history interpreted, the very meaning of "individuality," may undergo change. What might be his response, and what may the culture expect of educational research?

CHAPTER III

RECOMMENDATIONS

The problem of memory improvement cannot be tackled in general terms. It can only be solved by specific consideration of the kind of memory task which is to be accomplished, that is, what is to be remembered, who by, and when. In the light of these detailed considerations, the next step is to devise learning techniques which are appropriate for the accomplishment of the task. The final step is mastery of these learning techniques by the child himself. In short, the practical problem is one of developing learning techniques which are appropriate to the detailed requirements of a particular kind of memory task.

Opportunity to carry out learning is essential for the development of learning, and practice in learning can be effective in developing generalizing learning procedures--provided such practice is treated as an opportunity to discover the properties of learning procedures and to gain experience in their use. Of itself, practice in learning by no means guarantees development of improved learning techniques, even in children whose learning abilities are underdeveloped. Nor is improvement guaranteed by the mere giving of "rules" for learning. The child must come to understand such rules, not as a verbal formulae but in terms of his own learning activities; and he can only do this applying these rules in practice.

Despite our cherished ideals of individual choice and personal liberty we seem to harbor a deep need for uniformity. We deny ourselves a strategy of educational innovation that rests upon the conscious use of a variety of techniques, none of which alone, but all of which together, can provide a far richer educational program than we now provide for our children. We seem to assume that learning takes place in school and nowhere else. Nothing could be further from the truth than this myth of "Isolated Learning".

Looming large today is the myth of the Educational Machine. The writer has nothing against the use of technology in the classroom. But she doubts that it is wise to turn the teaching machine into an idol and expect it to save us. The "Educational Machine" will not save us. . . . Throughout the history of mankind, teaching has always been a creative business and will continue to be so as long as there are teachers and students.

Education is a human process, not a means for producing machines, laboratory animals or well-designed textbooks. A critical task of educational reform is to make it possible for teachers to be normal, emotional, responsive human beings.

In our pursuit of perfect rationality and behavior we negate other human qualities; we pay attention to some parts and ignore the whole. We fractionalize the lives of children into a series of problems, each to be dealt with by a different specialist. We tend to approach children as though they were unfeeling objects in need of fixing. We fail to treat them as human beings who have awareness, dignity, will, humor and love.

As already mentioned throughout recorded history, men have asked questions about memory. At the end of the nineteenth century, the answers to these questions began to be sought by systematic empirical inquiry into memory activities as they actually take place in this or that setting. Such inquiries have continued into the present day for, although much has been discovered, a great deal remains obscure. For the most part, these inquiries have not been undertaken for the sake of any immediate practical value.

Rather, they have been pursued as a part of a long search which seeks to understand the rich and marvelous functioning of human beings. In the course of this continuing search, discoveries have been made which can be used in practical living situations. More specifically, we know more than we did about the problems and complexities of effectively organizing the activities of learning. However, most of these advances have been made at a detailed level, have concerned the particular merits and demerits of this or that particular set of circumstances. At the level of tersely general practical advice, it can only be said that "memory improvement" is the problem of organizing the learning task with special regard to three aspects, namely, surveying the requirements of the task, organizing the material, and repeating what has been learned.

Educators must understand the limitations of learning and memory from the neck up only when they'll understand the fact that anxiety is very rarely relieved by intellectual understanding alone. Educational research, presently, offers promise for more permanent behavioral change in children than most of the other modalities used in present day classrooms.

Conclusions

Myths are powerful fantasies of how things ought to be. They make the world more comprehensive to their users. When they have lost their interpretive usefulness, myths do not die easily; they tend to remain embedded in a culture. One of the most serious facing our culture is the lingering presence of outmoded myths about the nature of education.

What is so obstructive about our educational myths is that they have become ossified within the structure of our schools. The myths that haunt our classrooms have been there generation after generation.

The plain physiological and psychological fact is that rationality can no more be divorced from the rest of the human body than the brain itself. Pure reason can exist only when the person's other human needs have been satisfied to a point where they will not interfere with long periods of rational activity.

We would be better off to seek a balance among the competing needs of any student: sheer hunger, to be alone, to receive attention, to be affectionate, to be silly and to communicate with friends, alongside the need to know. Perhaps the child's most crucial need is the need to be accepted for what he is rather than being molded into what society thinks he should be.

Today, in general, neurologists and psychologists believe that intelligence is more amenable to change through environmental stimulation than are such factors as language ability, interest and aptitude. In any case, for most persons--with the possible exception of the genius--the more enriched the environment, the more likely are the chances of learning to the limit of each individual's capacity.

Nevertheless, the biochemist and the teacher of the future will combine their skills and insights for the educational and intellectual development of the child. Richie needs a bit more of an immediate memory stimulator; Mark could do with a chemical attention-span stretcher; Jane needs an anticholestrerase to slow down her mental process; Joan some puromycin--she remembers too many details and gets lost.

The reactions of both chemical and electrical brain experiments are many. . . . Yet, inclusion of recent research typifying memory and learning prescriptions as an educational technique does not yet exist on a controlled deliberate, and systematic basis in the United States. Memory and learning devices are being used, presently, in and out of schools in different rubrics.

This research paper points to the need for more than cursory knowledge of the nervous system and how it functions in the learning process. There is need for better understanding of the intellectual, and other demands of everyday living.

At the very apex of man's equipment for learning and making his many adjustments stands the brain, the nervous system in general, and the capacity to profit by stimuli provided by the environment.

This research paper offered a broad view in the field of learning and memory development. In addition to discussing recent research and some of the general problems of education, it was also concerned with applications (medical, educational, clinical, and so on), techniques, dangers (real and imagined), theories (memory, conditioning, etc.) and attitudes (academic, ethical, and medical). The main solution was to separate fact from research in this highly controversial field of educational behavior.

The viewpoint and research of the author does not offer a panacea or a magical solution of the problems of memory and learning but that recent research may add to our knowledge of human behavior.

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