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THE HALF-SILVERED MIRROR: BRAIN ASSESSMENT OF LEARNING AND LEARNING SKILLS IMPROVEMENT - A DEMONSTRATION PROJECT WITH 8TH GRADERS

The Ohio State University
Ph.D. 1986

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THE HALF-SILVERED MIRROR:
BRAIN ASSESSMENT OF LEARNING
AND
LEARNING SKILLS IMPROVEMENT -
A DEMONSTRATION PROJECT WITH 8TH GRADERS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

by

David B. Andrews

* * * * *

The Ohio State University
1986

Reading Committee: Approved by:
Dr. Donald F. Haefele
Dr. Marlin L. Languis
Dr. Joseph L. Quaranta
Advisor
College of Education
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1986
To Delina
ACKNOWLEDGEMENTS

It is not possible to fully acknowledge the array of chance and good fortune that has brought this dissertation to its tardy light. The support of my wife, Delina Hickey, to whom this is dedicated, prompted me to pursue what I had long since decided to by pass. The wonderful circumstances which led me to Marlin Languis made the task seem not only feasible but the significance more than worthy. His vision backed by his personal investment in that vision, his nurturing warmth and humanity, his friendship and encouragement through the difficulties of any visionary quest, his belief that we can do better have sustained me through this harried and wonderful venture. Having the opportunity to discover a person like Marlin with the facilities and vision at the time when it was so needed was a blessing for which I will never be able to fully account.

No piece of research which bridges the chasm from technical complexity to educational application can possibly proceed without the assistance of many people. Dr. Joseph Guaranta and Dr. Donald Haefele have cooperated and abetted my somewhat unorthodox negotiation of the formalities of graduate education. Dr. Beatrice Quaranta helped in subject selection, scheduling and access to student records. Jim
McCracken has provided invaluable assistance with orientation to the lab and the technical maintenance of the equipment. Nina Gibson has assisted in the conduct of activities in the lab, relieving me from some of the distractions of other business. Dr. Micheal Torello and Dr. Bruce Dunn have aided me in grasping the research and the use of the technology for educational purposes. Special thanks must go to the folks at Bio-Logic Systems, Inc. who provided the essential technology, have listened and modified software and capability to meet the needs I perceived.

Ethan Andrews and Jon Hickey, my sons, have endured by requests to be subjects with only slightly flagging good humor. Robert and Marie Hickey, my parents-in-law, and L.O. Andrews and Ruth Andrews, my parents have supported us all through these thin and trying times. But most of all the thanks must go to my wife who through ill health, flatland fever and unfamiliar employ was always behind me, even when I wasn't.
### VITA

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CHAPTER 1

INTRODUCTION

Three folk of distant climes began the traverse of their fateful threads. Omnignos, father of the three, knew everything but the meaning of his own knowledge. To help him with this puzzling problem he required that each of the three children view his path with a glass. Narcos was given a mirror. Telos had to look through a window. Oikos received the half-silvered mirror. Each child was placed at a path. The glass was in place. The journey launched.

Narcos found that no matter what he did or where he went he always saw the same thing - himself. There seemed little point in moving about if the scenery never changed, so he didn't. Since he didn't know that there was anything else to see he put his energies into greater and greater detailed study of his world. A short period of viewing himself was followed by descent into the world beneath the visage. Many years of study of his within led Narcos into the tighter and tighter spiral of knowing his previous knowings. With such exquisite self-knowledge Narcos felt sure that he was the most fortunate of Omnignos' children and would surely be best able to deal with anything the world could offer.
Telos was exposed to the endless panoply of beckoning change. No matter where he went or what he did his window offered him visions of the new and varied earth. The ultimate tourist, he was driven on by the beauties and changes of the world. By comparison with Narcos he knew nothing of himself. There was so much excitement and variety in the distances he saw that nothing tempted him to delve within - so he didn't. Over the years Telos' experience began to resemble his travels, an endless array of visions of what could be - the dream residues of a vast unprocessed experience. Telos knew what could be and because of his travels felt quite sure that he could get there. But still he followed his visions.

Oikos was confused and frustrated at first. As he looked upon the world he had great difficulty focusing on anything. Movement changed experience, but there was always a persistent image imposed on it all. Fascinated by the change and the stability he begin to try to focus on one and then the other to help him understand each better. This was very difficult and challenging. It took Oikos many years to begin to understand the world of change and the world of constancy which he saw. Just as he was beginning to understand the differences and view them separately he was astounded to discover that the two (the changing and the stable images in the glass) were actually part of the same image. The difference began to disappear. The constant reflection now became the force that directed the change in the external and responded to it. The reflection could initiate, control and interpret but was joined with the transmitted images into a dynamic unity - Ergos.
Omnignos directed his servants to bring back his children when they had reached maturity. He would put them through a test to determine the role of self-knowledge. Narcos remained near at hand in his depths. Telos had wandered afar. Many days of search were required to find him and bring him back. Oikos had learned discourse. He quickly learned of his father's wish and returned.

Omnignos had devised a simple test of self-knowledge. He would remove the glass of each son and observe the effect. Each son was told that he had been a participant in a very special and important study. He had been wearing a glass which gave him a vision unlike that of any of his brothers. Now that he had reached maturity his glass would be removed giving him a new and full vision of life. As a test of his new vision, he would be placed in front of a path which, if followed correctly, would lead to the laurel wreath. Whoever succeeded in reaching the wreath first would wear it and succeed Omnignos as head of the family. All was ready for the test.

Unbeknownst to the three sons, Omnignos had created a test of great difficulty. Each path was a maze requiring skill in interpretation, adaptation, and the wise use of strategies and clues to its successful negotiation. Only the wisest would succeed. Narcos was sure that he knew himself so well that he could interpret anything and win the contest. Telos had traveled so much that he need only travel another journey to the vision of the wreath. Oikos, seeing that each of his brothers has only half his vision, was saddened for them and their limitations, but puzzled what this would mean in the test. He would try his best to make the maze a part of his Ergos.
The glasses were removed. Narcos was overwhelmed by the brilliance of novelty. Yet, he was sure that if he thought he could figure out what to do just as he always had before. So he closed his eyes and turned in, seeking to devine the solution. Omnignos is still trying to find a way to get Narcos to open his eyes.

Telos was shocked to see that the removal of the glass changed nothing. Overjoyed with this good fortune he rushed forward, as always. Telos could only respond to the external. There were laurel wreath pictures placed in the maze, but not always on paths that led to the wreath. Telos followed them all. One such sign was placed at the entrance to a tunnel which spiraled endlessly into the earth. Telos' journey continues, though he has yet to suspect that he has made a mistake or could be on the wrong track - there is only the external leading him on.

Oikos, who had long since stopped seeing his reflection in the mirror, also noticed the absence of change. The reflection was now within. He could see the maze and negotiate it. But he knew his limits. He could hypothesize. He could suspect and evaluate error. He could examine his own assumptions. He could change his strategy. Though the maze was long and difficult he persevered to the goal. The laurel wreath was his.

Omnignos was thrilled with this great revelation. He ordered that from now on all members of his family be raised with the half-silvered mirror. Soon thereafter Omnignos died. Oikos assumed leadership of the family. He immediately ordered that the half-silvered mirrors be removed from all and destroyed. His decree
was simple, "No one need wear the half-silvered mirror. The Ergos has taught me it is the gift we all possess as our birthright of consciousness. Our most important task is to learn to use it well."

Psychological research has always sought to increase our collective self-knowledge. To seek to understand the workings of our perception, our memory, our emotions or our brains is to seek information about the information seeker. Scientific psychology seeks to gain information about psychological processes which provide us with the ability to predict human events. When we have predictive power we gain the potential to control conditions, allowing us to control outcomes in accordance with our values and goals.

The scientific enterprise is a collective and public one. The methods of science are designed to ensure that findings are general and reproducible. Psychology is in the position where the findings are not just about the objective, but they change the state of the knower - a case study of the subject of the research. The fruits of psychological research thus have the power to predict and control what individuals do - not just other individuals, but ourselves.

Educational research seeks self-knowledge in the service of collective self-improvement. Education and child rearing are the quintessential applications of human self-knowledge. We have goals and expectations for our children and their education. We apply all that we know and believe about humans and their learning in our educational programs. Much of the research base for educational decisions comes from psychological research on learning, motivation,
social psychology and personality. The learner plays a key role in the success of education. As conscious individuals each learner selects and directs personal learning resources, and subsequent use.

The research program developed here is based on the assumption that the most successful learning will occur when the learner responds to the external demands of the learning with knowledge of self as learner. The more one can bring together an awareness of the interaction of the external and the internal, the better the educational results. Can topographic mapping of brain electrical activity act as a useful adjunct (the half-silvered mirror) to more conventional learning skills instruction and assessments in individual learners?

The half-silvered mirror cannot work well if the light is shined too brightly on either side. Success demands that the light be balanced on the side of self-reflection and on the external context within which the self acts. It is only by that balance that we can know ourselves and serve our goals - Ergos.

This study will develop a model for intervention to improve learning. An exploration with this model is used in which the graphic presentation of brain electrical activity is used to assist less successful 8th grade learners in understanding themselves and their learning better in the context of school learning.
Neither learning nor individual differences are matters of recent discovery. Yet with progressive social deauthorization (Jaynes, 1976) the burden of success has shifted from social units to individuals. Much interest has developed in understanding the basis of individual differences and discovering ways in which individuals can be more effective in the utilization of their personal resources. The demands of an increasingly competitive economy and rapidly accelerating informational complexity have directed some of this motive toward the enhancement of individual learning effectiveness.

Arguably one of the most significant forces in this movement has been Public Law 94-142 - The Education of All Handicapped Children Act. This law mandates the identification, assessment and appropriate education of all individuals whose effectiveness in the traditional classroom might be imperiled. The learning disabled individual covered by this act is someone who is capable of learning as well as the traditionally successful student, but is not able to
learn successfully in the traditional classroom without special adaptation. As the differences inherent in the learning disabled are confronted, the differences in all learners become more apparent. As the social pressures for greater learning and fitness for competition in the social economy increase, interest in the improvement of individual learners grows apace.

It will be a primary contention of this paper that all learning and all attempts to improve it must be considered in context. Accordingly, the context within which we operate can best be understood if we begin by taking a broad historical perspective. The development of a model which will be used for personal and social intervention, but which is based in a history of social philosophy, physiological research, psychological research and theory, educational research and theory has a labyrinthine contextual history to challenge any audacious enough to seek a coalescence. Several threads of thought and research will be explored in this chapter prior to the development of a model for a program of action. Each area discussed has a substantial history and literature of its own. This paper seeks to identify the contributions of all areas to a program of learning skills instruction which can bridge the gap between basic research and effective educational application.

Intelligence

When concern about social fairness of intelligence tests was first raised, it was the assertion of those who hoped to have "culture fair" tests that, at least within a given culture, differences in intelligence would indicate the differences in retention of
information (learning) amongst individuals who where presumed to have had roughly equivalent experiential histories (Cronbach, 1970). The implication was clear, intelligence was the manifest ability to learn. When the first attempts were made to assess intelligence in a systematic way (Binet, 1909) the task was explicitly clear – find a method by which individuals are not benefitting, or will not benefit, from compulsory education could be identified and, potentially, provided with a special education. Intelligence was to be an assessment of learning ability or potential (Gould, 1981). Even the most wide reaching of current models of intelligence (Sternberg, 1985) views learning and the potential for it as the central feature of intelligence. Though models of intelligence vary enormously and the focus on learning is often indirect, it is clear that any conception of the learner and any attempts to improve the performance of learners is inextricably bound up with our concept of intelligence.

The beginnings of the Chinese civil service exams as early as 2200 B.C. places the origin of social sensitivity to individual differences in ability beyond the reach of fruitful study. The Greek physicians and their philosophical cohorts (i.e. Hippocrates and Aristotle, in particular) defined individual differences in terms of potencies of bodily fluids. While this position was a step in the right direction, further progress required the Renaissance confirmation of the neural basis of human behavior – made germinal in Descartes' interactive mind-body dualism. On the threshold of a scientific psychology of individual differences Kant (1781) said there were "three reasons why a science of psychology was not possible; the
fact that the mind is affected while studying itself; the lack of spatial extent essential for any experimentation; and the absence of a mathematical basis, necessary for all science." Kant concluded that "psychology can, therefore, never become anything more than a historical (and, as such, as much as possible) systematic natural doctrine of the internal sense, i.e., a natural description of the soul, but not a science of the soul, nor even a psychological experimental doctrine." (Gardner, 1985).

The same context which caused Kant to despair caused others to seek his impossible. Two observations started the ball rolling: Franz Joseph Gall began systematic study based on his childhood observation that schoolmates with good memories seemed to have protruding eyeballs; Maskelyne, the astronomer royal at the Greenwich Observatory noticed, and began study of, the systematic errors in marking the transits of stars made by his assistant Kinnebrook. Gall was to begin the basis of the "spatial extent" while Maskelyne was to start the "mathematical basis." (Boring, 1950)

Gall, working in the tradition of the Scottish Faculty Psychologists (Thomas Reid, Dugald Steward and Thomas Brown), attempted to relate the organization of the nervous system to the observed functioning of the individual - Functional Localization (Krech, 1962). The school of thought he founded - phrenology - correctly inferred that the nervous system was the controlling mechanism for individual behavior and that the system was differentiated in function. At the time that he engaged in his efforts, there were no tools available either for the assessment of
individual human qualities or the assessment of the nervous system. Nonetheless, the desire for a personal information which came from an inscrutable authority combined with the skilled promotional abilities of his erstwhile colleagues and followers - Spurzheim, Combe and the Fowlers - made phrenology a powerful social force, particularly in America. It has been argued that the elegant harmony of phrenological information's descriptive accuracy and prescriptive clarity with it's somewhat ironic ethos of self-improvement and human perfectability were a great portion of the moving spirit behind the developers of American public education in the middle 1800s - especially through the thought of Horace Mann (Stern, 1971; Messerli, 1973).

In the absence of a method for non-invasive direct assessment of brain function Gall and his followers were left with the ersatz. His method assessed the bumps of the skull and inferred the size, and thus potency, of the underlying areas of the brain. While phrenology is currently a term which produces knowing grins of derision, the phrenologists set the tone in asserting that human performance was based on differentiated brain structures which were related to differential psychological functions. These could be assessed, and the results of the assessment could become the foundation for an educational program.

Maskelyne, galled by the systematic errors in Kinnebrook's recording, dismissed him and began musing on the source of the errors. Kinnebrook had been informed of his errors. Apparently with diligent effort, he had attempted to improve his accuracy - without success. Maskelyne concluded that the errors must be involuntary and represent
a systematic bias in Kinnebrook's perceptual processes. He named the correction necessary to eliminate this bias the personal equation and began systematic measurement of individual differences in response (first manifest in reaction time studies). He used the information he gained to make evaluations and corrections based on the observed personal equation.

With these early foundations, combined with the demise of the class structure and the rise of a complex urban capitalistic society (Weber, 1984), the stage was set for the scientific study and assessment of intelligence. Sir Francis Galton, troubled by the implications of his cousin Charles Darwin's theory of evolution and concerned for the improvement of the human race, began his studies of individual differences in ability - Hereditary Genius (1869). The eugenic theory and politic which grew from this work has been amply documented (Gould, 1981). His important legacy to us is the seemingly ineluctable conviction that individual differences in ability are hereditarily determined, are fixed, and can be assessed with adequate accuracy by a limited selection of very basic abilities and responses (note the isomorphism with the current work of Jensen, 1975, 1983).

Using the contributions of an infant experimental psychology (Wundt, 1873-74; Titchener, 1909; Ebbinghaus, 1885) and the pressures created by compulsory public education, Alfred Binet began the operational definition of intelligence. Binet had, early in his career, explored crainometry (the residual empirical form of phrenology) but had moved in the direction of wider ranging psychological investigations. When the French government sought a
method for determining who, at the low end of ability, was able to benefit from the prevailing education, they sought the leading psychologist and founder of the only psychological laboratory in France – Binet. The charge to Binet was to create a decision-maker. The instrument he developed (Binet and Simon, 1905) implicitly assumed that intelligence was directly related to school learning ability, was essentially stable (or at least not worth attempting to improve) and could be accurately assessed with a relatively brief test. Ironically, a year before the publication of the first version of his test, Binet expressed serious doubts about the feasibility of consummating his research program (Dahlstrom, 1985). With Binet’s test, the reification of the concept of intelligence (a term of nearly new-born status) was on its ballistic course. One wonders where we would be if his doubts had prevailed.

Sternberg (1985) has rather neatly conceptualized the subsequent history of models of intelligence. He notes that we have moved from purely descriptive models, to information processing models to various models which seek to include cultural context, to his own most recent model (The Triarchic Model) which seeks to include all previous models within a common framework and focus on the processes of self-government which structure the action of the whole.

Several observations of the current state of intelligence theory and research are needed before moving on. While Sternberg creates an illusion of evenness and of steady progress in our understanding of intelligence, there can be little doubt that the educational applications of intelligence (those for which the concept
was intended) are virtually exclusively descriptive/prescriptive - his geographic and computational models. As Sternberg’s own efforts (1985) clearly document, the spirit of those who study intelligence remains a hierarchical rubric translatable to empirical assessment from which diagnosis and prescription can follow.

Few of the individuals who are engaged in the understanding of intelligence have been inclined to consider the cognitive baggage which the term brings with it. Jensen has managed to singlehandedly sustain a cottage industry of research on the heretability of intelligence. Though this research is certainly defensible, the continued use of the term intelligence sustains the notion of a fixedness in ability ascribed to individuals, arguably one of the less productive vestiges of our Calvinist heritage. Howard Gardner (1983) proposes that rather than talk of intelligence we should adopt a more modular view in which there are 7 different "intelligences." Each of these operates independently - with a different neural basis, manifest in independent classes of those gifted in each or deficient in each intelligence. Gardner asserts that he chose to refer to these "Frames of Mind" as intelligences with very mixed feelings. On the one hand the whole notion of intelligence has a history of implied singularity, the very notion he sought to supplant; while, on the other hand this was the prevailing term and its use would more likely provoke the discussion he sought. Though he would clearly like to see the term replaced, he opted for intelligence. Sternberg, in attacking Gardner, states, "The multiple intelligences might better be referred to as multiple talents. For example, some might argue that the
tone-deaf person who is low in one important aspect of 'musical intelligence' is not mentally retarded in the same way as an adult individual who has never acquired verbal skills might be. Rather, the tone-deaf individual is lacking an aspect of musical talent." Indeed, one might well ask of Sternberg why each of the eight sub-components (some of which he refers to as abilities) could not also be called skills and the term intelligence dispensed with altogether. The argument between those followers of Spearman (1927) who believe in a general factor of intelligence with attached special abilities and those followers of Thurstone (1938) who subscribe to a pantheon of independent primary abilities is alive and well.

While there is good reason to conclude that the concept of intelligence has served as a catalyst to research on the intellectual processes of individuals, there is little evidence that the concept or any of its operationalizations have served constructively in the improvement of "liberal" (I use the term in its political theory sense, not its traditional use in higher education) education.

This brief overview of the historical and contemporary conceptions of intelligence identifies several specific issues pertinent to the improvement of individual learning ability:

1. Can learning ability be modified - the traditional heredity/environment issue?

2. Is learning ability a static attribute or a set of dynamic processes which depend not only on inherent abilities, but on methods of utilization of those abilities? This would include such perennially avoided questions as the relationship of motivation and
emotion and perception and attention to learning ability (intelligence?).

3. What is the role of the individual as a co-participant in the determination of his/her own learning ability? It has been assumed that the individual has it, the tester finds out what it is and the teacher and/or parents do something to it — where is the owner?

4. Is there any value in discussing intelligence rather than working with learning skills?

5. How can learning skills be maximized?

**Learning Theory and Research**

With the 1885 publication of Ebbinghaus' studies of memory, the experimental/theoretical methodology that had become the scientific method was introduced to the study of learning. As with all initial forays into the unknown, the researches of Ebbinghaus, while monuments to his genius and personal commitment, are the most preliminary of descriptive empiricism. By studying his own learning processes using nonsense syllables he was able to describe patterns of learning and forgetting (learning and forgetting curves), serial position effects, and begin discussions of interference phenomena. The processes of learning and memory could be studied in a systematic way. The results could be analysed and displayed in the same manners used in the "hard" sciences. Thus, seeds of an empirically validated theoretical account of learning had been sown.
Subsequently, at roughly the same time, Pavlov (1927) in Russia and Thorndike (1911, 1931) in the US begin the researches and theorizing which have strongly influenced applied learning theory and research in their respective countries to this day. Thorndike, based on his Cats in a Puzzle Box experiment, developed his three basic laws of learning. The law of effect stated that those behaviors which are followed by satisfiers will acquire a strengthened connection with the situation in which the behavior occurred; those responses which are followed by annoyers will have their connections with the situation weakened. In modern terminology, reinforcement strengthens a stimulus response connection, punishment weakens it. The law of exercise indicated that doing something produces learning (a notion developed much further in collaboration with John Dewey) - the more you do something, the stronger the connection. The law of readiness was Thorndike's concession to the fact that things didn't always seem to work the way they should. A given satisfier or annoyer would not always produce the expected results. Thus, individuals were deemed to need a basic state of "readiness" for learning to occur. Subsequent research disproved the law of effect with respect to annoyers and the strong form of the law of exercise: Annoyers didn't seem to weaken stimulus response connection, but probably had some, as yet unspecified motivational effect; exercise without a perceptible consequence did not produce learning (drawing a line 3 inches long doesn't get better unless you are allowed to measure the length of the lines you draw). This left Thorndike with a simple stimulus-response model of learning with satisfiers as the critical determinants of
learning. While Thorndike actively incorporated a number of subordinate theoretical considerations into his educational applications, his legacy to learning theory was really quite simple: Organisms do things and, those behaviors that are "reinforced" (i.e. followed by a satisfying consequence) will be more likely to occur again in the same stimulus situation; learning can be studied empirically, developed into theory and that theory can serve as the basis for making decisions about the appropriate form of education.

Thorndike was a soft behaviorist, even though his primary experimental work (Animal Intelligence, 1911) preceded Watson's formal midwifery of behaviorism (Watson, 1914). The message was fairly simple, direct and clear. The Zeitgeist was ready, the effect was powerful. Thorndike's influence on American education has been well documented (e.g. Travers, 1983). What is missing from the theory may be more interesting than what is included. First, there is only the most incidental role for the learner. While there are many assumptions about unobserved processes - e.g. the basis of readiness, response by similarity or analogy, etc. - the application of the theory is clearly intended as something done to the learner - a learner who comes to the situation with some built in response tendencies. Second, the concept of satisfier, while intuitively appealing - almost tautologically obvious - is utterly unspecified. As Skinner - building his radical behaviorist version of Thorndike - would discover, reinforcers only seem to behave in civilized ways when you don't give them any possibility to do anything else (Skinner, 1950, 1953). Thus, Skinner took refuge in the notion that a
reinforcer is anything that reinforces. Third, motivation, emotion, attention, perception, goals, and personality factors, while implicitly included in other concepts, are essentially absent. Fourth, there is, as one would expect from a good proto-behaviorist, no testable discussion of the mechanics of learning.

Pavlov (1927), based on his serendipitous digestion experiments with dogs, developed a model of learning which is at the same time vastly more reductionistic and mechanical than Thorndike's work, and much more expansive and comprehensive. The most distinctive feature of Pavlov's research and theory is his focus on the passive response of genetically pre-wired organisms to the juxtapositions of stimuli with which their world presents them. If an unconditioned stimulus happens, whatever stimulus happened at the appropriate time before it will tend to gain the power to produce a conditioned response similar to the response elicited by the unconditioned stimulus. The organism has no role other than as the bearer of unconditioned responses and the capacity for conditioning to occur in lawful fashion. Learning is the result of the way in which the world presents you with stimuli and nothing more. Ironically, Pavlov went on to develop a model for the "second signal system," a system of acquired conditioned responses that contains a substantial amount of autonomy from the immediate external stimulus system. The second signal system is the basis of language. Thus the Pavlovian being is at the same time totally dependent on the state of the social structure of stimuli which is its environment, and given an indeterminant autonomy from that environment by virtue of the second
signal system - language.

Subsequent developments in the learning theory of the Thorndike's and Pavlov's respective worlds are notable for the vast accumulations of data, the considerable exploration of details of mechanism and application to specific problems and the general absence of any major conceptual alterations - except in foreshadow. In Russia Vygotsky (1978) took the social context in which the individual was located, the personal social relationships and explored those features of the pavlovian universe. In America, Skinner incorporated both the work of Pavlov and Thorndike into his radical behaviorist non-theory; Hull (1943) and an army of neo-hullians put it all in logico-mathematical array (take that Kant!) thus generating the research necessary to assure their own downfall. Guthrie (1935) eliminated the critical feature of reinforcement, but replaced it with a theory which sounded quite analogous to Bishop Berkeley's declamations on the non-existence of objects. He suffered the damnation of neglect due to his theory's vagueness and apparent untestability. Tolman (1932) took the concept of reinforcement and converted it to the appealingly inscrutable status of confirmation of expectancy, foreshadowing current explorations of internal mechanics; but, he did so absent a methodology to proceed.

By the early 1960s psychology was in possession of a vast array of experimentation generated by tests of behaviorist theorizing. This work was well along to being totally unassimilable within any behavioristic framework. This state of pre-paradigmatic empiricism (Kuhn, 1970) was the head of Zeus from which the Athena of Cognitive
Psychology finally sprung. In the Zeus's head of science the
gestation period is lengthy and complex. The origins of this
revolution may reasonably be laid a number of places: John Dewey's
1896 paper, "The Reflex Arc Concept in Psychology;" Karl Lashley's
1948 paper, "The Problem of Serial Order in Behavior;" Jeffress,
1967); The 1956 Symposium on Information Theory at which George Miller
presented his paper "The Magic Number Seven Plus or Minus Two;"
Miller, Eugene Gallanter and Karl Pribram's 1960 "Plans and the
Structure of Behavior," perhaps most notably. Clearly critical to the
successful gestation were the contemporaneous developments in
linguistics, philosophy, anthropology, neuroscience and computer
science (most notably artificial intelligence) (Gardner, 1985).

The actual birthdate of cognitive psychology must be assigned
to the publication of Ulric Neisser's seminal Cognitive Psychology in
1967. Neisser assembled the experimental psychology research which, to
that point, had sought to make inferences about the internal processes
of the human-as-information-processor. The behaviorist restriction on
inferencing was to be shed (even though it had never been fully in
place except in the writings of Skinner and the methodology sections
of introductory psychology courses). The thrust of psychological
investigation was to turn quickly to the modeling of internal
processes. This was not an instant conversion, nor one without
precedent. Since the days of Hull "hypothetical constructs" had held
an honored, if contested, place in psychological theory. Most
recently they had precipitated a great prerevolutionary flourish in
the work of the Mathematical psychologists - Atkinson et al (1965),
Estes (1955), Bower (1967) and others. The availability of mathematical and computer expertise and the beginnings of artificial intelligence made for a happy marriage of the experimental motive of psychology and the modeling of internal processes so nicely accomplished by the flow-chart mentality of the computer scientists. The information processing models developed by the cognitive psychologists began rather simply with the filter theory of Broadbent (1957). Atkinson and Shiffrin (1968) added some of the first features of "executive processes." Subsequent developments, disproportionately from the students of Bower (Anderson, 1983) have raised the level of complexity of cognitive modeling to incorporate human linguistic activity, decision processes and the mechanisms by which such activities occur. Ironically the movement which was initially reviled for offering the ghost a spot back in the machine (Koestler, 1964) has moved to a level of determined specificity far beyond anything that behaviorism ever might have wished. As Anderson states in discussing his latest model, "production systems address the issue of control of cognition in a precise way that is relatively unusual in cognitive psychology. Other types of theoretical analyses may produce precise models of specific tasks, but how the system sets itself to do a particular task is a particular way is left to the choice of what production to execute next. Central to this choice are the conflict resolution strategies. Thus production systems have finally succeeded in banishing the homunculus from psychology." (Anderson, 1983, p. IX-X). One must only imagine the puzzled looks such an assertion, even with simpler statement, would elicit in a group of 8th graders (never mind their
teachers) to realize the difficulties in the application of such models to education.

The legacy which learning theory and cognitive psychology leave to the educator is mixed. While it is generally conceded that the cognitive revolution has occurred in psychology, it is much less clear what constructive information educators can find there. The basic assumptions are the same as those which informed the work of Thorndike and Pavlov - look for the smallest functional units; have the impetus for all learning be outside the learner; explain everything, but do so without reference to personal, historical or social context. As discouraging as this may sound, the progress offered to educators by current cognitive psychology research is quite real; however, it comes from outside the tradition that is learning theory - primarily from developmental psychology.

Before going on to look at the contributions of developmental psychology to a model of learning enhancement, it is worth summarizing the significant findings in learning theory and its cognitive descendents. To this author's knowledge there exists no single theoretical concept of any sort at any level on which there is complete agreement by learning theorists and cognitive psychologists. Such war horses as reinforcement, and short-term and long-term memory, among the most robust and elderly concepts in their fields, remain under intense debate amongst those who continue to proffer them any attention at all. Yet the research base which has been generated in the course of these internecine warfares is vast and full of observations and phenomena of significance to the improvement of
learning. Andrews (1978) has developed a set of guidelines for learning skills improvement which is a digest of specific experimental findings from the learning theory and cognitive psychology literature. While no such list could hope to be exhaustive, this summary consists of those items which appear to be best documented in the literature and most pertinent to the learning of an individual in educational contexts (see Appendix 1).

Development

Any account of development, cognitive or otherwise, must speak to two interdependent aspects of the developmental process: formal and functional. The formal aspect has to do with the "morphology" of the process: the sorts of cognitive entities that make up the successive outputs of development and how these entities are causally, temporally, and otherwise interrelated. . . .The other aspect . . . has to do with function and mechanism: the activities and processes of the organism somehow specified in relation to environmental inputs, by which it in fact makes the cognitive progress that has been formally characterized.

Flavell and Wohlwill, 1984

I doubt that cognitive ontogeny recapitulates cognitive phylogeny. I can imagine viewing the latter as a gradual emergence of isotropic systems from encapsulated ones; but nothing about individual cognitive development seems to me to suggest the corresponding ontogenetic process. (Deep down, I'm inclined to doubt that there is such a thing as cognitive development in the sense developmental cognitive psychologists have had in mind....)

Fodor, 1984

In my view, we will never attain even a first-level understanding of the principle forms of thought unless we trace their evolution from the relatively modular and encapsulated forms of processing which can be observed in infancy, to the far more open or isotropic forms characteristic of mature individuals. (Indeed, I think that the difference between encapsulated and unencapsulated or isotropic forms may prove to be less of a systemic and more of a developmental phenomenon.

Gardner, 1985
Depending on your point of view, development is everything, nothing or something in between. Even if you think that it is something, it is unclear whether you should study the knowledge states that are the sequential accretions of development or the transitional processes that produce the changes—or in what order. Whenever there is that much diversity in point of view, it is clear that the truth awaits discovery. Nonetheless, issues of development are of critical significance in the production of strategies for educational intervention—especially interventions which seek to produce lasting changes in the learning effectiveness of developing individuals.

Prior to the discovery of Piaget by American psychologists, developmental psychology was viewed by the behaviorists of the day with considerable disdain (Furth, 1981). The feeling was that development was merely the accumulation of experience so the best one could hope for was a description of the modal progress, given common learning opportunities. At best this was descriptive drudgery. The true psychologists, they felt, were those discovering the mechanisms by which learning, the true transformational force, occurred. Piaget changed all that by developing and demonstrating his maturationally driven stage theory of development (Piaget, 1954). It was only after 50 years of work on his theory and the transformational forces that he felt shaped development that he produced a final version of his equilibration model. Though this model is significant, the fact that it took that long to develop any sort of initial model of a mechanism of development is illustrative of the difficulty of the task.
Any program which seeks to transform the learning of an individual, especially pre-adult, must necessarily deal in mechanisms of development. Biological limitations, as suggested by Piaget, and Case, Pascuel-Leone, and Fischer (Case, 1984, Pascuel-Leone, 1970, Fischer, 1980, in press) would formally restrict interventions to specific ages at which the requisite cognitive capacities and processes are available. Others who discuss mechanism are of a more information-processing orientation and place no age-constraints on development (e.g. Klahr and Wallace, 1976; Siegler, 1981; Keil, 1981; Sternberg; 1984).

One of the hottest issues in development theory and research is "modularity" (Fodor, 1983; Flavell, 1984, Gazzaniga, 1985). "The notion of constrained faculties views humans less as all-purpose learning machines and more as biological organisms that have through the course of evolution, developed specialized 'mental organs' .... Each organ imposes its own set of constraints on the types of knowledge structures it uses, such that we have different domains of cognition with different formal properties." (Keil, In Sternberg, 1984) While this view could be written off as another ho-hum resurrection of the Spearman - Thurstone debate, the fact that the issue continues to rear up suggests that there are important unresolved issues. Of particular interest to the current work is the relationship of such an idea to issues of transfer of information learned in one domain to other domains (Brown, 1978). Stated differently, how, or is it possible to transcend the limitations that are placed on generalizability of knowledge?
A final dividing issue in discussions of development is the role of "expertise" as a constraint on new learning. In other areas of research this question would be viewed as the role of "knowledge base" in the ability to learn and generalize new learning (Ornstein and Naus, 1984). Information-processing theorists have spent considerable time exploring the nature and distinctions between procedural and declarative knowledge. In any work which seeks to deal with metacognition the nature of these issues can be quite significant. If it is possible to establish procedural knowledge relatively independently of the existing declarative knowledge and have the procedural knowledge applied appropriately to added bodies of declarative knowledge, that suggests a very different approach to learning skills instruction than if procedural knowledge is meaningless in the absence of a body of declarative knowledge in the context of which it is learned. This recalls the debates between Piagetians and Vygotskians on the relationship of concepts and language - which must come first.

While much could be said about the literature relating to these issues, there is no question that resolution is not at hand (Flavell, 1984). For purposes of the current discussion it is safe to assume that working with individuals over the age of about 12 is likely to eliminate primary concern with age-related constraints on development. Ever since Piaget fixed the age of onset of formal operations at 12 (Piaget, 1954) there has been little contention that biological maturation requires more time to completion. Epstein (1982) has suggested, on the basis of brain weight studies that there may be
another cognitive transition near later adolescence; however, the evidence to support this position is as yet undeveloped. With regard to the other issues which remain unresolved in the study of developmental mechanisms, Flavell (1984) suggests 10 guidelines for future research and theorizing.

1. Try to get clues about mechanisms of cognitive development by looking at mechanisms postulated for other kinds of development.

2. Assume provisionally that cognitive development is equivalent to learning.

3. Describe the "cognitive units" before the transitional processes.

4. Assume provisionally that cognitive change occurs.

5. Assume that children "develop themselves" more than they "get developed."

6. Consider cognitive changes that proceed without any present input or feedback from the external environment.

7. Consider changes in what children attend to, encode, represent, accommodate to, assimilate and the like.
8. Attempt to explain the apparently larger working-memory of older children.

9. Try to account for both big and little cognitive changes. Different processes may operate depending on the type of cognitive change that is occurring.

10. Attempt to explain individual differences in cognition.

Flavell nicely summarizes the issues which may be of significance for attempts to create cognitive changes — improved learning. Perhaps most importantly he includes in his list items which, perhaps only he amongst notable developmental psychologists would include, or could get away with including. Brief comment will be made on several.

Number two makes no distinction between procedural and declarative knowledge, it merely assumes that development occurs through learning. Heuristically this is wise — we can study learning, we have a harder time studying the biological bases of development. Most importantly it puts the focus on what we have the potential to control in the service of the outcomes we desire.

Number five makes reference to the burgeoning literature on metacognition of which Flavell can rightfully be considered the initiator. Much more importantly, he suggests that not only do the abstract knowledges of metacognition play a role in cognitive development, but many of the individual features which we may never be
able to understand are critical to the developmental process. Practically, this moves tantalizingly close to sharing the study of development with the developer - making the developer an active co-agent in the process and its study. The philosophical, political and educational implications of such a position are quite striking.

Number six is an extension of number five, but allowing for unconscious or automatized developmental processes. The true empiricist believes that these can be known and controlled. Flavell feels that, if that is possible, it is certainly not in the foreseeable future. Thus there are dynamic and self-regulating internal processes which should be taken as given and which play a key role in the course of cognitive development. This continues the move toward making the developer the subject of study, not the object.

Numbers seven and nine suggest that, even if there isn't modularity in the sense that Fodor asserts, there are a variety of cognitive processes which contribute to the totality of cognitive development. Further that these processes may develop in very different ways according to different processes. Flavell is conceding what the Neo-Hullians long ago conceded in learning theory - there is little hope for a unitary one-concept theory. Of particular interest is the assertion in number nine that there may be very different processes that apply to individual items and small groups of experiences, and very different processes which operate with abstract and general concepts.

Number eight acknowledges the well-known increase in size of short-term memory and the centrality of this observation to the
theories of Pascuel-Leone, Case, and Fischer. On the surface this may seem relatively esoteric, but it is directly related to the ability of an individual to "chunk" information, deal in abstractions and generalize metacognitive instruction.

Number ten though seemingly banal, is the most striking inclusion. The history of the division in psychology between the experimentalists and the clinicians is legendary. Murray attempted to clarify the situation by discussing nomothetic and idiographic approaches (Murray, 1938). Despite occasional detentes and summits (e.g. Bandura, 1982, Mahoney, 1976, Seligman, 1975, etc.) there is little evidence of a greater tolerance for idiographic methods amongst experimentalists than there has ever been. While it is not likely that this suggestion by Flavell will cause the wills of the nomothetes to crumble, the acknowledgement that the value of development theory lies both in its ability to deal with individual differences in development and to spawn fertile guides for use in the work with individuals is notable.

Of particular interest to the proposed model for educational intervention is the developmentally originated research on metacognition and its possible implications. It is to this literature that I now turn.

Metacognition and Metacognitive Instruction

Research on metacognition evolved out of attempts to understand the development of learning in children. Reese (1962) proposed that there was a stage in a child’s development at which verbal responses can occur, but they do not serve any mediational
function in learning. Many of those statements which adults interpret as the genius of their children are nothing other than appropriate uses of words where the adult understanding of the word is absent in the child and thus the word can not be used to mediate any actual learning related to that meaning. From this developed the mediation deficiency hypothesis which, extrapolated, states that there exists a stage in development when the responses which behaviorally compose a task are all available, but the task cannot be performed. At this point, the notion was consistent with Piaget’s idea that cognitive processes cannot occur or be taught without prior passage of the requisite maturational watersheds.

Flavell (1970) showed that a second stage exists where a child could use a particular mediating learning strategy successfully when directed to do so, but would fail to do so spontaneously. He labeled this production deficiency - the capacity to mediate existed as evinced by correct use of the strategy when given explicit direction, but spontaneous use (appropriate or otherwise) did not occur. Taken together, mediation deficiency and production deficiency (Kreutzer, Leonard and Flavell, 1975) formed the launching pad for the study of children’s knowledge of their own cognitive processes. Flavell (1970) suggested that the development of memory was significantly determined by the child’s knowledge of his memory processes and the resultant ability to control them. He christened this knowledge of memory processes metamemory. Thus began the developmental study of the “metas” - soon to be collectively known as metacognition.
Following Flavell's formulation there ensued a number of years during which research focused on "what the child knew and when he knew it." In studying production deficiencies an important next question was, what can be done to overcome them? The debate of the day was between the Piagetians who believed that cognitive development was controlled by biological maturation and the learning theorist who believed that all one needed was enough of the appropriate experience. Brown and her colleagues (Campione and Brown, 1977; Brown, 1978) studying retarded children, described the ability to overcome production deficiencies with explicit training using strategies spontaneously used by age-matched non-retarded children, but the failure of that training to generalize to future instances of the same task or to transfer to similar tasks where the trained strategy would be appropriate.

Since generality of a concept is the sine qua non of its mastery, much subsequent research attention of Brown and her colleagues, as well as Belmont, Butterfield and Ferretti (1982), Borkowski et al (1979,1985), and Cavanaugh and Perlmutter (1982), among others, has focused on production of generalization and transfer in memory training. In general results have been very disappointing with direct instruction, except where the assessment is of the same information in the same situation as the training.

Metamemory (or more generally metacognition) is useful to learning strategy instruction to the extent that conscious knowledge of a strategy or process influences the performance of specific learning task in an appropriate manner - whether directly, or through
the acceleration of a process of learning and automatizing appropriate processes.

Flavell (1981) suggested that an important mediator between metacognition and performance was cognitive monitoring. He divided cognitive monitoring into four classes of phenomena: Metacognitive knowledge is what is known by an individual about people as cognitive creatures; metacognitive experience is conscious experience that accompanies or pertains to any intellectual enterprise; goals (or tasks) are the objectives of cognitive activity; and actions (or strategies) are the cognitions or activities used to achieve goals. He proposes that metacognitive knowledge is not different from any other learned materials in the principles that it follows. It can be activated by conscious direction or can work without intention or awareness; but, in either case its influence on action is not conscious, but it can enter consciousness. Metacognitive experience arises in situations that expressly demand it; tasks requiring planning, evaluation, decisions and involves language. Metacognitive experience can alter metacognitive knowledge, can activate strategies, and can alter or add new goals. Flavell distinguishes between cognitive strategies which are used to make cognitive progress and metacognitive strategies which monitor it. Cognitive monitoring proceeds through the action and interactions of these four classes of phenomena - but in ways which he does not specify.

Flavell proposes that the study of metacognition needs to move beyond catalogueing to the study of the building blocks of cognitive competence. He believes that cognitive monitoring is a
vehicle to greater metacognitive experience and thus (in unspecified fashion) to enhanced performance. He acknowledges that there is potential for overuse of metacognitive knowledge (e.g. becoming so obsessed with how you do something that it interferes with the actual performance), but doubts that it is likely to be a problem in any but the most exceptional cases. Thus, he concludes, that training in cognitive monitoring is the appropriate vehicle to enhanced metacognitive experience, which increases metacognitive knowledge, which improves performance. While these causal connections were, and mostly remain speculative, his more recent thought suggests that the basic biological tendency to learn combined with what we now know of the mechanics of development would give the participation of the learner a central role in the mediating process.

Concurrent with and subsequent to Flavell's call for a greater role of cognitive monitoring many programs were developed which, more less explicitly, used cognitive monitoring training as the centerpiece of attempts to improve learning (Meichenbaum and Asarnow, 1979; Weinstein and Rogers, 1984; Jones et al, 1984; etc.). While none of these programs is ever a well controlled study and none that are unsuccessful ever get published, the evidence seems to support at least some value of self-monitoring for improved learning and performance.

Flavell (1981), following Flavell and Wellman (1977) developed a taxonomy of variables which are independent pieces of the overall metacognitive picture. Task Variables are those that relate to the unique features of any particular task - though he doesn't mention
It explicitly, this presumably includes the goals for that task.

Person Variables are those factors of an individual learner which are relevant to performance of a particular task—presumably including learning styles. Strategies are varied ways of approaching a particular task. Sensitivity is knowing what is appropriate at any particular time—this might include contextual and goal factors, but also sensitivity to variation in person variables such as mood changes, etc.; while the ability to increase the detail and precision of the framework increased and the application of the framework to the study of the development of metacognition grew, the progress in elucidating the relationship of metacognitive knowledge to actual performance lay largely dormant.

Lawson (1984) proposed a refinement of Flavell's analysis which helps in focusing on significant training issues. He distinguishes between executive processes (controls on one's cognitive activity—including strategies) and metacognitive knowledge (conscious knowledge about the cognitive processes—including the executive processes). One of the executive processes in Lawson's model is what Flavell called metacognitive experience, the process by which experience becomes metacognitive knowledge.

Lawson proposes that metacognitive knowledge is conscious and therefore reportable, is more able to be transferred across domains of knowledge and requires controlled effort. In applying this to studies of novice and expert performance he proposes that experts have automatized their metacognitive knowledge to executive processes and are thus more rapid, less effortful and more content appropriate.
Lawson points out that the key feature of successful performance is a large knowledge base which is manipulated by rapid automatic executive processing.

One of the limitations of executive processes is their tendency to be domain specific (Chiesi et al., 1979; Anderson, 1984; Bransford, 1984; and Kuhara-Kojima and Hatano, 1985). Implicit in Lawson's formulation is the notion that executive processes become generalized when they become conscious metacognitive knowledge, that this can occur best with comprehension monitoring, and that more complex domain general and specific processes can be automatized for use as executive processes.

Ornstein and his colleagues (1984) have produced a series of results demonstrating the importance of knowledge base on strategy use. They find that strategies which the descriptive developmental literature would lead us to expect to appear late in development, will appear much earlier and be used spontaneously and appropriately if children have a knowledge base which is sufficiently large, with proper content and organization. This suggests that the emergence of executive processes is initially determined less by the developmental stage or by any metacognitive instruction than by the specific schemata the child has acquired - the knowledge base. It also suggests that if the proper knowledge base is present appropriate learning strategies will emerge spontaneously - automatically. This presents an important challenge to those who would produce improved learning strategy use. Is it better to teach strategies or to teach the organized material which will allow the strategies to emerge in an
already automatized condition? While the question is valid and the answer important, a direct test in an ecologically appropriate context is, if not impossible, certainly not realistic. It is worth noting that until very recent human history virtually all learning strategies that anyone had or used were acquired by a process of spontaneous discovery, emergence or modeling. There was almost certainly no metacognitive knowledge except what could be generated when questions were asked specifically seeking to assess it.

Learning Styles

All of the early history of the study of learning, and virtually all of the current research in the psychology of learning has focused on the discovery of the general truths. The glory days of learning theory were always touched by variables which allowed for individual differences, but the goal was a uniform process with fixed mechanics. Educational applications of learning theory tended to minimize differences except in overall ability (IQ). It was assumed that the processes were the same in all individuals. Despite brief and minor flurries of interest in differences in preferred sensory modality (audials and visuals) the orthodoxy stood.

This approach provided great convenience and opportunity for the curriculum planner. If one assumes that all individuals learn in the same way, with only differences in inherent ability, then it is reasonable to develop a curriculum that contains the same materials for all people. It is reasonable to expect that the effectiveness of the curriculum for any given individual will be depend on the ability or motivation of the individual. This spirit takes the focus in
curriculum planning away from any individual differences and places it squarely on the instructional goals. The development of a curriculum requires a careful analysis of the goals of the instruction and the assembly of a set of materials and exercises which will systematically insure that the individual exposed to the activities will move in an orderly fashion through the identified competencies to the attainment of the educational goals. This powerful logic, aided by the economic incentive of mass sales of uniform packages of materials has assisted in keeping the educational focus on the specific competencies and goals of the instructional process and off of the individual differences the learners bring to the learning.

The assumption of the curriculum developer has tended to be that if the specific competencies and goals were adequately specified and written into the curriculum than the attainment of the goals was dependent on the teacher’s, student’s and parent’s ability to generate sufficient motivation, and the inherent ability (intelligence) of the student.

It took a curious line of research beginning in clinical psychology to introduce difference in learning style to education. Carl Jung (1923), while in some sense only following in the spirit of Hippocrates, was the first modern psychologist to develop a model of individuals in which specific types of individuals responded to environmental stimuli in consistently different manners. Extroverts were consistently more responsive to external social sources of information as a basis for action, while introverts would, in the same situation, be more responsive to internal sources of information. This
was not just a matter of extroverts seeking out social interaction and introverts avoiding it (though that was the case) but it was a direct difference in bias for the information sources. Jung's views led to the development of a variety of models of personality, perhaps most notably the work of Eysenck (1981), but his impact on educational thinking awaited more basic research by experimental psychologists.

Witkin et al (1962) keynoted the field by observing that individuals differed in the extent to which they relied on isolated vs. contextual determined information. Field dependent individuals would be influenced in their perception of vertical by the context in which it was displayed, while field independent individuals would be less influenced by the perceptual field. Witkin and his colleagues and followers found that there were distinct consistencies in individuals which held from task to task, differentiated between the sexes, and correlated with educational performance, among others things.

The dimension of field dependence/field independence was of interest since it seemed to be a consistent attribute of individuals that biased perception and response to virtually all events. Here was a personally attributed characteristic which was stable and global. Personality researchers, social psychologists and developmental psychologist (sprinkled with a few perceptual psychologists - remember Maskelyne) became interested in the cognitive style dimension as an additional rubric for individual differences. The appeal was perfect. Not only did it have the quantitative reductionistic appeal of measureables which led to fixed box categorizations, but there was the
additional tantalizing issue of origin and possible modifiability. Kirby (1979) provides us with a non-exhaustive list of major cognitive style dimensions. The most notable feature of her review is the significant overlap amongst various putative dimensions of cognitive style.

Kirby (1979) has reviewed the transformation of the research on cognitive style to learning style and to educational applications. There remains a considerable range of views on the appropriateness of any particular conception, proper inclusions, best ways to assess and the best uses for educational purposes. There are a few things that are generally the subject of agreement. Individuals perceive, learn and remember in different ways which are not strictly related in any way to their overall learning ability. In short, the notion of intelligence should go - to be replaced by models of individual strengths and weaknesses.

Because of its varied history the concept of learning styles is used in a variety of ways. Hill (1979) and others put a great deal of emphasis on particular modes of sensory processing. Dunn and Dunn (1978) emphasize individual preferences in learning environment. Letteri (1979) and others have preferred to look at specific attributes of processing in an information processing framework. Some of the diffident reception and application of learning styles concepts must be laid to the lack of any consensus about the domain of learning styles, their relationship to cognitive styles, and, most importantly, which dimensions one should believe to be real, and thus apply. While educators who seek relief from the straight jacket of intelligence and
motivation are excited by the learning styles conception, the more they know about the field, the more confusing it can get. Without tying it to a research base there is little reason to expect progress.

The relationship of learning styles to actual school performance is of particular interest, especially given the dominance of intelligence as a school success predictor. In the absence of an accepted standard of learning styles the vast majority of research has looked at the relationship of single variables to school performance—often performance in a particular subject matter area. Finding that students that are field independent are better in some subjects is all well and good, but when it isn’t always so and when other subjects are performed better by those with field dependence, the value of the particularistic descriptive study becomes unclear. These studies do not address patterns of learning styles or flexibility in their use or the possibility of changing learning styles, and performance, by intervention.

Special concern about these issues comes from those who work with students out of the cultural mainstream. The attachment of value to particular styles is a source of concern. Cole and his colleagues (1972) suggested, "Cultural differences in cognition reside more in the situations into which particular cognitive processes are applied than in the existence of a process in one cultural group or its absence in another." Anderson (1977), after extensive study of cognitive styles of lower class and minority children, noted that testing the individual in one sphere often produced very different results from testing the same individual in another sphere. She
concluded, "Cross cultural research on learning characteristics indicates that children demonstrate the same basic cognitive processes in some situations but that these processes are not necessarily reflected in cognitive performance tests in school....Cognitive performance is inextricably related to the social and cultural tradition which produced it, but cannot be directly correlated with cognitive style until further research is done on other variables such as social status, student's fear in test situations and invalid tests." Ramirez and Castenada (1974), working with Mexican-American children and their teachers, found that individuals exhibited different styles depending on the task at hand. They developed an intervention program which showed that it was possible to teach an extension of the style repertoire. Saracho and Spodek (1985) reviewed the literature and concluded that there was strong evidence of flexibility of style and that it was possible to teach individuals to utilize their non-preferred style. In an earlier study, Robinson and Gray (1974) summed up the evidence nicely, "The frequency of equal facility with each style was found more prevalent...than a single mode style. In addition, over one-half of the school learning tasks involved multiple mode styles."

A significant advance in the application of cognitive/learning styles came with the development of models leading to style profiles. Kolb (1977) best illustrates one approach. He proposes (drawing heavily on the work of Kurt Lewin (1935)) that learning is something of a dialectic process. Similar to Piaget's equilibration process, the individual goes through a cycle of
concrete experience, reflective observation, abstract
conceptualization, active experimentation and back to another concrete
experience and around the cycle again. Learning is characterized as a
cycle of processes. Learning style would be the extent that an
individual would tend to prefer various of the parts of the cycle.
Interestingly enough a clear ideal for a learner would be a balance of
the four vs. a strength in a particular mode. The importance of
flexibility and/or balance appeared before and will again.

Letteri's cognitive style profile best exemplifies a second
approach (Letteri, 1979, 1980, 1985, in press). Letteri surveyed the
literature on cognitive style and its relationship to learning
effectiveness. He selected seven dimensions of cognitive style which
both showed patterns of positive relationship with school performance
(independent of subject) and which seemed to have a justifiable
position in a model of human information processing. He modified
existing tests, or developed his own, to assess each style dimension.
Tests were conducted looking for the relationship between cognitive
style scores and school performance. He reports that he found 3 basic
patterns of cognitive style profile: I - where an individual has high
scores on 4 or more of the scales, which virtually perfectly predicts
performance at least one year above grade level; II - where an
individual has a mixed pattern of scores with three or less either
high or low, which virtually perfectly predicts performance within one
year of grade level; and III - where an individual has at least four
low style scores, which virtually perfectly predicts performance more
than one year below grade level. While his results have yet to be
confirmed by other experimenters, his use of a profile of cognitive styles corresponding to existing literature on information processing is an important development. His development of a system for intervention, altering performance on individual style scales, thus the profile, and the school performance will be discussed with other programs seeking to improve learning.

A third model of learning style is nicely represented by the work of Dunn and Dunn (1978). Their approach is to look specifically at factors which seem, both from existing research and intuition, to be involved in the learning success. Tests are developed to assess each of the resulting types of stimuli. The resulting Learning Style Inventory assesses the preference of each individual for an array of learning stimulus elements. The goal of the assessment device was to provide the teacher with information helping them to incorporate appropriate options into both their individual and group teaching.

Kirby (1979) discusses the ways in which learning styles information can be used in educational settings. In the spirit of aptitude treatment interaction research she proposes that there are five types of matches between assessed style and use of that information in educational programs (cf. Cronbach and Snow, 1977).

1. Capitalization Match - to play to the existing strengths of the learner.

2. Compensatory Match - to offset deficiencies by providing the learner those things which they cannot provide for themselves.
3. Corrective (Remedial) Match - to specifically teach skills which remove deficiencies that block performance of the learner.

4. Combination Match - any combination of the preceding three.

5. Challenge Match - a deliberate mismatch which will force the learner to develop adaptive strengths.

Kirby is quite non-committal with regard to preferences or situations in which each should be presumed the desired alternative. She strongly believes that the guiding criterion for any response to an individual's learning styles should be to ensure maximum transfer from the learning situation to other learning and performance. She also points out that any use of learning style information should be sensitive to the developmental stage of the learner. A six year old and an adult are likely to have very different capacities and propensities for flexibility and adaptation. These must be taken into account in any learning styles based intervention.

Kirby concludes her review by identifying the "ultimate transfer skill ... knowing and being able to work with one's own style." It is probably quite unrealistic to expect that any one of us can know in complete detail an individual's learning style(s), the characteristics of the learning task and situation, the individual's personal and motivational characteristics which may be based on personal or cultural history, and the goals which may be those of the learner or the learner's advocates. To think that we should attempt to assume full responsibility for assessment, diagnosis and
prescription in educational setting can only incorporate error into a situation which presumes the learner should be the passive recipient of the learning. Instead, to the extent that the learner can be familiar with individual learning styles and preferences, and accept them as a starting point, they gain the capacity to work with themselves and their learning in ways that will be personally more effective.

This section will conclude with several criticisms and suggestions for the learning style approach.

1. Rather than using factor analysis and intuitively based research demonstrations to create models of styles, build models of learning that identify the variety of processes that can, and do, influence performance, and the multiple pathways that may exist along the way. This must be done by directly relating research on brain function, cognitive and learning processes in a wide variety of populations of learners and learning types. The results will, almost certainly be very complex and confusing, but dismay not - is that not the case with humans?

2. Pursue the role of attitude toward self and self-as-learner in successful learning and effective learning activity selection. We have very little direct knowledge about where these attitudes come from or how they affect actual learning performance (level of aspiration research to the contrary notwithstanding). It is worth assuming, as a working hypothesis, that an individual who wants to learn something and believes in his/her ability will be most likely to find those personal styles and use them in the most effective
dynamic to achieve the desired ends. While this may be an overly optimistic assumption (there are many anecdotes which suggest cases where it would not apply simply - e.g. work blocks, etc.) the research into this area should begin to define the territory and the resulting appropriate role of the learner.

3. Continue research into the types of skills that are appropriate to the skilled performance in particular learning activities. This should look most intently for varied ways in which the same task can be adequately, if not skillfully, performed (e.g. visual vs. auditory readers, people who can get the right answers but can’t tell why or how, vs. skilled self-monitors, visual or spatial arithmetic learners vs. rote learners, etc.).

4. Research the way in which "skilled learners" make decisions about which learning style is appropriate for them in which type of task, and how they switch styles. Are there surface styles and deep styles where the process of transition from one to the other is as important as the styles themselves?

5. How much can individual styles be taught or improved? What are the types of experiences which produce changes in style strength and utilization? What lengths of training can be expected to produce what magnitudes of change? At what ages do what sorts of people have what sorts of changes occur and with what experiences? Are there metacognitive shortcuts to style improvement or change which can be effective at some age? What? How? What are their limits? What sorts of generalization can be produced by metacognitive override? While there are many types of research which suggest answers to some
of these questions, there has been little systematically directed at learning style issues.

6. It is important to look at the relationship between metacognitive information, the types of styles that an individual uses and their effectiveness. Is the metacognition necessary (see section on automatic processes)? If so, at what age? Can it interfere? If so, is it an age/developmental stage problem or an overgeneralization problem? How can the metacognitive information be given to an individual so that it will produce the maximum behavioral change in the desired direction? What is the appropriate role of the individual in this determination?

7. We need a method for evaluating the accuracy of learning styles claims which can by-pass the biases of the theorist and the learner. An important step will be to establish that there are differences in the functioning of the nervous system which correspond to differences in "learning style" and resulting performance in individuals. Preliminary observations suggest that this may provide us with a way out of the confusion of this literature relating not just to the models of learning style and their validity, but to effective learning performance directly (Languis and Wittrock, in press).

8. It is important to continue research into teaching styles and their relationship to learning styles (Lyons, 1982). A good place to begin would be look at the characteristics and modes of presentation of teachers who are found to be good at producing learning with a wide variety of learning styled students. They are
either very good at picking out the needs of the students and individualizing to meet those needs (certainly the case some of the time) or they are presenting the material in a form which makes it accessible to people with a wide variety of styles at the same time (most obvious in the style of those universally regarded as outstanding lecturers). The skills of the good teacher need to be more carefully evaluated, particularly as they relate to students of mixed and varied learning styles.

Research on learning styles is a strong step in the right direction - away from simplistic uni-dimensional categorization of individuals toward the appreciation of the complex dynamic of learning contexts. The current forms are prone to premature closure - the hypostatization of a preliminary and limited set of concrete references with relatively simple and apparent applicability. While this is likely a necessary step toward a more accurate and fruitful understanding of human learning, it is not in anyone's best interest to let research dwell on the precision and quantification of the premature. Research needs to continue in the directions outlined above toward a more mature understanding of learning and teaching - where learning style and the learner are a part.

Lucy

Lucy was a bright, energetic and verbal youngster. Although there had been some minor toxicity with her mother during the later stages of the pregnancy, there was a normal delivery and development. The only evidence suggestive of a problem was poor eyesight, in a family where all members as far back and as wide as anyone could
remember had excellent eyesight. Lucy learned to read before going to school. She was a very rapid reader who read everything that she could get her hands on. In school Lucy was never terribly comfortable. While everyone thought she was very pleasant and capable she hated school and performed with mixed success. She briefly attended a parochial school during middle elementary years where the teachers were particularly abusive, critical of her high level of activity and lack of disciplined attention to the mechanical details of school work. Through it all she read insatiably. In later elementary school she started, wrote, edited, printed and distributed a newspaper for her neighborhood. In Junior High School she loved to write. She wrote fiction and humor in great quantities and to universal high acclaim from teachers, friends and family alike. Her schoolwork continued to be marginal. She quit school twice, once to start a catering business and once to design clothing. She decided that the world of work was more than she was ready for. With the support of her parents she returned to school. In high school she found that she was asked to write expository prose - history papers, etc. Grading of the papers was now based on specifics of mechanics more than quality of ideas. Lucy now hated to write. She not only wrote schoolwork with great reluctance but stopped recreational writing entirely. She had never had good writing mechanics and her spelling was terrible. She was unable to pronounce or spell words she read, yet she continued to read in enormous amounts, very rapidly, and with excellent comprehension.
Lucy barely managed to get out of high school. After an unpleasant experience in summer sales work she went to a small state college to become a teacher. During the early stages of college she began to enjoy writing again. Her creative flair was highly rewarded, her mechanical weaknesses were temporarily ignored. She was strongly encouraged to become an English major. In her advanced work, especially elementary methods courses, she was again under the gun for mechanical deficiencies in her expository writing. She again hated to write and stopped. She would conceptualize papers for her friends who would write them and get A’s. She would write her own papers with great pain and anguish and get D’s.

After a period of teaching, Lucy began to pursue an advanced degree in counseling. This required more of the dreaded writing. She now found that the writing that she had to do was, even though it required formal research and documentation, similar in form and concept to her fiction writing. She was writing about characters and feelings and the ways of dealing with them. Though her mechanics were still weak and unpleasant, the completion of these papers was manageable, if not terribly pleasant. Over the years her graduate education continued along the same general lines. Though she never loved the writing, the things that she was writing were of interest and manageable. She continued to read everything and was universally acknowledged for her good ideas and insights. Whenever she had to write papers that presented problems, she would find someone who was good at the mechanics to help her with the editing and spelling. She completed a doctorate, including a dissertation, and began college
teaching.

She was an excellent teacher, full of sensitivity to her students, able to weave intricate lectures, an energetic scholar and researcher. Each time she came up for tenure or promotion there was criticism from the more traditional scholastics of her lack of writing and publication. Despite the fact that she had made numerous presentations to prestigious bodies, served in responsible positions in national professional associations, gotten grants and conducted research and was an outstanding teacher, she had not written. She had stopped writing everything other than the absolutely necessary; and even much of that was written for her by secretaries, colleagues, her husband or others.

After reaching the position of tenured Full Professor she received a Fellowship to conduct research while on Sabbatical. This was a great opportunity, but it brought up the ghost of her writing "disability." She was now expected to, not only conceptualize and research, but also write up the results in an expository form for an unknown and impersonal audience. To make things worse her writing would have to be reviewed, approved and edited by a vast army of colleagues. On the basis of these comments she would have to revise and edit through numerous drafts. Nothing could be turned in and forgotten. Well into adulthood, Lucy had to confront her "learning disability" and attempt to solve it directly.

Lucy has clearly managed to be successful in a career where very high levels of intellectual ability are expected. Her story is not terribly different than that of many individuals who have learning
difficulties in some area(s), hate school, but find ways to be successful nonetheless. All of these individuals have strengths in areas which support them by covering or compensating for their weaknesses. From some source they get the motivation and ability to work around the problem, often with considerable emotional cost and generally without actually coming to terms with the problem and developing the strengths present in their areas of weakness. Lucy had loved to write. When she wrote fiction, humorous fiction or expository prose which followed fictional format and dealt with feelings she was quite outstanding. She was an acclaimed teacher from elementary school level through to graduate school; talking is, at some level, writing with some different mechanics. Yet she was a terrible speller, very poor in the mechanics of sentence structure, and had great difficulty following the form demanded by scholarly expository prose. She was successful, but she stopped writing everything, including the writing that she had loved. It is important to note that people like Lucy are seldom, even now, diagnosed as learning disabled and given any special assistance.

Norman Geschwind (1982), shortly before his untimely death, avered that, "We all have learning disabilities in some areas." Later he said, "Knowing that one's brain is organized and processes differently from another's gives us the freedom to accept ourselves and our uniqueness and to make the first necessary step to doing something positive about it." (Geschwind, 1983)

The model to be developed here is based on the assumption that we each have strengths and weaknesses. Success in overcoming or
compensating for our weaknesses can be enhanced by self-knowledge (metacognition) and that one powerful path to that freeing self-knowledge is direct experience with the operation of one's own brain in the those areas where the problems may become manifest. Furthermore, strengths can be increased. The most direct and powerful way to accomplish that is to provide the individual with increased information about strategies which can be used to confront any learning task and a set of self-monitoring skills which can be used for a lifetime of "self-instruction."

Before looking at any specifics of such a process, let's look at what sorts of hypotheses we could derive from an examination of Lucy's history. Lucy could speak well (witness her teaching abilities). She could write well, except for the mechanics of spelling and sentence structure, if the writing was generated from feelings about people and situations and followed the forms of the fiction that she read insatiably all her life. If writing followed a logically ordered form of exposition, formally generated for the "universal" audience she had great difficulty with a coherent flow of the prose as well as the mechanics, even though all acknowledged that the ideas were good. Both speaking and writing are types of language production which are intended for communication with others. We might safety assume that language comprehension and production are quite fine in Lucy (reading, teaching and fiction writing). Lucy's college lectures were not just flights of fiction or feeling, but were often ordered logical presentations of the same sorts of material which would comprise written exposition - the only difference was that it
was spoken. As all who have ever attempted to take verbatim notes know, even slow speech is much faster than writing. Perhaps some of Lucy's writing difficulty has to do with processing speed or the development of strategies for keeping track of ideas so that they are intact when the mechanical production has caught up with the ideas. The fact that the difficulty seems to appear where there is an enforced formal structure which is demanded for addressing the "universal audience" suggests that she may have some difficulty in conforming to a structured sequence of steps and processes which do not generate from feeling (sequential vs. simultaneous processing). Given that she had some unpleasant experiences which came from punishment for poor mechanics, it is possible that a poor self-concept of herself as writer would interfere with her willingness to try to write (arousal and attention to writing), or the ability to direct, sustain or verify the quality of her writing (planning, sequencing and verifying). The fact that Lucy reads very fast combined with her poor spelling, poor ability to pronounce what she has read and her pre-school learning of reading suggest that she may be reading visually, not auditorily. Her representation of linguistic information may be visual/spatial vs. auditory/sequential. These idiographic observations may or may not be accurate, but each of these hypotheses is amenable to assessment. Furthermore, each of these hypotheses has a clear possible basis in known neural functioning. As Geschwind suggested, direct information about the functioning of her nervous system might have provided her with an authoritative basis for the development of personal adaptations which would have avoided many
of the difficulties with writing that have continued throughout her
life. Knowledge of alternatives and supervised experience in gaining
skill with them might have greatly enhanced her performance in
writing.

Lucy obviously had a great deal going for her. Many others
with learning difficulties have much less going for them. Many are
casualties - never finding adaptations and eventually developing
selective learned helplessnesses (Seligman, 1976). We can't know with
any certainty the limits of ability of individuals. We can readily
observe the consequence of learned helplessness. An educational
program which provides all individuals with information about
alternative approaches to learning, opportunities to explore and
utilize them, skills in self-monitoring, and an environment which is
supportive of their efforts is most likely to produce full usage of
whatever learning capacities exist. Individuals who experience
specific difficulties which create difficulties will additionally
benefit from authoritative information which introduces them to the
workings of their nervous systems directly.
A Model of Learning

There is not one kind of learning. It was the vanity of a preceding generation to think that the battle over learning theories would eventuate in one winning over all the others. Any learner has a host of strategies at command. The solution is in the learning how to go about learning before getting irreversibly beyond the point of no return. We would do well to equip learners with a menu of their possibilities and, in the course of their education, to arm them with procedures and sensibilities that would make it possible for them to use the menu wisely...You cannot improve the state of education without improving that of the learner. Yet the model of the learner is not fixed but various. A choice of one reflects many political, practical, and cultural issues. Perhaps the best choice is not a choice of one, but an appreciation that variety is what makes the practice of education something more than an exercise in cultural rigidity.

Jerome Bruner, 1985

Any attempt to develop a program for the modification of learning in individuals must necessarily assume a model of learning. There are no shortages of models of learning (Bower and Hilgard, 1981). The experimental literature on learning which has burgeoned so handsomely with the growth of the cognitive sciences is a seemingly endless array of demonstrations that particular types of processing can work in various situations. If it is possible to demonstrate that people behave in experiments in conformity with a wide variety of diverse conceptions of mental processes (e.g. different representational systems, different procedural knowledge and heuristics, different coding systems, etc.), then the central truth about learning must be the no one model of processing is completely accurate. A worthy model of learning must include the fact that, given the right conditions, learners can behave in a wide variety of ways—and do so effectively. Thus a useful model of human learning
must be a model of models - a meta-model, in which the critical issue
is the ability of the learner to perform in the manner most appropriate
in a given learning situation. Success in learning is more dependent
upon the "control processes" than on any specific knowledge, skills or
execution of a mechanism. Such a model would eliminate the "learning
disability" category and move individuals to various learning style
configurations, those not compatible with the way in which specific
subject matters are generally taught.

The goal of any learning model is to give focus to research
while enabling practitioners to improve the quality of learning.
Models which promote research are those which make testable
assertions, often provocative and wrong. Those models which are
likely to produce better learning are those which are clear and simple
enough to be understood by teachers and learners where the methods of
effective application are also clear, understood and feasible. Models
aimed at each of these purposes may be very different on the surface,
even where they are representing the same processes and based on the
same research data.

If we assume that central to the best model of learning is
the "meta-processing," the study of learning should focus on these
processes, their acquisition, skillful selection and execution. It is
implicit in these assumptions that a crucial factor in effective
learning is the accurate assessment of the context of the learning —
including the context brought to the learning by the learner (self).

The model presented here begins with the assumption that all
individuals are learners. Andrews (1968) developed a model of human
thought and action based on the simple notion that the nervous system is a very complex uncertainty reduction device, one whose precise nature and structure depends upon the total context within which it finds itself at any given moment. The basic premise is that the nervous system will, when conditions create "uncertainty", act to reduce that uncertainty - thus maximizing the information contained within the system. There are a vast number of subtleties in the way in which this one simple concept operates. Though the theory was never published, and will not be fully developed here, it will serve as an underlying principle in the proposed model. In simple form, the reduction of uncertainty is the creation of information, which is learning (cf. Piaget's equilibration).

Of critical importance is that internal representations can be a source of that uncertainty. Internal representations are "modularized" by both structure and experience so that internal inconsistency "uncertainty" may be as much the norm as the exception. A set of knowledges or processes applied to one domain may be totally inconsistent with those applied in another. This is objective uncertainty, but subjective uncertainty results only when circumstances force the conflict - normally as response conflict (see definition of response below). One important source of individual difference will be the degree and type of experiential modularization inherent in each individual's nervous system.

Conscious human knowledge - especially metacognitive knowledge - creates a single centralized arbitrator of action while it is in operation. Thus the modularities of external conditions and
internal dis-integration are temporarily overridden by the single voice of authority that consciousness provides (Jaynes, 1976). Thus one way to produce generalized action when it is to introduce an heuristic to consciousness. When consciousness of the need is present it will serve as the generalizer and provide the option of strategy selection on non-contemporaneous grounds. Before we can understand the operation of these control processes, we must know something of the system on which they operate.

Human learning requires input and representation. If it is of educational interest it must be of consequence in some output. Because of the interconnectedness of the nervous system, the clear evidence that internal models, ideas, goals, etc. can influence action without external input, and the evidence that learning can occur without the actual occurrence of any concurrent output, it will be assumed that anything that occurs to the nervous system up to the final motoneuron is a stimulus and anything that the nervous system does after the initial sensory neuron is a response. That makes everything in the middle both, thus, allows for internal interaction and ends the absurdities of black box S-R psychology.

All learning starts with stimuli. These can enter the learning process by any number of pathways. The external pathways are the well known sensory systems. We must also allow for internal sources of stimulation - biological conditions of the individual, emotional states, personal preoccupations, attitudes or sets and all the other structural features of the nervous system at any given time. The learning of an individual will be influenced by the relative
ability of each source of stimulation to convert the events that trigger them into neural representations - the stuff of processing. An individual with poor resolution in auditory channels will have difficulty making fine auditory discriminations and make poor representations of sounds. This will mean that other input channels will be relatively more effective in learning (for the moment we will suspend discussion of origin of this state or modifiability).

The next step is the process by which individual events are isolated and identified for representation, further processing or transformation. Selective attention does not necessarily mean that the information will enter consciousness, merely that the information will be selected and isolated in a discriminant form permitting further processing.

Part of this process is built into the nervous system. More powerful stimuli are more likely to be isolated than weaker. Less frequent stimuli are more likely to be identified. The nervous system is tuned to be particularly prone to isolate some types of stimuli, e.g. human faces, speech sounds, etc. Beyond this the determination of isolation is based on the accumulated knowledge of the individual which creates a subjective uncertainty value for the individual (e.g. the greater tendency to be distracted by one's name in a dichotic listening tracking task). The combined structural givens and the accumulated wetware of experience are the knowledge structures that determine isolation.

Representation also has many options which are determined in similar fashion. It is possible that individuals have greater or
lessor capacity to represent information in their nervous systems in particular forms (e.g. spatial representations, visual representations, categorical form, propositional structures, specific details, global wholes, sequentially, etc.). It is also likely that experience determines the most likely types of representations, whether or not they are directly determined by the given neural structures (Hubel and Wiesel, 1962; Hirsch and Spinelli, 1970).

In accord with Luria's model (1973, see below), the knowledge structures is a house of many mansions. In keeping with artificial intelligence modeling, these knowledge structures contain declarative and procedural structures, the information which determines the uncertainty, and thus the arousal and attention. They include the representational formats and the structures which determine what representations and generalizations of these representations will occur. They include the procedures and processes which organize the output, provide the basis for the models against which on-going activity is monitored for information value and contain all of the executive programs which are the basis of the control processes. It may appear as though this model of the learner creates from Sherrington's enchanted loom (Sherrington, 1906), a seemless web - a reticulum of unknowability and untestability.

To some extent that is the case, but the details of that philosophical argument will be spared the reader. It is important that the very structure of the input systems of the brain will create different, and normally isolated representations and procedures and planning and execution and verification systems. While synesthesia
exists, it is certainly not a universal. That which keeps sensory systems isolated will tend to keep resulting representation systems (knowledge structures) isolated. Language is also a powerful structuring and isolating system. To the extent that information is acquired through language, the access to that information will be through the same language which stored it. In this sense this model proposes structurally and experientially encapsulated knowledge structures. With increasing experience which creates interactions of sensory processes associated with establishment of knowledge structures and with the unifying power of language and conscious manipulation, there will develop isotrophic forms—generalizations of knowledge structures which tend to unify, albeit at another level, the encapsulated knowledge structures (cf. Pavlov's second signal system).

It is important to note that the isotrophisms that are thus created are not necessarily isotrophic with the foundational knowledge structures. Thus we can have the type of inconsistencies and overgeneralizations that Gazzaniga identifies in beliefs and actions (Gazzaniga, 1985).

Executive processes, as stated at the beginning, are critical to the successful operation of this system. At this point the unknowability of the knowledge structures of an individual becomes important. Executive processes can be entirely unconscious. They can also be conscious, as in the case where they have been given by direct linguistic instruction as metacognitive knowledge. Many have puzzled over the difficulty of getting the metacognitive knowledge to generalize or transfer. This model says that metacognitive or
conscious knowledge is the same as any other knowledge — that is, to
the extent that it is present in the knowledge structures activated in
a situation it will affect the resulting behavior. If it is not
activated, it might as well not exist. Metacognitive knowledge and
conscious control processes are just another piece of the knowledge
structures. On the one hand, they will work when they have been
automatized into isotrophic forms which are generalized across the
knowledge structures. On the other hand, the time binding (Korzybski,
1958) properties of language give linguistically based metacognitive
knowledge the potential to generalize as long as there is a cue that
triggers placement of the proper executive process in the response
generation sequence. For example, if you know that you can do math
better when you represent the information as visual images there is no
guarantee that when math comes along you will start doing any visual
imaging. However, if you can identify that this is a math task and,
at least covertly, scan through what you know about how to do math
well, you are likely to come upon the declarative structure "I do math
better when I make visual images" which, given the power of linguistic
control of output processes (or at least internal self-direction)
makes it more likely that you will generate visual images while doing
the math. Thus, metacognitive knowledge can take an advantageous
position to the extent that the form in which this information is
structured includes a self-cueing device that will trigger its use in
the appropriate situations (thus the value of self-monitoring).

This is not only true for the more traditional notions of
executive control processes, but is also true for the creation of the
internal conditions which are optimal for effective learning. In the same way that I can cue myself to use visual imagery, I can cue myself to sit up straight, or study in the evening, or remember that I need to know chemistry if I plan to be a doctor or that I should take several deep breaths before I study to reduce anxiety, etc. What Dansereau (1978) refers as to Mood in his MURDER study system can be under conscious control in the creation of optimal learning conditions.

While early in development learning is under direct control of the knowledge structures, in adulthood there is greater and greater control by the linguistically coded and stored metacognitive knowledge (Second Signal System). Thus, beginning at about the period Piaget identifies as the beginning of formal operations, development of learning skills via metacognitive instruction plus instruction in self-monitoring and self-cueing should be most effective.

Individual differences in learning performance can exist in any of the following parts of the learning system:

1. Input Systems
2. Representational Systems
3. Transformational Processes
4. Knowledge Structures
5. Output Systems
6. Executive Processes

The first three and fifth have the distinct appearance of biologically bias - they may be modifyable, but there is likely to be strong initial bias or limitations. The fourth is the product of the
totality of personal experience in interaction with the status quo system. The sixth is the system with the most potential for relatively easy modification. It is here that most attempts to improve individual learning, especially in short-term interventions, have focused their efforts.

**Learning Skills Instruction**

Attempts to train improved learning, memory or thought are nothing new. Yates recounts a fascinating history of memory systems, beginning with Simonides of Cos, reputed first practitioner of the method of loci (Yates, 1966). There is good reason to believe that many systems of memory enhancement have been in operation since earliest human history. Gideon, Jaynes and others have suggested that the human artistic artifacts are actually only eidetic memory systems. Most speculation on the origins of writing centers on their function as an externalized memory system which could be transported where numbers could not. There is much reason to believe that early poetic writing was the transcription of spoken words, probably conveyed in song to enhance the recall of their bearers.

Self-conscious instruction in specific methods to improve learning, memory and thought is actually, Yates' recounting notwithstanding, a very recent impulse. The two most common forms of instruction are programs for developing memory techniques and study skills instruction. These approaches have in common that they provide the learner with a specific set of steps and procedures which, if followed, are reputed to lead to improvement in memory or school learning. In this sense these are a cross between algorithms and
heuristics, generally mechanical in application and without concern for individual differences in learners but requiring the learner to determine when and whether they will be used.

Memory techniques (Mnemonic devices) are normally presented as aids to recall of those things that you wish you could remember, but don't (e.g., Lorayne and Lucas, 1974). The recall of specific associations is relatively dis-articulated and removed from the body of a personal association network. Thus, the task of the mnemonic device is to take the "meaningless" association (for example, a name and a face) and create a meaningful framework which will improve retention of the association and, more importantly, retrieval.

Virtually all mnemonic systems are combinations of the method of loci, peg word systems, link systems - including the keyword approach, or systems of imagery. These are often combined with systems for creating uniqueness of the associations (von Restorff effect) to reduce interference and built-in procedures for systematic memory search to convert recall tasks to recognition.

Mnemonic systems work. The techniques are ones that individuals with good memories routinely use without instruction (see section on automatization). However, there has been much criticism of pure memory instruction on the grounds that it leads to the creation of flypaper learning - the recall of impressive amounts of information which have little relationship to each other. Thus limits are placed on its use (recall vs. thought, creative activity, etc). Luria's example of the memory expert who was lacking in any appreciable evidence of conceptual powers, despite a prodigious memory, is often
cited as anecdotal evidence of this problem (Luria, 1973). However, Levin (Pressley and Levin, 1983) and his colleagues have shown that the keyword method not only leads to increased recall of individual associations, but leads to greater facility in the subsequent use of that information in more meaningful ways. The other major criticism of memory skills instruction has been that the skills can be learned and used, but the skills are commonly not used spontaneously after completion of the instruction.

While any system for improving learning should include mnemonic devices, instruction in the devices is clearly not sufficient. As the literature on learning styles suggests, there will be considerable differences in the ability of individuals to use various mnemonic devices and the tendency of the individual to use them in flexible and appropriate ways. Successful instruction in memory skills needs to include the individual characteristics of the learner and tactics for the transfer of the skills from the learning situation to the situations in which the learner needs to use them.

Study skills instruction can best be illustrated by the most durable and best known method. Robinson (1961) proposed the SQ3R method as a structured strategy for improving individual learning of assigned school reading. A learner should first Survey the material to be learned; Questions are asked that one would reasonably expect to be able to answer at the end of reading; the material is then Read; an immediate Recite follows during which the questions are answered; and, at a time in the future a Review session is used to refamiliarize the learner with the material and promote long-term retention. The first
two steps prepare fertile ground for the receipt of the information (cf Advanced Organizers, Ausuble, 1960), the third introduces the information, the fourth makes sure that the information is well attached to the fertile ground and the fifth makes sure that with a little cultivation the roots take hold. In contrast to most mnemonic device instruction, this method provides great individual latitude in the types of questions the learner asks, how the surveying is done, the nature of review, etc. There is a relatively small collection of learning principles included in the conception of this system. But despite this there are seemingly endless individuals who have become familiar with this system and report that it was at least a little helpful in improving their school learning. At the same time, there is no evidence that the method produces experimentally demonstrable improvement beyond a suitable control instructional procedure.

There is an enormous array of "Sons of SQ3R." Each takes the propositions that: the well prepared mind will learn better; and, that some sort of review, processing or repetition is helpful, and builds it into a study skills system. The urge to acronym seems to know no bounds. Dansereau's MURDER system (1979) differs from Robinson's system in two notable ways. The M (mood) acknowledges that there exist an number of attitudinal, situational and motivational factors that contribute to learning. These must be prepared before there is any reason to expect efficient learning. The E (elaborate) suggests that it is important to go beyond the "repetition" implied in SQ3R and produce elaborated associational networks for the information to provide greater meaning, greater longevity and greater ease of access.
Newer systems, such as Dansereau's, incorporate additional findings from cognitive psychology and the psychology of learning, but suffer from the same affliction as SQ3R. They are easy to remember, easy targets for success attributions, but there is considerable doubt that they actually produce substantial systematic change in learner behavior.

Another approach to study skills instruction is the delivery of a broader arsenal of facts and techniques. Pauk (1972) has developed an oft-reprinted and widely used book of principles for effective studying in college. The principles are broad ranging, from the personal and attitudinal, to the technical (notetaking) to more esoteric principles from research which may apply to specific subject matter areas. In talking with students who have read this book the almost universal response has been that there are a lot of good ideas in there; a few of them which seemed consistent with what they already do have been used; but, almost none of it is retained or used in the long term. I suspect that this is not so much a problem with anything that is said in the book, but the fact that the information is presented in a book which is unconnected with specific individual learning tasks or individual learners.

Fenker (1985), who has worked with Dansereau, has written an example of another type of popular learning skills book. Fenker's book suggests that learning is the goal, not studying. He presents a sound array of information on the processes of learning using a personalized and comic style. I know of no information that directly addresses the issue, but I suspect that the results of his book are
not terribly different than those of Pauk, except that people enjoy reading it somewhat more. Other books adopt similar approaches to the problem. Baddeley (1982) sticks much closer to the research literature of cognitive psychology. Buzan (1983) adopts a breezy and optimistic style, almost cheerleading, but while making general reference to a wide variety of specific research findings. Cermak (1975) deals more specifically with memory and stays close to the literature. Many others spin off loosely woven thoughts and recommendations for a market that is known to exist.

A rather different approach focuses on the creation of the circumstances in which the inherent learning capability of the individual will be able to express itself. Purkey and Novak (1984), writing primarily for teachers and not learners, discuss methods by which individuals may be "invited" to join in the joys of learning in school settings. This apparent flirtation with the romantic excesses of the 1960s draws heavily on the literature of personality research and social psychology and proposes specific types of approaches and activities which can produce learners - giving them permission to learn and providing an environment which invites entry and participation and reward through natural consequences.

These written materials are not actually programs for improvement of learning skills. However, actual curricular programs are often comparable collections of principles and activities; but, they have the advantage of being worked into learning situations with learners under the direction of a responsive instructor. On the surface, this contextualizing would lead us to suspect much greater
effectiveness. Recently developed and implemented programs often blur the lines between learning, thinking and intelligence. All are designed to assist individuals in being more effective as learners and/or thinkers. Some focus specifically on school learning. Some focus on specific populations of individuals. Some seek utopian intellectualizing of the underclasses of the world (Machado, 1980). Some look at a single skill as the critical vehicle to learning improvement. Some look at a wider array. Since the numbers of such programs is quite considerable, only a small sample of them will be reviewed here in an attempt to give a sense of the variety of extant approaches.

Unfortunately, a large number of programs for learning enhancement have been developed and utilized for entrepreneurial purposes (e.g. Learning to Learn - Heiman (1984); 4-MAT - McCarthy (1983); CoRT - deBono (1976); Instrumental Enhancement - Feuerstein (1990); HOTS - Pogrow (1985), among many others). While the urge to profit from one's creations is certainly fitting, the effect has been a proprietary protectiveness preventing researchers access to full information on the contents of the programs, opportunity to evaluate them, or access to the evaluative experiences of the developers. Such programs may be outstandingly effective and well founded in the research literature, but we can evaluate them primarily by their promotional literature and the testimony of those involved. To the extent that public information is available about these programs they appear to be essentially the same types of materials included in more accessible programs. Sadly, discussion of such
programs will, of necessity, be almost entirely omitted from what follows.

A number of programs have based their work on metacognitive research. The primary focus of their intervention has been the development of self-monitoring skills. If good learners are good at self-monitoring and possess extensive metacognitive knowledge, then it might follow that if individuals can be taught good self-monitoring skills they may become more efficient learners. While no one program has made the teaching of self-monitoring the sole focus of instruction, it occupies a central role in almost all of the systems that will be discussed below. It is assumed that if an individual is to follow through a complex process of learning activities it is necessary to be sensitive to present behavior in relation to the goal. This permits the flexibility and redirection that is characteristic of good learners (Simon, 1979; Peterson et al, 1982a and b). Furthermore, if explicit metacognitive knowledge is to become integrated into the executive processing of the individual in at least quasi-isotrophic form, anything which is able to identify relevant metacognitive principles will have a distinct advantage over principles given directly from an external source. Thus the metacognitive experience which comes from self-monitoring will lead to metacognitive knowledge which, with additional use and self-reinforcement, lead to generalization and transfer. Only Letteri's system, of those discussed below, does not explicitly work to produce increased self-monitoring, and even his approach will have self-monitoring as a strong by-product.
The majority of systems are combinations of learning strategy instruction and self-monitoring. Dansereau (1978) and Weinstein (1978) have been leaders in the development and researching of such systems. Weinstein's system builds heavily on teaching learners to use elaborative processes. These processes, essentially extensions of Wittrock's (1973) idea of generative processes, and cognitive research on association strategies, teaches the students to take what they have been exposed to and build elaborations of that information to, and with, those things already familiar. These then give associative structures which create meaning and enhance retrievability, building on the existing knowledge structures. In addition, promotion of elaboration will necessarily enhance attention to and involvement in the material at hand, as well as self-awareness implicit in the elaboration process. Dansereau (Holley and Dansereau, 1985) has put a great deal of emphasis on the use of spatial strategies to enhance learning. Noting that the grandfather of all memory strategies, the method of loci, utilizes familiar spatial structure to order memory storage and search. Building on the putative differences in representational processes of the two hemispheres, he develops a model for the representation of information in spatial structure—Networking. When a learner builds a network the information must be transformed from the, usually, textual form into relationships and associations which are meaningful for the learner. When the information is represented that way, the learner gets a cognitively different look at it which both allows evaluation of the representation generated and a memory organization which is compatible
with the individual's knowledge structures. To the extent that dual representation in the modes commonly ascribed to left and right hemisphere is an advantage, the use of spatial strategies will take advantage of it.

Other systems have been developed which place primary emphasis on the affective foundation of effective learning. McCombs (1984), developed a system which focuses on teaching self-awareness and thus an affective comfort with personal strengths and weaknesses that will maximize effectiveness. Her system is specifically focused on the motivational side of learning effectiveness and builds on the role of the instructor as a model.

Meichenbaum and associates (Meichenbaum and Asarnow, 1979) have been in the leadership of developing programs which teach the learner behavioral principles of control - then teach their use in the modification of their own learning behavior. This extension and focus of the social learning principles originally researched by Mischel (1968), while relatively narrow in scope, has the potential to provide the learner with a powerful set of tools for self-modification. Effective learning skills instruction also requires information which helps the learner know the types of modifications they seek. Despite some of the encouraging evidence Meichenbaum presents, the idea of an individual being the behavioral shaper for him/herself has all of the limitations of the behaviorist approach in working with others - see Methodology section below.

A large number of programs (many leaning toward the entrepreneurial) have been developed to produce enhanced higher order
learning skills. Lohman (1985) and Segal, Chipman and Glaser (1985) have reviewed several of these efforts. These approaches vary widely in origin and purpose. Feuerstein (1980) was originally interested in "instrumental enhancement" of learning and thinking abilities in "retarded" individuals. He found such success that he, and his followers have extended their efforts to the general population. The basic plan of the program is to get individuals to explore options in their thought processes and examine their application to various conceptual situations. By enhancing options, learning will improve.

de Bono (1976) proposes a program of lateral thinking. He exposes individuals to a variety of clever and interesting activities which demonstrate variety in approaching learning and problem solving situations. The assumption is that by breaking sets and promoting more varied thinking, there can be unlimited potential for creative problem solving and, derivatively, learning. Hayes (1981) coming from the artificial intelligence tradition which relies on the comparison of experts and novices - discovers the types of heuristics and strategies that are used by the experts and then teaches them to the novices.

Lipman (1976) believes that the concepts and methods of philosophical thought, if taught to children will give them the power to reason, think, and by inference, learn at much higher levels. Whimbey and Lockhead (1980) have a program of problem solving skills which are taught through direct instruction. While they are not specifically concerned with learning, the borderline between learning and problems solving and thinking is seldom clear. The most striking feature of all these approaches is that they all work. Not only that, they all work
well. The concern for anyone interested in enhancing learning, thinking and problem-solving ability must be, in what situations do they work and for what people? Rarely are any learning instruction programs tested in any situation other than one very similar to that in which the instruction occurred. Furthermore, the Hawthorne effect (Homans, 1941) is essentially never controlled (though as will be discussed later, it may be important that it not be).

There are a great many programs which have been developed by individuals for their own purposes containing bits and pieces of several of the above types. These mixed programs are difficult to assess, but may cast some light on further development of general effective programs. Andrews (1984) taught a course to college students introducing the theory and research of learning and cognitive psychology, included exercises and examples designed to make the students relate abstract principles and findings to their current concrete learning concerns. Exercises in self-monitoring and self-awareness were included, as were traditional learning strategies, and sensitivity to personality and contextual matters in learning.

Near the end of the course a reading test was given. It was found that individuals who were in the course did better on the sections of the test that specifically measured concepts and applications, but did worse on specific factual recall than a control group not in the course. Furthermore, there was less difference in individuals who were not explicitly reminded to use what they knew about how learning and memory work. These effects were smaller in individuals who had been specifically "probed" to explore their own learning process
rather than just learn the concepts. The evidence indicated an overgeneralization - those skills that had been acquired from participation in the course were applied in a novel task, but there appeared to be a decline in use of the skills that led to better recall of specific facts in the reading passage. There was no long term follow-up with this experiment. It would be interesting to see if this difference persisted, or if those who participated in such a mixed course were able to apply their self-monitoring skills to produce more completely appropriate strategic behavior later.

One rather different approach to learning skills has appeared to produce quite remarkably positive effects. Letteri (1979) identified seven dimensions of cognitive style which, based on the literature and a comparison with an information processing model, seemed most likely correlates of school performance. The seven dimensions are: Analytic; Reflective - Impulsive; Tolerance for Incongruous Experience; Cognitive Complexity; Leveling - Sharpening; Breadth of Category; and Focus - Non-Focus. Tests were taken from the literature, modified, or newly developed to measure each dimension. Student profiles fell into the three patterns discussed earlier - highly correlated with school performance. In an attempt to modify school performance, exercises were developed slowly introducing individuals to the concepts of the dimension where their performance was not the appropriate direction. The training was not specifically to the task, but was a carefully graded introduction of the concepts, shaping performance through a series of exercises designed to change the cognitive style test performance, and thus the cognitive style
profile. He reports that the training program not only works to change performance on the relevant dimensions in the desired direction, but that the students' school grade performance shows movements in the expected direction— into the appropriate profile type—in virtually all cases! These changes are at least as large as any reported by any other researcher. They are also the only ones that are obtained by instruction in basic cognitive styles which are not directly related to the tasks (school performance) on which the individual's learning ability will be assessed. These findings have yet to be replicated, or assessed for long-term effect, but they warrant very serious consideration by researchers and practitioners.

One problem with learning strategy teaching is the relatively short period of the teaching and testing. If students are taught organizational strategies and have nothing that they particularly want to organize, there is little reason to expect strategy use after the immediate demands of the experimental task are over—possibly even before the generalization test. It might well be that when there is some desire for organization the strategy, assuming adequate knowledge base, would appear quite spontaneously (as in Ornstein's research). The sleeper effect in attitude change research, the greater fragility of episodic memory, attributional errors in memory processes (e.g. déjà vu, cryptamnesia, etc.) and modeling research all suggest that specific skills and memories can remain long after initial learning and emerge in context appropriate fashion. Long-term studies of teaching effects are clearly needed.
Riccio, Richardson and Ebner (1984) have reviewed the relationship of context changes to retrieval decrements. They note that while it is well demonstrated that generalization gradients flatten with the passage of time (i.e., one would expect greater generalization of a learned response the further away from the initial learning), changes of context (presumably changes on generalization gradients) produce deficits in memory performance which seem to increase with the passage of time. This apparent paradox can be resolved by assuming that some features of "context" are discriminant stimuli (those features which are essential as cues for retrieval or response) and thus have very steep generalization gradients (small changes produce large response decrements); while many other features, singly or in groups, are incidental to retrieval and thus generalization flattens over time with no significant effect on recall or performance. State dependent learning seems to be an example of "context" which is an essential part of the reinstatement of the pattern which identifies the correct response. This is an example of "internal" context. The internal context of the learner appears to be much more important to generalization than the external. Perhaps the focus of learning skills instruction should be on making instruction more compatible with internal context and on the individual's ability to control that context.

Two phenomena in the literature of discrimination learning may help us with this issue. Terrace (1963) described a phenomenon which he labeled errorless discrimination learning. If pigeons were presented with two stimuli where there initial tendency was to always
to respond to one of them (peck a lighted key rather than a dark one),
the positive stimulus to which the animal responded could be slowly
changed to virtually any other stimulus with the discrimination held
intact (errorless learning). While the technique is essentially the
same as one of Guthrie's proposals for weakening a response (changing
the stimulus conditions slowly to produce a new response in an old
situation), Terrace identifies some specific desirable features which
results from this training procedure.

1. There were less errors than in traditional discrimination
   learning. Learning was faster and performance superior.
2. There is no emotional behavior (CERs) attached to
   this more skilled performance. Since performance
   is under the subject's control there is no opportunity for
   the development of learned helplessness or task inappropriate
   extinction.
3. There are no disinhibition errors. Changes in
   context do not produce errors or decrements in performance.
4. There is no behavioral contrast. In discrimination
   learning, but not with errorless discrimination, periods
   of inability to use a response or inappropriateness
   may be followed by overreaction when the stimulus
   appears.
5. There are no peak shifts - the strongest response is to
   the discriminative stimulus and not shifted away by the
   avoidance.
These characteristics suggest that if you start with an existing response tendency and shape the behavior from that to the desired behavior, you get more rapid discrimination learning, more accurate performance and less susceptibility to error inducement or interference due to non-relevant responding (e.g., anxiety). Rilling (1977) points out that errorless discrimination should not be taken as a unique phenomenon, but rather as an end point on a "less-error" continuum. The implication is that the less errors in the acquisition of a discriminative response the better; and, there will be less errors if the learning starts with those discriminations that the individual already possesses. Since one key issue in learning strategies is discrimination of the appropriate points for use of the strategies, moves in the "less-error" direction might produce more rapid acquisition and automatization.

Another phenomenon of interest is known as autoshaping (Brown and Jenkins, 1968). In autoshaping the animal (all these studies were initially done with rats or pigeons) is to learn a response (e.g., to press a bar for food reward). Conditions are created in which the response is more likely to occur spontaneously than it normally would (e.g., a light comes on in the bar, which evokes an investigatory response by the rat, which results in the pushing of the bar, which is followed by the food reward, which increases the likelihood the rat will press the bar again). Under these conditions the rats teach themselves to press the bar rapidly and without any intervention by the experimenter. Rat bar press shaping can be a very long slow and error-riddled process when the rewards are given by the experimenter.
Even highly skilled rat shapers can have failures and very long slow shaping with mixed results and stability. With autoshaping, the behavior is learned more rapidly, and, as with errorless discrimination learning, the behavior is used more appropriately with less errors, less distraction or potential for disruption.

Taken together and extrapolated to human learning skill, these two phenomena suggest that learning will be best and use of the acquired skills will be most appropriate and least easily disrupted if the learning starts with the existing response tendencies of the learner and attempts to create conditions in which the responses will be emitted most spontaneously. Taken with the tendency for generalization to increase spontaneously with the passage of time, this suggests some possible conditions for effective learning skill teaching:

1. Work with skills appropriate to existing knowledges
2. Let student responses be the lead
3. Minimize errors in the course of the learning
4. Expect the strategies to generalize with knowledge base expansion.

If some of the skills are executive skills that assist the learner in confronting a difficulty or frustration with a strategy to eliminate errors, the learner has the capacity to create "less-error" learning conditions for him/herself, and thus be a better learner in all conditions.

Several issues need to be mentioned in connection with specific programs of learning skills instruction. This discussion has
not included a review of specific pieces of research which show that a particular learning skill can be taught and that individuals do better in a particular learning task using it. Production deficiencies phenomenon are well established and little worthy of further note; a program to improve learning skills in a particular learning area in the short term is a very different matter than long-term general improvement of learning; the power of the Hawthorne effect makes interpretation of the specific assertions of the experiments problematic; and the relationship of the strategy studied to the subjects selected is seldom clear. Learning skills include the appropriate application of a skill in the proper area. The learning skills that may be appropriate in a history class may be very different from those necessary in an art class, never mind learning how to get along with your little sister. It is unrealistic to think that the improvement of learning skills in a relatively brief course can include all the subtleties of selection and application of strategy. It is for this reason that so many people have included self-monitoring skills as a central part of their instruction. If these skills are learned well in relationship to an internalized sense of self as someone who can and wants to learn, the individual is in a position to teach him/herself learning skills in direct relationship to personal learning styles and strengths. The continuing impact of natural consequences as the guide to self-teaching can't be improved upon by short-term learning skills instruction.

It has been found by a number of researchers that the response of individuals to learning skills instruction is not uniform
(Biggs, 1984). Nothing could be less surprising. However, the pattern of response is illustrative of an important principle in the model that follows. Individuals who are identified as having high ability seem to respond relatively well to direct instruction—use of metacognitive information that the individual must personally convert into action. Individuals who are identified as being of lessor ability tend to benefit most from practice in the mechanical use of skills, not abstract information about them. To be sure all these studies are conducted in the short-term and looking at relatively limited domains of application, but these observations make clear that the learner's personal characteristics must assume a central role in the type of instruction, its rate, goals, etc. As Henry Head observed, "We must beware not to invite our observations to sleep in the procrustean bed of our hypotheses." (Head, 1926).

Learning skills instruction can be seen to be universally successful. We can't know if this is only because unsuccessful experiments never come to light, the individuals doing the experiments are all right, the hawthorne effect drives all, there is so much room for improvement that virtually anything will help, or some combination of all of these. Surely one should not curse success, but rather look for the common elements which can be incorporated into better learning skills instruction and into programs to assist teachers in teaching better learning during the course of subject matter instruction. Three tasks seem most pressing in this area: One, identify the common elements of success and attempt to blend them into a harmonious whole (because of differences in structure and execution, meta-analysis is
very problematic; however, it is time to begin that effort for learning skills instruction); two, develop procedures which can independently confirm the underlying mechanisms of this process to assist in validating both assertions, process and results (e.g. brain research methods discussed below); three, identify individuals who don't seem to benefit well from such programs and work to locate causes and procedures for assisting these individuals in improving their learning.

The Brain and Education

While there has been a long and complex history of the study of the brain in psychology, the brain and its relations to educational processes is a barely newborn field. Although there may be little controversy about the existence of relationships of the brain and learning, the interest of educators in information from brain researchers has been limited. It is worth mention that the area in which there has been most impact (the two hemisphere and their differences) has been most notable for its metaphoric power, not its experimental accuracy. In fact, Hardyck (1985) virtually defied anyone to present any evidence about the operation of the two hemispheres which could be translated into a significant piece of educational policy or practice. Nonetheless, the power of the metaphor has been considerable. To begin to gain a sense of the potential use of brain information in educational arenas it will be necessary to look at what we know about the brain. To assess needs and opportunities for utilization of this information in education will require a sense of education.
Education has been, and mostly continues to be, a method for cultural transmission (Spindler, 1963). In the presence of an established and essentially stable culture there is no need for, or interest in educational theory or innovation. However, when social stability is less, when pluralistic social values prevail, when belief in past methods wanes, or when rates of change make the goals of the education matters of contention, need for guidance infests the world of the educator (Toffler, 1974). We appear to be in a period of exceptional confusion of values and goals for our education. American education has gone through a wild array of interesting fads, forays, and flagellations during the 20th century (Ravitch, 1983, Cremin, 1969). In such a period there will be considerable numbers of volunteers for the position of modern Moses - leader of education from the wilderness. Short of the appearance of some devine source of authority for educational policy of the future, we are reliant upon the ability of the volunteers to demonstrate a credible case for their proposals. Those cases which catch the metaphoric fancy of educational policy makers will be adopted (e.g. New Math, Open Concept Education) regardless of the readiness of teachers, students or parents to provide an environment in which they can work. It appears that the zeitgeist seeks direction in providing hope for the greatest individual achievement - education as the ticket to personal success. At the same time, there appears to be limited tolerance, at least amongst educational administrators for adoption of proposals which are not extremely well based in a foundation of formal research. They have been burned too often with nice sounding ideas or
heavily marketed programs.

In this ethos, and with the availability of current brain research techniques, a program of educational innovation which seeks confirmation in the authority of brain research would seem worth consideration. For creation of such a program we must avoid the temptation to look only at the most recent research and extrapolate, instead we must read the minutes of the last meeting to gain a perspective on the meaning of current brain models and research.

Though Gall has been mentioned previously, it seems fitting to begin the discussion of brain research relevant to education with Phineas Gage (Restak, 1984). Gage, a serendipitous brain researcher, removed the frontal lobes of his brain with a metal rod while assisting in the construction of rail beds in Vermont. His inadvertent frontal lobotomy, with the assistance of the promotional wizardry of P. T. Barnum, focused some considerable attention on the functions of the brain. He had removed the portion of his brain that most distinguishes humans from our evolutionary antecedents; and yet, though there were changes, they seemed relatively quite minor. Thus began the use of the fortuitous brain lesion as a source of information about human brain function and human thought.

From the time of Phineas Gage to very recently, all research which has contributed to models of brain function in humans has been from studies of accidental or surgical lesions, or extrapolations from animal studies. The entire history of this field of science must be understood in the context of the conflict over the issue of localization of function (Krech, 1962). From the time of Gall forward
the most prominent strategy in brain research has been to attempt to identify the function that is effected by a particular areas of the brain. From this elaborated set of functions, a generalized model of brain function would be developed. Despite repeated demonstrations of the limits of this model, it remains the predominant model for researchers and theorists - consistent with their quantitative and reductionistic methods. Fritsch and Hitzig identified specific functions for motor areas; Broca and Wernicke identified language specific areas; Jackson, despite a somewhat more global view, described specific loci as sources of generalized epileptic seizure activity; Kluver and Bucy described specific functions for the temporal lobe; Penfield and Jasper seemed to identify specific cortical loci for memories; Hess and those who followed his methods found specific functions for hypothalamic and other subcortical structures; Pribram and others found specific functions for the Frontal lobes; Milner and Scoville, inadvertently, discovered specific functions for the hippocampus, Magoun and others found specific functions for the Reticular Formation; Olds found the location of reinforcement in the Median Forebrain Bundle - later, contemporaneous with John, evidence of the location of permanent memory in the reticular formation. The methods, the pattern and the findings go on and on.

Yet, from very early on contrary evidence was available and has mounted. Flourens found that lesions in what we would call association cortex, produced no specific functional effect. Lashley (1929) demonstrated the amazing elusiveness of memory, even at one
point concluding that perhaps it didn't exist. Pribram, in the spirit of Lashley (his mentor) suggested that the brain might work like holograms, with distributed information storage. Functions that had been assigned to a particular structure repeatedly turned out to be less clear and/or less localized than they seemed. Destruction of an area of the brain which had been assigned a quite specific function (e.g. feeding control in the lateral hypothalamus) did not necessarily lead to the loss of the behavior, or prevent its subsequent reappearance. Developmental studies showed functions that appeared to be localized in specific structure in adults were able to locate themselves in other structures if the normal locus was removed from an individual at an early enough age (Geschwind, 1982). Even the specifically sensory and motor areas of the cortex which had been viewed as the last bastion of unambiguous localization of function were found to have functions of the other sort (sensory in motor areas and vice versa). To those who wanted the brain to be simple and tightly organized - in the spirit of the telephone switchboard metaphor - this was all very disconcerting.

Despite the confusion in the literature, the theory building urge was powerful enough to lead to the production of an unending stream of models of brain function. Though the prevailing theoretical urge was, and continues to be a flow-chart model of localized functions, Lashley's model began the joining of the issue. Lashley, never one to muddle in the middle of an issue, proposed that the entire brain worked together (Mass Action) and that each area of the brain had equal capacity for participation in any given activity.
(Equipotentiality). The end of the continuum was defined. Lashley did not tell us quite how all this might work - he merely expressed his frustration with his inability to find any location for an obvious human function - memory.

It awaited Hebb (1949) to develop a model which moved back to the middle ground. His vastly underremembered and undervalued theory stated that sensory events set up patterns of perseverative activity in networks of cells, which with sufficient continued action would be converted to structural changes in the networks of cells associated with the patterns of activity producing specific responses. There were relatively specific sensory and motor functions, but there was a semi-amorphous distributed network of cell interactions which defined the remainder of psychological functions. Specific responses could function as sub units of superordinate networks of activity, creating the complex associative network so long a park of psychological theory. Even though Hebb's theory was quite speculative when it was proposed, more and more of the pieces he proposed have gained support from more recent research.

Models subsequent to Hebb became a more cluttered and varied lot. Miller, Gallanter and Pribram (1959) suggested a concept without a model - TOTE units. Ashby (1965) proposed a mechanistic model in the spirit of artificial intelligence which had powers of feedback, self, correction and ultrastability, but no attempt to reconcile it with the brain directly. Young (1964) proposed an elegant model, based on the function of the visual system of the octopus. While elegant, it was the extrapolation of a concept rather than a structure-function model.
for the human brain. MacLean (1973) proposed a Triune brain which accounted for changes in both brain and capacity with evolution, but told us little of value about how the system works to produce our thought and action. Individuals far too numerous to mention proposed models for the function of specific parts of the brain which were presumed to fill important functional needs for a model of the whole brain. Most notable early examples are Magoun's conception of the reticular activating system, Olds' localization of reinforcement, Stellar and other's models of various hypothalamic mechanisms, Pribram's modeling of frontal lobe function - and a vast array that have fallen into well deserved obscurity (e.g. Kriekhaus and the mammillothalamic tract).

As brain research information and experimental psychology on learning and memory became more specific, the resulting models of function followed apace. During much of the 60s and 70s it was often difficult to see what possible relationship to human functioning some of the research and models could possibly have. Increasing specificity often leads to distortion of the whole. It is then that a new approach or model or area of research must lead us from the wilderness. That line of research was the beginning work of Roger Sperry on the differences in function of the two hemispheres. Very simply what Sperry did was take the observations on the differential functions of the left and right hemispheres and begin systematic research. His initial studies on animals demonstrated the necessity of the corpus callosum for communication between the hemispheres.
As is often the case, a happy utility for this information in dealing with a real medical problem created a population of humans permitting the first systematic investigation of hemispheric function (Sperry, Bogen and Gazzaniga,). This research captured the imagination of a remarkable array of folks. The oft observed and noted fact that human knowledge and thought could be either linear and sequential or holistic and simultaneous was given concrete representation and extension (the left and right hemispheres) and removed from the realm of idle metaphor. In a sense metaphor met metaphor. Left and right got associated with deductive and inductive (among numerous other dichotomies - see Ornstein, 1972) and had a location (spatial extent - Kant!) which certified a reality. No better argument for the potential power of brain research in driving educational thought and action could be made than what has happened with the left brain/right brain concept.

Parallel and independent clinical observation and research moved its own descriptions of brain function. The basic model for clinical inference is the traditional subtraction paradigm - take something away and see what is not happening that was happening before. Infer, tentatively, that the function that has disappeared was the function of that area. Broca (1861) used this model and it remains the primary model of clinical neuropsychology. Before briefly reviewing this research note should be made of the limitations in the subtraction paradigm applied to human brain injuries. First, both fortuitous and surgical brain lesions are imprecise in ways which can make the methodologically pure cringe. Gunshot wounds and strokes,
for example, are not consistent in the area of brain that is
destroyed. Though there are classic stroke patterns, the exact
location and extent of brain damage is quite variable. Even when
lesion is produced surgically there can be considerable uncertainty in
the precise extent of the excision, other tissue whose critical
connections may have been severed or blood supply which may have been
interrupted. All too often the extent of the lesion is inferred from
the behavior and no autopsy is performed to confirm the precise
location and extent of destruction. There is also considerable
evidence of movement of functions as they are established during
development. Damage to an area at one age or stage of development may
produce very different effect from damage to the same area at another
age or stage of development.

Even if we have quite precise information about the site of
damage, there are many interpretation of cause of loss, other than
that a specific function was located in that removed tissue. While
there is considerable evidence of very precise and fixed function in
the nervous system, especially sensory and motor systems, there is
more evidence of complex interactions in the majority of the nervous
system. Loss of a function after destruction of an area could mean:
The area is the one and only location where that function is performed
or can be performed (the most common assumption during most of the
history of this research); the area may be able to perform the
function, but others may also; the area may be one of any number of
areas of brain tissue which is necessary for performance of the
function, the area may be one through which information necessary for
the function flows but in which no functionally significant activity occurs. Such possibilities can muddle the data. However, given the vast numbers of brain injuries which have been studied with some care, it is possible to use the method of double dissociation to feel reasonably safe in concluding that specific areas are essential for a specific function and others are not. The method of double dissociation requires that when one area is damaged a function is lost and another function is not, while when another area is damaged the other function is lost and the first is unimpaired. When this occurs one can feel safe in concluding that the areas under consideration are specific in their necessity for the respective functions. Given enough observations it may be possible to conclude that a given area is the one and only which is critical for a particular cognitive function, or that it and others are critical - perhaps with slightly different contributions to the function. In this way it has been possible to begin a relatively detailed mapping of the normal areas of involvement in specific psychological functions. It is important to note that the general conclusions that an area is necessary for a specific function does not mean that it will be in all individuals of all stages of development.

Heilman and Valenstein (1985) provide a thorough review of the clinical literature on the relationship of brain areas and psychological functions. For one who seeks to use this information for educational intervention, the results are both quite encouraging and punctuated by puzzles. Many of the areas which have direct involvement in specific language functions are clearly established,
while the subtleties of processing which are so critical in different varieties of specific learning disabilities are less easily defined. For example, while the comprehension of language seems to be based in Wernicke's area in the left hemisphere, precise identification of area of involvement in phonological encoding, morphemic encoding, prosodic processing, syntactic evaluation and semantic evaluation are sufficiently entangled and involve sufficient numbers of other areas of the brain that the precise localization (particularly using electrophysiological techniques in intact humans) will require considerable additional research and may even be technically beyond us). Some highly precise functions seem quite localized (e.g. prosopagnosia - an inability to recognize faces resulting from very specific lesions in the right parietal hemisphere), while other functions seem bafflingly diffuse (e.g. the interpretation of metaphor). Despite the room for clarification, the evaluation of brain injury has lead to the development of very useful models.

The model that offers the greatest utility to the research and intervention program proposed here is that of Alexander Luria (1973). Luria, relying almost exclusively on the Russian tradition - via Pavlov and Vygotsky - and his own studies of brain injured patients developed a model which ties together the best of functional localization and more dynamic interaction, while tying it to more specific educationally relevant functions.

Luria proposed that there are three functional blocks of the nervous system in the production of human cognition and action. He is not specifically interested in the underlying systems of functional
localization - biological maintenance systems of the hypothalamus, cortical sensory or motor systems, etc. He is interested in taking the pattern of cognitive deficits which he observes in individuals with varied head injuries and producing a model of generalized brain functions. Because he views the brain as a dynamic interacting organ he both localizes the three functional blocks that he proposes and attempts to blur some of the boundaries. His masterful synthesis is reminiscent of James MacGregor Burns notion of a leader - one who is able to most effectively produce a synthesis of the most significant prevailing inherent contradictions of a time. Functional localization and dynamic interaction are both neatly conjoined in his system.

The three functional blocks in Luria's system are hierarchical in structure (and evolution). Each consists of at least three cortical zones: The primary (projection area) receives impulses from or sends impulses to the periphery, the secondary (projection-association) area is where incoming information is processed or programs are prepared for disposition, the tertiary (zones of overlapping) are the latest systems of the cerebral hemispheres to develop and are responsible in man for the most complex forms of mental activity requiring the concerted participation of many cortical areas. In terms of the learning model presented earlier, the primary areas are inputs and outputs, secondary are representational - including the decoding to motor outputs, tertiary would include transformational processes - including executive processes.

The first functional block establishes arousal and attention. This unit is the responsible for regulating tone, waking and mental
states. The areas which control cortical arousal and tone are not in the cortex, but in subcortical structures. Luria feels that the study of the reticular activating system revealed the vertical organization of the structures of the brain. Activation can be general or specific — arousal vs. attention (drive vs. cue). There are three sources of activation, intentions, formulations and plans (language based). This system is functionally interactive with the other two systems in a democratic communication process; however the organization is vertical in that the efficient functioning of the second and third blocks depends on the functioning of the first, and the functioning of the third requires the intact operation of the first and second.

The second functional block is the unit for receiving, analysing and storing information. Specifically this second functional unit engages in simultaneous or successive processing of incoming information. This unit begins with the primary sensory projection areas. There is then a modality specific analyser (synthesis). The tertiary zone is the zone of overlapping (concerned with integration of excitation arriving from different analysers). There is diminished specificity of the hierarchically arranged cortical zones, as well as a progressive lateralization of function.

The third functional block is located most anteriorly, in the frontal lobes. This unit is the most general and that which most distinguishes humans from other learners. This unit enables programming, regulation and verification of activity relative to programmed plans. The pre-frontal cortex is "super-generalized" tertiary cortex — the ultimate regulating areas. Phineas Gage and
other more medically precisely frontal lobotomized individuals, most prominently lost the ability to plan and to monitor their own behavior relative to that plan.

Luria develops at some length the specific functions of specific lobes of the human brain relative to his model. For purposes of this research, the precise details are not pertinent. What is particularly valuable in Luria's work is a model which at the same time conceptualizes brain function in the context of specific functional areas while providing for dynamic interactions which can be relatively readily translated into specific educationally relevant cognitive functions. The major drawback is that the model is built almost exclusively on observations with the brain injured. Nothing in this research in any way guarantees that the functioning of any area of the brain in the intact individual will directly correspond to the function(s) lost when the same area has been destroyed.

It is with the ability to observe the functioning of the brain in the intact individual and in normal cognitive activity that we have the potential to both evaluate the quality of models built upon brain injury data and develop new models which can be utilized for both educational and research purposes. This is the promise of the research using electrophysiological techniques discussed in the Techniques section.

A simple summary of the state of brain knowledge useful to educators would include: Luria's three functional blocks represented as; one, greater activity in an area with Event Related Potentials - less when looking at Alpha with Frequency analysis (see below); two,
simultaneous more right hemisphere activity, successive more left hemisphere activity; three, frontal lobe involvement; Broca’s area, language production; Wernicke’s area language comprehension; Supplementary Motor Cortex, motor planning; Right Parietal, spatial skills and facial recognition; Math skills, left hemisphere; writing, left frontal – Exner’s area. By using these relatively simple guidelines a fairly complex set of human cognitive processes could be viewed using electrophysiological techniques.

The catch is that, based on our exploratory observations in the Brain Behavior Laboratory, virtually all of these relatively safe observations are subject to significant individual differences, and in some cases outright contradictory evidence. What is most striking in the existing observations using topographic brain mapping during cognitive tasks is that there is so much variation from one individual to another in the nature of the brain involvement in a task. The same individual will show considerable difference from time to time with slight changes of attitude, attention or strategy. In some cases the areas of the brain involved, while generally consistent with the framework listed above are variable enough to make standard generalizations seriously errant. The interpretation of the educationally relevant cognitive activity of an individual’s brain cannot be made solely on the basis of knowledge of the brain or expertise in assessing brain activity; this process must utilize the convergent information from the above, the knowledge of the tasks and the context in which the testing is done, and, most importantly, the interpretations and insights of the individual about what he or she is
For example, the author had his brain waves recorded while performing a modestly demanding mathematical task (counting backward by 7s from 692). The existing research suggests that this task is one that will be preferentially performed by the left hemisphere. The literature, from the time of Berger, indicates that involvement in a task is accompanied by the blocking of Alpha waves. Yet, when the author's brain waves were recorded during this task, the alpha waves were observed exclusively in the left hemisphere and not in the right - indicating that the right hemisphere was the one involved in this task. The authoritative interpretation of this observation might be that there is some difficulty that would interfere with arithmetic, and thus an attempt to perform the task with the less skilled hemisphere. To the contrary, there is no evidence of a math difficulty, but rather when asked how he does math, the author responds that it is a visual spatial activity, literally seeing spatial units moving about for additions and subtractions, etc. Only by having that piece of information does the brain observation and this math ability make sense. It would also explain why there was some difficulty "shifting gears" to doing algebra, why graphs and geometry were very easy, and why another process of "shifting gears" was necessary when doing calculus. Had this information been known before these events, strategies for learning these subject matters might have been developed which would have greatly eased the transitions.

The information from the brain is quite useful in making educational evaluations and developing educational interventions; but,
it is critical that the individual, the learning context and the learning tasks be part of the interpretative process.

Problems of Assessment - Automatization

While there may remain the gatherings of rear guard debate, it is generally agreed that there is, at the very least, a proximal neural antecedent of human thought and action - if there is not absolute identity. This means that if it were possible to find the correct method for viewing the action of the human brain it would be possible to observe directly the processes of the mind. The history of psychology, and especially testing, has virtually inhabited the issue of the relationship of observed behaviors and the actual processes that were their basis. Hull (1943) wrestled mightly with the distinction between intervening variables (those useful in making predictions about behavior, but with no implication that they represented anything real), and hypothetical constructs (concepts intended to represent real processes). The issue of validity, especially construct validity, has been the central issue in testing - does this test test something which is real and do so accurately.

Until recently, direct assessment of the action of the nervous system in relationship to human thought and learning was seldom even considered since the possibility seemed so remote. Human assessment has been a continuing fallacy of misplaced concreteness driven by the perceived need for diagnosis, prescription, and evaluation. Decisions had to be made and none of the historically familiar methods seemed up to the task. The availability of valid methods for direct observation of the processes of the nervous system of an individual involved in
educational tasks would provide enormous clarification to assessment.

Meehl and MacCorquedale (1954) first discussed in detail the continuing concern of assessors who seek to use their information for purposes of prediction (arguably, all assessment which is used at all is used for prediction). The central concern in the debates over clinical vs. statistical prediction are, as is often the case, the unaddressed underlying philosophical issues - is the human accurately representable as a limited set of explicit numerical values and their actions; or is there a consequential percentage of the variance in human behavior which can only be represented by the complex dynamisms knowable only through the intuitions.

More recently various schools of research and thought growing from the structuralist tradition have expressed and demonstrated considerable doubt about the ability of an individual to have anything resembling fully accurate knowledge about him/herself. Freud (1899) must be considered the starting point, but from the linguistics of Chomsky, to the anthropology of Levi-Strauss, to semiotics, to Fodor’s modularity, to Anderson’s production systems, to Hofstadter and Dennett’s (self-reflexive systems) to Gazzaniga’s modular social self, it has become quite fashionable to suggest that there exist pieces of our functioning which are isolated and difficult, if not impossible, to know and assimilate to other pieces of our functioning.

The implication of this thought is that there are processes which are in the realm of conscious processing and there are others which, while potentially in the same realm, are not easily known, or amenable to fusion into a unity of functioning. Prime among these are
those processes which have recently been studied by cognitive psychologists under the banner of automatic processes. Lashley (1948) clearly prepared us for such work with his assertion that there are sequencing processes—especially in language use—which must occur automatically and previous to the occurrence of responses.

Assessment of individual learning will be most meaningful in the context of the learning, the learner and the goals. Independent assessment, while useful for diagnostic/prescriptive purposes, does not include the social context and goals. These are what the individual carries along as personal context. Effective learners will be those who have an internalized set of models and goals against which on-going action is evaluated. For greatest efficiency, this internal evaluation will become an automatic process. It is to the process and workings of automatization that we now turn.

Beginner's luck is not what you do when you don't know what you are doing. It is what goes away when what you know isn't so; it comes back when you can do without knowing.

Andrews, 1986

Seeing is Forgetting the Name of the Thing One Sees

Book Title — by Lawrence Weschler, 1982

Automated information processes are modularized but ... controlled ones are not. Most of the simple perceptual functions with which Fodor deals in his section on the applicability of the modularity thesis are fully or largely automatized by adulthood. Thus, according to the present view, they access modular, or local subsystems of declarative and procedural knowledge. But some more complex functions can also be automatized after large amounts of practice or experience and under the right conditions. By automatizing such functions, experts can free processing resources for novel kinds of stimuli, whereas novices do not have such resources freed for dealing with novel stimuli.

Sternberg, 1985
The discussion of automatic processes and the automatization of learned processes has become fashionable, contentious and critical to any discussion of improvement in individual learning. There is no debate that cognitive processes can occur in the absence of conscious direction. There is also no debate that some initially consciously directed processes can become automatized. The issues that remain in doubt are the characteristics of operation of automatized processes (e.g., non-consciously directed, though like Freud's preconscious they may be available to conscious control) and how they differ from non-automatized; the relationship of these processes to effective learning; the best way in which to automatize and have the best possible operation of the process in generalized learning situations. Marcel (1983a,b) using a backward masking paradigm has shown that, in the absence on conscious knowledge of an event, a full array of recognition, remembering, responding, and semantic associating can occur. He concluded that there is nothing that cannot occur as well without consciousness as can occur with consciousness. He further develops a complex model of the processes by which events can come to consciousness. Essentially all cognitive processes precede consciousness, leaving it an almost incidental by-product occurring primarily when there is an internal conflict in the automatized processing requiring additional or alternative examination for adequate disposition. (cf Jaynes, 1976 - for the phylogenetic origin of consciousness). Shiffrin and Schneider (1977), and Anderson (1983) among many others, have attempted to remove the homunculus from cognitive psychology by the development of models for automatization.
of processes. These models are derived from the decision processes of artificial intelligence, and while they are interesting and provocative, there is no reason to assume that there is any necessity in the processes they describe being isomorphic with human neural processes. In fairness, it is not safe to assume that they are not isomorphic until we have further direct research on human nervous system action in on-going cognitive activity - especially research which looks not only at group differences and task differences, but also individual differences. At present we can safely conclude that automatic processes have considerable capacity for complex cognitive activity and that the automatization of an activity can make available further processing capacity for other activities (e.g. compare the adult bicycle rider who can read a book while riding, with a beginning reader and bike rider).

Automatic processes that exist in the given neural structure and appear with little evidence of specific maturational or experiential augmentation (perhaps the case in the child prodigy) seem to operate exceptionally efficiently with little, if any, conscious direction. Conscious direction of activity can be extremely disruptive (e.g. the loss of beginner’s luck, or trying to consciously direct your activity during a complex task such as skiing or playing basketball). On the other hand, in linguistically competent individuals there is no doubt that conscious knowledge of a strategy or procedure can improve performance in the task at issue (Brown, 1978).
For the purposes of this discussion it will be assumed that automatic processes fall into never conscious and initially conscious categories. Never conscious processes include the automatically performed, the biologically given, the maturationally and experientially acquired which were either acquired without linguistic encoding into conscious format or were never drawn to conscious processing because the question was never asked (M. Jourdan phenomenon). Those processes which are, or were consciously directed (metacognitive knowledge) become automatic by having the responses produced under their direction be congruent with the anticipated goals, and by overlearning. In other words, automatization is nothing more than an elaborate form of habituation where the low information value of the event is not due only to stimulus qualities, but to the congruence between the self-generated response and the learned or self-generated expectation of outcome. A response which always works may be automatic, but if it doesn't "work" it may re-enter the realm of the metacognitive conscious processing for reaccommodation - much like the dripping faucet that stops is noticed. Thus, metacognitive instruction in learning processes will need expectations of outcomes, and practice for the instructional processes to become automatized so that there is additional capacity for other activities. They will become deautomatized when they don't fit with expectations - this will allow for the use of conscious processes to reevaluate the situation and develop a new strategy, which if correct, will lead to relatively rapid reautomatization of the processing.
It should be noted that the absolute key for the effective automatization of learning processes (metacognitive instruction about learning skills) is a clear sense of the goals of the learning against which the on-going behavior is compared. When there is a match there is automatization; when there is a mismatch the information comes back to consciousness for an opportunity for repair. The presence of a representation of the goal and the continuing attention to the activity relative to that goal are essential. This will encompass Luria's third functional block - planning, sequencal, verifying - identified as related to frontal lobe functioning. It also means that self-monitoring and performance monitoring are crucial, as well as self-maintained expectations. Thus, issues such as achievement, level of aspiration, and attribution are very important pieces of the nature of this monitoring and subsequent success of learning.

Automatic processes can increase the available processing capacity, but they can also lead to errors. Learning sets or functional fixedness may be automatized processes. While automatized processes have been highly praised and promoted, their value can only be as great as the continued monitoring of the course of action relative to accurate representations of the goal. Self-knowledge has some expistemological problems. Monitoring of self's behavior and actions with respect to a goal or process which is internally represented avoids that problem and keeps the eye on the goal at the same time (cf Bem's Self Perception Theory).
Techniques

Progress comes from techniques, which become the carriers of ideas....Ideas are of no use without techniques.
Allan Newell, 1985

I don't want to spend my life working on a metaphor. I would like to work on a mechanism.
Michael Posner, 1984

When I point at the moon don't mistake my finger for the moon
Zen Saying

A wise man was visiting his friend the professor. He asked if he might be allowed to visit an American school to enable him to get a view of how the future would go here. The professor thought that was an excellent idea, secretly hoping that the wise man would provide him with some insights he could use in preparing his students for teaching. So off they went to a middle school in El Centro.

The first stop was an eighth grade social studies class. The teacher was instructing the students in the proper way to learn the material for the upcoming test. "The important thing in history is to obtain a framework which provides meaning to the times and peoples that we are studying," said the teacher. "Once you have learned the important features of the lives and times of our ancestors you will be better able to understand the important issues of our times, the choices we have and their consequences for the survival of our culture. The only way to create such a framework is to learn a number of specific names, dates and facts of the period we are studying. You may not consider it fun, but you must learn the names and dates to give meaning to what follows.

"Here's now you do it!" The teacher proceeded to instruct the students in a keyword method of mnemonics and the method of loci which would enable them to learn all the names and dates they would need to pass the exam. The teacher was obviously pleased with his enlightened approach to education. Not only was he teaching the students the material of history, but he was teaching them how to learn the material so that they would be better learners in the future. The professor was delighted to see that the teacher was now using some of the ideas he had taught him at State U. six years ago.

The professor was particularly gratified to see the attentive notetaking of the students. For a class of eighth graders to be that involved in a social studies class seemed quite a marvel.

During the declamations the wise man was heard mumbling, "20...20...20...19...20...20..." At one point in his sad eyed enumerations the wise man was seen to fix his stare on a boy on the far side of the room and utter an almost reverential "19." For a long time the man was silent, gazing at the boy. The professor, fascinated with this pulse pausing, looked to the boy for a clue to the wise man's interest. The boy was not particularly different in appearance
from any of the others; but, he alone in the class was unencumbered by the lesson. Between bursts of drawing on his paper he dreamily scanned the clouds outside the classroom window. At first the professor could not see what the boy was drawing. He uneasily shifted himself to the other side of the wise man to get a better view. Although he could still not make it all out, he was sure that there was something resembling a battlefield in front of a castle on the page.

The professor and the wise man were snapped from their respective fascinations by the teacher’s rousing review of the principles presented during the day’s class. When the class was over the professor and the wise man thanked the teacher for the opportunity to observe. The professor, ever eager to understand, could hardly restrain himself from asking the wise man what he had thought of the class. He would never admit he didn’t understand what was going on in the class, after all his job was to teach about that; but, he was baffled by the fascination with the inattentive student and all that numerical mumbling.

"What did you think," he coolly asked the wise man.

The wise man clicked his tongue, "You have many mathematicians in your country."

The professor, thrown into a disinhibited state, blurted out, "What was all that mumbling 19 and 20 about?" Afraid that he might have been a bit too blunt he quickly added, "I was interested to know what it was that you saw in that boy who was drawing?"

"In my country there were many people put to work during the last war in the service of the military," he began. The professor thought how much he hated it when his friend began one of his parables, but courtesy and a desire to understand restrained him. "In one small village near a bomb factory the natives were renowned for their art and sensitivity. Their culture was unchanged for centuries. They were recruited by the factory to pack the bombs in boxes for shipment to the areas of fighting. The first day, the most trusted of the natives slowly counted out the bombs and loaded them into the first box. At 19 he stopped and declared the box full, even though there remained a bit of room at the top. From then on the natives always put 19 bombs in each box.

"After 2 months of this work, an American officer was sent to the village to check on the shipping operation. He was a mathematician by training who had been assigned to insure efficiency in military operations. On seeing the boxes with 19 bombs and a little space he demanded to know why 20 bombs were not packed into each box. The native leader explained that the boxes were full when they contained 19. The mathematician insisted that from that point on each box must hold 20 bombs. The first box of 20 bomb boxes were being loaded on a truck for shipment to the front, the mathematician and 6 workers were killed when a bottom dropped out and the bombs exploded.

"You see, a mathematician may gain much power and note, but his life can not be long. No matter what, a mathematician can never stop at 19. He must always count the next number to 20."
The professor, not wanting to show his bafflement, asked, "But what was your attraction to the student who was drawing?"
"He had stopped at 19!"
(Adapted from a concept of V. S. Naipaul - A Bend in the River)

The study of cognitive processes and the brain rightfully dates to Gall (1795), but he was totally lacking in a valid method. Beginning with Dax (1836) and Broca (1861) and continuing on the present day the major source of information about cognitive processes and the human has been the adventitious manna of the head injury. While there have been considerable gains from this approach (Heilman and Valenstein, 1985). There are as noted before severe limitations. There can be no control of the precise type and location of an injury. There is no control over the characteristics of the individual to whom the injury happens. The injury to one area may cause deficits in a myriad of functions whose relationship to the injured area may be nothing other than a few axons passing through the lesioned site. But most seriously, the use of chance lesions as the methodological basis of conclusions about the workings of the intact brain violates the a cardinal rule of research - don't generalize your results to populations which you have not studied. There is nothing to say that the functioning of the injured brain is not altered from the workings of the intact brain. The lesion method, as discussed elsewhere has provided us with profound insights into the nervous system. It does not provide us with a method for study of the intact brain or any necessary truths about it; but, until Hans Berger that was all there was.
In 1929, Hans Berger demonstrated that the electrical activity of the brain could be recorded in the awake and intact individual. The electroencephalogram (EEG), a non-invasive method for the observation of brain activity, was now available. But the method had severe limitations. First, even to this day there is considerable debate about just what the electroencephalogram is, its source and control (Allison, in Donchin, 1984). But it was also impossible to differentiate any particular cognitive event from the background of on-going activity. It was possible to tell when the EEG looked different, but not possible to clearly associate it with particular thoughts or mental processes.

It was necessary to wait for major advances in statistics and the advent of high-speed, large capacity computers before significant advances could occur. The major breakthroughs were the averaging of brain electrical activity occurring when a particular signal or task was presented repeatedly - the Event Related Potential (ERP), and the analysis of the raw EEG into component frequencies - Fast Fourier Transform (FFT).

FFT takes raw records of electrical activity of the nervous system, recorded as potential differences between pairs of electrodes, and analyses the complex waves into specific frequency components, including the amplitude of each. Though there remains considerable room for research into the actual origins and controlling mechanisms of any particular frequency of brain wave activity, abundant evidence has developed that the frequency of brain activity varies depending on the type of activity in which the individual is engaged. Berger first
noted that if he had his son (his first subject) open his eyes the pattern of the recorded activity changes from what he had labeled Alpha waves to a smaller, higher frequency wave form which he labeled Beta. Since Berger's pioneering effort the use of FFT analysis has allowed highly precise analysis of the patterns of electrical activity present in various areas of the brain during varied types of tasks.

Alpha waves (8-12 Hz) have been assumed to be associated with a state of relaxation. Attention was identified in early research with the desynchronization of the alpha waves and their assumed replacement with beta waves (>13 Hz). These simplistic conclusions from the visual examination of ink-writer record EEG have had to be modified with the availability of more sophisticated EEG analysis. Alpha activity increases have been shown to represent increased cortical inactivity (Gevins, et al., 1979). Decreases in alpha have been correlated with cortical arousal (Davidson and Schwartz, 1977). Languis and Wittrock (in press) report several researches which indicate greater amounts of Alpha in "pure dyslexia." Dunn (1985) finds that baseline eyes open Alpha amplitude is a useful basis for division of individuals into Analytics (lower than average Alpha amplitude) and Holistics (higher than average Alpha amplitude). He finds these levels significant predictors of types of strengths in reading and learning tasks. Dunn (personal communication) regularly finds that increases in Alpha amplitudes are accompanied by increases in Beta amplitudes, rather than the expected complementarity that has been assumed from visual inspection of EEG records. Thus, it would appear that recording levels of amplitude of Alpha waves should, for
the present serve as the best indicator of arousal.

Signal averaging opened the door to separating the on-going activity of the nervous system from the response made to a particular signal. If the same event is presented a large number of times and brain wave activity is collected in a precise time-locked manner with each occurrence of the event, the resulting epochs of brain waves can be averaged. The on-going background activity of the brain should average to zero over a large number of trials and you should be left with a waveform which is the specific signature of the action of the proximal area of the brain in response to the repeated event. This technique opened up the door to specific examination of waveforms which correlated with experimentally designed cognitive events. The resulting Event Related Potentials (ERPs) revealed phenomena (e.g. the P300 wave) which demanded careful correspondence with the theory and research of cognitive psychology.

ERPs have been classified into two major groupings - Exogenous (determined primarily by the characteristics of the external stimulus); and, Endogenous (determined primarily by the individual's processing of the stimulus) (John, 1963). The endogenous are the ERPs that are of greatest interest in research seeking to understand individual differences in processing. Three primary and prevalent ERPs have been identified: the N1, P2 and P3. Many other potentials have been identified, but their reliability and discriminability is sufficiently low that they will not be considered further at this time. The N1 is a negative going wave with a peak at approximately 100 msec after a stimulus. It has been found to be maximal at CZ (see
10-20 Electrode Placement System - Appendix N) and distributed primarily in the frontal areas. The amplitude of the wave is relatively sensitive to factors which are expected to alter selective attention (Hillyard et al, 1973; Picton and Hillyard, 1974).

P2 is a positive going wave, centered at CZ and centrally distributed, peaking somewhere in the neighborhood of 160-200msecs after the stimulus. There is no consensus on what to call it. It is variously referred to as a memory consultation or a response decision or organization (Donchin, 1984). P3 is a PZ centered wave, concentrically distributed, peaking at approximately 300msecs. P3 is found when an individual must make a significant discrimination as a basis of a response (which may not have to occur externally). The more unusual the sought event, the larger the P3 is. The more the individual has experienced the event, even if the objective probability stays the same, the smaller P3 gets (Andreassi, 1980). The most common term for the cognitive processes represented by P3 is "context updating" (Donchin, 1984). Each of these waves is readily discriminable and measureable. Although there may be more cognitively significant waveforms and relationships in the ERP, these ERPs represent the most preferable targets for assessment.

The primary drawback of FFT research is that it is essentially index variable research. One can identify differences in the frequencies present in specific areas of the brain during specific tasks for specific individuals, or patterns that are characteristic of specific types of tasks (Galin and Ornstein, 1972) or of people (Dunn, 1985). These data are certainly interesting, but they bear the curse
of all index variable research - i.e. we can see that there is a difference, but we can't be very sure what causes it or what it means. It is only by a method of convergent correspondance - demonstrating the same type of phenomenon with regard to the same area of the brain or type of task from several different points of view - that we can gain any confidence of the underlying mechanics, never mind any facility in its use. One of the chief advantages of FFT research is that it can be used in a subject doing any task.

With ERP research, some of the same difficulty exists. A P300 is an impressive neuroelectric event. It is thought to be of considerable significance with regard to learning (e.g. Donchin refers to it as the brain's updating of context). But, after 20 years of research there is very little that we can say about the P300 which goes beyond the generation of further research hypotheses. The most important drawback is that use of this method requires the subject be exposed to the precisely same event for a large number of times in succession so that the results can be averaged. Very few events in life require 50 repetitions of the same event in the same conditions in very close proximity. Though there is considerable research which indicates little effect of fatigue on cognitively significant waveforms, there is reason to believe that the experimental situation may not correspond to more normal activity. The advantage of the ERP method is that by appropriately defining a task, the waveform can be obtained which corresponds to a very specific event (e.g. Kutas and Hillyard (1983) having a word end a sentence which is cognitively anomalous with the preceding portion of the sentence).
Both FFT and ERP research have suffered from inconsistency in the conduct of research. Researchers use different types of electrodes, amplification systems, numbers and placements of electrodes, accept different degrees of quality of electrical contact, have poorly coordinated tasks, have questionable subject selection procedures, average different numbers of signals, among many other variations in methodology. While this is a concern with all types of research, it is particularly problematic where the sizes of electrical signals that one is studying are mostly single digits of microvolts. When this is combined with the sizable differences between subjects in waveforms present in any particular task, it is easy to feel frustrated with the products of so promising a research tool as the EEG. On the positive side, given the methodological problems inherent in the research, the amount of encouraging data and research should be taken extremely positively. Of particular concern was the fact that a vast array of data and theory (Flourens, 1824, Lashley, 1929, Pribram, 1971) made clear that the whole brain was involved in cognitive activity, but essentially no one used a full array of electrodes covering the entire brain area (Jasper, 1957) for any of this cognitive research. The prospect of 16-20 electrodes worth of data to analyze was more than even many of very strong heart could abide. Though there had been a few attempts to produce graphic display of many points (Tikonov's Toposcope, Cited in Luria, 1973), no breakthrough's had occurred.

One of the most serious problems with applications of EEG research has been that the data were only intelligible by an extremely
highly trained expert. While a novice could see a specific
difference, and perhaps act on it (as with the craze for conditioning
alpha waves through biofeedback) there was little that could be done
with the data to give them persuasive power. In 1979 a major change
in the way in which data was displayed became available (Duffy, 1982).
Duffy's BEAM system (Brain Electrical Activity Mapping system) took
the data from a full array of scalp electrodes, used an interpolation
algorithm to establish putative values for intervening points and
converted the resulting electrical values to a system of color coding
for visual display. These systems are still undergoing tinkering with
colors, display format, interpolation system, etc., but Duffy's basic
concept remains intact. With this system it is now possible to locate
activity visually in brain space, but also look at sequential time
slices of processing and observe directly movement of activity from
one area of the brain to another. In a technical sense there is no
more information here than there would be from the same analysis done
on individual electrodes in the pre-BEAM manner. The effect of the
system is to create powerful graphic images of activity changes in the
course of specifically selected cognitive events. This imaging system
may, through the power of the graphic display, make information about
brain function available to the brain user in a form which may enable
an ameliorating self-familiarization. Such a tool is a perfect example
of a technique which bridges the quantitative and the qualitative. On
the one hand the method provides us with an enormous amount of
precisely collected quantitative data. On the other, data are
presented in an interpretable and applicable qualitative fashion. The
conversation is embodied in the technical qualities of the medium (McLuhan, 1964).

Another variant of ERP technique has recently been explored. The "Probe Technique" operates on the assumption that when a part of the brain is directly involved in a cognitive task, the response capability of that part of the brain to an irrelevant stimulus (the probe) will be different from the response which occurs when that part is not involved in a cognitive task. In principle, it becomes possible to monitor the involvement of the brain in various cognitive tasks by recording ERPs to an irrelevant probe and looking for the differences between the response and the response when there is no cognitive task. While there have been some encouraging findings using this method (Shucard et al., 1977, 1981, in press; Papanicolaou and Johnstone, 1984; Galin and Ellis, 1975; and Federico, 1984), there are some serious methodological concerns yet to be resolved.

The research has been troubled by the use of varied types of probes. The issue is the difference between baseline response and task response, but unknown interactions of this difference with visual, vs. various types of auditory probe are unknown. The systems of referencing electrodes have varied considerably from lab to lab, making comparability of results, at best, difficult. There has been little attention to habituation problems with the presentation of the probe, and thus the need for rather elegant experimental designs to insure equivalence of baseline and task probes. It is not at all clear what an appropriate baseline task is. What is nothing—in an awake and alert human? The assumption is that an area involved in a
task will have less resources with which to respond to the probe, and will thus produce a smaller response than the baseline condition. Yet a high percentage of the cortex of the brain is inhibitory. If the involvement in a given area was excitatory and the involvement in another area was inhibitory, it would be expected that one would show a larger response than to probe baseline and the other would show smaller – which is which depends on the precise system of electrode connections, parameters and referencing system. In the Brain Behavior Lab, for example, we have data that the amplitude of response to an auditory probe is larger at all of 16 electrodes when the subject is learning a list of words effectively, relative to doing nothing, while there are no differences of response amplitudes between baseline and the same subject in the same session learning a list less successfully. Nonetheless, the technique offers the prospect of directly observing brain activity during learning by getting a specific picture of the degree of involvement of various brain areas in the task. Furthermore, the prospect for observing individual differences and within subject differences is encouraging.

Use of the probe with topographic mapping offers even more enticing prospects. In the course of preliminary experimentation with the probe technique, the technical facility to make a single map which is integrated over a large time period of the response to the probe led to the discovery of significant baseline shifts in the electrical activity corresponding to differential involvement of the brain in a task. These were different than the peak values of particular waveform responses of the probe which have been the focus of interest
in previous probe research. For example, if an individual was asked to learn a list of words during probing using one of various learning strategies (e.g., trying to create visual images, attending to similarities in the sounds of the words, putting the words into categories, etc.) when the resulting ERP data are viewed as a single map integrated across the entire epoch of data collection, differences in the maps appear which are consistent with both performance and known differences in the strengths and weaknesses of the processing of the individual. What is most encouraging is that the differences are in the form of single visual images which indicate both the overall degree of involvement in the task and differences in involvement of various areas of the brain known to be preferentially used for specific types of processing.

Through the graphic display of EEG data we now have available a large number of vehicles for taking the cognitive processing of the brain and making it available in a qualitative form. The method provides a huge amount of quantitative data for research purposes; but, it also provides a qualitative display that can become a piece of a process involving the individual directly in understanding his/her personal neurocognitive processes. Armed with this information the individual is in the position to take control of his/her learning processes in a more effective manner - controlled by subsequent natural consequences.
Methodology

The methodology selected for research presumes a philosophy. Within the framework of a traditional disciplinary investigation this presents few issues worth addressing. The prevailing methodology of the discipline is applied to the issue under study - usually an issue which grows directly from the literature that has been developed using that methodology. This has been an exceptionally fruitful approach to the development of disciplinary knowledge and to interdisciplinary advancements amongst disciplines which share common philosophical assumptions. However, when the research at hand seeks to bring together fields that have traditionally adopted very different methodological assumptions questions inevitably arise.

In the human sciences these problems are most common and continue to be most vexing. From the first days of Weber and Fechner in psychology through the Science of Education movement there has begun, and continues to reign, a friction between those who support the positivistic methods that are central to the history and philosophy of science and those of less determinant "humanistic" methodology. The positivistic method, though evolving through various approximations, came to full flower in the post-Frege and Russell and Whitehead era. Karl Popper established the philosophy of disproof as the heart of science. Under this approach science works at the great truth table, but with the constraint that it is not possible to enter any T's, only F's. From the pattern of the remaining empty cells one assumes an operative truth for whatever has the least evidence against it, at least until such time as counter-examples (new F's) appear.
While the method plays conservative it has served well in focusing research on narrowly defined tests of beliefs and assertions. The truth evolved as the negative space of the rising empirical falsifications. This lovely flip-flop of the assumptions of Baconian Induction continues to be central to the scientific method as applied to the human sciences - even to the assumptions built into hypothesis testing with the sacred statistics (e.g. null hypothesis).

Recently there have been various challenges to positivistic method from within. Skipping over the extrapolated significance of Einstein’s Relativity Theory and Heisenberg’s Uncertainty Principle from physics and Godel’s Proof from logic and the tradition of relativistic thought that follows (e.g. Matson, Capra, Zukav), the logic which supports the method has been under serious siege, even while the methods have, in the absence of an alternative, marched on undaunted. So strong was the hold of method on psychology that when Skinner wanted to publish some of his classic operant conditioning studies with only single subject data he found no takers and had to start his own journal (Journal of the Experimental Analysis of Behavior). Kuhn sounded the first volley, by asserting the subjective beliefs of scientists (paradigms) determine the questions asked and the interpretation of the results of research in a most unobjective way. Feyerabend (1978) went further to suggest that all methods were of equivalent validity. His epistemological dadaism spited itself by not going to the obvious conclusion (ironically consistent with the traditional method) that, even though all methods were of equivalent validity the ultimate test of the method was the use of the data and
conclusions which come from it. In applications to human action this means the use of research conclusions in the areas of human social and political subjectivism.

At the same time developments in philosophy, cognitive science and psychology were lending support to a softening of positivistic rigidity. Fodor, working from the Chomskian tradition (if anything so young can be said to have a tradition) began exploring his philosophy of modularity. Essentially he asserts that areas of human experience can operate as independent modules with different logics and mutually incompatible "beliefs." Under such circumstances truth would be truth depending on how you look at it. Dennett and Hofstadter explored the philosophy of self-reflection. Though H. L. Mencken, with disdain, referred to such activity as Omphalopsychic, their explorations have begun to make discussions of the philosophical status of human self-knowledge more acceptable.

Cognitive science and some of the methods developed in its pursuit (e.g. the talking aloud protocol) have given new credance to the subjective and to the possibility that there are internal and external contextual factors which add a place beyond positivism in the human sciences and their applications.

In psychology the researches of Kahneman and Tversky (Kahneman, Slovic and Tversky, 1982; Tversky and Kahneman, 1978) and those who have followed in their path (e.g. Nisbet and Ross, 1980) have established that even in the presence of overwhelming expertise individuals will often make choices and decisions which go against all of that expertise and rely on a subjective categorical bias. If
nothing else these researches should make us very cautious in our optimism about the acceptance of the "truths" discovered by any method of human science into the procedural knowledges of the practitioners.

Taken together, these developments have created a considerable methodological dis-ease amongst those of positivistic bent who are inclined to consider the implications of their methods.

On the other side of the methodological fence are those who feel that the basic data of any human science is the subjective experience of the human. Phenomenology has a long and rich philosophical history. Its impact on research method has been determined primarily by the goals of the researchers. Those who have viewed research as the pursuit of the truth have eschewed phenomenal subjectivity with venom. Those who are practitioners with humans in the social arena have been much more inclined to embrace it. Education is a particularly interesting case in that the efficiency movement spawned by Taylor, the numeracy motive described by Kline and the science of education movement, among others, have created a body of research whose followers continue to attempt to apply quasi-positivistic methods to educational research.

A particularly interesting example of a dividing point is the Hawthorne effect, psychology's version of the placebo. In research in the positivistic tradition anything which alters the expectations of the subject of the research in a way that might alter the outcome of the research is considered unacceptable. The scientific shibboleth is double-blind. Rosenthal and Jacobson's classic study Pygmalion in the Classroom demonstrated that the expectations of the teacher can
alter the resulting performance of their students (there is considerable doubt as to the validity of the statistical procedures used in the analysis of their data, which ironically casts doubt on their conclusions, even though virtually no one doubts that the basic concept that they demonstrated has validity). Interestingly one of the major uses to which this study has been put is to argue against the use of standardized testing which may produce falsely low expectations in some student groups - this in spite of the fact that the study looked at the effect of artificially raised expectations on the performance of the students.

One approach to utilizing these data would be to attempt to eliminate any basis for false expectation - e.g. make more accurate tests. To the extent that the ethos that spawned this research has had an impact it is in that direction. Another approach would be to try to create positive expectations among teachers for all students. Another more radical approach would be to assume, with Bruner (1985) and Flavell (1984) and George Kelly (1955), that the ultimate experimenter is always the individual him or herself. That our goal should be to create the most positive self-expectations possible in each learner.

From this point of view the Hawthorne Effect becomes an interesting puzzle. On the one hand research should attempt to eliminate subjective expectations of the subjects so that the independent variables under study can be assessed without confound. On the other hand, the expectations of the individual are a universal presence in all real-world human activity. This would argue that all
research which seeks practical application should include subject expectations as a variable. Furthermore, a highly sought goal would be to find methods for maximizing the Hawthorne effect to the attainment of the desired ends. Since subjective expectations cannot be eliminated in the arena of application, should there by any attempt to eliminate then in research? Rather shouldn't they be assumed, encouraged and included as a part of the research and assessment?

Bethea, at the 1986 American Educational Research Association convention interrupted her paper to announce, "I should have mentioned that the results of this study apply only to the sample that I studied. It always bothers me when people don't mention that."

It is implicitly assumed that all specific studies are of samples representing larger populations. Generalization of results assumes equivalence of the sample and the population. But with what we know of the significance of cohort, cultural context, social and personal context, might it not be better to agree with Bethea? If each study applies only to the sample studied, each study is actually an intervention. Ethical conduct of an intervention demands that it be done with the best attempt to produce the maximum possible good for all the participants. Full use of the Hawthorne Effect would be appropriate.

The conflict of methods is severe in any research where the ultimate goal is to assist individual learners in better utilizing their learning abilities in on-going social context. Precise definition of terms, operationalization of concepts, measurement and analysis of data are essential to a valid understanding of the results.
of the experiment. Yet any research in which the traditional scientific method is rigorously applied will eliminate all of the richness of individual differences and contextual factors which are central to human thought and action - the arenas from which the research originates and in which applications of the results must operate.

"Perhaps research ... is nothing more or less than another voice in the conversation - one that stands alongside those of parents, teachers and others." (e.g. learners) "What works depends of the kind of work one wants inquiry to do, which in turn depends on the paradigm within which one is working."

Smith and Heshusius, 1986

The method adopted here assumes the epistemology that supports the quantitative approach is an essential correspondent, but logically incompatible with the epistemology which supports qualitative research. Unfortunately this must be stated in these terms, though quantification or qualification per se are not the issue. The confusion that Smith and Heshusius discuss at length seems derivative of poor definition. There are certainly ways to quantify the data of case studies, interviews, naturalistic observations, quasi-experimental designs, or subjective statements. What alienates the current forms of qualitative and quantitative methods is the assumption about truth and the criteria of its attainment. In the quantitative method, it is assumed that there are kernels of truth which, if all of the annoying distractions of life can be controlled, can be discovered and put to use in controlling outcomes. As more
truths are discovered, the method and the knowledge thus attained will triumph over all. The qualitative method rests on the epistemological assumption that truth lies in the subjective digestion of experience by those who will act on the interpretations in "ecologically valid" contexts. Truth is in the interpretive processes of the knower and user, not in an absolute physical reality.

The case study methodology has served as the primary vehicle for contextual study in education (Welch, 1981). In this method the program, school or individual(s) of interest are studied according to the idiographic methodology first proposed by Murray with regard to psychological investigation. Variants in the application abound, but the key ingredient is that the investigator allows a significant role for the subject of study in the determination of the parameters of the study. As with current models of procedural knowledge in cognitive psychology, it is assumed that the subject of study can have any number of key issues, structural forces, strengths, etc. There is no single procrustean set which is adequate to the assessment of all situations. The degree to which the individual brings in a predetermined structure for study or lets the situation help shape the structure of the study is highly variable - as is the quantification of any data which are accrued. The key feature of the case study is the attempt to engage the whole context of the study in the study - not just select features which the experimenter has pre-selected, controlling for all other variability.

The case study demands a larger role for the experimenter in the post hoc evaluation and interpretation of the collected data. At
the same time the authoritativeness of the results are diminished by the lack of objectivity, and the results are given greater impact to practitioners by the inclusion of additional context in the study. By Bethea's assertion, all case studies are interventions—demonstration projects whose evaluation is, in part, in the hands of those who may choose to model their efforts on the results of the demonstration.

The issue of authority lies at the heart of the matter. As O'Donnell (1986) asserts in his history of behaviorism, in periods of self doubt there is need for methods that will provide authoritative answers. The selection of a method is more a matter of the authority which one intends to assign to the results (and the interpretations by the reporters) than any inherent value of a method for educational research. If one seeks to base future actions on the authority of the research results, untrammeled by interpretation or context cloudings, then the "quantitative method" is appropriate. If one seeks to assert the role of individual non-scientists in the authoritative basis for action, a "qualitative method" incorporates the context into the study—at least to a degree. While the issue is often viewed as epistemological, it would appear to be more volitional and conative—upon what grounds will we justify our actions.

The human processing and thought patterns which have been stereotypically assigned to the right and left hemisphere are logically incompatible, as are the assumptions upon which quantitative and qualitative research are based. Nonetheless, it is unthinkable that human thought and action could operate in its current form in the
absence of either type of processing. Language, the archetypic human activity clearly requires sequential and simultaneous processing. Educational research must accept the importance of a "conversation" (Pask, 1975) between the methods of gaining new information and the methods by which that new information must necessarily be incorporated into the basis of action.

In his groundbreaking discussions of education for the two hemispheres Ornstein made much of the teaching methods common in mystic communities and traditions - especially the Sufi. He liked to cite the example of the teaching stories (not appreciably different than biblical parables) in which there is a sequential series of activities communicated through the temporal mechanics of language, but the point of the story is the metaphor - the value that is conveyed by the story.

The method adopted for this developing research program moves to the extremes while attempting to insure continued mediation through maintenance of a distributed middle. Get a direct assessment of the activity of the learning processes of an individual's nervous system using traditional quantitative methods. During this direct assessment, performance measures are obtained for the individual as well as the assessments of brain activity. While this assessment is of a single individual, the brain data consists of numerous repetitions of an event, with the results averaged. The results are compared with data for other subjects, but more importantly, they are compared with the performance and brain activity results of the individual on other tasks. The tasks are selected in a way designed
to identify the consensus array of cognitive processing skills, which are known or suspected to have differential brain localization and which have potential educational significance.

Direct brain data is new to the educational arena, performance data is not. By having both available, the less familiar data can be used to validate the findings from the more familiar, and at the same time, the brain data can become more meaningful (see Premack, 1965 on the nature of reinforcement). The results of this assessment will be the basis of an intervention program - a program in which both traditional "learning-how-to-learn" instruction will occur and learning in which the student will be fully involved in the interpretation of results and development of strategies. Again, traditional instruction in how to learn is the familiar norm - usually related to existing performance data. Learner involvement in the interpretation of data and the development of a course of action, while the primary characteristic of most of human life, is relatively uncommon in traditional education.

The individual, with the mediating familiarity of performance data and traditional instruction, will be involved in a direct conversation between the quantitative data of brain activity and the qualitative data of personal experience. In a very real sense, this method will allow the person to talk with parts of him/herself directly - parts that are normally not accessible (cf Fodor's Modules - creating isotropism/cognitive development).

Scientists and educational practitioners are no different than the other subjects of attitude change research. A primary force
in producing the change necessary to lead to behavior change is the prestige of the source of information (Abelson, 1969). For research to have a positive impact on individuals from a wide range of methodological positions, there must be included in the research design methods which enjoy prestigious status for each. The most encouraging outcome of such research would be changes in behavior where the individuals can be directed by the most prestigious information of all—direct personal experience.

It is the assumption of this method that all positive change in the action of an individual is change in an individual (tautological, but essential). It is the basic contention of the whole area of Aptitude Treatment Interaction research (Cronbach and Snow; 1981) that desired changes in single individuals can be concealed in no change or opposite changes of other individuals included in the research sample. If we accept that there may be aptitude treatment interactions (a notion whose truth seems beyond question, despite some of the disarray in the data of those who approach this with a strict quantitative method), the key case must always be the interaction of any treatment with an individual learner. It is precisely the individuality of this approach that commends it to work with those learners who have not seemed to flourish with other methods. Thus, the number of subjects in the research have bearing only in the use to which quantitative methods (i.e., statistics) may be applied. Any number of subjects above 0 is appropriate. The test of the method is in the conversational bridge that it produces—drawing together the window and the mirror.
Model for Improvement of Learning

To those involved in education the desireability of good learning may seem a cliche. Yet we do not measure good learning nor do we attempt to teach it in any systematic way; rather, we teach and measure the acquisition of specific skills and knowledges, while assuming that learning is a given (the clinging legacy of intelligence's semantic tyranny) or that if the "basic skills" are acquired all else will take care of itself.

Let's put this in a somewhat different perspective. The average individual in our society will spend approximately 6 hours a day for 180 days for 12 years in school. This totals 12,960 hours of intentional instruction. If we charitably ignore the literature on time-on-task and assume that all these hours are fully occupied in directed and intentional instruction, and if we assume that in the average individual's lifetime roughly as much directed intentional instruction goes on outside school as in school, we have an estimate of approximately 25,000 hours of learning under the instruction of a self-conscious teacher (i.e. one who both has and accepts the some responsibility for the outcome of the instruction). If we assume that the average individual is awake for 16 hours a day and lives 75 years, there are roughly 423,000 hours in which an individual can be learning and doing with prior learning. When compared with the seemingly charitable estimate of the time in which another is responsible for an individual's learning we find that, even so, only 6% of waking time has the responsibility for learning in the hands of someone other than the learner. There can be little doubt that the overwhelming majority
of the waking life of an individual is not under the directed instruction of another. Stated otherwise, the vast majority of the learning of an individual is in the hands of the learner - not a teacher. And this does not include the role of the learner in the success of the efforts of the teacher. It is perhaps most pressing in times where social and informational change are occurring with unabating acceleration that the most valuable legacy of a quality education would be that the schooling has made the individual a good learner.

Rather than enumerate items which have been experimentally demonstrated to correlate with better learning performance, The development of a model for improving learning will be approached from a point of view incorporating the learner in the development of the learning/instructional strategy. This is done not out of any disrespect for the literature, but out of a recognition that the experimental methods used and historical biases in the ways the question has been addressed preempt any significant role for the learner. The resulting collection of observations and conclusions are interesting and, no doubt valid, in their own domains. However, the numbers and diversity of the observations and their implications are exceptionally difficult to assimilate into a coherent framework and are subject to the abuses of overemphasis.

Attitude change literature, not to mention politics, make it clear that any idea which requires intricate explanation will have a difficult time making any impact. The experience of education in the 1960s and early 1970s is ample evidence of the power of simple ideas
in times of confusion (or as Brinton put it, "failure of nerve") (Ravitch, 1983). The model proposed here begins with a concept similar to that which motivated the educational experimentation of the 1960s but attempts to provide additional structure to assist in the understanding of a method for producing good learners. It should be noted that this work is in no way intended to be a total philosophy of education, but is to apply to the specific development of strategies and programs for the improvement of learning in individuals in educational settings so that they will be more likely to leave their formal education, not only educated, but as good learners for the other 94% of their lives.

The initial assumption is that all people are learners. Except in cases of physical limitation all humans learn to walk. Except in the rare case of extremely severe neurological impairment all individuals learn to understand and use a complex language with nothing other than functional exposure to a language. All individuals learn complex patterns of social interactions. While there is no question that the speed and quality of learning of these vary considerably from one person to another, there is no question that these complex learnings occur quite spontaneously, in context, in the absence of any intentional instructional efforts, and have occurred essentially the same way in all human cultures throughout recorded history. The fundamental conclusion is that there exists in all individuals a "readiness to learn" that is consummated when that individual encounters the various stimuli of the human world.
The early form of this readiness to learn is determined by the biological givens of each individual at birth. This neurological potential for learning is progressively altered through developmental changes and the accumulation of new knowledge, both procedural and declarative knowledges. At any given time in the life of an individual there exists some maximum potential for learning which is the accumulated residue of neurological givens, inevitable maturational changes in those givens and the "wetware" additions and alterations of experience. It is important to note that those experiential alterations can affect learning capacity either positively (Enhancers are those things which increase capacity) or by interferring with the action of those factors necessary for full expression of current capacity (Enablers are those things necessary for full expression of current capacity. Deterrents interfere with the ability of the enablers to work). Having mastered the concept of number and the basics of arithmatic will "enhance" the ability to learn algebra; having learned that you are good at math will "enable" algebra learning, even if the actual neurological/developmental/ experiential potential for learning algebra is identical in both cases. Thus the potential for learning can be enhanced by the addition of new information - facts, skills, strategies, and control processes; and, its effectiveness can be less than optimal due to deterrents which prevent the full expression of the potential.

The concept of rate is more central in another area where control of complex interacting systems is quite critical to basic life processes. In any biochemical reaction a large number of factors
contribute to its rate. Biochemistry, like learning deals in complex interactive systems where we may be interested in changing the behavior of the whole system in order to produce a specific end result. The appropriate conceptualization for producing such changes is better established and accepted in chemistry than in learning.

The traditional and most prevalent mode of chemical intervention has been, and mostly continues to be, enlightened trial and error. We try what seems intuitively plausible from among the known options. We look for patterns from one body or another, one culture to another, one nutritional pattern or another, one medication or another, a set of side effects of another procedure, etc. Once a good observer finds a promising lead a careful process of research establishes the accepted treatment procedure for producing the specific desired result. Most approaches to learning improvement have followed the same basic pattern.

A more elegant solution has become more common in biochemistry. In this approach one first carefully establishes the characteristics of each of the contributors to the reaction and determines "under normal physiological conditions: which step(s) or contributor(s) limit the rate of the reaction. Efforts to alter the reaction can focus directly on the rate limiter(s). If that which limits the rate can be altered directly, the rate of the reaction will be under direct control. Thus the greatest control over the final state will come from the intervention.

This rate limiting model is certainly simple in concept, but it conceals a large number of subtle complexities which must not be
overlooked. The successful use of this model for an intervention requires quite detailed and precise information on the complete workings of all the features of the system. Practically, rate limiting must be an evolutionary approach - a combination of the more precise and the ad hoc. As more details of the system are learned what was thought to be the rate limiter may be replaced by something which was previously unknown. The system may change so that a rate limiter is no longer a rate limiter. The desired outcome may change, including the tolerance of error so that an old rate limiter king falls. Of particular importance is the fact that a system can be in a position of ultrastability (Ashby, 1965) because of complex interactions of a large number of rate limiters. (Ideally pure and applied educational research should be in a dialogue producing some of the same sort of ultrastability.) When this happens a great number of individual changes in the system may each produce some movement in the desired direction. No one or two changes may produce all the change that is desired. In the extreme, what changes rate in one system may not produce the same effect in what was thought to be an analogous system because of the existence of features whose presence were unknown. Perhaps most importantly (for purposes of analogy with educational learning processes) no amount of change in a variable which is not a rate limiter will have any effect on the rate. If a system is working at its maximum rate without the addition of more "mathemapotion", no addition of heat will make any difference - unless it makes more mathemapotion.
This rate limiting model offers intriguing analogies with human learning - a complex arrangement of simultaneously necessary conditions which determine the state of the whole system. In pursuing the analogy with learning, attempts to improve learning would be most efficient and effective if the efforts were made to identify and manipulate the rate limiter(s). To pursue the analogy a bit further, where cognitive psychology has sought to identify the various boxes which are to be connected in modeling the mind, a rate limiting approach must focus on the dynamics of transitions between the various "boxes" in the system.

As we move from the chemical to the educational domain, the details of the analogy become less useful. Factors unique to the practical nature of the human condition must gain a central role in the development of a model for improvement of individual learning through the manipulation of rate limiters.

1. Enhancers and Deterrents - Some rate limiters will be true limiters - i.e. preventing the system from doing what it is fully capable of doing; while other rate limiters will be the absence of information, experience, processes or controls which will alter the system and enhance its capacity.

2. Short-term and Long-term effects - Some rate limiters may be easily altered in the short term but produce no long term change. Some rate limiters will require long term intervention to produce the types of changes which will alter rate on a permanent basis. Attempts to alter learning by short term interventions should focus on those rate limiters which can be altered in the short term in ways which
maximize the long term change.

3. Internal vs. External Control - In applying the rate limiting model to human learning, we must consider those factors within the internal control of the learner and those unlikely to ever occur without external intervention. Like the nature/nurture controversy over origins of intelligence, the internal and the external are necessarily mutually interdependent and probably inseparable. To any who seek to assist learners in the improvement of their learning, the optimal strategy will focus on those external changes which produce the greatest change of rate for the least investment. The payoff comes in the 94% of the time where the individual has personal responsibility and control of learning.

4. Transfer - When attempting to produce improved learning it is often the case that the changes that are actually desired are at least somewhat different and occur in very different contexts than in the arena of original instruction. Optimal changes in rate limiters will not only produce the change at the time of the change, but will provide generalizable changes to be used in appropriate ways on future occasions, in unknown and novel situations.

Before developing a specific model for intervention the four factors identified above will be discussed further.

1. Enhancers and Deterrents are not necessarily easy to identify. Individual interpretation of the causes of behavior is critical to know the way a change in any feature of the environment will affect performance (Attribution Theory, Heider, 1967, H. Kelley, 1967). Something that is an enabler in one situation may act as an
enhancer in another. For the purposes of this research model it will be proposed that there are categories of factors which act as deterrents and enhancers. Specific factors will be used only as examples of operationalizations.

Enhancers must start with "knowledge structures," the biological, maturational and experiential residue of the phylogeny and ontogony of the individual. But these are the givens. Enablers will be anything which adds to the capacity of the individual to utilize these structures effectively. Ornstein and Naus' (1984) research makes quite clear that additional information which is presented in the proper fashion can elicit the spontaneous use of learning strategies which enhance effectiveness. Tversky and Kahneman (1978) make clear that procedural knowledge (heuristics), while it can produce erroneous performance, primarily will produce increased effectiveness when used in a domain appropriate fashion. Metacognitive training suggests that knowledge about "knowledge structures" can enhance the individual's ability to learn (Andrews, 1984). One important item to include in the array of enabler is good models of learners. The work of Bandura (1971) and his followers of the social learning persuasion have shown that powerful changes in all realms of human behavior can come from exposure to models.

For purposes of making a distinction, it is assumed that learning occurs at an optimal level, given the existing knowledge structures, without concern for the deterrents. Thus, motivation, which all agree is necessary for performance, will be assumed to be an enabler. That is, the absence of motivation in the optimal amount can
interfere with learning performance. The presence of motivation cannot make the system work beyond its capacity. The literature on attention, curiosity, motivation strongly suggest that, motivation is at the peak when the activity engaged in has the proper informational relationship with the knowledge structures. In other words, motivation is only an issue when the information to be learned is less than optimal for the existing structures. An enhancer strategy attempts to create the readiness to be motivated by the experience and learn it – e.g. add knowledge or specialized strategies. An enabler strategy tries to increase performance by the direct manipulation of motivation.

Deterrents will be considered to fall into two categories: first, self-concept; second, motivational. Self-concept, from this point of view, cannot improve performance, a poor one, or self doubt, or low levels of aspiration can limit optimal performance. Specifically anything which is "self-alienating" will tend to divert from those areas of learning activity are most appropriate for existing knowledge structures. Metacognitive knowledge will tend to be isotrophic and break down the modularities. In this sense, an inflated sense of self can lead to the belief that one knows that which one doesn’t, not try any more, and learn less, just the same as a poor self-concept. The key feature in this first category of limiter is self-alienation. In a very real sense, the knowledge structures brought to a learning task are self-as-learner. This includes not only the knowledges and processes (declarative knowledge and procedural knowledge) which are possessed, but the full
complement of interrelationships among them and the executive processes which direct their execution. To the extent that there are pieces of that system which are isolated (alienated) from others there can be conflicts which interfere with the execution of the existing capacities. These are the internally controllable context effects which can be the mediators to produce greater generalization over time and thus more appropriate use of metacognitive information and executive processes when guided by a responsiveness to natural consequences (monitoring).

Thus the optimal learners must include the full range of factors usually included under personality. The full-functioning personality (self-actualized in Maslow's sense (1954)) will be a better general learner than the fragmented and conflicted. One must be very careful when getting into the relationship between personality and learning to avoid confusing the optimal learning of that individual and the optimal learning of a given subject matter. There can be no doubt that an individual can do his or her optimal learning and do much more poorly on a specific task than they might with additional enhancement. Though it will not be a part of any study coming directly from this model, this strongly suggests that "therapy" in a reasonably traditional sense may be what is needed to modify a rate limiter in some, maybe many, cases. The other potential confusion the goal of learning. Who is setting the goal for the learning, using what criteria? For educational purposes we must assume that the goals and appropriate standards for attainment are primarily, if not exclusively set by individuals other than the
learner. While this model is built on many assumptions about the natural functioning of man, it is not a Rousseauian Natural Man model. The internal models that can be so important in monitoring and automatization are not givens - they are acquired from experience, can be enhanced and be the basis for a trophic learning process (Whyte, 1968).

The second conceptual category of deterrent is motivation, used here in a somewhat broader sense than traditionally. In Luria's sense (Luria, 1973) motivation is that which produces the optimal level of arousal/attention in the first functional block. This will be directly related to allowing the other two functional blocks to operate in an optimal fashion - i.e. learn effectively. While inattention is an obvious problem, the opposite end of the arousal continuum - anxiety loosely speaking - will prevent performance at the level of full potential.

2. Short-Term vs. Long-Term - Any intervention which seeks to increase learning efficiency has a number of potential rate limiters to address. An efficient investment of time would dictate that the intervention work in those areas where the greatest change can be produced in the least time. Therapy may be quite valuable, but it is not the stuff of which a course on "study skills" is made and cannot fit into the same sort of position in a school curriculum. Knowledge structures are the sum of the totality of an individual's experience. An attempt to alter learning by adding specific facts to the knowledge base may be quite important, but it is not something that can easily occur in a short time. This is the realm for changes in the
curriculum and the attitudes and behaviors of parents and teachers — a worthy task, but a large one. Changing the dynamics of motivation may be quite important, but it is likely to be a weak short-term strategy. It is the assertion of this model that the greatest positive change in the direction of long-term learning enhancement can come from changes to executive processes (permitting the application of varied strategies to learning), reduction in self-alienation (removing some of the impedance to the full utilization of the available resources — including the enhancements to executive processing), and developing of goal setting and monitoring skills.

3. Internal vs. External — Good learners have an internal locus of control (Rotter, 1966) which will incline them to pursue alternatives when learning is unsuccessful, make them more likely to organize and direct their own learning, and more active in the selection of learning strategies which they feel appropriate for them in the task (Biggs, 1984). One with a sense of external control is more likely to be a passive learner who quits easily and makes little effort to alter the circumstances or him/herself in relation to the learning task. A good program of learning improvement needs to provide the individual with the feeling that he/she has control over learning processes and has choices available that will provide success.

4. Transfer — The literature on transfer is enormous to say the least. The standard finding in learning theory and research has been that the more similar the situation in which the learning occurred to the situation in which the later learning or performance
is, the greater the transfer (Bower and Hilgard, 1981). Cognitive psychology has tended to hold to the same position, but with the addition that various internal mediational processes can create similarity of situation in the head when it doesn't exist in the external circumstances. Thus, for example, imagining yourself doing what you are learning in the situation in which you want to do it can mediate the transfer from one situation to a relatively different one. Having an internal cueing mechanism could do the same - the teacher says you can learn history better by X; you recall that whenever you identify you are trying to learn history you should do X. All you need to do to get yourself in a position to use this new technique is notice that it is history and you are trying to learn. The research on transfer of metacognitive learning is mixed, and only slightly encouraging. Those cases where there is the best evidence of transfer are those in which motivational/affective tactics are used (e.g. McCombs, 1984). It should be noted that these experiments are with very narrowly defined learned tasks and occur over very short periods of time. One interesting possibility is that mediation of transfer will occur by reducing self-alienation. Those processes that are the essence of self-alienation are compartmentalizations which restrain generalization (beyond the modularity of Fodor (1985), but similar to that discussed by Gazzaniga (1985) with regard to belief). To the extent that some degree of "decompartmentalization" can occur, it would be expected that learning processes would tend to generalize better - thus transfer to more task appropriate situations. Good learners tend to be much more fluid in their learning approaches. It
is also possible that this process could be enhanced by having the individual, while not just a big happy cerebrum of harmony, have a fluidity of processes which can be utilized to bridge gaps, as necessary. Thus, for example, individuals who have the capacity to utilize more than one member of a dichotymous learning style pair have the option of selecting the approach that is most useful for the task they are engaged in or the domain of their knowledge structures in use.

This model for learning skills improvement presumes the ideal program will require substantial change in teacher education, curriculum, parent attitudes, organizational and administrative structure in school— all of which require major long term efforts. The interventions that are likely to produce the greatest changes of "rate" in the short term intervention must:

1. Seek to produce the maximum potential for continued self-directed learning skills improvement.
2. Give the individual the greatest possible enhancement of control over their own learning.
3. Focus on the rate limiters (enhancements or deterrents) — as best we can identify them.

Based on the preceding oversight of the literature, those areas which seem prime candidates as rate limiters and offer apparent opportunity for successful short-term intervention include:

1. Knowledge of, and successful experience with, a variety of learning strategies.
2. Self-monitoring skills: setting goals and monitoring progress toward those goals.


The social and personal context in which such an intervention will be successful includes the following features:

1. Since it is assumed that long term effects will come from natural consequences, short-term effects will increase if the greatest possible authority is attached to the information. This is particularly true with brain information which shows the learner
   a. that he/she has a brain that works
   b. that the brain has strengths
   c. that the strengths, when used result in improved learning

2. Learning skills instruction occurs in relation to types of learning interesting to the individual.

3. The learning of executive control be pursued as rapidly as possible, but the individual set the pace.

4. Successes be maximized. Make attributions individual and to processes and effort.

5. The Hawthorne Effect be used to its fullest - make the learners believe there is something special about them and/or the instruction they are getting.
6. Let the instructor be an effective model - a person they can respect, but who shows and externalizes the learning processes that are used.

7. Learning should be in as natural a situation as possible. Natural consequences should be available as much as possible.

The following is a sequencing of steps that would reasonably be followed in a learning skills instructional program. There will be no discussion of needed changes in teacher education, selection or evaluation, or in curriculum.

1. Begin with introduction of "representation" options instruction, goal selection probing and self-monitoring questions from the beginning of elementary school. Much of what is sought will happen if individuals are just asked to examine how they are doing things, and not just what they are doing. This will also include exposing students to direct examples and modeling of executive statements and the variety of approaches of other students.

2. With any student who is not fully successful in any basic area a standard neurocognitive assessment will be given. This is intended to be of the same order as current assessments for "identification" but will be for anyone who is perceived as having any difficulty in any basic area. With the development of neurocognitive expertise and assessment techniques described above such evaluations will be relatively quick and easy. Initially these assessments would include a standard assessment battery. As brain mapping technique is refined and protocols of educationally relevant tasks are developed, the complete assessment can be built around the brain mapping.
What is the advantage of a neurocognitive assessment? From the history of phrenology (Stern, 1971) we know that information about the brain, even if it is wrong, can have very potent effects on individual beliefs and actions. Festinger et al. (1956) demonstrates that powerful attitude and behavior change can occur when an individual is exposed to information which is assumed to be authoritative, but which is also removed from the possibility of scrutiny. Unfortunately this state can lead to a passive responsiveness to the authoritative source (Seligman, 1975). The conditions which will prevent this passive response to authority will occur when the information is authoritative and the individual is in a position to directly control the source - the half-silvered mirror.

The graphic output of brain mapping has the authority of being a peek at the true source of action; can be demonstrably controlled by the individual who is being assessed; and results in a visually powerful and dynamic graphic which can be relatively easily understood by the most naive individual. These qualities give the results of neurocognitive assessments great potential authority in helping individuals understand the workings of their own cognitions while providing a sense of the ability to control and change them.

Results of these assessments will be shared with teachers and parents so that they can understand strengths of individuals which can be used as the basis of more effective learning strategies. With older children more of the specific information about the assessment can appropriately be shared. For purposes of keeping the assessment
intelligible, it will be best to use Luria's model, using amplitude as an index for block one, right-left differences for block two, and front-back differences for block three. As techniques get more precise it may be possible to move to more refined assessment; but since many types of learning tasks will be a part of the protocol, the differences in the three blocks can be seen in varied learning and performance areas.

3. During Middle School each student will take a learning skills course which will be designed to formalize the information which was given indirectly in elementary school. In particular, there will be familiarization and practice with learning strategies and executive processes, work on goal setting and self-monitoring, and problem-solving in natural situations.

Students who are experiencing difficulty would be candidates for a neurocognitive assessment. At this point the results would be shared with the individual for interpretation and the development of strategies for the future.

The attached protocol (see Appendix 2) currently in use in research in the Brain Behavior Lab, will provide an indication of tasks which could be included in a standardized assessment. With time, a composite protocol can be developed, the numbers of tasks will be reduced and tailored to specific assessment purposes. In all work the active participation of the assessed individual in the selection of tasks to assess should be used to give them an active role and a favored position in interpretation. Given the variety of learning styles, subject matters and goals it should never be assumed that any
The goal of this program is not only to improve the learning of individuals who participate, but through the authority of the direct assessment of the brain's activity to influence parents, teachers and students toward more realistic and effective learning.

Hypotheses

The preceding model offers a considerable number of potential hypotheses to assess in an exploratory research program. It is the primary contention of this approach that the most usable data are case study data of individuals as they relate to personal and learning context. An intervention program will be conducted with 8th graders, including pre and post brain assessment and a complete assessment of a comparable group of successful learners. The evaluation of the program will be conducted as case studies of individuals including changes in grades, brain assessment and performance data. The number of individuals included in this project is sufficiently small to make statistical conclusions somewhat suspect. Even so, eight specific hypotheses will be assessed in these data. Tabular summaries of all the research data will be presented for each group.

Specific hypotheses to be tested are:

1. Successful learners will show higher levels of "activation" (Luria's block 1) in learning task brain data than the unsuccessful learners. Activation will be defined as (depending on the task) the reciprocal of alpha power, ERP peak amplitude or ERP peak amplitude suppression in "probe" tasks. Luria's model presumes that the effective functioning of blocks 2 and 3 depends on the functioning of
block 1. It would be predicted that better learners will show greater levels of activation. The three selected measure represent different methods of assessing neural activation.

2. Successful learners will show greater internal vs. external locus of control - more so for a school related measure of locus of control than a general measure. Metacognitive research (Peterson and Swing, 1982a and b) shows that those with greater self-knowledge are better learners. If that self-knowledge is to be effective, the individual must assume internal control of its use.

3. Successful learners will be more analytic as measured by performance on the Concealed Figures Test. Letteri (1980) finds greater analytic style in successful school learners.

4. Successful learners will show more variability in performance with various strategies - but unsuccessful learners will show more variability in brain data. Greater metacognitive knowledge, when used should produce greater variability in performance using different strategies. However, Kimmel (1985) reports that individuals with lower ability are found to have greater variability in brain electrical activity patterns - less coherence (see 7 below).

5. Greatest variability in brain data across tasks and scalp sites will be seen within subjects; within groups, between groups and between tasks will be less variable. It is speculated that individuals vary more in response to different tasks than among tasks, groups or scalp sites. This would suggest that individual data on specific tasks will predict a larger portion of total variance than task or group data.
6. Successful learners will show greater strategy use in free recall - 
use of order information, categorizing recall, variety of strategies 
and strategy shifts. This follows from the metacognition research. 
However, it is anticipated that the less successful learners will 
report and exhibit idiosyncratic strategies.

7. Brain data for the less successful learners will show less 
"coherence." Coherence will be measured by the inverse of the number 
of identifiable peaks in ERP data smoothed three times. Kimmel (1985) 
speculates, based on a model of Nebylitsyn (1964) that if there is 
more variability in the nervous system (less functional stability) 
there will be less consistency in the processing of a stimulus, and 
thus less clarity of ERP peaks. This would produce smaller peaks, as 
in 1, and greater numbers of individual peaks in the waveforms.

8. Successful learners will show greater response to "cognitive load" 
in ERP tasks. A way of measuring both automatization and strategy use 
is to look for the ability to screen out an irrelevant stimulus and 
identify a significant one. This should be manifest in the difference 
between the P300 peaks for the relevant and the irrelevant stimuli. 
The difference between a simple detection and a discrimination is less 
clear. On the one hand, greater levels of processing of any event 
might be expected in the successful learners - thus little difference 
between the two; or, the good learner might have a greater 
automatization of the less demanding task, and thus a greater 
difference.

Other data which are relevant to these hypotheses will be 
discussed in the course of data presentation and qualitative review.
CHAPTER 3

PROCEDURE

Research Approval

This research was covered under approval number 81H0312, issued by the Biomedical Sciences Human Subject Review Committee, and number 85B0143, issued by the Behavioral and Social Sciences Human Subject Review Committee, both of The Ohio State University, to Dr. Marlin Languis, Director, Brain Behavior Laboratory (see Appendix 3). A research proposal was submitted to the school district where the research planned (see appendix 4). The research program was presented to the Principal and Counselor at the research site. They approved the project and offered their assistance.

Subjects

Two groups of six individuals were selected from the 8th grade students from a middle school in an upper middle socio-economic level suburban midwest community. The experimental group consisted of individuals who were identified by, (1) the guidance counselor, and (2) IQ tests and/or achievement tests and grades as being significantly less successful than it seemed appropriate to think they
could be. IQ scores or achievement test scores were not available for all individuals selected for study. At least one was present for each individual. In all cases IQ scores were above average and/or achievement scores were over the 70 percentile. The selection criteria were deliberately kept relatively unrestrictive since it was intended that the results be applicable to as wide a range of individuals as possible. For the purposes of this study individuals whose poor school performance was apparently due to serious emotional or behavioral conditions, as identified by the school guidance counselor, were excluded from consideration. Twelve individuals were initially identified as meeting the criteria — Ten males and two females. Information about the research, permission forms, and the intervention program plan were sent to parents by the school (see Appendices 5, 6, 7, 8). Five permission slips were signed and returned initially. Follow-up calls by the guidance counselor produced a sixth participant and permission slip. The participating group were all male. Profiles of the participating individuals will be presented, along with group data in the results section.

The control group was selected after the experimental group. Six males were identified and confirmed by the guidance counselor to be comparable to the experimental group in all major respects, except that they were all regular honor roll students. No attempt was made to directly assess individual IQ scores for all individuals. Those results available confirmed the similarity of the individuals in both groups in all indexes of development and ability except learning ability as manifest in school.
Overview of Assessment and Intervention

Each of the six members of the experimental group was called to a group meeting during a free period in the school day. The project was explained to them and their agreement to participate sought. Some displayed a lack of enthusiasm characteristic of 8th grade boys who do poorly in school, but all agreed to continue in the program.

At the initial session each individual was given a brief overview of the program (see Appendix 7), a preliminary schedule of the program (see Appendix 9), and asked to fill out a general information questionnaire and briefly discuss his learning interests, strengths and weaknesses (see Appendix 10).

An individual session followed at which each individual was asked to talk about his methods of learning, difficult and easy areas in school activities and asked to complete two paper and pencil tests of locus of control – the Nowicki-Strickland Locus of Control Scale for Children, the Nicholls School Locus of Control Test (see Appendices 11, 12). In addition, each individual heard a free recall list and provided his immediate recall (see Appendix 13). Each individual in the experimental group was scheduled for two neurocognitive assessments at the Brain Behavior Laboratory at The Ohio State University. Individuals in the control group were assessed one time.
Neurocognitive Assessment Procedures

Each individual was picked up at the end of the school and brought to the Brain Behavior Laboratory. The assessment was completed and the individual returned home within a total time of 3 hours.

Each individual's head circumference was measured and the appropriate size electrode cap (Electro-Cap International) was positioned on the head by nasion to inion and left to right pre-auricular notch midpoint for CZ placement to accurately locate scalp sensors according to the International 10-20 electrode placement system (see Appendix 14). The skin was scrubbed at each active electrode site using Omni-Prep and the wooden end of a Q-Tip. Each electrode cup was filled with Electro-Gel (Electro-Cap International). A Grass gold cup electrode was positioned with Beckman electrode paste at FZ1 as a ground. Reference electrodes were Grass gold cup electrodes attached to the ear lobes with Beckman electrode paste and linked. 16 active electrodes were used (see Appendix 15).

The individual was seated in a comfortable chair with a hospital tray table positioned at a comfortable height in front of him. The electrodes were attached to a Beckman polygraph electrode connector box. All impedances were checked before and after data collection. Impedances at all sites were maintained at 1-3 Kohms. The connector box was connected to a Beckman Accutrace 200 16 channel polygraph. The polygraph was run with 60 and 30Hz filters on, the Low Pass filter set at 35Hz and the High Pass Filter set at 1Hz (Time Constant .16). Sensitivity was 10uV/mm. Ink writer record was
collected during all data collections. The polygraph was calibrated with the Brain Atlas brain mapping computer system using a 100V pulse.

Output from the polygraph was sent to the Bio-logic Systems Brain Atlas for analysis and conversion to color-coded topographic display. Sixteen channels (F7,F3,F4,F8,T3,C3,C2,C4,T4,T5,P3,P2,P4,T6, O1,O2) of EEG data are used as the basis of map production. Voltage values for all points which lie between the electrode sites are estimated by a 4 point "nearest neighbor" interpolation. Resulting values are displayed as colors corresponding to a 16 color voltage scale. To maximize contrast of the visual display, the color scale can be raised or lowered by repeated factors of 2. For any electrode on any map it is possible to get a digital voltage readout of its value for data analysis. Data can be viewed from a top view, a left or right view, or a left minus right or right minus left view.

For Frequency analysis (Fast Fourier Transform - FFT), the data are collected in 2 second epochs. Each epoch is analysed into its component frequencies by half Hz intervals over the range from 0Hz - 31.5Hz. Fourier analysis of the data from each 2 second epoch takes approximately 8 seconds. At the end of that period a second 2 second epoch is sampled and analysed. The analysis of that epoch is averaged with the first. This procedure is repeated until the desired number of samples has been collected. In all FFT data collections, Four 2 second epochs were collected.

The resulting data can be displayed one .5Hz map at a time or the whole series scanned through sequentially. A map can be displayed which show the "integration" of the activity from any selected
interval - either as a single map for a specific interval or as 12 maps equally subdividing the specified interval. The "integration" can be either a summation of the values within the interval, maximum values in the interval, a signed average or an unsigned average.

Event related potentials (ERPs) can be collected for epochs from 256msec to 4096msec. With any epoch, the resulting data will consist of 256 data points (i.e. the sampling rate of EEG when the epoch is 256msec is 1000Hz. The sampling rate when the epoch is 1024msec is 250Hz.). In all ERP collections in this research the epoch was 1024. Each sample is retained as a running average with succeeding samples. The results are displayed when the pre-set number of samples have been collected.

ERP data can be viewed as a single map of the voltage values for each of the 256 data points in the selected epoch. Interpolation and color coding are the same as with FFT data. It is possible to scan through the data points, watching the movement patterns of electrical activity during the averaged epoch. In contrast to more conventional ERP research, topographic mapping allows easy view of the origins, spatial and temporal distribution, movement and resolution of any potential. Maps "integrating" the activity of any specified interval of the epoch may be displayed, either as single maps or as 12 equally distributed maps within the interval.

ERP data can be collected simultaneously from two different events. For example, an individual can be presented with two different tones randomly presented according to a predetermined probability. They can be instructed to respond to one tone and not the other. The
data from each tone can be collected separately, stored, analysed and displayed independently to allow examination of neurocognitive differences in the response when physically similar events are processed differently.

The Brain Atlas Normgen program allows individual data collections to be summed with any others of the same type (i.e. FFT with FFT and ERP with ERP) to produce a group mean file and a group standard deviation file. A Control File is produced which can be used for statistical comparison with any other data collection of the same type. For example, FFT data can be collected from a large number of individual engaged in a task. These can be made into a normative file using Normgen. If an individual file is collected and a judgment is desired about its normality, it can be compared with the Control File from the normative group and a map showing Z score differences displayed. This will show, by color code, the Z score differences, their spatial location and the frequency bands in which they occur. The same type of comparison can be done with ERP data. All of the types of data display mentioned previously are possible with these Z score maps.

Brain Atlas also provides the researcher with Bank Mathematics. This feature allows any set of data to be manipulated mathematically and the results redisplayed. For example, if we want to know the difference in an individuals FFT data while he is reading and drawing we can collect each, take them into the Bank Mathematics, subtract one from the other, display the results in any of the ways discussed previously. We can now see a visual display of the
difference between the neural processing of an individual in different tasks. This can be done for any type of data.

With all sixteen data collection channels a 100uV window is set for artifact rejection. Whenever that value is exceeded in any channel at any time during a data collection epoch the data sample is discarded and another sample collected for analysis. All data collections were stored on floppy disks for subsequent display and analysis.

Data Collection Procedure

Each individual's data collection was recorded on a Brain Behavior Log sheet (see appendix 16). Prior to brain data collection, each subject was given the Edinburgh Handness Inventory (see appendix 17) and a history taken including items which might be expected to effect EEG data (see appendix 18).

Brain assessment consisted of the protocol shown in appendix 19. Each subject first completed 18 collections for Frequency Analysis as follows:

1. Eyes Open - relaxed, starring forward
2. Eyes Open - relaxed, starring forward
3. Eyes Closed - relaxed
4. Eyes Closed - relaxed
5. Imagining a Class Situation where Skilled Learning is Occurring
6. Imagining a Class Situation where Poor Learning is Occurring
The remaining brain assessments were as follows:

1. Auditory Event Related Potential - Subject responds to a 1000hz tone with the same characteristics as above, except that it is presented with a .2 probability - no stimulus occurs with a .8 probability. Data are collected for both the non-stimulus and the 1000hz stimulus to which the subject is to respond by pressing a counter with both thumbs. Accuracy is
determined by monitoring audible clicks of the counter
with the on-going count of the stimulus presentation.

2. Auditory Event Related Potential - Same as 2. except that
the space which had no stimulus now has the 500hz tone as
presented in 1. Collections and accuracy checks are the
same as in 2.

3. Auditory Event Related Potential - no response required;
75db 500hz tones presented to both ears at a rate of
.7/sec 100 times. Tones had a 10 ms rise and fall time
with a 10 ms plateau.

4. Reading while an irrelevant "probe" auditory stimulus is
presented. The stimulus is the same as in 3. and is
presented 50 times. (Raygor)

5. Reading - continuing the same passage - Frequency analysed
data is collected as above. Reading is continued until 3
minutes have passed. The subject is asked to circle the
last word read.

6. Reading Test - Frequency data is collected during
completion of a test on the material just read. (Raygor)

7. Concealed Figures Test is taken during the Probe stimulus,
as in 4. (Thurstone and Jeffrey, 1955)

8. Concealed Figures Test is continued during collection of
data for Frequency analysis. At the end of 5 minutes the
subject is asked to stop.

9. Mental Rotations Test is given during the
collection of Probe data, as above. (Crawford, 1979)
10. Mental Rotations Test is continued during the collection of data for frequency analysis. At the end of 3 minutes the subject is asked to stop.

11. List learning during a probe stimulus. Subject is directed to use an Auditory Coding Strategy. See Appendix 24.

12. List learning during a probe stimulus. Subject is directed to use a Categorizing Strategy. See Appendix 24.


14. List learning during a probe stimulus. Subject is directed to make a story of the words. See Appendix 24.

(Lists used for each task were randomized. The order of the learning tasks was held constant)

15. Stroop - Subject is presented a visual display of the word RED, BLUE, or YELLOW. The word may be printed in the same or a different color. The subject is to press a counter with both thumbs when seeing the word - regardless of color of the print. Data are collected for BLUEs and non BLUEs separately. Accuracy is assured as above.

In all tasks in which frequency data were collected, the Brain Atlas was set to sample Four 2 second epochs of raw brain wave
from each of the 16 channels.

In all tasks in which averaged event related potential (ERP) data were collected data collection was for 1024 msec epochs at a rate of .7 collections/second. Artifact rejection was always on. For Probe tasks and the AEP Baseline the individual received 50 75 decibel 500Hz tones presented to both ears at .7 per second. Tones has a rise and fall time, and a plateau, of 10msecs each. For the AEP Detection task the individual was presented with a 1000Hz tone in the same manner as above, but presented at random with a .2 probability of occurrence every .7 sec. The task was to press a counter button with both thumbs whenever the tone was heard. Data was collected from 1024 second epochs for each .7 sec. Those epochs where there was no stimulus were stored and averaged in one bank, those where the tone occurred were stored in another. Both wave forms were stored on the floppy disk. For the AEP P300 Oddball task the conditions were the same as for the AEP Detection except that during the intervals when there had been no tone previously, the 500Hz tone sounded. The individual was to press the counter in the same manner as previously. It is important to note that the sequence of stimuli was not the same in the AEP Detection and AEP P300 Oddball task since the stimulus sequence was not preprogrammed, but the probability of the respective stimuli held constant for each .7 second epoch. For these two collections stimuli were presented until 30 of the stimuli to which the individual was to press the counter had been collected for averaging
The Stroop task consisted of color names (Yellow, Red, Blue) which are presented visually in a color which could be the same as the word or different. The individual was to press the counter whenever the word blue appeared, regardless of the color of any stimulus. The word blue appeared with a probability of .25 in a total stimulus presentation of 120 stimuli. Thus the color blue appeared 30 times. These stimuli were generated by software developed by Jim McCracken in the Brain Behavior Lab on an Apple IIE computer with 64K. The stimuli were presented to the subject with an Amdek Color 1 Monitor 30 inches from the subject at eye level. Each stimulus was centered on the screen, 3 inches high and varying from 4 to 8 inches long.

Data were collected into two banks - Blue and non-Blue - and stored to floppy disk. A fixation spot was affixed to the middle of the screen. The individual was instructed to look at the dot.

**Task Performance**

With all tasks where the counter was used the number the individual had on the counter was recorded and compared with the number of stimuli presented to confirm accuracy.

Performance data was collected from Draw-a-Person, Serial Subtraction, Written and Oral Report of Memorization, Phonetic and Non-Phonetic Spelling Lists, The Concealed Figures Test, The Mental Rotations Test, Reading Speed, Reading Test Accuracy, and All List Learning Activities.

During all activities individuals were asked to report on strategies they may have used, or any observations they might have about the process. Though these data were not used for systematic
analysis, they were extremely useful in forming qualitative judgments about the individual and assisting in the intervention.

The second neurocognitive assessment following the intervention consisted of the same protocol and methods as the first except that the Stroop data were collected only during the second session.

**Intervention**

After completion of the first neurocognitive assessment, the experimental group participated in a program of learning skills improvement. The program was divided into three parts: One, getting the individual familiar with learning, learning skills and options available in successful learning; two, utilizing the information from the neurocognitive assessment to assist the individual in coming to accept his abilities and have some sense of the strengths he possessed; three, exercises in practical application of the learning skills which seemed most promising to areas of school learning in which the individual was most eager to make progress. Throughout the intervention the guiding philosophy was to relate all activities to those areas and subject where the individual saw difficulties, but most wanted assistance.

The intervention consisted of, at least, 8 sessions of approximately 45 minutes each. At least four of these sessions were individual, four group. Howard et al. (1986) found, in a meta-analysis of dose-effect relationship in psychotherapy, that 8 sessions produce improvement - both from the individual's point of view and independent
assessment - in approximately 50% of individuals. To get over 70% required 26 sessions. The inflection point in the curve was at 8 sessions. The similarities between psychotherapy and learning skills improvement have never been directly examined; however, there is sufficient surface similarity to use this meta-analysis as guidance in the design of the intervention. There are reasons to believe that larger or smaller numbers of intervention sessions might be appropriate, depending on the goals of the intervention, the number of individuals with whom substantial improvement is sought, the degree of the improvement and the practical context in which the intervention is completed. For this intervention 8 sessions was adopted as an appropriate working minimal number for a short-term intervention - long enough to expect discernable positive results; short enough to expect relatively good compliance and perseverance, and fit within the available time in the school year.

Modern education is beset by many complexities which make a highly structured program with a group of students extremely problematic. Activities which are structured and sequenced have great difficulty when individuals miss sessions due to illness, family vacations, etc. Sessions need to be as flexible as possible to avoid the problems of teacher illness, intervening assemblies, holidays, etc. Furthermore 8th Grade boys asked to participate in a voluntary activity designed to assist them in learning may be inclined to be deflected from the path to the session on occasion. As a result it was decided that the intervention program should be designed to require as little necessary order or timing as possible and to be
independent of the number of individuals with whom one is working in a given session. Sessions had from one to six individuals present and occurred with as little as one day between sessions and as much as four weeks for some individuals.

It was initially assumed that each individual could be persuaded of the value of these activities and that no further incentive would be necessary. Once the members of the experimental group had quickly dispelled that assumption, each individual was offered $20.00 to complete the sessions and second neurocognitive assessment. All individuals completed the intervention, but not without numerous missed and rescheduled appointments. One individual was unwilling to participate in the final neurocognitive assessment regardless of incentives or inducements.

As indicated above the program of intervention was designed to be as flexible as possible. Thus there is no specific outline of activities or fixed order in which they must happen. While this creates difficulties in communicating the method to others or in teaching its use, it greatly enhances the ability to adapt the program to the schedule available and the individuals participating.

**Intervention Description**

The most important feature which unifies the intervention program is the continued focus on greater understanding of learning, how it works in self, how it can be used better in personal learning, how it can be improved through long-term self directed control, and direction toward practice in specific learning tasks the individual was currently completing.
Each session group or individual begins with a request for examples of personal learning situations that may be important. This might include current assignments, puzzling concerns, interesting observations, recent successes, personal goals or anything that may come up relevant to learning. Many sessions dealt with issues of attribution for personal success or failure. In all cases attempts were made to get the individuals to examine their personal patterns of learning. Any attempts to deflect responsibility to external causes or to stop consideration of the issue were turned back to the examination of the issues. All discussion was based on the assumption that there were answers or solutions to all issues and that they could be found by these individuals. Foreclosing or summary statements were omitted from this portion of each session. A modified socratic probing was used throughout.

This activity was carried throughout the intervention. Individuals were encouraged to bring in work that was particularly good or particularly puzzling. Discussion focused on their examination of the behaviors, the circumstances and possible directions to solve the problem. This portion of the program was designed to develop self-awareness in the context of immediate learning situations, and to produce a greater sense of personal responsibility for outcomes (internal locus of control). Group sessions were used to make the individuals aware that they were not alone and to see other's approaches, problems, strengths and solutions.

During the early sessions, each individual (in all but one case this was done in a group) received specific instruction in a
model of learning (see appendix 25), discussion of the skills commonly found in skilled learners (see appendices 26, 27), and a review of a synopsis of learning skills (see appendix 1). The attached appendices were the framework from which the work proceeded. The discussion always drew on examples of learning situations known to be important for the individuals - regardless whether these were school related or not. Several of the participants were quite interested in skateboarding - thus, examples from learning to skateboard (a skill not possessed by the undaunted experimenter) were frequently included and used to draw parallels with school learning.

Related to each of these sessions were "homework assignments." In the absence of any real control over the individual's performance, the assignments were given, but no attempt was made to collect results. In fact, rarely did any of the individuals actually complete specific assignments. They did, however, have seeds planted which tended to improve the quality of the discussion at the next meeting. For example, when discussing the model of learning, each individual was asked to pick one school and one non-school learning task they were interested in. They were then to consider which input system, representational format, transformations, outputs systems and executive processes they might want to use to be most effective. Such questions were generally over the heads and beyond the motivation of these individuals, but when guided through discussion of these issues in the subsequent meeting there was much evidence of developing comprehension (see appendix 28).
Coupled with these discussions were the introduction of specific suggestions of methods for improved learning and retention. The specifics suggested depended on the issues and the individual under discussion. It was assumed that during the entire course of the intervention program it would be possible to cover a wide range of specific learning strategies and options. The goal was not to make sure that all options had been discussed, but to provide the individual with potential enhancers while building confidence that they had personal control and could improve the quality of their learning.

Roughly in the middle of the intervention, and at the second brain assessment, the data from the initial assessment were discussed with the individual. In no case were specific diagnostics or prescriptions provided. Rather all data were viewed from the point of which types of strategies and tasks seemed to correspond to which sorts of performance and brain data. Where obvious patterns relevant to either Luria's model or to the specific research hypotheses appeared, they were identified and discussed. The presentation of the data was designed to:

1. Assure the individual that the brain was there and worked.
2. Try to suggest patterns of brain usage, suggestive of processing biases. These could be used to try to understand known weaknesses.
3. Try to suggest strengths and appropriate strategies for their utilization in problem areas.
All brain discussions were conducted in the spirit of co-experimenters. The individuals were made to feel that they were key participants in the interpretation of the brain maps. Each individual was given a brain map to take home.

The final 2 sessions contained some summary, review and the mutual development of strategies for continued action. In all cases the individuals were encouraged to continue self-monitoring and development through the experimenter’s modeling of self-questioning.

When the final assessment was completed a review of the observations and suggestions for each individual was prepared. A copy was sent to the individual, his parents, and where agreed to by them, to the school file. In addition, complete plans and materials for future learning skills interventions were given to the participating school.
Due to the exploratory nature of this project, data analysis is both simpler and vastly more complicated than in a traditional quantitative or qualitative research design. On the one hand there is an enormous amount of quantitative data available from the brain assessments and the performance tests; but the numbers of subjects are small enough to make any quantitative conclusions from them tentative. On the other hand, this research is not a more traditional qualitative study - e.g. multiple baseline case study, etc. Instead, what we have here is the potential for examining a wide variety of data from several individual and three group conditions to look for patterns that may be consistent with existing research and theory, or suggestive of research lines that warrant more systematic pursuit.

The collection of brain data in the manner discussed here, and with the tasks used, is sufficiently new that there is very little guidance to systematic interpretation. In fact, those methods previously used for such data interpretation have been largely antithetical to individual evaluation and use of the information in intervention. The attempt to look at these data in relation to a substantial number of performance measures has not been tried
previously. The relationship of that information to school performance adds further complexity.

The evaluation of the information with respect to possible consequences of learning skills intervention adds a level of subtlety to the data, especially in the short-term covered by this research. These factors may make analysis of the results somewhere between a projective test and problematic; however, it is from data far less comprehensive that we make educational judgments about individuals on a regular basis. If the research methods developed here are to be of educational value it will be necessary to take the available information about an individual (including performance data and brain assessments) and make productive decisions - whether we are the researchers, teachers, parents or students. Quantitative research confirming specific assertions awaits further research.

Case Studies

DD

DD is the second oldest of 7 children. His father is disabled and retired - future work possibilities are unclear. His mother is a homemaker. Poor performance in school led to assessment for learning disability in 1st grade. He was found to have a Superior IQ, but difficulty completing tasks and a poor self image. He was identified as learning disabled - unspecified - and provided with tutoring. At the end of 6th grade he was given a complete psychological assessment. Though there was some weak organization in his Bender-Gestalt and some uncompleted sentences on his projective
tests, he was found to have a WISC-full-scale IQ of 144. Everything else (except grades) was in the same league. At that point a decision was made to phase him out of LD tutoring. There has been no assistance or special programming for the last two years.

DD has always been relatively pleasant, independent and generally aloof. During some sessions he will decide that he has sat long enough. He gets up and wanders around, still attentive and responsive where it is appropriate. When he decides that it is time he will sit down again, drape himself across the table and we go on.

When appropriate subjects were first sought for this research the counselor immediately identified DD and said that "He's LD and would be good to study." He likes history, but strongly dislikes English - particularly the grammar and spelling. With more probing he indicated that his real weakness was in math. He had managed to do relatively well with it until recently, but they had begun pre-algebra activities with many steps and he hated it. His earlier identification as learning disabled had been based on his writing, spelling and grammar primarily.

He is an avid reader of adult books, especially horror books, fantasy adventure and history novels. He has an excellent sense of story structure and the flow of events. He follows and enjoys debates, easily keeping track of the flow of events and arguments so that he can later identify remote inconsistencies. He dislikes things which require discrete parsed steps in the processing - math, spelling, memorizing specific information, but likes the descriptive part of math and memorizing places which he locates in spatial context
for recall. He started taking Spanish, but dropped it because it was too hard. He said that he enjoyed the discussion of the culture and the flow of sound in the language, but had difficulty with the specifics of memorizing vocabulary and grammar. He plans to take French at the high school where his brother is one year ahead of him and can help.

Though he appears to be a very sensitive person and something of a loner, he has recently discovered sports and become actively involved in football and lacrosse. In marked contrast to TD, he has a superb sense of the flow of events in a game; however, he is not physically equipped or sufficiently developed in the basic skills of the game to play with any regularity. He is particularly fond of his relationship with his friends. He seems to like learning things from the individuals that he likes ad lib, rather than the physically or time structured learning more characteristic of school.

DD had relatively little insight into his learning strengths and weaknesses. He seemed to have adopted a strategy of putting the effort necessary in to those things where it worked and doing the same thing where things didn’t work - regardless of the outcome. His interest in self improvement was limited, though he knew that he could be doing much better. In many senses he was tolerating school - boring as it was, and educating himself with his own reading.

Despite having a slight strabismus (of which he is aware) he would like to be an airline pilot, but eventually would like to enter a career in politics. When this was pursued he indicated that he was fascinated with the complex ways in which things worked in government.
He thought things were a bit of a mess and would like to be where the action is—see what he could do. When asked how he felt about some of the more arduous features of political life—the long hours, meetings, travel, working with difficult people and problems, slow progress, etc., he thought about it awhile and said that was ok.

DD's performance data were revealing of a pattern of considerable ability mixed with limited effort. His scores on the pre-test were in the middle of the average range for the unsuccessful learners on all measures except reading speed and accuracy, free recall, and locus of control totals, where they were well above average, and spelling—especially non-phonetic—where he was well below average. His School Locus of Control scores were initially 6 internal and 6 external. Post-test were minimal except in a shift for the School Locus of Control to 9 internal and 3 external, and an increase in his rating of attentiveness from 3 to 5. His behavior at the post-test brain assessment had changed from a very passive compliance with the demands of the task to an active curiosity with the process and the significance of the results.

Brain assessment data for DD showed relative high levels of alpha waves which decreased appreciably from pre- to post-test. Probe amplitudes and latencies were most characteristic of the pattern of the successful learners—indicating a relatively good ability to "tune out" the irrelevent stimuli. The distribution of activity in the detection, AEP P300 and Stroop indicated rather diffuse waveforms with some displacement to the left and a substantial pattern of frontal potentials—characteristic of many of these less successful
learners, but less evident in the more successful learners.

DD appears to be an individual with some limitations in concrete analytic sequencing activities. However, he shows considerable facility in compensating for these limitations by the use of strategies which rely on his facility with more dynamic flows of events. His relative lack of success appears to be primarily due to a lack of effort, largely dependent on his difficulty in finding value in the school activities. His grades are in the C+ range or higher most terms. They could clearly be improved with additional challenging activities, but show no signs of putting him seriously at risk.
Figure 1 – DD Eyes Open Alpha Waves. Relatively high levels of Alpha are seen in central right and left hemispheres, but not at the midline.
Fig. 2 - DD Alpha Waves During Reading. Notice the higher levels of alpha in the left hemisphere, suggesting that DD is using relatively more right hemispheric processing during reading.
TD

TD is a very large, physically mature individual. He leans toward being overweight, but has recently gotten involved in football, wrestling and lacrosse. Though his ability is not as great as the promise of his size, he has become quite dedicated to these pursuits and shown considerable improvement -- both in ability and attitude.

TD's natural father died of a heart attack at age 23 when TD was two. His mother remarried when he was four. He only recalls his step-father and has a very close relationship with him. Mother is an employment counselor. Step-father is a loan officer at a bank.

His school history is full of references to his exceptional ability combined with his very poor achievement. His most recent achievement tests show scores consistently over the 90 percentile -- expect where there is need for precision and control -- mechanics of writing, math computation, English expression. He is frequently given reports showing concern for absence of attentiveness, impulsiveness and tendency to daydream. He is generally very verbal, tending to dominate group activities. He is also strongly inclined to react to a concept in the discussion and report a personal anecdote or examples which lead to the conclusion that much of the rest of the world is stupid or unfair.

Teachers and his counselor confirm that he has developed a very manipulative style. He is quite positive and responsive, but engages in verbal tactics which divert discussion from what he has done and why, to irrelevant features of the situation.
In watching his participation in sports he displays a style which seems delayed by thought about what he should do next. This gives the impression that he is always a little behind the action. Once he decides what he is going to do he goes ahead and does it, even if it is no longer appropriate. His conversation is largely facts and argument by anecdote. Rarely does he string together more than a sentence which flows from one thought smoothly to another. When asked what he would like to learn better, he said that he wanted to be able to learn plays in sports. For example, when one play is called in football and then they change the play later, he gets confused and often does the wrong thing.

He reports that he reads quite frequently. He most likes science fiction and fictionalized history. When asked if he liked history he reported that he didn’t like it because there were too many facts. In class he likes things where you do something—debates or labs—rather than lectures or films.

TC likes doing things that are mechanical. He feels that he would like to be some sort of scientist or do research; however, when pushed he didn’t think that he would like to be a real researcher, but rather someone who works in a lab where some sort of research takes place.

He presents a somewhat ironic front. At the same time that he appears very attentive and motivated to try to learn and learn better, he uses every opportunity for any personal change or growth to verbally deflect the responsibility to some external source. Extended discussions with him generally result in the feeling that, even though
there has been highly informed and questioning dialogue, there has been very little comprehension by TD of the concepts - only an accumulation of facts and reactions to them. This occurs at the same time that there appears an intense questioning interest in issues that deal with these very concepts.

In one discussion of the relationship of "psychology" and brain, he kept coming back to the issue and wanting to know more of the evidence that I could offer to support my position. When the discussion was over he seemed facile in the verbage but completely baffled by the concepts of our discussion.

TD shows all the signs of an individual who has a very concrete verbal and narrow focus. He does best in science and math - worst in english, history and language. He switches from one issue or position very poorly - though his ability to pursue a position is extremely good.

His scores on the measures of locus of control were the lowest for internal of anyone tested. This is nicely confirmed by his discussion of his learning and school behavior. At no time would he ever concede that any feature of his performance was the result of his actions. He always attributed all learning consequences to external sources - primarily teachers. No amount of attempt to get him to look at what he did showed any immediate change in this pattern. Whenever the discussion got perilously close to his being trapped and having to admit personal responsibility, he would loudly proclaim an anecdote which redirected the discussion.
Despite this TD shows considerable interest in improving his understanding of the working of the brain, especially his own.

None of the performance data showed any particular pattern of strengths or weaknesses, or differences from the group of the unsuccessful learners. On the Post-Test virtually all scores were slightly improved. The only one of note was the shift from a 4 internal score on the School Locus of Control to a 7.

TD's brain data were strongly supportive of other evidences. He had very low levels of Alpha waves. His probe peaks were very large, suggesting an relative inability to tune out the irrelevant stimuli. In fact, he complained about the difficulty of concentrating on tasks while the tones were sounding in his ears. Detection, AEP P300 and Stroop all showed a strong pattern of very large amplitude peaks for the early components and relatively very small P3 peaks. This appears quite consistent with his tendency to be extremely attentive to events in his environment, but to engage in relatively little contextual interpretation of those events. Additionally, there appeared to be very broad separations of right and left hemisphere activity and considerable diffusion of activity in these tasks to the frontal areas.

TD would clearly benefit from instruction which forced him to engage in elaborative processing and interpretation of the factual content. He was very responsive to suggestions that he work on rehearsing sequences of actions to try to produce a "flow" of action - both in sports and classroom learning. We worked on activities which forced him to change strategy, focus quickly from one task to another
or integrate several pieces of information. He does this with considerable difficulty, but felt that there was a "good feeling" that came from being able to make the quick changes with comfort. He showed considerable interest in the information from the brain assessment—not wanting to leave at the end of the post-test assessment. Twice since the completion of the project he has seen the experimenter and asked when he can get all the results of the testing. He appears to have become much more open to information about himself and eager to begin trying to use it.
Figure 3 - TD Detection ERP for CZ - Notice the large N1 and P2 and the absence of any P3.
Figure 4 - TD Oddball ERP for the Target Stimulus for PZ. Notice the double N1 and the five peaks that make up the P2 and P3 Complex. This is a good example of a "non-coherent ERP."
OI was very reluctant to participate in this program. Only after lengthy discussions with his mother was he willing to attempt it. He has been tested and tested from the very beginning of his schooling to try to find out why he isn’t doing well. Though he was by far the most personable and cheerful of the individuals with whom I worked, he has been continually frustrated by attempts to find out what is wrong and do something about it.

He scored the highest in the entire city on a kindergarten reading readiness test. Yet his reading performance has always been very poor and very labored. He has had a full and oft repeated battery of medical and psychological assessments. The results suggest that he has a sluggish focus response of the eye, somewhat poor visual memory and visual sequencing problems. His third grade WISC Full Scale IQ score was 128. His grades remain very poor, even though he works well over twice the average study time of the other individuals each night. After the period of extensive assessment he became somewhat withdrawn – trying to be inconspicuous and slip through as easily as possible. His grades have continued to be borderline – requiring attendance at summer school to avoid retention. He received special Learning Disability tutoring for three years, but the parents were doubtful it was helping and had it discontinued. He seems pleased that he is allowed to work on his own with everyone else.

His parents have recently divorced. He lives with his mother, with whom he has a very good relationship. He relatively rarely sees his father and seems quite unconcerned about that. His
father is a dentist, his mother owns and operates a weight reduction business.

He, despite his assessed visual difficulties, is quite a good artist and aspires to be a photographer. He is right-handed, but writes in the inverted position. One sibling and the mother are left-handed. His greatest current love is skateboarding - at which he is extremely good.

Recently his mother has been very active in working with him and the school to provide more structured learning. He is given extra time to ask questions of the teachers and receive some tutorials from them. The mother comes to the school and supervises structured study times. Structured and supervised study times are provided at home. While OI doesn't act enthusiastic about all this, it is done very supportively and he seems pleased that he is improving his understanding and performance. All of this is at the mother's initiative - none is through any identification, or development of an Individual Education Program.

He reports that the most difficult subject is English, but this is because he is very poor at spelling, and remembering and utilizing the parts of speech. He most likes math, and does consistently best in it. He shows a definite flair for the people side of school. He is very sensitive and considerate of teachers and peers. He most enjoys the biographical side of classes - especially artists.

Through all the activities he has been the most seriously interested in understanding what is going on in his head and trying to
get on to what to do about it. He fairly actively tries to control others in the group who are uninterested or distracting. He asks questions that are pertinent and very thoughtfully considers the answers. Of all the individuals in the group he has the greatest sense of his own cognitive processes and the most willingness to try to understand processes and what to try.

When the brain mapping was done initially, OI’s mother asked if she could come along and be mapped too. After addressing the preliminary quality of this research and the tentativeness of any possible conclusions, she felt strongly that if there was any possibility that OI seeing her brain might help him, she wanted to do it. She indicated that she felt that many of the difficulties that she had in her own schooling were very similar to those that OI was having. She felt that she had been quite successful since and that anything she could do to help OI keep his positive self-image was to the good.

OI’s performance data is consistently below average, particularly Reading Speed, Accuracy, Spelling and Subtraction. Though he exhibits a generally hopeful attitude, he often expresses doubts that he has any real control over his school performance. The only notable performance change from Pre- to Post-Test was a doubling of the accuracy ratio on the Concealed Figures Test.

Brain assessment data for OI were both fascinating and confusing. His Alpha levels were generally quite low. His probe peak values were relative small and not particularly variable. In the Detection, AEP P300 and Stroop tasks, though his performance was
perfect, the usual waveforms were almost indiscernable. The usually focal N1, P2 and P3 peaks were so spatially diffuse and "incoherent" that it was difficult to decide where the peaks were, both spatially and temporally. There was a clear distribution shift to the left for the P300 peaks and a dramatically greater frontal involvement in the P3 peaks than is normally the case.

OI was diffident, but compliant, at his first assessment. At the second he was the same until near the end when he began wanting to see the maps and have me tell him what they showed. He was particularly interested in the relatively diffuse distribution of waveforms and the greater involvement of the frontal lobes in the processing. He felt that he was working very hard to try to figure out ways to use the strengths that he felt he had, but was often frustrated by the lack of measurable results. He wanted to stay for well more than the originally allotted time at the end of the session to talk about the maps and their meaning.

OI was the only individual to show very strong improvement in his grades from the first two grading periods to the third. It is likely that this was due primarily to a strong involvement of his mother in the school and organizing his study and review times.

Great strengths appears in OI's sense of the dynamic and conceptual. He is very weak in sequential processes and the mechanics of language and math. It is interesting to note the strong similarities of this pattern to that of his mother. Her strategy with OI is to try to keep his positive attitude through the trials of school and help him develop personal insights and work habits that
will allow him to utilize his strengths in the post-school environment. No other recommendation would seem more appropriate.

Figure 5 - OI Oddball ERP Pre-Test for PZ
Figure 6 - OI Oddball ERP Post-Test for PZ. Notice the greater amplitude and somewhat greater "coherence" in the post-test waveform.
Of all the individuals worked with BO had the attitude and demeanor of the most beaten down. He showed very little enthusiasm for anything and very little hostility or anger either. He is the last child of a very high achieving family - 6 years after the last previous child. His father is a physician who no longer practices, but is the president of an alcoholism rehabilitation center. The mother is a co-founder of the rehabilitation center and works there as a counselor.

BO had recently begun playing the guitar and was very enthusiastic about music, guitar and his practice. He spent most of his time in his room practicing the guitar. He had found that since he had a tendon in the fourth finger of his left hand cut when he was younger, he couldn’t do the fingering well. During an inventions unit in school he designed a splint for the finger which would hold it in position for fingering various cords. He was pleased that it worked and eager to continue the guitar. By six weeks later he had gotten frustrated with the effort required to play well, even with the splint and quit playing - this in someone who couldn’t think of anything that he wanted to do for a job other than, maybe, be a musician.

BO was first tested in 2nd grade. He was seen as slow and inattentive. He never finished his work. He was felt by his teachers to be very capable, but something was wrong. He was found to have a WISC Full Scale IQ of 110, 127 if a distractability factor correction is made. With one administration of the test verbal was substantially higher than performance. With another it was equally extreme the
other way. Despite a lengthy cataloguing of strengths and weaknesses, he was qualified for LD assistance based on his math achievement test performance - math has tended to be his strongest subject, both in performance and by his own assessment.

LD tutoring continued for a year - 4th grade - at which time he was found to be working up to his level. All support services were stopped. From 1st grade on he has been threatened with retention. He has managed to escape retention only through attendance at summer school since 4th grade. He was retained in 7th grade. There has been no improvement in his grades. He fully expects to flunk everything in 8th grade and be retained again - barring a stellar performance in summer school. At the same time that this seems to bother him, he shows no signs of desire to do anything about it.

He has a history of about 10-15 absences a year for a variety of miscellaneous ailments. He has the appearance and manner of a very allergic individual and did admit to hayfever, but brushed it off as unimportant.

He feels that he has poor listening skills. That he is easily distracted and thus misses important parts of assignments. He can't get motivated to work, procrastinates, forgets to do things or turn them in and gets failing grades. He feels that the most important thing for him to learn is to concentrate better and be better motivated. His parents, he feels, just want him to be successful. He feels that he is able to learn very well, but only in spurts. He can't seem to continue the type of effort that it takes to be able to perform at the level of success that he feels appropriate.
Often during conversations he would say things like, "I just need to make more effort to learn." And then, a few minutes later he might say that he is just a poor learner and doesn’t care.

Conversations with the parents were indicative of considerable concern and bafflement with the inability to generate any sustained effort and success. They had a family full of children who had been very successful by only telling themselves to try hard. With BO trying hard seems a considerable effort and only produces success in small spurts. His feeling of ability to work at a level that will result in the desired level of performance is so slight that he is inclined to give up.

Even though he knows that he can do better, the highest grade he has gotten in any major subject during the entire school year is a D+, and that is the only non-failing grade.

In looking at his school file it was found that he had wanted to be taken out of the "informal" program at the school he was in and returned to the "contemporary" program at the school in whose district his family lived for the four years he had been in the "informal" program. His parents felt that it would be best for him to have a less structured program that could try to build on his strengths and improve his self-concept. At almost every opportunity he would mention how much he hated the "informal" program that he had been a part of for four years.

At times he would show considerable interest in finding out what made him work and try to put it to good use. But, like his other work, this came in small spurts separated by rather large periods of
drifting. Virtually never did he show any active interest in trying to pursue or figure out anything. If he didn't get any grasp of the matter immediately in unprocessed form he would let it go entirely. Despite this he had a strong feeling of internal control, but only if he wanted to bother. He knew he could control things, but had retreated to the safety of not testing the truth of that conviction.

Initially BO was the most reliable of the individuals in appearing for intervention activities. Toward the end he kept "forgetting" about meetings or scheduled appointments - even where he had said that he wanted to meet and had picked the time. When time came for the final brain assessment he missed 3 appointments. After the third time, when a fourth attempt to schedule was made, he announced that he didn't want to have the final brain assessment. He would give no reason other than that he had lost interest - "some things are just not worth it." No attempt to convince him, offer any special opportunities, privileges or money would change his mind - even with one additional attempt.

BO's performance and brain data were notable only in the relatively low levels of everything. While Alpha levels were low, probe amplitudes were as well. Detection and AEP P300 amplitudes were relatively low for all components. Waveforms showed some tendency toward hemispheric independence and very little significant frontal components.

BO, though his father is a physician who expressed great concern about his condition, appears the least "engaged" individual of the group. He walks, talks and responds lethargically. He has no
special goals or directions, and only in spurts exhibits any particular desire to change that. It would be appropriate for him to have instruction in a smaller group where he can be challenged directly to become involved in learning activities and their consequences. Until he can be engaged in learning activities it will be very difficult to produce any significant change in his learning knowledge, controls or performance.
Figure 7 - BO Oddball ERP P300. Notice the asymmetry of the peak.
Figure 8 - BO Oddball ERP - Frequent (Non-Target) Stimulus P300.
Notice the symmetry and the relatively small difference in amplitude between the target and nontarget stimuli.
WM was the least willing individual in the study. At our first meeting he slouched in his chair with a permanent expression of disgust. His only question was, "How come I got picked?" When told that he had been picked as someone who was felt capable of doing much better in school than he was, he scowled and resumed his slouch. At the end of the first session he agreed to continue, but said it was only because a friend KU was also going to be in the study.

WM's father was a severely disturbed Viet Nam veteran who had been in and out of the VA hospital for most of the period since he left the military. He had left the mother when WM was 6, never to be heard from again. The mother is a successful computer programmer who appears to have formed a strong relationship with WM. At age 4 his father forced him to change from writing with his left hand to his right hand. He has used his right hand for everything since. His left eye is dominant.

He indicated that the only things that he liked much were skateboarding, sports and working with his mother's computer. His main irritation with the meetings with me was that they would occur during the only period of the day when he could go to the computer room at school. He planned to become an architect, but showed no concern that he would need to do well in school or learn math in order to attain that goal.

His relationship with his peers was generally hostile. His one fairly close friend KU was an easy target for abuse. WM tended to relate to males exclusively with scarastic comments and physical
force. He was often a conspiratorial leader, but his scowling
demeanor seemed to attract few followers.

WM’s school record was poor and getting worse. Despite his
assertion that he could average better than B, his average had been
consistently well below C, with only his math grades tending to
average better.

He indicated that he never reads, except skateboard
magazines, and that is mostly looking at the pictures. He learns best
from doing things or visual presentation. He hates trying to learn
auditorily, especially facts out of a meaningful context. His ability
to identify personal strengths and weaknesses in learning was poor –
only leading questions elicited any usable insights.

Though his sense of internal control was relatively high (33)
he attributed school outcomes primarily to easiness of the task or
personal effort. When you talked to him you came away with the
impression that he felt he could do most anything (easy to attribute
to bravado), but with continuing exposure to him it became easy to
believe that he could, if he would make the effort.

For example, during the neurocognitive assessment the
experimenter had to be away from the lab for about 20 minutes. WM and
KU remained there, indicating that they wanted to play video games.
Upon the experimenter’s return KU was contentedly killing aliens. WM
announced, with a visible sense of pride, that he had figured out all
the function keys and display modes for the Brain Atlas, and proceeded
to show that he indeed had. It should be noted that the experimenter
spent a good part of 6 months working on figuring how to operate the
various function keys for the Brain Atlas. WM has largely mastered them on his own, with no prior knowledge of the goals of the activity, in approximately 20 minutes.

WM was the most difficult individual to get to participate in continuing intervention activities. He would miss appointments with regularity. He would insist on changing the topic, saying how stupid everything and everyone was, and generally being as negative as possible. It took continuing effort and regular bribes to get any level of participation.

Performance data were consistently above average for his group. Most interesting were the 3 increase in Concealed Figures Test results from pre to post-test, and the increase in his rating of himself as a learner from 4 to 6.

During all assessments WM got very serious and appeared to work very hard at the task at hand. The first session he said he did that just to get it over. During the second he began, about half-way through, wanting to see his maps and have me talk about them. He kept wanting to see more and talk about how they were done and what they mean, rather than going on. When we went on he continued seriously. At the end of the session he wanted to talk about his learning and his maps. His manner had gotten much softer and more open over the course of the intervention and assessments.

WM's brain data were the most like those of the successful learners of the entire group. There was some evidence of hemispheric independence in Alpha waves and ERP data, but amplitudes, latencies and distributions were quite typical of the successful learner.
averages. WM appeared to be the one individual in the intervention group for whom the primary issue in his learning success was his willingness to make a positive effort.

At the last group meeting he expressed a genuine concern to begin passing his subjects so that he could go to the high school. While the results are yet to be seen, he showed much increased willingness to examine his own behavior and make some attempt to put his considerable strengths to positive use.
Figure 9 - WM Oddball ERP. Notice the split peak, relatively low amplitude and 320msec latency.
INTERVAL: 8.00 to 12.00 Hz
Unsigned average area under curve.

Figure 10 - WM Alpha Reading. Notice predominantly right hemisphere and posterior distribution.
KU

KU is a pleasant, relatively passive individual who has the capacity for seeming to be working on doing something else while he is doing most anything. Our first meeting was generally cordial, though he had relatively little enthusiasm for being involved in the project. He felt that was he able to learn relatively well, but didn’t have any interest in doing it. When asked what he thought he might like to do for a job he said it didn’t matter, then added that probably something in sales. When pressed he indicated that he liked skateboarding and bicycles and might like to run a store where he sells and repairs these items. Or, he might like to sell cars. He thinks he works well with people, but he enjoys the idea of selling or repairing the items — though he doesn’t do any repairing of those things that he has now.

His parents are both employed, mother is a rehabilitation counselor and father is the vice-president of a construction company. He enjoys a life of considerable leisure and substantial affluence. He enjoys computers, but only for playing games. He likes watching movies on his VCR. He indicated that he didn’t like to read, did it little and was a very slow reader. When he read it was mostly car, bike or skateboard magazines, though he read an occasional mystery.

His insights into his own learning and behavior were virtually non-existent. He showed very little interest in making any attempt to figure it out. When asked what he did if he didn’t understand something that he was supposed to do, he immediately indicated that he would ask someone else, rather than attempt to figure it out himself. With some probing, he indicated that he liked
very structured work and testing. Written tests were tolerable if they only asked for a main idea. He prefers projects where he can actually work with something or discussions where he can participate rather than any type of learning activity which is passive — lecture, filmstrips, movies. It is worth noting that while he said he liked movies and watched many (he showed on several occasions that he knew what he had seen and what it meant), he very much disliked the didactic movies that were fairly common occurrence in his classes. He said that they were just a bunch of facts — no action.

His grades have been very poor on a continuing basis and have remained unchanged. His average in major subjects is below D. He has had to go to summer school on a regular basis to avoid retention. He was retained after 7th grade, after threats of retention from the beginning of his education. He indicated that he felt he could receive grades of about B average if he tried; but, he wasn’t interested because school was too boring. In the third grade he was put in an adaptive physical education program to try to help him integrate activity of the right and left sides of his body. This lasted for one year only.

His relationship with his classmates appeared to be relatively outgoing but superficial. He tried to appear a "with-it" person, but seemed more reactive than active. A great deal of what he did seemed to be following WM.

His locus of control score (28) was relatively low, yet he scored high on internal locus of control for school activity. He had a perfect split on the Edinburgh Handedness Inventory, writing left
handed, having left eye dominance and ear dominance, but doing the majority of other items with the right hand. The pattern was idiosyncratic - not simple fine motor/gross motor split.

Early testing had indicated that he had reading difficulty, but there was no evidence of a basis for the problem and it was attributed to poor motivation. He had somewhat poor auditory discrimination (18 errors on the Wepman Test of Auditory Discrimination), but the tester suspected that this was due to poor attention. All other measures were normal. He has very poor handwriting. When this was seen early he was given a course of prescribed physical education, based on the presumption of a perceptual/motor problem. Without evidence of change in performance, this was discontinued after a little over a year.

In the neurocognitive assessment he was the least able to keep on task of any of the subjects and was the most irritated by any discomforts. As time went on he became more and more distressed and less cooperative, while refusing offers to take a break. When the session was over he assumed a boastful demeanor, as though he had valiantly conquered a herculean labor.

His performance scores tended to be above average except where he has obviously disinterested or where he tried to show his prowess by going very fast and making very large numbers of errors. He seems determined to impress others with his ability. His mother came to the last brain assessment. When she arrived he proceeded to tell her how well he did on various tasks, how well he could read, how rapidly he had done an assignment at school. Mother asserted that she
had been just like him in her youth, but had later learned how to use her strengths, graduating summa cum laude from college. She told him repeatedly that he just needed to keep believing in himself and working hard and things would eventually work out. She told me several times what a great self-image he had. He looked at his shoes through this.

KU's brain data showed relatively very large Alpha waves across tasks. He frequently showed total hemispheric separation of the distribution of the alpha. With probes, his amplitudes were very large and the waves very diffuse. He seemed to have considerable difficulty blocking out the tones and focusing on the task. On the Detection, AEP P300 and Stroop he had diffuse distribution of the wave forms, relatively very large N1 and P2 peaks and a relatively very small difference in P3 between relevant and irrelevant stimuli. He seems to have considerable difficulty discriminating between the relevant and the irrelevant in school work, performance and brain data. He also showed relatively very large frontal lobe potentials and late latencies in all three of these tasks—primarily at the second assessment. This would appear to suggest that he is beginning to try to utilize "strategies" to assist him in making the discriminations and integrations that are normally difficulty for him.

The problem of grades and retention has focused his attention on serious attempts to come to an understanding of his learning and how to utilize it productively in school. The change in his attitude toward the project and the brain data was most apparent in KU. Initially he had shown irritation and disinterest. At the end of the
second assessment we had an extremely mature discussion about his strengths and how they could be better utilized - totally initiated and sustained by his questions and comments.

Figure 11 – KU Oddball ERP P300. Notice hemispheric split and short latency.
Figure 12 - KU Alpha Reading. Notice the relatively posterior distribution and lack of lateralization.
General Observations on Case Studies

One of the basic assumptions of this research model is that individual's, when confronted with intelligible pictures of the actions of their own brains, will be moved to a state of reduced self-alienation. This self-alienation is a deterrent to full utilization of learning capacity. Thus, the utilization of brain mapping as a part of a learning skills intervention will greatly enhance the overall long-term effect. Due to the relatively short-term nature of this research and the difficulty of identifying and assessing self-alienation in relation to individual learning, this research leaves direct investigation of those phenomena to future investigations. However, the experimenter's role as "participant observer" in this project allowed ample opportunity for a semi-formal ethnographic assessment of this issue.

The individual descriptions given above include many of the pertinent observations for individuals in the group; but, when the whole group is considered together the impact is much stronger. All of the individuals began the program with very depressed affect ranging from rigid attentiveness to inert unresponsiveness to a guerrilla warfare of social hostility. When each of the individuals first saw pictures of their brains they were guardedly interested to cautiously curious. During the individual sessions where brain activity was discussed directly the interest and active interpretation of the discussion was clearly the greatest of any of the sessions. At the beginning of the final session, all of the participants wanted to look at the ink writer, delighting in doing things that made it
change. All of them wanted to look at the maps of their brain activity at least once (most of them every time) between tasks. All of them wanted to look at at least one of the ERPs as the activity changed with time. And, most importantly, all of them asked questions about what specific things meant in relation to their learning.

The most striking contrast was between individual conduct during and after the first neurocognitive assessment and their conduct after the final neurocognitive assessment. The first sessions took about two and one half hours per person - beginning to end. The second sessions took better than 3 and one half hours per person - even though the actual data collection was much more smooth. At the end of the second session each individual was driven home - 20 minutes to 30 minutes per person. Although there was some variation in the animation of the discussion, all individuals wanted to discuss their brain maps and their learning. All were clearly open to better understanding of their own learning and acceptance of their responsibility to participate in its utilization. All actively inquired about what the maps showed, what it meant and the types of things that they could do about it. There could be no question that they wanted to know about themselves and work toward some self-improvement. The two individual's who had previously been identified as learning disabled were both very encouraged to discover that there were ways that they could learn. Neither was pleased to accept that they might have to do something that successful learners didn't. Neither was pleased to learn that learning how best to utilize their strengths might be a long and challenging process. Each
clearly had a very different sense of the possibility of the task from their initial assessment.

One could not help but get a strong feeling that all these individuals had utilized the "authority" of the brain maps to move them to a position of responsible acceptance of their active role in the determination of their personal success. The hostile world outside and the unquestioned world inside were on the way to a constructive interaction. Interestingly, this dramatic change in personal conduct was accompanied, as we shall see below, by very little change in scores on locus of control measures.

Hypotheses

1. Successful Learners will show greater "Activation."

FFT data were taken for unsigned averages of the frequencies from 8 - 12 Hz (Alpha) from all 16 electrodes for all eyes open tasks. Means and Standard Deviations were computed for unsuccessful learners for the pre-test and the post-test, and for the successful learners.

ERP peak values were computed for all probe tasks and for all task relevant stimulations. For probe tasks the values of N1 and P2 were identified, the peak to peak differences obtained and those subtracted from the baseline AEP N1 and P2 peak to peak difference values. For Stroop, the Auditory Detection task and the AEP P300 (High-Low Tones) task, peak values were obtained for N1, P2, and P3 and averaged. For all ERP peak value assessments, the record was first "baseline corrected" by averaging all 256 data points in the record and setting that average value equal to 0. Tables 1, 2, and 3
present these results.

Table 1 - Alpha Amplitudes For All Eyes Open Tasks

<table>
<thead>
<tr>
<th></th>
<th>Pre-Test N=6</th>
<th>Post-Test N=5</th>
<th>Successful Learners N=6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>Mean 3.0uV</td>
<td>Mean 1.81uV</td>
<td>Mean 1.81uV</td>
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<tr>
<td></td>
<td>Std Dev. 2.59uV</td>
<td>Std Dev. .45uV</td>
<td>Std Dev. .47uV</td>
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Table 2 - Probe Amplitudes - N1 To P2 Peak To Peak Differences. Baseline Eyes Open, Averaged Values For All Cognitive Tasks And Differences Between The Two.

<table>
<thead>
<tr>
<th></th>
<th>Baseline Pre-Test N=6</th>
<th>Task Post-Test N=5</th>
<th>Difference</th>
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</thead>
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<tr>
<td>Unsuccessful Learners</td>
<td>Mean 10.61uV</td>
<td>Mean 12.30uV</td>
<td>-1.69uV</td>
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<tr>
<td></td>
<td>Std Dev. .52uV</td>
<td>Std Dev. 1.42uV</td>
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<tr>
<td>Post-Test N=5</td>
<td>Mean 12.68uV</td>
<td>Mean 13.02uV</td>
<td>0.34uV</td>
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<td></td>
<td>Std Dev. 4.68uV</td>
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<tr>
<td>Successful Learners N=6</td>
<td>Mean 9.57uV</td>
<td>Mean 11.74uV</td>
<td>-2.17uV</td>
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<tr>
<td></td>
<td>Std Dev. 1.56uV</td>
<td>Std Dev. 1.62uV</td>
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</tbody>
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Table 3 - ERP Peak Values - AEP Detection, AEP P300, Stroop - N1, P2, And P3 Values Averaged

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
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<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>Pre-Test N=6</td>
<td>10.71uV</td>
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<td></td>
<td>Post-Test N=5</td>
<td>8.46uV</td>
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<tr>
<td>Successful Learners N=6</td>
<td>Mean</td>
<td>9.26uV</td>
</tr>
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</table>
Figure 13 - Less Successful Learners Stroop P300
Figure 14 – Successful Learners Stroop P300. Notice greater amplitude and longer latency.
The FFT data not only supports the hypothesis, but shows a change of the unsuccessful learners, over the course of the intervention, toward the level of the successful learners.

The Probe data strongly suggests that the standard dogma about the probe (i.e. greater involvement in a cognitive task leaves less resources available for response to the irrelevant stimulus) is in error. In all cases the averaged ERP to the probe is larger than to the stimulus in the baseline condition. If one assumes that the engagement in cognitive tasks is primarily drawing on the pool of inhibitory neural activity, the results are supportive of the position in the hypothesis - greater change from baseline by the successful learners.

Peak values of ERP are also, apparently not supportive of the hypothesis; however, if task relevant waveform (e.g. p300 are looked at separately from the other peaks) the predicted difference appears. This will be discussed in connection with hypothesis 8.

2. Successful Learners will show greater Internal Control - more so for the school related measure.
Table 4 - Children’s Locus Of Control Scores

<table>
<thead>
<tr>
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<th>Mean</th>
<th>Std Dev.</th>
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<tr>
<td>Unsuccessful Learners</td>
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<tr>
<td>Pre-Test N=6</td>
<td>30.50</td>
<td>3.51</td>
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<tr>
<td>Unsuccessful Learners</td>
<td>31.00</td>
<td>3.67</td>
</tr>
<tr>
<td>Post-Test N=5</td>
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<tr>
<td>Successful Learners</td>
<td>30.33</td>
<td>6.47</td>
</tr>
<tr>
<td>N=6</td>
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Table 5 - School Locus Of Control Scores

<table>
<thead>
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<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
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<td>Unsuccessful Learners</td>
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<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucky</td>
<td>3.83</td>
<td>2.13</td>
</tr>
<tr>
<td>Total External</td>
<td>Mean 6.0</td>
<td>Std Dev. 1.67</td>
</tr>
<tr>
<td>Clever</td>
<td>Mean 2.83</td>
<td>Std Dev. 1.72</td>
</tr>
<tr>
<td>Tried Hard</td>
<td>Mean 3.17</td>
<td>Std Dev. 1.17</td>
</tr>
<tr>
<td>Total Internal</td>
<td>Mean 6.0</td>
<td>Std Dev. 1.67</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucky</td>
<td>3.60</td>
<td>2.14</td>
</tr>
<tr>
<td>Total External</td>
<td>Mean 4.60</td>
<td>Std Dev. 1.67</td>
</tr>
<tr>
<td>Clever</td>
<td>Mean 2.80</td>
<td>Std Dev. .54</td>
</tr>
<tr>
<td>Tried Hard</td>
<td>Mean 4.60</td>
<td>Std Dev. 1.14</td>
</tr>
<tr>
<td>Total Internal</td>
<td>Mean 7.40</td>
<td>Std Dev. 1.67</td>
</tr>
<tr>
<td>Successful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucky</td>
<td>4.17</td>
<td>.98</td>
</tr>
<tr>
<td>Total External</td>
<td>Mean 5.34</td>
<td>Std Dev. 1.03</td>
</tr>
<tr>
<td>Clever</td>
<td>Mean 3.67</td>
<td>Std Dev. 1.37</td>
</tr>
<tr>
<td>Tried Hard</td>
<td>Mean 3.50</td>
<td>Std Dev. 1.05</td>
</tr>
<tr>
<td>Total Internal</td>
<td>Mean 6.67</td>
<td>Std Dev. 1.03</td>
</tr>
</tbody>
</table>
The Children's Locus of Control Scale shows no differences between the successful and unsuccessful learners or from pre to post-test in the unsuccessful learners. In conversations with those taking the test it was clear that they had some significant conflicts between what they thought appropriate to put down on the test and what they felt control over in their lives. Two of the most strongly independent and self confident of the successful learners had the lowest scores on this scale. Both also have very controlling mothers who have created a "success-or-else" feeling in these individuals.

The School Locus of Control Scale shows a difference, between the groups as predicted, but also shows a relatively strong shift from pre to post-test in the unsuccessful learner group. This difference is more revealing when results are separated for the portion of the test dealing with something where the individual has received a good grade and something on which they have received a poor grade. As can be seen in Table 6, the major changes occurring with the intervention is a decrease in the tendency to attribute poor performance externally. This is primarily due to the Lucky attribution which drops from 1.67 to .6 for those assignments where the poor learners have received poor grades.

Table 6 - School Locus Of Control - Good Grade Attribution vs. Poor Grade Attribution (Means Only)

<table>
<thead>
<tr>
<th></th>
<th>Good Grade - Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>3.67</td>
<td>2.17</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>3.60</td>
<td>2.40</td>
</tr>
<tr>
<td>Successful Learners N=6</td>
<td>4.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>


3. Successful Learners will score better on the Concealed Figures Test.

Concealed Figures Tests were scored for speed (number completed) and accuracy (ratio of correct to incorrect responses).

Table 7 - Concealed Figures Test Scores - Speed And Accuracy

<table>
<thead>
<tr>
<th></th>
<th>Speed</th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>Pre-Test N=6</td>
<td>Speed</td>
<td>Mean 22.67</td>
</tr>
<tr>
<td></td>
<td>Accuracy</td>
<td>Mean 1.06</td>
<td>Std Dev. .47</td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td>Post-Test N=5</td>
<td>Speed</td>
<td>Mean 24.60</td>
</tr>
<tr>
<td></td>
<td>Accuracy</td>
<td>Mean 1.97</td>
<td>Std Dev. 1.52</td>
</tr>
<tr>
<td>Successful Learners</td>
<td>Speed</td>
<td>Mean 20.67</td>
<td>Std Dev. 3.93</td>
</tr>
<tr>
<td></td>
<td>N=6</td>
<td>Accuracy</td>
<td>Mean 9.00</td>
</tr>
</tbody>
</table>

Not only are the predicted differences observed in accuracy scores, but the unsuccessful learners moved slightly in the direction of the successful learners. Speed scores show no differences.
4. More Variability will be seen in performance with various strategies by the successful learners, but the unsuccessful learners will show greater variability in brain data collected during the same tasks.

It was expected that the more successful learners would be better at utilizing the strategies which they have found to be personal strengths and will thus produce greater variability in performance scores on list learning activities. However, it was expected that the less successful learners will show greater variability due to poorer ability to focus strategically on the tasks. It is assumed that the ability to maintain greater focus on the task and adaptation to varied strategy directions will produce greater overall recall by the successful learners.

Table 8 - Performance On All List Learning Tasks

<table>
<thead>
<tr>
<th></th>
<th>Mean Correct</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>7.92</td>
<td>1.77</td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td>8.80</td>
<td>1.98</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful Learners</td>
<td>10.80</td>
<td>2.33</td>
</tr>
<tr>
<td>N=6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9 - Brain Data On List Learning Tasks - N1 And P2 Probe ERP Peak To Peak Differences

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>13.26</td>
<td>0.73uV</td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td>12.80</td>
<td>1.46uV</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful Learners</td>
<td>11.12</td>
<td>1.34uV</td>
</tr>
<tr>
<td>N=6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The hypotheses are confirmed by the performance data and by the comparison of the unsuccessful learners pre-test data and successful learners data. Furthermore, the unsuccessful learners moved toward the successful learners on both means and standard deviations in the post-test of performance. With the brain data, the unsuccessful learners moved beyond the successful learners in variability on the post-test. Though any conclusions would be premature, this would suggest that one of the effects of an intervention is to produce "over-compensations" in areas of strength or potential.

Interpretation of Peak-to-Peak values is somewhat ambiguous due to the effects of baseline shifts and baseline corrections on the data. If we look at the N1 and P2 components separately we see that the amplitude and variability shifts which correspond to the hypothesis are seen for P2. With other preliminary data collected in The Brain Behavior Lab, Probe ERP differences have been observed in N1 and not P2. The reasons for these differences will require further exploration. Because the Brain Atlas provides only averaged data for ERP waveforms, it is not possible to look at variability within individuals on these list learning tasks in any meaningful way without a much larger sample of data collections. The N1 and P2 data are presented in Table 10.
Table 10 - N1 And P2 Probe ERP Values For List Learning

<table>
<thead>
<tr>
<th></th>
<th>N1 Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners Pre-Test N=6</td>
<td>6.11μV</td>
<td>1.01μV</td>
</tr>
<tr>
<td>Unsuccessful Learners Post-Test N=5</td>
<td>6.16μV</td>
<td>0.78μV</td>
</tr>
<tr>
<td>Successful Learners N=6</td>
<td>6.74μV</td>
<td>1.21μV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P2 Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners Pre-Test N=6</td>
<td>7.16μV</td>
<td>1.43μV</td>
</tr>
<tr>
<td>Unsuccessful Learners Post-Test N=5</td>
<td>6.64μV</td>
<td>0.80μV</td>
</tr>
<tr>
<td>Successful Learners N=6</td>
<td>4.39μV</td>
<td>0.34μV</td>
</tr>
</tbody>
</table>

5. Greatest Variability will be within subjects. Between groups and between tasks variability will be less.

This hypothesis is directed at differences in brain activity which will be seen when looking at task, between person, and within person. Most research has looked at differences in tasks or differences in people. Experience with brain mapping suggests that the biggest differences are within people rather than between tasks or between people.

The current state of the technology makes any assessment of these differences preliminary. Even the exceptionally labor intensive collection of individual points from individual records cannot help answer questions about the specific types of tasks selected for study, or the individuals selected, or the sample size.

Microvolt values were obtained for all 16 electrode points for the Alpha range for all subjects on all tasks where frequency data
were collected. Variability between tasks was computed by making an aggregate file for each task using Normgen. These task files were then grouped using Normgen and the standard deviation values across electrodes averaged. Between groups differences were computed by making an aggregate file of FFT data for each group. The difference values for each electrode were obtained and mean and standard deviation computed. Between individuals was computed by creating an "all task" file for each individual, then computing the mean and standard deviation values for these files for each electrode point. Within individual variability was obtained by using Normgen to compute means and standard deviations across all eyes open tasks for each individual. Alpha variability across all 16 electrode sites was averaged to give an individual variability score. These were averaged across individuals.

Table 11 - Alpha Amplitude Variability Between Tasks, Between Groups, Between Individuals And Within Individuals

<table>
<thead>
<tr>
<th></th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Tasks</td>
<td>.22uV</td>
</tr>
<tr>
<td>Between Groups</td>
<td>.30uV</td>
</tr>
<tr>
<td>Between Individuals</td>
<td>.48uV</td>
</tr>
<tr>
<td>Within Individuals</td>
<td>1.37uV</td>
</tr>
</tbody>
</table>
These values appear to relatively strongly support the hypothesis; however, the necessity to manually extract data, by color, from maps for each data point allows sufficient subjectivity into the process to avoid strong conclusions. Furthermore, the differences in numbers used in the computation of variability in each case and the methods necessary for variability computation make any quantitative conclusions very tentative. Given these limitations the data do support the strong subjective conclusion that one gets in looking at individual subject data — and thus, a much stronger role for internal context (variability) in learning and educational decision-making. It would be well for separate studies to look at this issue with methods permitting more statistical precision.

ERP data were not used for testing this hypothesis due to the difficulty in determining the specific points which are appropriate for inclusion in the calculation. For example, should peak values of N1 and P2 be used only when the stimulus is irrelevant, or should they be used when the stimulus is relevant, or should we use latencies, or P3? Even though the author lacked confidence that this hypothesis would be confirmed by these data, it appeared, on subjective examination that the ERP data exhibited the same pattern as was found with the FFT data.

6. Successful Learners will show greater strategy use in Free Recall

Free recall lists were scored for use of order information, clustering of responses in recall, number of identifiable groupings of
strategies, number of identifiable different strategies. Order Information was scored in two ways: one, number of the words in the clusters at the beginning and the end of the list that are recalled - the total is divided by the total number of words recalled; two, position of the words in the original list which are the first 10 words in the recall list (words are assigned numbers from 1 up, from the beginning of the list, and from 1 back from the end of the list through the last 10 words in the presented list. The total points of the first 10 recalled words are the order points total. The lower the total, the more the individual has used order information in their learning and recall strategy).

### Table 12 - Recall Of First And Last Words

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>.34</td>
<td>.08</td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>.28</td>
<td>.16</td>
</tr>
<tr>
<td>Successful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=6</td>
<td>.41</td>
<td>.09</td>
</tr>
</tbody>
</table>

### Table 13 - Order Points

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>238.75</td>
<td>35.50</td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>237.6</td>
<td>31.46</td>
</tr>
<tr>
<td>Successful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=6</td>
<td>227.5</td>
<td>35.80</td>
</tr>
</tbody>
</table>
Table 14 - Cluster Points

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>.66</td>
<td>.66</td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td>.80</td>
<td>.31</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful Learners</td>
<td>.94</td>
<td>.09</td>
</tr>
<tr>
<td>N=6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 15 - Strategy Shifts

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>4.02</td>
<td>2.01</td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td>4.38</td>
<td>1.67</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful Learners</td>
<td>5.42</td>
<td>1.23</td>
</tr>
<tr>
<td>N=6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 16 - Variety Of Strategies

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td>1.88</td>
<td>.83</td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td>2.26</td>
<td>.77</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful Learners</td>
<td>3.61</td>
<td>.87</td>
</tr>
<tr>
<td>N=6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In every case the hypothesized prediction held true.

Furthermore, in all cases, though the trend was not always strong, the post-test performance of the unsuccessful learners moved in the direction of the scores of the successful learners. In this type of task there are only two major strategies available: one, use the order of the words in the list to facilitate recall; two, use some type of associative structuring to enable more efficient memory search. Order information is both a useful index of sequencing skill and of the tendency of the individual to recognize the "built-in" primacy and recency. The Serial Position Curve shows a strong advantage to initial words (primacy) in such a list and a weaker advantage to the last
words (recency) (Bower and Hilgard, 1981). The clustering measure indicates the tendency of the individual to identify and utilize for recall salient associations in the stimulus situation. The number of strategy shifts is an indication of the tendency of the individual to move from one strategy to another. In this task it is very easy to become overwhelmed with the number of words to be recalled and give up. The number of strategy shifts will give an indication of the individual’s recognition of the value of approaching the task from more than one perspective to avoid "getting stuck." The number of strategies utilized suggests the variety that the individuals will tend to bring to bear on a difficult task, as well as being a potential indication of a type of cognitive complexity.

Because the strategies are not absolutely objective, there is subjectivity in the strategy shift and number scoring. There is no way to guarantee that a string of words represents a particular strategy in the search of the individual. For purpose of scoring these, strategies were groupings of first and/or last words, groupings of categories build into the list, groupings which indicated reference to objects in the immediate physical environment, groupings indicating apparent personal emotional associations, groupings which suggested use of auditory or visual similarity of stimuli, functional groupings suggested by items in the list (e.g. school related items), idiosyncratic strategies (e.g. going back through the list and adding items suggested by previous recall, patterns of errors which bridged categories, etc.).
7. Successful Learners will show less positive peaks in ERP data (more coherence) than unsuccessful learners.

All ERP data were displayed and smoothed with a three point averaging routine 3 times (this eliminates irregularities in the waveforms due to ambient electrical interference). The positive peaks were counted in the first 500 msec of the ERP for eight electrode points: F3, F4, C3, C2, C4, P3, PZ, and P4. The literature shows that identifiable peaks are all focused at C2 or P2 (Donchin, 1984), thus the information from the peripheral electrodes is a less useful index of coherence of processing - accordingly they were not counted. Because the amount of interference in the data is variable, and 3 point smoothing done three times will eliminate variable amounts of that interference, the conclusions from these data should be considered tentative - even though they consistently go in the predicted directions.

Table 17 - Coherence

<table>
<thead>
<tr>
<th>Description</th>
<th>Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>Mean 50.59</td>
<td>10.04</td>
</tr>
<tr>
<td>Unsuccessful Learners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>Mean 46.94</td>
<td>9.12</td>
</tr>
<tr>
<td>Successful Learners N=6</td>
<td>Mean 41.90</td>
<td>6.99</td>
</tr>
</tbody>
</table>
Figure 15 - Relatively Coherent P300 ERPs
Figure 16 - Relatively Incoherent P300 ERPs
Figure 17 - Relatively Spatially Coherent P300 ERPs
Figure 18 - Relatively Spatially Inherent P300 ERPs
In examining the data it became apparent that there was considerably more "coherence" in response to task relevant stimuli (Detection, P300 and Stroop) than to task irrelevant stimuli (AEP Baseline and Probes). Since Stroop was collected from the unsuccessful learners only once, the coherence included here are for only the first exposure to each task for each individual. This is pre-test data for all tasks except Stroop. The data are presented in Table 18.

<table>
<thead>
<tr>
<th></th>
<th>Unsuccessful Learners</th>
<th>Successful Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Relevant</td>
<td>Mean 41.73 Std Dev. 4.24</td>
<td>Mean 36.88 Std Dev. 4.30</td>
</tr>
<tr>
<td>Task Irrelevant</td>
<td>Mean 51.98 Std Dev. 3.19</td>
<td>Mean 45.72 Std Dev. 5.35</td>
</tr>
</tbody>
</table>

One could infer that if task relevance produces greater coherence, individuals who are more focused on the task will also have greater coherence of brain data. Though these data are, at best preliminary observations, they are consistently supportive of those conclusions.

8. Successful Learners will show greater response to Cognitive Load

If an individual is going to selectively respond to events in life, it would be expected that the greatest learning would occur if there was a greater response to the significant events than to the insignificant events.
In the Detection, AEP P300 and Stroop tasks there are irrelevant events (in the case of the Detection this is the occurrence of nothing) and events which are to be the basis of a response. In case of those portions of the ERP which are selective attention and response decision, there would be expected to be relatively little difference based on whether the stimulus is response relevant or irrelevant. These would be N1 and P2. In the case of the ERP component which is indicative of significance – P3, it would be expected that the successful learners would have a greater increase in the amplitude for the relevant stimulus.

Table 19 - Detection Task - Amplitudes and Latencies - N1, P2, P3 - Amplitudes in uVs

<table>
<thead>
<tr>
<th>Learners</th>
<th>N1 Amplitude Mean</th>
<th>Std Dev.</th>
<th>N1 Latency Mean</th>
<th>Std Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsuccessful</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>-14.58</td>
<td>2.60</td>
<td>112msec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.52</td>
<td>7.81</td>
<td>192msec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.41</td>
<td>3.12</td>
<td>300msec</td>
<td></td>
</tr>
<tr>
<td><strong>Unsuccessful</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>-12.50</td>
<td>3.12</td>
<td>104msec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.70</td>
<td>3.64</td>
<td>184msec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.59</td>
<td>2.60</td>
<td>300msec</td>
<td></td>
</tr>
<tr>
<td><strong>Successful</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=6</td>
<td>-5.98</td>
<td>2.60</td>
<td>120msec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19.27</td>
<td>4.16</td>
<td>192msec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14.58</td>
<td>6.77</td>
<td>320msec</td>
<td></td>
</tr>
</tbody>
</table>
Table 20 - AEP P300 - Amplitudes And Latencies - N1, P2, P3 - For The Irrelevant Stimulus - Amplitudes In uVs

<table>
<thead>
<tr>
<th></th>
<th>N1 Amplitude Mean</th>
<th>Latency Mean</th>
<th>N2 Amplitude Mean</th>
<th>Latency Mean</th>
<th>N3 Amplitude Mean</th>
<th>Latency Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsuccessful Learners</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>-8.13 Std Dev. 1.04</td>
<td>100msec</td>
<td>7.29 Std Dev. 0.00</td>
<td>192msec</td>
<td>4.36 Std Dev. 0.00</td>
<td>240msec</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>-6.64 Std Dev. 1.04</td>
<td>100msec</td>
<td>5.72 Std Dev. 1.04</td>
<td>188msec</td>
<td>3.25 Std Dev. .52</td>
<td>264msec</td>
</tr>
<tr>
<td><strong>Successful Learners</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=6</td>
<td>-7.68 Std Dev. 1.56</td>
<td>104msec</td>
<td>3.51 Std Dev. 2.08</td>
<td>224msec</td>
<td>2.21 Std Dev. 2.08</td>
<td>328msec</td>
</tr>
</tbody>
</table>

Table 21 - AEP P300 - Amplitudes And Latencies - N1, P2, P3 - For The Relevant Stimulus - Amplitudes In uVs

<table>
<thead>
<tr>
<th></th>
<th>N1 Amplitude Mean</th>
<th>Latency Mean</th>
<th>N2 Amplitude Mean</th>
<th>Latency Mean</th>
<th>N3 Amplitude Mean</th>
<th>Latency Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsuccessful Learners</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Test N=6</td>
<td>-10.15 Std Dev. 0.00</td>
<td>100msec</td>
<td>10.54 Std Dev. 1.56</td>
<td>188msec</td>
<td>14.06 Std Dev. 3.64</td>
<td>304msec</td>
</tr>
<tr>
<td>Post-Test N=5</td>
<td>-5.85 Std Dev. 2.08</td>
<td>100msec</td>
<td>5.07 Std Dev. 2.08</td>
<td>172msec</td>
<td>10.80 Std Dev. 2.60</td>
<td>292msec</td>
</tr>
<tr>
<td><strong>Successful Learners</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=6</td>
<td>-7.81 Std Dev. 2.99</td>
<td>108msec</td>
<td>6.25 Std Dev. 2.08</td>
<td>208msec</td>
<td>13.02 Std Dev. 4.68</td>
<td>316msec</td>
</tr>
</tbody>
</table>
Table 22 - Stroop - Amplitudes And Latencies - N1, P3 - For The Irrelevant Stimulus - Amplitudes In uVs

<table>
<thead>
<tr>
<th></th>
<th>Unsuccessful Learners N1</th>
<th>Successful Learners N1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude Mean</td>
<td>-5.96 Std Dev. 2.08</td>
<td>-5.20 Std Dev. 1.80</td>
</tr>
<tr>
<td>Latency Mean</td>
<td>132msec</td>
<td>128msec</td>
</tr>
</tbody>
</table>

Table 23 - Stroop - Amplitudes And Latencies - N1, P3 - For The Relevant Stimulus (Blue) - Amplitudes In uVs

<table>
<thead>
<tr>
<th></th>
<th>Unsuccessful Learners N1</th>
<th>Successful Learners N1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude Mean</td>
<td>-5.33 Std Dev. 3.64</td>
<td>-1.82 Std Dev. .52</td>
</tr>
<tr>
<td>Latency Mean</td>
<td>132msec</td>
<td>132msec</td>
</tr>
</tbody>
</table>


In all cases where the unsuccessful learners did a task in the Pre-Test and Post-Test (all but Stroop) the amplitudes of the second time were smaller than the first. With repeated exposure to a task, even if only twice and as much as three months apart, the amplitudes decrease. This suggests that as response to a task becomes more automatized the neurocognitive indices will decrease. N1 and P2 latencies decreased from first exposure to second. The successful learners had shorter latencies for each of these. P3 latencies are consistently longer for the successful learners; but, there is no clear pattern for P3 latencies amongst the less successful learners from first to second trial. This suggests that the more successful learners engage in processing which is slower to develop to its maximum, more potent in its processing and more responsive to stimulus significance.

Amplitudes of N1 and P2 are consistently smaller for the successful learners, suggesting that process is more automatized. The difference between the relevant and the irrelevant stimulus is always greater in the successful learners, confirming the cognitive load hypothesis. There is no clear pattern of shift in this relationship amongst the less successful learners from Pre-Test to Post-Test.

Performance Data

All performance data collected, and not previously presented, are listed in Tables 24, 25, 26, and 27.
Table 24 - Performance Data - Means And (Standard Deviations)

<table>
<thead>
<tr>
<th></th>
<th>Unsuccessful Learners</th>
<th>Successful Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Test</td>
<td>Post-Test</td>
</tr>
<tr>
<td>Handedness Test</td>
<td>13.5</td>
<td>12.5</td>
</tr>
<tr>
<td>16=All Right</td>
<td>SD (3.39)</td>
<td>(3.78)</td>
</tr>
<tr>
<td>Handled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading Speed</td>
<td>86</td>
<td>75.2</td>
</tr>
<tr>
<td>(lines read)</td>
<td>(33.18)</td>
<td>(34.05)</td>
</tr>
<tr>
<td>Read Accuracy</td>
<td>.50</td>
<td>.65</td>
</tr>
<tr>
<td>(percent correct)</td>
<td>(.29)</td>
<td>(.24)</td>
</tr>
<tr>
<td>Mental Rotations</td>
<td>9.67</td>
<td>9.8</td>
</tr>
<tr>
<td>Speed(#completed)</td>
<td>(2.73)</td>
<td>(3.42)</td>
</tr>
<tr>
<td>Mental Rotations</td>
<td>2.37</td>
<td>4.09</td>
</tr>
<tr>
<td>Accuracy(ratio correct to wrong)</td>
<td>(2.75)</td>
<td>(4.15)</td>
</tr>
<tr>
<td>List Learning</td>
<td>6.83</td>
<td>9.20</td>
</tr>
<tr>
<td>Auditory Strategy</td>
<td>Correct</td>
<td></td>
</tr>
<tr>
<td>Errors</td>
<td>.98</td>
<td>.4</td>
</tr>
<tr>
<td></td>
<td>(.82)</td>
<td>(.55)</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0)</td>
</tr>
</tbody>
</table>
### Table 25 - Performance Data - Means and (Standard Deviations)

<table>
<thead>
<tr>
<th>Category</th>
<th>Unsuccessful Learners Pre-Test</th>
<th>Unsuccessful Learners Post-Test</th>
<th>Successful Learners Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category Strategy</td>
<td>9.00</td>
<td>10.2</td>
<td>11.33</td>
</tr>
<tr>
<td>Correct</td>
<td>(0.67)</td>
<td>(2.39)</td>
<td>(3.27)</td>
</tr>
<tr>
<td>Errors</td>
<td>2.52</td>
<td>.2</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>(1.21)</td>
<td>(.45)</td>
<td>(0.0)</td>
</tr>
<tr>
<td>Visual Imaging</td>
<td>7.83</td>
<td>7.6</td>
<td>10.5</td>
</tr>
<tr>
<td>Correct</td>
<td>(2.31)</td>
<td>(1.95)</td>
<td>(1.38)</td>
</tr>
<tr>
<td>Errors</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>(0.0)</td>
<td>(0.0)</td>
<td>(0.0)</td>
</tr>
<tr>
<td>Recall in Order</td>
<td>8.00</td>
<td>8.2</td>
<td>11.33</td>
</tr>
<tr>
<td>Correct</td>
<td>(1.26)</td>
<td>(1.10)</td>
<td>(2.5)</td>
</tr>
<tr>
<td>Errors</td>
<td>.17</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>(.51)</td>
<td>(0.0)</td>
<td>(0.0)</td>
</tr>
<tr>
<td>Order Errors</td>
<td>.67</td>
<td>1.4</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>(1.63)</td>
<td>(1.10)</td>
<td>(0.0)</td>
</tr>
</tbody>
</table>
Table 26 - Performance Data - Means And (Standard Deviations)

<table>
<thead>
<tr>
<th></th>
<th>Unsuccessful Learners</th>
<th>Successful Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Test</td>
<td>Post-Test</td>
</tr>
<tr>
<td>Free Writing (words generated)</td>
<td>15.33 (2.34)</td>
<td>13.8 (1.10)</td>
</tr>
<tr>
<td>Serial Subtraction</td>
<td>3.75 (2.16)</td>
<td>4.6 (1.95)</td>
</tr>
<tr>
<td>Errors</td>
<td>1.33 (1.50)</td>
<td>.6 (.89)</td>
</tr>
<tr>
<td>Phonetic Spelling Ratio Correct</td>
<td>.43 (.16)</td>
<td>.46 (.32)</td>
</tr>
<tr>
<td>Non-Phonetic Spelling Ratio Correct</td>
<td>.24 (.30)</td>
<td>.70 (.27)</td>
</tr>
<tr>
<td>Free Recall Correct</td>
<td>11.5 (2.33)</td>
<td>14.6 (3.36)</td>
</tr>
<tr>
<td>Errors</td>
<td>3.02 (1.51)</td>
<td>1.8 (.84)</td>
</tr>
</tbody>
</table>
Table 27 - Performance Data - Means And (Standard Deviations)

<table>
<thead>
<tr>
<th></th>
<th>Unsuccessful Learners</th>
<th>Successful Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Test</td>
<td>Post-Test</td>
</tr>
<tr>
<td>Self Ratings (Max=7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attentiveness</td>
<td>3.33</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>(1.37)</td>
<td>(.84)</td>
</tr>
<tr>
<td>Learning Ability</td>
<td>4.16</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>(.75)</td>
<td>(1.0)</td>
</tr>
<tr>
<td>Organization</td>
<td>3.83</td>
<td>4.40</td>
</tr>
<tr>
<td></td>
<td>(.98)</td>
<td>(1.95)</td>
</tr>
</tbody>
</table>

Although there was no intent to discuss specific performance data beyond those mentioned in the hypotheses, it is rather striking to note the consistently superior performance of the successful learners and the consistent movement by the less successful learners in the direction of the successful learners on post-test scores.

School grades are listed in Table 28
Table 28 - School Grades - Grade Point Averages For All Classes - On A 4 Point System - Means For All Group Members

Unsuccessful Learners
First Two Grading Periods - 2.05 (before intervention)
Estimate for Third Grading Period - 2.80
Actual for Third Grading Period - 2.50 (mid intervention)
Estimate for Fourth Grading Period - 2.80
Successful Learners
First Three Grading Periods - 3.46

These changes are rather substantial, considering that the 3rd grading period grades came during the middle of the intervention. It should also be noted that this includes the grades for art, physical education and other areas where positive participation is at least as important as the quality of that participation. The observed differences from pre to post intervention were smaller when only the traditional academic subjects were considered (1.123 - 1.417); and, most of the difference in the major subject grade change was due to one individual whose average was .375 for the first two grading periods and was 1.75 for the third grading period. However, 5 of the 6 participants showed grade improvement in both the 4 major subjects and overall.
CHAPTER 5

DISCUSSION

Brain Data

This preliminary investigation into the relationship between brain electrical activity data in topographic maps, school performance and the effects of a program of learning skills intervention are very encouraging. Level of activation is shown to have a relationship with school success, and to change as a result of the intervention program. Variability is more strongly associated with internal characteristics of individuals than with tasks or individuals or groups. Waveform coherence is associated with task relevance and individual learner characteristics. Cognitive load appears related to individual school success and shows some directional changes with experience. Automatization appears related to individual learning success and to result directly from experience - even if the experience is relatively small. All of these strongly support the continued investigation of brain electrical activity in relation to learner success and intervention.

The data using the probe technique are consistent with learner characteristics and intervention effects, but are the opposite direction from the findings normally reported in the literature. It
is not possible to make any conclusions from this, but clearly further investigation into the probe technique, its methodology and application are appropriate.

One brain pattern appeared in several of the less successful learners, and 2 of the successful learners. In this pattern there were strong patterns of activity in both hemispheres which were non-communicating at the central electrodes. When this pattern was initially observed, it was suspected that this might be indicative of poor hemispheric integration in the poor learners. However, the pattern showed up in two of the successful learners. On more careful examination, both of these individuals were exceptionally analytic by all measures. They were very concrete in seeking direction, very literal and very rigid in execution of tasks. Interestingly, each of them has a very creative flair, but they exercise it quite selectively in specific activities, and then only when they consciously switch to the "be creative" mode. By both conventional and brain standards they exhibit limited hemispheric integration, they function very well in school and show "right hemispheric" mode - but selectively.

Most striking are the patterns of individual differences in brain data in relation to individual learner characteristics. Research on electrical activity of the brain has looked for descriptions of identifiable wave forms. Here we have looked at individual waveforms in relationship to individual learning characteristics. These have been found to be consistent with performance data, experimenter observation, school records, and student self reports. The intent of this research was not to establish any definitive relationship between
a brain wave pattern and a particular ability or performance; but rather, to illustrate the presence of relationships which supported such further investigation. Such patterns have appeared well beyond initial expectation.

**Learner Success**

The subjects in this research were roughly comparable in capability, as indicated by existing IQ test data, School Achievement Tests, and Counselor assessment. Their school success has differed markedly. Performance data and grades would be expected to show differences between the successful and less successful learners. The differences that appear in the brain data add a new dimension, especially given their relationship to the more traditional types of data.

There were no clear patterns of deficits in the groups which indicate specific brain indices of learning difficulty. This is not surprising, given that the less successful learners were not selected to fit to any pattern of specific deficits. It was interesting to observe the variability in individuals in both the successful and less successful learners. There were individuals in the successful learners with strong patterns of specific deficits (spelling weaknesses, poor handwriting, poor math performance, etc.) suggestive of very real limitations. However, all of these individuals have found ways to compensate for these weaknesses so that they function effectively in school.
The findings are very supportive of the position that school success has more to do with the degree to which the individual has found the best pattern of interaction between personal strengths and school task demands, than any real limitations of individual characteristics or brain processing patterns.

**Intervention**

It was hoped that by developing an intervention program with this age group, sufficient metacognitive knowledge could be instilled to produce both short and long-term changes in attitudes toward self, learning and in school learning performance. Given the relatively brief period of this intervention and its exploratory nature, the degree of changes in performance data, brain data and school grades are far more than had been expected. The explanation of these results is significantly complicated by the methodology adopted for this research. When research goes from neurocognitive assessment, to performance data, to supplementary intervention, to school performance, and when there is the complex of factors associated with maturation, the approach of time to enter high school, the personal characteristics of the experimenter and individual relationships with him, assigning a clear cause for these results is difficult. Some items on which there was positive improvement seem difficult to account for by the process of the intervention (e.g. changes in non-phonetic spelling performance). But the fact that virtually all things tested showed improvement in the direction (or occasionally beyond) the performance of the successful learners strongly supports
the conclusion that these results are not chance.

It should be noted in evaluating the effect of the intervention on performance that none of the intervention dealt directly with strategies for improving performance on any of the performance tests. Many of the processes and strategies discussed were potentially relevent to these tasks, but no attempt was ever made to relate discussion in the intervention to any of these tasks directly. In observing the behavior and conversation of the individuals during the Post-Test it seemed that two clear changes were present. One, the individuals seemed more seriously engaged in the tasks. It was as if they had come to believe that they might be able to do well and made a more serious attempt to do so. Two, there was much greater curiosity about the brain maps, what they meant and what could be learned from them. No count was made of the number of times individuals asked questions about the maps or turned around to see them during the testing, but it was clear that the successful learners did so much more often, while the unsuccessful learners markedly increased this behavior during their Post-Test.

The changes observed in the School Locus of Control Assessment suggest that the intervention had a very positive effect in getting the unsuccessful learners to believe there were reasons for their poor performances and that they could do things to turn them around. The intervention model assumed that factors which prevented an individual making any effort in learning would act as deterreents in performing to capacity. Clearly, believing that school failures are attributable to luck puts them where no effort is warranted.
The form of this intervention was clearly successful in producing additional usable information about learning and functional changes in performance. The focus on activities which are of concern to the participants, rather than instruction in specific skills, appears to warrant continued exploration. The most encouraging aspect of this intervention is that, in contrast to most interventions, there were changes in a wide variety of areas – brain, performance, and school – most of which were not directly addressed in the intervention.

**Individual Differences**

Hypothesis 5 was formulated on the assumption that the changes in the cognitive processing of individuals as they approach varied tasks is more significant than either group differences in tasks, individual differences or the differences in the groups studied. In the absence of a research literature which addressed this issue, the hypothesis was generated from experience with brain maps of varied individuals in varied tasks over the period of familiarization with brain mapping technology. The results are strongly supportive of the hypothesis – though, as stated before, there is reason for replication before any firm conclusions are accepted. Should these data hold up in future research it strongly suggests that a major ingredient in educational success has been virtually totally excluded from educational research and curriculum development – the internal context of the learner.
We have studied the differences that occur in various tasks. We have studied differences in identified groups. We have studied individual differences independent of group identification. But, for lack of an accepted methodology, we have not considered the internal context of the learner - the state of the learner which interacts with the task in the external context. This should be a major focus of future methodological and educational pursuits.

Individual differences are normally construed as semi-permanent personal attributes of fixed value. When we add to this the range of variability in the performance characteristics of the individual we have a very different construction of individual differences. An individual is not just a collection of specific predictive attributes, but is a range of flexibility. This range of flexibility interacts, under the direction of personal control processes, with the external context and tasks to produce the behavioral results. Prediction of results requires attention to the range of flexibility, the control processes and the state of the internal context. This argues strongly for a more central role of the individual in the development and execution of learning activities. Not only does this increase the range of flexibility (given variable activities), but it produces greater development of personal control processes and makes the internal context central to learning. This will bode well for the 94% of self-directed learning.

It is not possible to look at brain maps of large numbers of individuals doing the same task or large numbers of tasks done by the same individual without an overwhelming sense of the variability that
exists in brain activity and performance. The present study has shown that there are patterns of relationship between that variability and the performance of individuals in more traditional educational activities. It awaits further research to identify more specific indices, or patterns of indices which will be more specifically predictive of educational performance. Hopefully, this research will follow the multi-level methodology utilized here so that the results will not solely be predictive, but will engage the learner in the development of better understanding, development and utilization of individual capacities.

Model for Brain Assessments

The Brain assessments utilized in this study are roughly akin to the assessments of intelligence originally developed by Binet. A mixture of tasks have been included which combine standard assessments and methods, and a variety of tasks which appear to cover a range of learning skills that are assumed to have educational significance. The refinement of any assessment protocol must be viewed as a continuing process. It is clear from this study that several guidelines should be a part of any development of brain assessment protocols.

1. In all assessments great care must be used to ensure that the activity assessed is the brain activity associated with cognitive processes and not differential patterns of muscle movements, tensions, eye movements or other artifactual data. These movements are
interesting and revealing in themselves, but much care must be taken
to separate the neurocognitive from the neuromuscular. In doing this,
tasks which make as similar demands for movements as possible should
be utilized.

2. All assessments should be seen as supplantary and complementary
to contextual observations. Even the most carefully controlled brain
assessments of the most basic processes have room from error created
by the context of the testing and the attitudes and strategies of the
subject.

3. Because the internal context of the subject is a key piece of the
information necessary for interpretation of brain assessments,
self-reports of subjects of strategies and attitudes should be
included with all data collections and interpretations. This is
particularly important since the greatest positive impact will be on
the self-knowledge and self-monitoring that results. If the
individual is actively involved in the data collection and
interpretation process both of these will be increased.

4. Allow the subjects to participate in the selection of types of
tasks that will be included in the assessment. This will enable them
to feel a greater role in the process and investment in the results.

5. Assessment protocols should never be viewed as global or final.
Since learning context is a critical piece of cognitive functioning -
as even Sternberg concedes - protocols should be created in relation to the learning context at issue. Assessment should occur for those areas where there are concerns (e.g. difficulty with reading and writing, or math, etc.) with reference to areas of cognitive strength - not presume to be measures of global ability. Routine assessments of the masses or comparative scoring of results are to be avoided.

6. Assessments should be built around the assumption that effective cognitive processes have six key and assessable subdivisions:

1. Inputs - Sensory Processes and Their Neural Representation
2. Representations of Those Inputs
3. Transformations of Those Representations
4. Outputs - Motor Processes and Their Organization
5. Executive Control Processes - The Regulation and Utilization of the Other Four. The Distinction Between Conscious and Non-Conscious Processes Should be Downplayed as Much as Possible.

6. Knowledge Structures

Model for Intervention

The intervention program pursued here worked at several disadvantages. The selected individuals were unsuccessful, but not necessarily formally identified as such. Participants were not involved in their selection for participation. The participation was voluntary. Participation required an investment of time in a program
of unknown potential for a self improvement that might not be strongly sought. Under these conditions eager and cooperative participation is difficult, even with the best efforts. Despite that, there were strong evidences of positive change from this project.

As indicated in the model, there are long-term and short-term approaches to the improvement of learning skills. In all cases such a program must be integrated into on-going and mandatory portions of the educational curriculum. As will be mentioned later there are parts of an intervention program that should be separated from existing course work; but, even these will be of greatest use if they occur in context. This is extremely important! The vast majority of learning skills programs are either given as separate "decontextualized" learning to learn, or learning to think units, or are given as enrichment for the motivated volunteers. In doing this we will either miss many of the students or present the activity in a way which will miss having any impact with a great many students.

Long-term interventions must take the form of altering the vision of the curriculum in general and in all specific subject matters. The over all goal of any curriculum should be for the individual to learn a variety of facts, knowledges and processes, as well as to provide the basis and motivation for successful continuing learning. The latter has too often been omitted. To achieve this all subject matter curricula should follow the following guidelines.

1. Students learn in varied ways in all subject matter areas.

All instruction should provide students with varied means for active interpretation and processing the information in the
manner which is most familiar. Never assume that there is just one right way to learn anything.

2. All Students must acquire a fund of information and concepts which form an organized structure of knowledges and processes.

3. Students must be active participants in these processes. Concepts that have just been learned from direct instruction can only be repeated, not actively used to assist further learning.

4. All Students must be assumed to be learners. It is the teacher's role to challenge the students, hold high the standards, help the students find the representations and strategies that work for them. Never assume a student can't learn, at worst assume that the student has not yet found the way that works best.

5. There are tricks (heuristics and unique organizations) to all fields. Make sure each individual is given exposure to and experience with the tricks of the field. The teacher must understand that it is their role to teach learning as well as the subject matter.

If long-term interventions are done fully and well there will be no need for short-term interventions. Short-term interventions are based on the assumption that, even in the best system, there will be need for concentrated study and there will be individuals who will not respond well to long-term methods. As suggested in the model, short-term interventions should focus on rate limiters. Rate limiters are of two sorts: one, absence of capacity; two, underutilization of capacity. Absence of capacity can be addressed in the short-term by
activities which enhance executive control options and processes. Underutilization can be reduced by activities which improve self-acceptance, active participation in learning and monitoring skills.

The intervention program outlined in the procedure section is designed as a model of a short-term intervention. Students are exposed to models of learning strategies, given experience in selecting and utilizing those that are most likely to work for them, given activities to make clear that they can learn, given exercises to convey the sense of learning strategies in context, and approached through maieutics as a vehicle to improved monitoring of self and task. This program is, however, out of context. In being a separate activity removed from the flow of educational business the anticipated transfer of the learning is, as observed, small and slow.

The ideal short-term intervention will occur in the course of individual subject matter instruction. The basic form of the activity will vary with the subject matter and teacher, but will approximate the types of activities outlined in this "out of context" model.

In a particular subject matter area, the instruction can occur with a central goal of having the student leave as a better learner of the material of the course than when he/she entered. To do this, it is necessary for the teacher to understand the types of representational, transformational and executive systems that may work in the learning of their subject matter. The teaching emphasizes the factual content (the stuff of most behavioral objectives) as well as the organizational structures of the knowledge taught.
The "new math" moved in the direction of teaching the organizational structure of math, but did so without attention to the learning of the content—a functional context with that structure—or with teachers who understood the reasons for the undertaking. In working with math with various students it often appears that the problem with learning a math concept or procedure is the absence of adequate understanding of some more basic concepts. For example, many students show no evidence of a concept of number in relation to anything other than number (e.g. no sense of number as size, distance, weight, ratio of any sort, etc.). Such a condition in a student would preclude any meaningful conceptual grasp of fractions, decimals or more advanced concepts.

Students will develop their own representational and transitional systems to the extent that the teacher presents material which forces them to engage in an active manipulative process—take the material given and do something with it which produces a product whose worth or accuracy can be assessed. The use of physical activities, examples, students generated applications, and rhetorical questions will all tend to produce such action in students.

In addition to producing organization to new knowledges, the teacher in a content course can enhance learning skills by modeling them. If the discussion is of a period in history and its relevance to current issues, the teacher might launch into a monologue which explores relationships and issues in ways that it is hoped students might follow. Teachers can teach students perseverance and research skills by displaying the limits of their own knowledge and the
processes by which an active mind seeks information and answers—
rather than either knowing the answer (and never being wrong) or
avoiding the issue.

There are "tricks" in all fields. These learning skills can
be worked into the discussion of specific subject matter areas. Yates'
The Art of Memory, is a wonderful example of the study of memory
devices in the context of the flow of history. Such integrations of
learning skills instruction into a subject matter curriculum, not only
enriches the variety of the discussion, but provides the students with
contextual experience using a variety of learning strategies and makes
likely that they will learn more of the material the teacher is
attempting to teach.

This demonstration project indicates that success with a
short-term intervention is possible, but it will be with great effort
when it is voluntary and taken out of context. Long term integration
of learning skills development is likely to be more effective, both
for the context of the on-going learning activities and for the
continuity of the skills utilization.

There is a place for "out of context" activities. There will
always be individuals who, for a variety of reasons, are not
successfully reached by the curriculum. The form or content of
subject matter or instructional environment will be uncongenial;
personality mis-matches will occur with teachers; parents will provide
little or undermining support for school effort; peer conflicts will
diminish self-concept or participation, etc. Individualized attention
in the course of short or long-term interventions may reach some of
these individuals. Others may continue non-successes. There will also be special populations of individuals who have limitations that are specific, e.g. those with specific learning disabilities. These may best be approached in groups of those with similar needs. With many of these individuals it may be socially undesirable or restrictive to provide the assistance in mainstreamed group context. For them, some activities removed from the group will be appropriate.

Individual neurocognitive assessment will be most useful with members of this group. The authority of the direct neural assessment will provide the most persuasive power, give the most individual opportunity for guided reflection on personal learning characteristics and best ways to use them, and active participation in the interpretive and prescriptive process. The effectiveness of the neurocognitive assessment, as outlined above, in creating productive self-reflection, while difficult to formally document, is most impressive to all who have used it. If this is coupled with specific opportunities for instruction and use of learning skills that are tailored for the individual and their learning needs, it will be possible for the individual to return to the normal course of classroom activities with a new perspective and tools for effort and success.

The ideal for such out of context assessment would be for it to utilize as much context and social support as possible. Under the best conditions the assessment and intervention will be conducted by a team of individuals: the student, the teacher (or teachers) most involved in the areas of the student's difficulties – preferably
teachers with whom the student has the strongest personal relationship, parents, and other personal peers. These folks, working with the neurocognitive specialist will be able to produce the most active involvement in the development of strategies and the greatest support for their transfer.

The success of such an intervention program requires the continuation of a conversational research program as outlined below.

**Brain and Education Research Program**

Topographic mapping of electroencephalographic data takes complex data from the brain and converts it to a single dynamic visual display. Computerized manipulation makes it possible to display this information in a vast and largely unexplored variety of graphics. While the information in the visual display is no greater than that available in the standard ink-writer EEG record, the ease of viewing and interpreting the data and the power of the graphic open numerous exciting avenues for research and application. The research program proposed here is divided into three discriminable yet interactive areas. Each area of research will proceed simultaneously with the other two, using the data from them to both enhance the research efforts and increase the applicability of the results.

The proposed lines of research are:

1. Basic research on the action of the brain as a vehicle to both understanding and assessing cognitive processes and effective educational practice.
2. Studies of improved methods for data analysis and display.
3. Intervention programs both with teachers and learners.
Each of these three areas can stand alone— as it traditionally has; but, to "build a better mousetrap" all pieces must work together.

The relative ease of topographic mapping of brain electrical activity provides us with the opportunity to conduct research where we see not only the performance of the individual, but can ask for strategic (process) information from the subject and compare both with direct assessment of electrical activity of the brain. In this manner it is possible to begin resolution of basic issues which bear directly on our educational practice (e.g. individual differences, learning styles, role of attention in learning, effect of various learning conditions, social processes, etc.). Grouped performance data provide generalities, while both grouped data and individual data which includes both performance and brain activity assessment looks directly at the issues of individual learning.

1. Basic Research

There are three areas of basic research. The first looks at basic cognitive/neurological processes— their understanding, assessment and the use of that information in educational settings. The second will look for improved methods of data collection. The third examines characteristic personal "styles" and variation in processes which affect educational learning— including development of assessment and diagnostic processes.

A. Basic Cognitive Processes

There are a number of very nagging questions in the study of human cognition which have not been resolved by traditional normative experimentation. Some of the most vexing have dealt with individual
differences, their modifiability and the difference they make. The availability of brain mapping technology allows the relatively easy examination of performance data from standard psychological experimentation in comparison with studies of basic brain processes. There are several lines of research which must be pursued if we are to be able to effectively apply the result.

A few features will be characteristic of all lines of research in this section:

1. All research will include both brain and performance data. This will permits a comparison between the assigned task and brain activity, and comparison with the performance of the task. This is essential when results will apply to improvement of performance, not just compliance with assigned task. Research will be directed toward identification of cognitive and brain process patterns that characterize effective learning.

2. In all research, the "subject" will be included as a participant in the research. Performance is not terribly enlightening unless one also knows the particular strategy or process that was used. For example, we have evidence that the same individual can do math as a predominantly left or right hemisphere dominant activity depending on minor changes in approach to the task. These subject data will not be assumed accurate in all cases, but rather be a basis for evaluation of data for possible further research.
3. All research will look not only at grouped data but at the variation of individual data with performance. We have evidence that suggests that within "normal" groups with varied learning styles performance may be very different from brain activity corresponding to learning styles. In averaged group data these differences would be lost.

4. Subjects in research will be assessed for psychological characteristics other than just brain activity and performance. Such assessments as handedness, locus of control, learning style assessments, etc. will be used as a basis for establishing bases for observed individual differences, as well as helping to establish construct validity for existing assessment devices.

5. Research data will be kept in a management information system which will allow for post hoc analyses as various categories of subjects reach meaningful size.

6. Use of this management information system will be for establishment of normative developmental data on standard assessments (e.g. FFT of eyes open and eyes closed, visual event related potential - pattern reversal, auditory event related potential, oddball auditory discrimination - P300, etc.)

7. The MIS will be the basis for longitudinal data collections of individuals followed through their development. School data and individual assessments will be
collected throughout. Emphasis will be on establishing which changes are due to accumulated knowledge, processes, metacognitive knowledge, or pure aging.

The basic research will be directed toward identifying brain activity which correlates with cognitive processes. Research will aim at validation of basic cognitive concepts, evaluation of individual differences in the use of those processes and the relationship of both to educational performance.

The first line of basic cognitive research will use a subtraction paradigm. Tasks of increasing levels of cognitive complexity will be given to subjects. Brain activity will be recorded at each level. By designing the tasks so that each is essentially the same as the previous, but with one additional cognitive demand, it will be possible to subtract the results of one from the next and see the brain processes which are characteristic of each step. By looking at individual’s brain activity in relationship to performance it will be possible to identify diagnostics for specific processes. This will not only allow the use of this information for the assessment of individual strengths and weaknesses, but also permit direct assessment of the effectiveness of activities designed to improve performance where the skill at issue is a necessary one, or presumed so. For example, if an individual is to press a button whenever he/she hears a word, an event related potential can be recorded from a number of words presented at random. The same thing can be repeated where the individual is asked to press the button only when the word begins with a particular sound. By identifying the difference between these two
tasks it is possible to identify the brain wave patterns which are characteristic of auditory discrimination. These results can be analysed in relationship with individual reaction time and accuracy (score correct responses and errors separately). It would then be possible to identify changes in auditory coding ability, as opposed to skills in learning compensatory strategies which utilize other modalities - e.g. compare developmental changes to see if there is a relationship between the brain wave pattern and performance.

Figure 19 - Sample Subtraction - Successful Learner Oddball ERP Minus Detection ERP. Displayed waveforms indicate the additional processes involved when the task requires a discrimination between stimuli.
As another example, present the subject with a standard verbal oddball task (e.g., the subject is presented with a list of words, one at a time, with a random mix of frequent nouns and infrequent geographical names. They are instructed to "press a button whenever you see a name of a place." ). An unannounced test of recall will follow. The task is repeated with a new set of words, but this time the subject is instructed to push the button and try to remember the words because there will be a recall list at the end of the presentation of the list. We can now look for brain wave forms which are related to performance differences where the learning is "incidental." We can look for the same where the learning is "intentional." We can also look for the brain wave pattern differences in these two tasks and compare them with performance differences.

This basic research paradigm can be extended from threshold detection tasks (e.g., subliminal perception activities, hypnotically induced positive and negative hallucinations, etc) in any sensory modality (hearing and vision are priorities due to their obvious relationship to school learning), to essentially any type of thought process, or semantic process. With the subtraction paradigm, performance data and topographic mapping a complete system of assessment can be developed which may be used as a dependent measure in the evaluation of any educational treatment (e.g., the degree to which a particular teaching style tends to promote effective attention, the effect of the relationship of the individual to the teacher on the "engagement" in the learning, the effectiveness of
metacognitive interventions, etc.

One of the key issues in learning theory and research has been the role of "intention." By the use of the subtraction paradigm in combination with specific sets of task instructions it is possible to identify brain wave changes that are characteristic of intentional learning effort and their relationship to performance. An individual is presented with a sequential list of anagrams. Within that list are randomly placed words. The instructions, in standard oddball form, are to press a button when they see a word. Unbeknownst to them, at the end of the task they are asked for a free recall of the words. Subsequently, they are given a similar list where the task is to press the button when they see a word, and try to remember it for the test which is to follow. By subtracting the results of the first from the second task, data will be produced which indicates the process, for each individual and for the group, which accompanies intentional learning effort. These results can be compared with performance data to identify, not only effective performance, but effective intention and processes which are characteristic of effective incidental learning.

A second step in the application of this technique would be to look at data where different strategies are applied intentionally. Those which produce, not only greatest movement toward the "optimal" brain pattern (i.e. that pattern which is characteristic of optimal performance), but performance improvement may be those most appropriate for use by that individual at that time. Application of this information to an intervention will be discussed below.
A second line of basic cognitive research will attempt to determine the nature of the changes in processing that occur during the course of movement from initial exposure to a task through mastery of the task to overlearned automaticity. The general changes will be examined in grouped data; individual differences will be examined to attempt to determine indices of more rapid learning in various areas.

Using either FFT or Probe data collection, brain activity can be collected from an individual over the course of repeated learning trials - from initial exposure to overlearned effortless recall. It will be possible to look at the changes that occur during this learning process, as well as individual differences. In particular, attention will be paid to characteristics of activity on first exposure which are predictive of more rapid mastery. The same activity will be conducted where ERPs are recorded from selected items during presentation. These will be evaluated during the course of the learning to identify patterns of change and characteristics of the response in those who learn more quickly.

Another approach to this same matter of automatization is to look at the process by which a consciously mediated process becomes more automatic. While recording ERPs, individual reaction times can be recorded to numbers (e.g. oddball) where the infrequents are even numbers and the individual is instructed to press a counter when they see an even number. A second collection occurs after the individual is instructed that they are now to press the button only when the number added to the previous one is an odd number. This will initially require some mediation (difficulty of the task can be
adjusted to the age of subjects). This will produce longer reaction times and should produce an altered wave form which represents the additional mediation required. If the task is not too difficult, over a relatively short period of time the need for mediation will disappear as the task becomes automated. The reaction time will decrease and the brain waves should change, reflecting the change in processing. This will allow not only a direct look at the changes that occur with mediation and automatization, but also performance data to confirm the changes and individual differences. Anything that we can do to produce more effective, rapid and generalizable automatization of learned responses is to the good. It should be noted that once the basic experiment is completed it will be possible to use the paradigm for examining tasks of varied complexity, mediation, and for varied types of individuals.

A great variety of tasks can be explored which may have relevance for understanding specific learning disabilities, their basis and compensations for them. For example, one feature commonly seen in "learning disabled" individuals is difficulty in making right/left discriminations. There exists a large literature on mirror drawing, but it is virtually exclusively top/bottom reversals. It will be possible, using a model developed for the study of the acquisition of mirror skills amongst dental students, to do mirror drawing tasks which require learning a right/left reversal. During the learning brain wave data can be recorded from "learning disabled" individuals who have right/left problems, learning disabled individuals without such problems and normals. There will be brain wave data and
performance data. Following the basic experiment it will be possible to assess the effect of various strategies on learning of the right/left reversal and the associated brain activity. While it is not a primary initial focus of any of this research, it is reasonable to expect that when indices of more effective learning or learning strategies are found, biofeedback could be used with an individual to assist them in learning how to learn better (notice this is not directed at the learning of a specific activity - though there may be some places where that is appropriate - but, learning more about what they can do to learn better generally).

A third line will look at brain processes which correspond to cognitive events that the individual identifies. The current technology will allow us to have the subject make a response, having the period of brain activity which preceded the response collected for averaging. This will allow us to examine a whole array of brain and cognitive processes which the individual can identify, but which are not readily produced on demand for traditional data collection procedures. As an example, individuals could be given problems (e.g. anagrams). When they think they have an answer they press the button. Over a large number of trials the results could be averaged and reveal the areas of the brain which are involved in the process preceding an insight and the nature of that insight. Further, it would be possible to look at any of these processes in terms of the individual’s performance and at differences among individuals. There is good reason to believe that individuals can very quickly learn to time their button pushes to very accurately correspond with a given
cognitive event. Once the technique has been refined there are virtually unlimited specific researches which one might wish to pursue. Some of the more obvious interest might include: What happens when someone encounters something that they don't understand or are not familiar with or which produces anxiety; what occurs with specific steps in complex processing tasks (e.g., borrowing in subtraction, etc.); what type of processesing takes place prior to the decision to make an eye movement in reading; what activity precedes the decision to attend; what occurs when you encounter something which is "interesting" or "stupid", etc. As an adjunct to this research and a vehicle to more refined research into reading processes, a method can be developed for the collection of brain data using specific visual targets and an eye tracking device as a trigger. When this process is used it is possible to look, not only at more general brain process, but at brain processes which correspond to very specific linguistic codings.

A fourth line will look at those events which may provide indices of the effective attention and discrimination processes so necessary for learning. It is assumed that the more clearly an individual's nervous system transports a signal, the more effectively it can be perceived, analysed, stored or remembered. Note, this is independent of any issues of perceptual or cognitive style. One who learns well would be assumed to be one who is able to protect this signal from noise (nervous system noise as well as any other). A research program could look at raw EEG amplitude response to the presentation of a stimulus, from the incoming sensory components to
the "late" or endogenous components. It might be expected that more effective learning would occur where there is least decrement in signal as it passes through the system. It would also be expected that an effective continuing response could be accompanied by a stability of the EEG response to a stimulus - less habituation, higher peak amplitudes, smoother waveforms. It would also be expected that there would be less interference of "irrelevant" stimuli in the waveforms of task relevant stimuli. All of these issues, and many others related to attentional and discriminatory processes, and their relationship to automatization of response, are amenable to direct examination using existing EEG brain mapping technology.

B. Improved Measurement of Neuroelectric Indices of Cognitive Processes

The second line of basic research is the development of better methods for the reliable recording of brain electrical activity. The goal is not just more accurate measurement, but measurements which reveals the educationally relevant cognitive processes of the brain. This second line of research will include on-going study of:

a. Most efficient system for electrode placement. This will include developing a prototype "helmet" placing electrodes automatically using a point in the center of the brain as the placement target, rather than surface scalp measurements. This helmet development will include research into "clean" low impedance solutions for good electrode contact. With the capacity of
topographic mapping it will be possible to precisely map the degree of error obtained in recording from inaccurate electrode placements. Arrays of electrodes can be closely packed on various areas of the scalp and the correlations of values for placements of different spacing easily computed. This will facilitate the development of a placement system which provides the maximum accuracy for localization of brain function within known error of measurement.

b. Development of systems for artifact detection and removal. Virtually all data contains potential muscle artifact confound. While it is likely to be impossible to remove all possibility of stimulus linked contamination of records, a system of separate muscle and movement detectors, combined with subtraction routines and post-hoc data selection will be developed for use with topographic mapping of brain data.

c. Exploration will continue with the optimal "reference" electrode system. There are several different systems of reference electrodes, none of which have been fully explored for their appropriateness with the application of topographic mapping. In particular, a system using an aggregate of all active electrodes as a reference electrode, while reducing average potential amplitudes, will remove considerable artifact and enhance viewing of differences among various electrode sites.

d. Exploration of better ways to screen out ambient interfering potentials. While there has been much work on this, the quality of the results is often disappointing. In particular, it will be
desirable to identify ways to minimize problems in "non-lab"
recording environments. The most promising approach is the develop­
ment of more efficient software based digital filtering systems which,
not only remove 60 cycle, etc. interference, but also can be used
in interactive combinations to remove common subject artifact
signatures.

e. FFT, ERP, CSA and Probe methods of data collection, while
needing further research, have been relatively widely used.
Gevins has done considerable work with the analysis of individual
epochs of raw EEG. Topographic mapping provides a window on single-
trial raw data analysis which will be explored for the most effective
methods of analysis and display - see below. In particular, patterns
of interaction (coherence, involvement, integration, etc.)
will be explored. Raw EEG analysis is by far the quickest and least
intrusive method of data collection. If appropriate methods can be
developed for the timing of data collections and analysis of the
results for subsequent display, a great many avenues and potential
breakthroughs await. As a piece of this project, research will be
conducted on the use of eye tracking instruments as a source of data
collection triggering. This will allow the direct examination of
processing associated with natural reading.

f. It can be assumed that when an area of the brain (for our purposes
an area can be defined as the pool which contributes to the data
recorded at an individual recording site) is involved in a cognitive
task the overall level of electrical activity in that area will be
altered from the condition when it is not involved in that task (at
rest). That involvement can manifest itself in 3 recordable forms: The level of positivity of that site relative to a reference can be increased; the level of negativity of that site relative to a reference can be increased; or, there can be a change in the frequency spectra produced in that area. Notice that a change that is of the pattern of positivity and negativity, but which leaves the overall charge relative to the reference electrodes unchanged can not be detected from a single electrode unless it produces a frequency change. With this in mind, it would seem appropriate that if one is engaged in a sustained cognitive activity the baseline electrical value of that area relative to the reference should change or the frequency should change or both. Again, note there are other possibilities, but there are, as yet no ways to detect them. If we were to sample repeated epochs of raw EEG and average all points in all samples, those areas involved in the task should show baseline shifts from a neutral state; or there should be frequency shifts. Limited exploration in our lab has shown promise for this technique. While the subject is engaged in a task, repeated samples of raw EEG are sampled and averaged. When this is completed, FFT data are collected. The subject is unaware of any collection. The data can be compared with control or other cognitive conditions. Research with this technique will show if it is practical and accurate. If it is it will provide the advantage of data recording while the individual is engaged in naturalistic activity, without the intrusions of the probe or the repetitions of the ERP.
Figure 20 - Sum of Baseline Values of EEG for BO while Learning a List using an Auditory Coding Strategy
Figure 21 - Sum of Baseline Values of EEG for BO while Learning a List using a Categorizing Strategy
Figure 22 - Sum of Baseline Values of EEG for BO while Learning a List using a Visual Imagery Strategy
Figure 23 - Sum of Baseline Values of EEG for BO while Learning a List using an Order Strategy
Figure 24 - Sum of Baseline Values of EEG for DD while Learning a List using an Auditory Coding Strategy
Figure 25 - Sum of Baseline Values of EEG for DD while learning a List using a Categorizing Strategy
Figure 26 - Sum of Baseline Values of EEG for DD while Learning a List using a Visual Imagery Strategy
Figure 27 - Sum of Baseline Values of EEG for DD while Learning a List using an Order Strategy
C. Personal Styles and Educational Relevance

There is considerable evidence of individual differences in cognitive processes. Discussion of the educational application of these results has ranged from the apocalyptic to the ridiculous, but seldom with reference to any confirming data. Using brain mapping technology it is possible to directly identify underlying differences in individual response to specific types of learning tasks and apply the results of these assessments to educational practice.

A first task would be to try to bring some order to the discussion of cognitive styles and learning styles. Using the basic research findings from the above, it will be possible to assess individuals in educationally relevant tasks, looking at performance and brain data. When this is combined with assessment on standard measures of cognitive style differences we can see which putative differences are attributable to similar neural processes and which represent real differences in processing style.

Once neural indices of cognitive styles differences have been identified and related to basic cognitive processes, we can study the degree to which these biases in processing can be altered in individuals. The literature and opinion on modifiability are often more revealing of the political position of the proponents than of the limitations or flexibility of individual processing. By having assessments of brain activity and of individual performance, both on specific tests of cognitive style and educational tasks it will be possible to monitor the effectiveness of interventions and more fully understand the limits of plasticity.
A parallel line of research will be particularly helpful in achieving the goals of the above. There are a great many special populations who "seem" to have significant differences in their cognitive processing, with corollary differences in their educational performance. By conducting systematic assessments of groups of these individuals with a standard battery of neuro-cognitive assessments it will be possible to gain valuable perspective on the findings from "normal" populations. Among those from whom these assessments will be especially valuable are: sub-categories of identified learning disabled, mentally handicapped, "idiot savants," congenitally profoundly hearing impaired, congenitally blind, individuals with attention deficits, individuals with exceptional abilities - prodigies, individuals with exceptional general ability - the gifted, individuals with known brain damage - aphasics, split brain patients, etc., categories of psychiatric patients with difficulties which may be educationally relevant - e.g. depressives, anxiety neuroses, etc.

When a sufficient fund of data is available on the differences in "cognitive style" and processing strategies, a concurrent program to identify cognitive skills necessary for success in various educational activities may be consumated. Part of the preemptive ethos of the educational community has been that there is only one way to learn any given subject matter - usually the way that the teacher learned it. Individuals who have explored their own cognitive processes, that of their friends, families, colleagues or students may know than there are many ways to do multiplication successfully, but that information has never been established in a way
which has had broad curricular impact. Once neural process characteristic of various "learning styles" have been identified it will be possible to take individuals who show skill in given subject matter areas and: 1, identify the types of cognitive processes which are characteristic of successful individuals vs. those less successful; 2, demonstrate the variability that exists in the processing of individuals who are able to be successful; 3, develop and evaluate curricula which provide greater access to those whose styles are not congruent with the prevailing demands of the conventional curricula. It should be noted that this does not mean that the teacher must be the one who will adapt, but may mean that we will identify, using research mentioned above, techniques for improving the cognitive style availability for an individual to have increased success in a given subject matter.

Accompanying this research into student variability in learning style would follow a parallel investigation of learning style of teachers of various subject matter areas and levels. The process by which one selects, or is selected, to be a teacher of a given subject at a given level is clearly biased toward specific types of cognitive and personal styles. By assessing the styles of teachers, using the confirming adjunct of neurocognitive assessment, it should be possible to assist teachers and those becoming teachers to better appreciate their cognitive biases and tolerate, if not fully understand or respond to, the variety of thought processes and strengths present in their students.
A next piece of this third area of basic research will be the development of a neurocognitive educational assessment battery which can be used for the direct assessment of the processing of individuals, most especially those with educational difficulties which are puzzling to teachers, parents or the individuals themselves. This battery would be developed from an array of tasks that have been shown to identify processing differences and their relationship to educationally relevant learning activities. By using a complex array of methods for the assessment of cognitive processing and by having a battery which can be used for the assessment of the performance of an individual specific to an educational learning activity, the assessment will provide information which can be useful in development of remediation and/or compensation, but be specific to resist the global application of diagnostic labels. The difference between saying that someone has an IQ of 92, and saying that the individual has difficulty with reading due to a deficiency in Wernicke’s area processing of a specific set of speech sounds, should be apparent. In the second case it could be viewed as analagous to finding out that you tire easily when you run because you breath incorrectly. You can work on developing a better method for the use of the resources you have. Any battery would be considered "never finished" to encourage continued responsivity to changing environment, learners and goals, as well as provide opportunity for "the assessed" to participate in the evaluation by task selection.

A final focus of this third area is the relationship of teacher behavior, characteristics and relationship to student and
learning. For there to be relatively rapid change in educational process, the attitudes and education of teachers would seem to be the optimal point of attack. To make significant progress in the morass of biases, theories, traditions, personal habits and political persuasions, it would be helpful to have some direct evidence of the effect of various teaching patterns and characteristics on both short and long term student learning. The data from topographic brain mapping may be helpful here.

For example, when we have identified indices of effective "attention" we can easily assess the effect of various teacher characteristics on the production of them - including individual differences. When we have identified the variety of forms that individuals learn and remember effectively we can explore more complex teaching strategies which increase aggregate effective attention - not just changes in "normative" individuals. When we have a better understanding of the neural basis of "structure" or "discipline" or "effort" or "responsibility" or "personal attribution", etc. we will be able to establish how we can better produce desired ends. When we know various indices to look for in brain activity it will be possible to evaluate long and short term effects of authoritarian teaching methods, nurturing teaching methods, etc. When we know more about the processes of automatization we can apply that not only to improved methods for accelerating instruction, but also the instruction of teachers. When we know more about the limits of flexibility in cognitive controls and abilities we can expend our effort more judiciously. And all these types of information can be applied
directly to the pre and in-service education of teachers.

2. Improved Data Analysis and Display

The power of topographic brain electrical activity mapping is its ability to convert the vast complex of information available in an EEG to a visual graphic of relative simplicity and persuasion. When this is combined with the use of cognitively and educationally significant tasks, the potential for bridging the gap between basic research and educational practice has never looked more promising. The danger lies in the temptation to utilize the resulting information in misleading and distorted ways. The prevention of this lies in the development of methods of data analysis and display which represent and clearly identify functionally significant cognitive events. Many important future developments will come as a natural consequence of progress in the research lines outlined above. Others will require considerable exploratory research and development.

At present there are three basic forms of data which result from EEG data collection: Raw EEG, Frequency analysis of the raw EEG (FFT), and Event Related Potentials (ERPs). Each of these types of data have been collected, observed, analysed and interpreted for a sufficient period of time to provide many researchers with the solace of familiarity. Yet within each form of data collection the computerized analysis and display options provided by topographic mapping and microcomputers quickly shake the comfort of old habits. Taking FFT data and the Bio-logic Systems Brain Atlas, it is possible to look at the data as power spectra for individual channels, to look
at whole brain maps for any .5Hz from 0 - 31.5 Hz, look at integrations of the activity of any size group of adjacent .5Hz bands, look at any of these for only the left hemisphere, the right hemisphere or the right minus left or left minus right, look at 4 maps of the traditional Alpha, Beta, Theta, Delta bands, look at grouped data from repetitions with a single subject (including maps of standard deviations), look at grouped data from several subjects, look at standard deviation maps of an individual collection vs. some "normative" group, look at differences between the collection and any other - either with the same subject or anyone else. And that doesn't even begin to discuss the types of tasks that you could use for FFT data collection. In addition to this, there is a program for the collection and display of Compressed Spectral Array data. This is just a different display of frequency analysed data. Data can be displayed as power spectra for individual channels with updates at specified periods, as numerical power data for any bandwidth you set, or as updating color bars representing the power in each of the selected frequency bands. While there exists a literature relating amount and distribution of alpha wave activity to cognitive involvement in the task, the topographic mapping work to date casts serious doubt on the generalizations that exist in these data. Given a full head's worth of frequency data analysed into a vast set of band possibilities, the need for further research to determine the optimal frequencies to display and the best way to display them should be clear.
The above considers only FFT data. Within ERP data the possibilities are at least as complex. The traditional ERP format repeats the same stimulus event some large number of time locked repetitions. The results are averaged and the resulting waveform assumed to indicate the electrical response of the brain to the event and/or task at hand. There exists unresolved debate on which components of the waveform are likely to be most revealing. Roy John’s Neurometrics looks at the very short latency events. Virtually all of the rest of the cognitive psychophysiology looks at the longer latency events. The existing literature does not have vehicles for looking at waveforms which are isolated from one another, except by the tasks that are assigned. Thus, especially in the long latency potentials there is much evidence that the observed potentials are aggregates of several neuroelectric events. The subtraction paradigm discussed above should allow a more direct look at the individual components. But in addition to the matter of which components of the waveform are pertinent, there are many methods of display and analysis which need to be examined.

The Probe technique assumes that fixed pools of neurons contribute to the potentials recorded at individual electrodes. When that pool of neurons is engaged in some cognitive task, less of the pool should be available to respond to some irrelevant stimulus occurring during the performance of the task. This has lead to the assumption that a probe stimulus will produce smaller response in those areas of the brain which are utilized in a cognitive activity—in proportion to the degree of involvement. There exists a modest and
growing literature supporting this conclusion. However, all these
data have been collected with a small number of electrodes—usually 4
or less, with a wide variety of reference systems, and varied types of
probes and probe patterns. In our preliminary work with topographic
mapping and the probe we have found that the neat picture appearing in
the literature is anything but neat. First, those peaks which are
studied (N1 and P2 usually) are normally of maximum amplitude at the
midline, while they are being used to assess lateralization of
function. Second, there is no a priori reason that these peaks should
be any more meaningful or indicative of shifts in cognitive processing
than any others—they just happen to be more prominent and more
easily measured. Third, we have found in many cases, including this
research, that the amplitude of response to the probe stimulus
actually increases in some cases rather than decreases. These
concerns suggest that this methodology, while promising needs
considerable examination before it is applied wholesale. The capacity
to produce topographic maps which integrate the activity over various
intervals of the ERP epoch has indicated that which segments and how
large the segments viewed with the probe significantly alter what is
seen. Of particular interest has been the finding that if the entire
epoch is integrated into a single map there appears to be an excellent
correspondance between the differential sites of activity, subject
reports of their individual strategies and known functional
localization of the brain. A major project in the application of the
probe will be to determine which way of examining probe data yields
the most useful information. This will be particularly fruitful after
the basic cognitive studies outlined above have been completed.

The findings from large latency integrations lead to the investigation of "no probe" analysis, mentioned above. While the preliminary investigation of this display technique is encouraging, there are many technical issues yet to be resolved. Is the level of amplification necessary to see differences sufficient to seriously lower the signal to noise ratio? How critical is the balance of the electrode impedances for accurate results? How much effect is there of slight variability in amplifier parameters? Will differential skull and scalp thicknesses and conductances prevent meaningful between subject comparisons? Even if these questions are answered it will take some work to decide the optimal number of samples that are to be averaged and integrated to get the maximum task effect, without averaging any baseline shifts down to the point where the residual noise overtakes the signal.

Raw data offers some interesting potentials with this research. Data is lost with all data manipulations. If the manipulation is designed to enhance the visibility of a signal which is embedded in noise, averaging or frequency analysis characteristic of ERPs and FFTs respectively are the vehicle. This clearly is the method of choice in seeking specific potentials or components which are neural indices of specific cognitive events. However, in making the transition to whole awake individuals learning in complex social environments the question of what is signal and what is noise becomes much less clear. Raw EEG, for all the difficulty of interpretation, is what the whole brain is doing in real time. The issue is how to
take the information that is there and identify the portions of it that are germane. One of the features which is becoming available in topographic mapping is the facility of taking the raw data, or analysed data, from all channels used and performing any type of statistical analysis one wishes on it. When that is completed, values can be re-entered for display as topographic maps. These are not displays of electrical potential values, but displays of values which may be derived from analysis of the data. For example, some might be interested in the degree to which areas of the brain correlate in their activity with other areas. Correlation coefficients could be computed so that "spatial coherence" measures could be displayed for any task as a topographic map. Preliminary observations with single trial, or low N averaged, data suggest that strong differences will show up with this type of analysis which correspond to individual differences characteristic of "learning disabilities."

The possibilities, using this basic, method are staggering. It would be possible to display data according to a virtually unlimited number of statistical manipulations. We could look at lag and lead correlations indicating patterns of movement of activity; we could display "degree of interaction" measures - of special interest to some would be those between the two hemispheres; we could look at average amplitudes (high and low), numbers of peaks and on and on. On one hand the prospects are cause of some doubt as to the speed with which optimal analysis and display methods may be determined. On the other, the speed and power of the current, and evolving, computerized analyses makes the task much more rapid than at first glance. It is
also the case that there is considerable guidance in the literature of psychology, neurology and education as to likely leads — especially those which have been inaccessible until this technology became available. The other thing that is important to keep in mind about this research program is that all data will be used in comparison with performance data. The issue is not what is the true meaning of wave form X? The issue is what is the relationship between specific patterns of brain wave activity and specific types of performance, in specific individuals or groups. In this way it should be possible to develop relatively simple methods for analysis and display of data which can make the points needed for the benefit of students, parents and educators — the persuasion of the dedicated quantitative researcher will take somewhat longer.

We are still displaying the data of the EEG in a fashion only slightly removed from the days of Hans Berger. In other sciences there exist a large number of methods for the enhancement of electrical signals of sorts analogous to those received in the EEG. Image enhancement techniques used in photographing the remote and the small; the techniques of the radio astronomers; the math used for resolving the physical chemist’s x-ray diffraction images, etc., all embody mathematics which may be extremely useful in enhancing the accuracy and interpretability of EEG data. The development of CAT scan, MRI, and PET scan techniques have greatly improved our biological imaging by the superposition of available math on existing data. Topographic mapping has done the same thing. It is important that we begin exploring the use of image enhancing algorithms on EEG
data. The finer the analysis we, the more accurate the statistical procedures will be.

It is particularly exciting to speculate on the possibility of using the array of data available from a full complement of scalp electrodes to generate a three dimensional image of the sources and movements of electrical activity. Though high levels of three dimensional precision may be difficult to obtain due to differences in various conductance and resistance parameters, visual examination of ERPs and topographic maps strongly suggests patterns of subcortical origins and movements of specific activity. There is little doubt that the application of available image enhancement and source location algorithms will be able to provide us a much improved image of the electrical activity of the brain.

3. Intervention Programs

Given the qualitative nature of human educational action, any successful use of the basic research information discussed above must be connected to actual educational practice. As indicated previously there is much lost by having information collected in one domain go forward without discourse with those areas from which the information comes and to which it is expected to apply. Thus, any successful research program must not only do the basic research which establishes the basis for effective action, but also be involved in educational interventions - current and future - which seek to utilize existing information and that gained from the on-going basic research. Research in The Brain Behavior Laboratory makes it very clear that without the perspective of educational practice and the subjective insights of the
individual learner, the interpretation of neurocognitive assessments is at best conjectural. At the same time, the insights from the neurocognitive research program are extremely valuable in the development and evaluation of programs of application.

Intervention programs will be focused on change in three groups:

1. Individual learners – of all age levels – including parents where appropriate
2. Teachers – Pre and In-Service
3. Educational Policy-Makers – including the whole array of politicians, administrators, curriculum developers and evaluators

The first of these will need to precede the second two to the extent that it will be much easier to persuade teachers and policy-makers of the value of the information derived from the research program if there exists a body of data establishing valued consequences from the application of that information. To the extent possible all levels of individuals will be involved in the research program at all times. There will be greater ease of application of any results if individuals at all levels and of all types have had some involvement in the development, planning and execution of the research program at all other levels (See Research Team below).

A. Individual Learners

The ideal intervention program would identify at a very early age those who need assistance and provide them with the experiences
enabling them to take full advantage of their potential later. This ideal is some way off. To get there requires answers to some developmental questions (e.g. must interventions of certain sorts wait until the attainment of specific levels of cognitive/neurological maturation?). It is necessary to get a better understanding of the types of skills that are valuable at various points in the educational process. This means that initial intervention efforts must look at groups of individuals at a variety of age and developmental levels who are engaged in a variety of types of educational tasks.

The model for intervention is based on the assumption that the strategy to produce maximum change in a short-term effort should:
1. Attempt to identify "rate limiters" and focus efforts on them, and
2. Focus attention on both the instruction in skills and information that will "enhance" learning capacity, and those personal characteristics whose presence will "enable" the individual to fully utilize the capacities he or she has. It is a guiding faith that those individuals with learning difficulties who, nonetheless, manage to be educationally and/or personally successful are able through some combination of factors to discover ways to utilize the strengths they have. In this regard the most successful interventions will be those that are able to produce the conditions from which the individual will be able to continue "self-development."

The program discussed here would make an adequate working model for an intervention program, but, foreclosure of options would be quite premature. Given the importance of context in effectiveness, the involvement of the teachers and learners in the development of an
optimal program may be a critical element in success (see Research Team below). The guiding principles for initial intervention efforts are three: One, provide the learner with information which gives heuristics, increases options, self-knowledge and self-monitoring; two, provide as much contextually relevant experience in the application of that information as possible; three, attempt to develop the maximum possible sense that each individual is a capable learner who can succeed with the proper application of their individual strengths.

The form that such a program takes will differ considerably with the age and learning goals of the individual. A pre-school individual with indications predictive of reading difficulty would be approached very differently, than an 8th grader, a college student, or a self-directed adult learner. The successful development of interventions depends on maintaining on-going programs with individuals of varied ages and keeping a flexible attitude. Initially work will be focused on 5 groups: 1 group of pre-school or beginning primary school; A group of late primary school - early middle school; A group from late middle school - early high school; a group from early college; and a group of adult learners. These are selected as a minimum number for getting a good cross-section of developmental processes. They are also selected as individuals who are at educational transitional points, as we now organize our schools.

While issues of sex, race, socio-economic class and community type are touchy, they are relevant to educational intervention. Initially research will be conducted from available populations. As
the program advances research will expand to look at individuals from various other traditional demographic categories. However, it is extremely important to note that the total orientation of this research program is on the development of understanding of individual differences in cognitive processes (not group differences) and the development of educational programs which can build from that information.

All experimental interventions will involve the collection of brain data and the utilization of that information as a part of the intervention. Until evidence accumulates to the contrary it will be assumed that this information will provide a powerful vehicle to convey information to individuals about their own cognitive processes, cognitive processes in general, and ways to enhance their resources and utilize them fully. As noted earlier, it is assumed that there is no distinction between educational research and educational intervention.

The evaluation of all intervention programs is problematic. Most research requires an immediate evaluation of the results and conclusions. This research is no different. However, the real test of the effectiveness of an intervention is the long term change in the learning of the participants. The short-term phase of the evaluation will look at changes in brain activity, using the procedures developed in the basic research program, self-evaluation, school performance, appropriate performance tests, and assessment devices which will look for changes in "cognitive style", attitude toward self as learner, self-awareness, knowledge of learning and personal cognitive
processes, and self-monitoring. Information from parents, teachers and other pertinent individuals will be included.

Long-term evaluation will begin with the short-term data and consist of follow-up with treated individuals. Evaluation can be repeated at appropriate intervals over a several year period. It is likely that some of the effects will be markedly augmented by subsequent "short-course" interventions. These will be tried and results evaluated in similar fashion. As additional data is utilized with teachers and educational policy-makers it is expected that changes will be possible (initially in demonstration projects) in school curricula and organization which can act as long-term interventions and be assessed with long-term evaluations.

B. Teachers

The recent history of education is littered with well intentioned innovations which have failed, at least in part, due to the failure to involve the teachers in the development and implementation of resultant programs. If there is one place where the greatest long-term change can be produced it is the pre and in-service education of teachers.

Pre-Service Interventions

Exposure to information about the brain's workings is an unlikely candidate for a central role in teacher education - as well it should be. It would seem folly to attempt to teach future teachers the subtleties of the brain's structure, functioning and the use of
recent technology in educational research. Yet, it is valuable to have teachers better prepared with information about the basic processes with which they work. The possibilities for new information pertinent to educational practice are strong enough that it would be a mistake not to make sure all future teachers have some exposure to the literature and methods which will be having an impact on future educational thought and practice. In this sense inclusion of information from brain research and basic research into cognitive processes would be an important part of any pre-service curriculum.

Perhaps more importantly, teachers are working in a time when there are tremendous conflicting pressures on them. The numbers of theories of instruction, curricula, positions on discipline, evaluation, etc. can be very confusing to any teacher. What is often missing from the preparation and support provided teachers is some authoritative information which they can use to confidently justify their teaching practices and intuitions. No teachers can teach successfully if they are constantly looking over their shoulders to see if they are doing what the book says they should be. No teachers can be effective if they feel unprepared to defend their actions.

The literature of teacher education shows that the lessons learned in pre-service education are primarily replaced by an interaction of the intuitive biases of the individual as they are found to "work" in the classroom, and the school context in which they find themselves. To the extent that we wish to have pre-service education have lasting value there needs to be a foundation of ideas and procedures which have a defensible authority behind them. History
makes clear that ideas and collections of research data to support them do not do the job. There are political forces which will always transcend the mere presence of good ideas, even with good data. One of the assumptions in the development of this research program is that we can begin to clarify some of the foundation assumptions about learning which are the basis of educational policy decisions and teacher behavior by providing direct evidence of brain function during educational learning.

It will be the practice of this program to have on-going research into the affect of brain research and data as a component of pre-service teacher education. In particular emphasis will be placed on the assessment of both attitude change and behavior change of prospective teachers over the periods from the beginning of their training through to the time where they are experienced teachers. It is expected that it will be of particular value to these individuals to have an opportunity to see data from the operation of their own brains in various learning and teaching contexts. In the same sense that it is considered valuable for psychoanalysts to have a training analysis so that they understand the relationship of their personal dynamics with those of their patients, it will be of great value for future teachers to understand their own learning patterns and biases so that they can consider these in working with their students — especially those whose patterns of strengths and weaknesses are very different from their own. A specific research program will focus on the impact of brain assessment information of the attitudes and teaching behaviors of pre-service teachers.
**In-Service Interventions**

One of the criticisms faced by teacher education, and teachers more generally, is that the field is "lacking a body of accepted research findings." It is clear that those levying this criticism are quite unaware — as, sadly, are many teacher educators — of the vast body of "generally accepted research" about learning, cognitive processes, social dynamics and processes, organizational processes, human development (just to mention a few of the most germane). In our desire to focus on the "relevant" in teacher education we have tended to teach most in those areas which are most subject to political assault (e.g. best method for classroom discipline, best method to teach fractions, etc.). We have not been able to accept that there may be a multitude of "best" methods, the appropriateness of which will depend on the particular context in which it is applied and the goals of the process. If we were to focus more on teaching basic information pertinent to education we would have greater success in seeing that information applied successfully in whatever context the individual taught. This criticism should be considered particularly pertinent in the case of the practicing teacher — who may have been teacher during the period of much of the basic research.

Most other professions (e.g. medicine, law, etc.) have the continuing problem of rapidly changing information which is basic to their skilled practice. They have evolved extensive systems (although some would say not extensive enough) of professional education.
Education has fairly elaborate systems of in-service training, teacher workshops, etc. However, relatively few of these have focused on basic information about underlying learning and thinking processes, and to the extent that they do, they tend to be so brief and so poorly articulated with the daily business of the teacher that the impact on sustained classroom practice is little (and may even be negative if the brief exposure tends to fragment the teacher's vision of the task or create self-doubt).

A successful in-service program must not only provide the teacher with information which is accurate and useful, but provide a continuing structure and support to assist in integrating that information into on-going practice. As a part of this research program there will be a program of in-service activities with teachers in selected school districts. Each of these programs will include formal instruction in the current state of information about the functioning of the brain and human cognitive processes, exposure to information which illustrates personal cognitive processes (including brain mapping) and the cooperative development of a long-term program for the enhancement of current educational practice to incorporate that information. Select districts will be used to insure that there is support for the effort from the principal, teacher, school board, etc. Evaluation will be in all the traditional ways, but will also include changes in teacher attitude, and in select cases assessment of changes in brain activity, cognitive and learning styles that may correspond to the program of activities or other assessment indices.
C. Policy Makers

It has never been considered seemly for researchers to view their role politically, except to the extent that there is politics in the gaining of research funding, professional publishing and organizational governance. Yet in research which seeks to promote a greater cooperation amongst all the participants, from basic researchers to social incorporation of the results of the research findings, it is imperative that the research program maintain continuing contact with policy makers and implementers. While it may be strained to call such contact "interventions" - that is exactly what they are: interventions in the information fund that these individuals use as the basis of their decision-making.

Policy makers come in many varieties and at many levels. We have everything from parents (note the origins of 94-142) to school boards, to curriculum developers and publishers, to officials in governmental agencies, to principals and superintendents, to elected governmental officials, to accreditation agencies, to professional associations, among many others. As indicated below in the discussion of the research team, involvement of individuals from all of these groups in the development of research ideas and programs for communication of the research findings is quite important. These individuals are not adverse to scientific information and tend to be flattered by invitations to participate in professional discussions. It is a relatively simple matter to invite participation at planning meetings, research presentations, symposia, programs developing implementation strategies, etc. This will be an important continuing
effort by those involved in this research program.

The major intervention effort will consist of involving these individuals directly in the research and data collection. As we establish a bit more experience in using brain mapping technology, we will have good ideas about methods for demonstrating underlying cognitive processes, differences in learning strengths, effects of learning interventions, differences in learning strategies and styles, etc. By having individuals from the policy making sector participate in the research as subjects we can, not only have them better understand the research and its findings, but see the actual differences in what their brain does in different circumstances and the differences in different individual's brain processes when successfully doing the same tasks. Over a moderately brief period of time it will be possible to accumulate a body of information which can illustrate the variety of relationships between the brain activity of individuals and their successful functioning in society. Though it would not be a primary goal of this program, I suspect that an appropriately assembled collection of "brain maps" of varied famous and successful people would have enormous impact on some of our attitudes toward "the right way to teach" and the "things that must be learned." To be sure collection of such a "file" would require the utmost care in what is collected and how the results are displayed. But the impact of the undoubted variety would, no doubt, be considerable.

The important characteristic of the policy maker intervention is the direct involvement of the individual in the research as subject
- having the opportunity to participate in the testing, see personal brain, maps and see the impact of relating those maps to insights about personal functioning. These individuals are all folks who are relatively "successful" in life and probably not an appropriate group for attempts to produce improvement in their ability to learn; however, the impact of seeing the brain maps as a tool for self understanding and the potential for the use of that information will not be missed. The ultimate goal of this intervention is to have the policy makers understand the research and the potential value of it as a result of personal involvement in it. This will enable the findings from the research to be more readily accepted and incorporated in a manner the body politic finds congenial.

**Research Team**

The effectiveness of this research program depends largely on the assembly of a research team which covers the range from the most basic research skills to the most general social interest in the application of the results. The assembly of research teams in recent years has occurred primarily either where the task was so big that a large group of technical specialists were required (e.g. much basic high energy physics research) or where the interdisciplinary nature of the research made necessary the involvement of specialists from the various related disciplines. Educational research - while it has its basic and its applied side, has a much broader range of participants in essential fields and has seldom included anything approaching the full range in its research projects. In part this could be attributed to the rather different "styles" of thought of basic cognitive
researchers, elementary teachers, school principles, teacher education professors and school board members (to mention a few). But if there are differences in the thought of these folks which make for difficulty in the communication of interests and information flow in a research team it does not speak well for the influence of the information from one group on the ostensibly related activities of another. While such a research team may be somewhat cumbersome and fractious, success in educational ventures demands that the effort be made, if only on a small scale initially.

The involvement of individuals from various disciplines and interests will work best as a relatively loosely structured "skunkworks." To the extent that there is a "policy board" which determines the specifics of the basic research effort, those with desire for concrete answers to traditionally phrased educational questions will retard that effort. To the extent that the basic researchers are able to determine what form their research will dictate for educational application, those who must do the application will be "out of their element." To be successful this research effort must give priority to each group of individuals in their own domain, but generate an environment of free and heated exchange of idea and opinion which is totally focused on the improvement of educational practice.

Another feature of most research teams has been the desire to find the best possible, and available, individuals for each piece of the task. Certainly in the world of high energy physics, biochemistry or design and construction of a space shuttle this is most wise.
However, in the conduct of educational research it is often necessary to work with whomever is available for now—meanwhile working to improve the resources. All school systems will be less than perfect. It is necessary to work with the full array. On the other hand, if one is seeking to make sophisticated technical adjustments in the optimal methods for data collection and analysis it is wise to have individuals who are fully conversant with the existing literature and skilled in the necessary techniques. Here there is an optimal balance. Many have observed that the specialists we have been producing in graduate schools and who appear as junior faculty have such exquisitely developed technical skills and knowledges that they easily and successfully pursue existing theoretical models and research paradigms. This is certainly not a blanket indictment, but suggests that the successful implementation of this research program, while it should never shun expertise, would be well to have the participation of "technical" experts who retain or have gained some perspective on their work, allowing them to work more effectively with the diversity of members on the team.

In some cases individuals with technical skills but totally lacking in any perspective on the totally of the project will be exactly what is needed. Many of the details of data collection and analysis require individuals of very high levels of sophistication in electronics, computer technology, computer programming, statistical procedure, etc. These people may be knowledgable about educational practice or psychological research, but it is not in any respect necessary to the project. What is needed are individuals who do
understand the scope of the project and can explain what is needed to
the technically skilled in a way which allows them to work
effectively. It is easy to imagine the need for some set of
electrical connections which an electronics wizard from some 8th grade
could provide much better than a skilled electronics technician who
has a set of limiting preconceptions about acceptable and appropriate
design. The assembly of a research team must keep a balance between
the expert, the creative and the social appliers of the results.

The team will require representation from all of the
following fields:
1. Neurology - anytime there is the evaluation of brain activity
of individuals there should be available the expertise of those
specialized in that evaluation.
2. Pediatrics - though not all research will be on children, much of
the most important research will have developmental issues as
central matters.
3. Cognitive Scientists - these may be psychologists,
anthropologists, artificial intelligence experts, psycho­
linguists, philosophers. They must be specialists in
subject matter research and methodology.
4. Electronics Technicians - complex equipment design and main­
tenance issues abound.
5. Computer Experts - this will include those facile in the design of
efficient computer systems to solve new and complex problems
and individuals skilled in programming those systems to perform
necessary functions.
6. EEG Technicians - The collection of data and the operation of the equipment during data collection require the availability of individuals with considerable skills and experience.

7. Statisticians - The analysis of collected data presents a multitude of complex statistical issues.

8. Psychiatrists/Psychologists/Counselors/Social workers - many of the issues surrounding successful intervention are as much involved with personal/family/social dynamics as they are with specific cognitive issues in educational learning.

9. Teachers - all types of teachers of all levels and all subject matters.

10. Educational Administrators - Principals, Superintendents and staffs have important insights into the implementation process.

11. Educational Politicians - School Board members, members of State Boards of Education, members of State Departments of Education, members of Education Committees of State Legislatures, representatives of Federal educational agencies, members of local, state, regional and national educational organizations should all be involved in the process. While this may seem to approach the unmanageable, the nature of this involvement is essential to any significant speedy impact on educational practice.

12. Parents - Understanding of learner characteristics and support for the development of effective utilization of strengths requires the support of parents. Parents are often especially helpful in providing information useful insights into the dynamics of individual learning patterns.
13. Teacher Educators - The information about learning which is given to future teachers about learning is critical to effective implementation of the findings of this research program.

14. Curriculum Developers - The structure of new curricula must include the information gained from this program. It is important that representatives of the publishing industry be involved. There is often the danger of premature application of half-baked results of research; however, involvement of individuals from these constituencies will both help the researchers understand the mechanics of implementation and the implementers understand the context into which they introduce their wares.

15. Learners - The most important participants are the learners who not only allow themselves to be a part of the research program, but, by their active participation in the interpretation of the findings and their insights into their own internal processes are essential to the advancement of the program. It is also critical that we realize that individuals do the vast majority of their learning under their own control - thus the learner's active involvement in the research, intervention and evaluation of its consequences are critical.

Such a group of participants will involve organization and the guiding direction of individuals who have a clear vision of the goals of this research program. Clearly not all of these groups of individuals will be involved in all pieces of the program - but they can never be far away. The key feature for any individual participant
in the program is a belief in the potential of the research. Not all of the participants need to be technical experts in anything. Not all need to be highly creative. Not all of the participants need to have "the big picture." They must be committed to trying to work with the others in the program to conduct research and development directed toward improvement of educational practice.

This work has suggested many starting points for research and applications. There is much to be done. We must reconcile the images in the half-silvered mirror. The tempting security of Narcos and Telos easily turn up the light on their sides of the glass. But in each of us resides our own keen eyed Oikos whose vision must be sought.

/Conclusion/

This research has been an exploratory venture into the realm of high-tech enhancement of self-knowledge in the service of educational goals. By its nature such a pursuit must draw on a multitude of disciplines and bodies of research. Many more areas for further research have been identified than have been foreclosed - self-knowledge is a complex multidisciplinary pursuit - as rich in opportunity for fertile synthesis as for data collection or analysis.

In spite of the hydra-like development and direction of this effort, the results have been far more encouraging than one might expect in such a quest. Hypotheses which were intuitively plausible but not well developed by the existing literature were confirmed. Basic methods of data collection were explored and found fruitful. School performance, manifest self-concept, attributional processes,
performance and brain data all showed concurrent movement in positive directions with a relatively minor period of intervention. It can only be hoped that this research will contribute to continued multi-disciplinary educational researches.
APPENDIX A

LEARNING SKILLS

The following are some principles which may help you improve your learning.

Most Important - Each individual is different. Each person has different abilities, strengths and weaknesses, different styles of learning, different past experiences, different interests, different motivations. It is not possible to say anything that is guaranteed to be important or work for all people. All things must be adapted to you and your past experience. The following are only some general principles and guidelines to help you think about the matter and alter some of your patterns for the better. There is no guarantee any of it is easy - there is no doubt the improvement is possible.

GENERAL PRINCIPLES OF LEARNING

Serial Position Curve - In any learning activity which has a beginning and an end, those things that are near the beginning will tend to be best remembered, those in the middle worst remembered (if at all) and those at the end better than the middle, but usually not as good as the beginning. In other words, your worst learning will be of those things which are in the middle. You should try to increase the numbers of startings and stopings and decrease the amount of middle to your study time. Do other things (see below) that will help you remember middles better.

Repetition Interval - Everyone knows that repetition of something improves your memory of it. But repetitions that are too close together or too far apart are of relatively little value. Repetition should be spread out so that you get the maximum benefit from the first time you do something (much learning goes on after you do something not just during) but haven't yet lost the memory of the first time. This means organizing your time, spreading out your repetitions to optimal intervals. There is no magic interval; it depends on you and what you are learning! Generally repetitions have to be closer together at the beginning and can get further apart as learning improves. Repetition by itself is very weak. Organization and association are much more important. Repetition mainly gives you another chance to associate.

von Restorff Effect - Things that are different will be remembered better than things that are more usual. But they must really be different to you in your recent experience to do any good.
This is one of the things that can be used to help improve middles. You attend to the usual and are better able to recognize it later. But it is very hard to think of things that are truly unusual for you. Thus the von Restorff Effect is hard to use intentionally.

Zeigarnik Effect - Tasks which are uncompleted will be remembered better than those that are finished - there will remain a tension to complete them which seems to improve memory. In a practical way that means that you are better off to start to study something with a big general question that you want to know the answer to, but which your studying probably won't entirely answer, than to start studying with the sole purpose of learning what you can.

Magic Number Seven Plus or Minus Two - Humans can accurately remember only about 7 things unless there is some organization to them. Memory is actually very poor - it is only organization and variety in what we perceive that allows us to remember the enormous amount that we do.

Categorization - Organization - Things in categories that are familiar to you will tend to be remembered better than things which are not organized in any way. Things can be organized in a variety of ways; on the basis of the physical characteristics (sound, shape, color, etc.), on the basis of a grammar you use to organize them, on the basis of some category of meaning or use, in order, related to a personal feeling, or in some other idiosyncratic way). In studying, the creation of categories for what you are learning and relating of those things to categories that are already familiar will make them much more permanent in your memory and more easily accessible later.

Association - It is important to remember the distinction between learning and retrieval from memory. Learning is really only a vehicle to have something be retrievable from your memory as you may need it later. Memory retrieval is based on associations - connections between situations you are in and your memory, and between the various things in your memory. The more associations you have for something the more readily you will be able to retrieve it from your memory later. Thus learning is an Active process of forming associations with what you already know will be much more effective than learning as a Passive process in which you just let yourself be bathed in the information or just repeat it. The definition of Meaning most commonly used by psychologists is the number of associations something produces. The more associations something produces, the more meaningful it is. More meaningful associations are remembered more easily. This active process of creating associations is called encoding.

Short-Term Memory, Long-Term Memory and Consolidation - We have at least two kinds of memory (maybe more, but at least two). Short-term memory is memory which has a small limited capacity and lasts a short time, fading away if nothing is done to move things from it into long-term memory. All new learning goes into short-term memory first, so an important part of effective learning will be improving transfer into long-term memory - memory which is stable, reasonably permanent and of virtually unlimited capacity. Two things
are important here. One, things that are associated with what is already in long-term memory move into long-term memory much more readily than things for which no such association is made. Any active processing of new things which makes associations with familiar memories will help. Two, there is a process which goes on after exposure to something which is important in getting short-term memories into long-term memory. This process is called consolidation. If you put some lumps of pineapple into a shape of a face in some jello and set it aside to jell, after awhile the jello would be firm and the pineapple pieces would remain a face. However, if you shook the container around before the jello had set, the pineapple pieces would be moved around and the face would be unrecognizable. Consolidation is a little like the setting of the jello. Things that have happened need a little time to consolidate without any disruptions if they are to enter long-term memory. Anything that happens after another event will tend to diminish the memory of the first event. Things to be learned tend to interfere with each other if they are close in time or if they are similar. If I write a sentence with no spaces and no punctuation it would be difficult to read, never mind remember.

So when you try to learn something you should make sure that you provide spaces and punctuation marks (little beginnings and ends). If you don't you will interfere with consolidation of that material.

Attention - Motivation - There is very little learning that occurs without attention to what is happening. Attention is directed by our past experience - what is in our long-term memories. You pay attention to what is interesting (meaningful) to you. If something is not interesting to you something must be done so you will learn it effectively. It is always worthwhile to take some time before starting any learning to consider why it is that you are about to learn this thing, what you expect to know afterward that you don't know now and (most importantly) how this material relates to things that are already important to you. This is easier if you know what's important to you. Something that is too familiar tends to be boring. Something too unfamiliar tends to be incomprehensible. The ideal is something which is somewhat familiar but novel enough to be interesting.

Much the same could be said of motivation. Motivation derives from one's past experience. If you are to be motivated to learn something it has to be something that is related to something that is already important to you. If it isn't, you must spend some time establishing those relationships before you will be able to learn it effectively. One additional aspect of motivation is how much of it you should have - Arousal. It is clear that you can have too little motivation and that you can have too much motivation. The optimal level of motivation is somewhere in the middle. Generally the simpler
the task, the higher the optimal level of motivation will be. With very complex tasks (like most textbook material) a relatively lower level of motivation is better — allowing greater time to understand, interpret and evaluate. As with the time interval for repetition, there is an optimal in the middle somewhere. As with repetition, there is no magic answer to the question, what is optimal. It is not hard to tell when you lack motivation — it is often harder to get yourself to do those things which can be done to improve it. A fairly good general guideline for too much motivation is — if you find yourself feeling anxious or rushed, you are probably too highly motivated and will not be learning efficiently. Plan ahead and allow yourself plenty of time.

Discriminative Stimuli — Specific stimuli tend to produce responses. The more responses you make to a specific stimulus or set of stimuli, the more difficult it will be to do any one of the effectively. If you sleep, study, drink, talk with friends, go berserk, etc. at different times in your room, you will find it relatively difficult to study in that environment. It is best if you have some specific stimulus or stimuli which are specifically associated with studying. Whenever they happen you study and nothing else. These can be particular locations or times or schedules, or states of mind or lots of other things. To be effective as a learner, there must be discriminative stimuli for learning. Effective retrieval of material from memory requires the use of discriminative stimuli for specific material. Unless things you learn are kept distinct with specific cues you use to get at the memories you will be confused when trying to remember, be unsure of what you remember, and forget. Forgetting is primarily due to interference between various similar things that you have learned which do not have discriminative stimuli which can be used as retrieval cues so that you lost the ability to remember them.

Reinforcement — Feedback — If you don’t know the consequences of what you do you don’t learn anything. Imagine trying to learn to draw a line 3 inches long without being allowed to measure the length of the lines that you drew. To learn there must be feedback — a test is another name for feedback. The best tests are those that you provide yourself or other forms that are not a part of a grading process — merely something which allows you to discover what you have learned. Testing yourself with questions, discussing with others who are studying the material, trying to do something with the things you are learning, suggestions of what you ought to do, all will be means of gaining feedback.

Positive feedback is when you find that you have learned something — something good happens as a result of what you learned. This is most commonly called reinforcement. The best reinforcement for learning is the satisfaction of feeling that you know something that is important. Much that you learn doesn’t seem all that important and other forms of reinforcement are felt to be necessary. Grades are one, but they are not always under control. You can provide yourself with reinforcements or you and your friends can do it
for each other. When you have studied effectively for a reasonable period, do something which you find rewarding. Not only will this provide some punctuation to your studying, but it will also make it so that you enjoy the studying more. Reinforcements work best when they are somewhat erratic and unpredictable, but they seem to keep happening. These Partial Reinforcements tend to produce much more regular persistent behavior and are probably the basis of what we usually call intrinsic motivation - doing it because you want to do it and not because of the reward that you expect to get at the end. It is hard - maybe impossible - to effectively put yourself on a partial reinforcement schedule. Others may be able to do it to you, but the best way to produce partial reinforcement is to let the periodic and unpredictable excitement you get from learning something new and interesting do the job. This works best if the task you define for yourself is to understand the big question - e.g. how does the mind work to produce human behavior, or how did American history make American what it is today, etc. By starting with the big question you not only set yourself up with the possibility of having unexpected (partial) reinforcements (insights), but you also use the Zeigarnik Effect, since you can never get the final answer to the big question - an uncompleted task.

Different Styles of Learning the Same Thing - There are a variety of different ways that different individuals will use to learn the same thing and different ways that the same thing can be learned by the same individual. It is a matter of some contention what difference it makes which way things are learned. It is worth your while to know that the different ways exist and some of what they may mean. The best learners know their strengths and switch their approach to whatever works best for them on a particular learning task.

Sensory Preferences - Different people seem to have different preferences (and abilities) to learn using one sensory system or another. Some people learn best from seeing situations. Some learn best from hearing someone talk about something. Some learn best from reading about it, etc. These preferences are worth keeping in mind in finding the most effective means for your study. As a general rule, the more senses you can involve in your learning the better you will learn it, regardless of which sense is primary. Imagery - projecting yourself into what you are learning - is very helpful.

Cognitive Styles - Individuals have different biases in how they perceive, interpret and think about the same thing. Some will consistently enlarge their perceptions of things. Some will consistently diminish their perceptions. Some will look for the broad general principles. Some will tend to focus on details. Some will look for patterns, some will look for isolated facts. Some will look for labels, some will look for relationships. Some will focus on people. Some will focus on things. As a general rule the more ways you are able to look at something, the better you will understand it and the better you will be able to remember it.
Episodic and Semantic Memory - We all seem to have the ability to remember details of what happened when and where and to whom (episodic memory) and to remember the meaning of what happened (semantic memory). There is considerable controversy about what these are, how they work and how they are related to each other. It is clear that individuals differ radically in their inclination to use one or the other type of memory and that the two types have different values for different types of learning. Most of the things mentioned elsewhere in this paper are of some value in developing your ability to use one or the other of these modes.

Right and Left Hemisphere Differences - There has been much interest of late in the differences between the right and left hemispheres of our brains. It appears that for the average person, the left hemisphere tends to be better at dealing with things logically, sequentially, deductively and linguistically; the right hemisphere tends to be better at dealing with things subjectively, intuitively, holistically, spatially, emotionally. The important feature of this for thinking about learning is that we can deal with things in a sequential, rational way or we can deal with them in a more simultaneous, intuitive way. There is no evidence that one or the other is necessarily better, but they are certainly different ways with different implications and applications. At present we know very little about how to engage one mode or the other voluntarily. Using both together is almost certainly better in most situations.

Frontal Lobes of the Brain - While not directly related to the discussion of learning, it seems appropriate to mention here that the portion of our brain which is primary distinction between humans and other creatures (large frontal lobes) is critical only for allowing us to create long-range complex sequential plans and then follow our own plans (self-monitor). We should use this to get the most of our human learning ability.

Metamemory - Strategies for Memory Improvement-Mnemonic Devices - Metamemory is what you know about how your memory works. Much of the preceding is in the form of metamemory material. The present evidence is that knowing about the ways in which your memory works has little, if anything to do, with getting your memory to work better. Memory improvement must be learned in the same way everything else is learned - by doing it and having it work. Memory strategies and mnemonic devices can and do work. But they are no instant miracles. Once you know what they are you must learn to use them and especially when and where to use which. These will be discussed in more detail in the section on memory improvement below.

Cycles of Efficiency - We all have periods where we can't seem to do anything, other periods when we feel as though everything is working perfectly. We now know that there are regular cyclic patterns of various physiological and behavioral functions. We don’t know too much about what causes them, how they interact in an individual, how flexible they are, etc. All cyclic patterns that have been studies can be modified - often with dramatic effects. "Night people" can become "morning people," and vice versa. At this point it
is probably best just to be aware of the patterns of your efficiency and to adjust to them. It is not wise to try to study at a time when you are 9/10 zombie. It is better to go do something else until "somebody is at home." Become aware of what you do which improves your efficiency — do it when you need to be efficient. Don’t work when you are being inefficient — you will just be learning to be better at being inefficient.

Different Types of Material — Different Intended Uses — There are many different types of things that we learn and many different uses to which we intend to put them. There are some radical differences between learning to ski and learning the causes of the American Revolution. Learning something so that it can be used for a multiple choice test is not the same as learning it so that you can use it as the need arises throughout your life. This is not the place to attempt to enumerate all the types of learning and intended used for them and detail all the differences inefficient learning. The truth is that we really don’t know the answers to most of the important questions you might ask. From what we do know, it again appears that the characteristics and dispositions of the individual may be more important than anything else in determining what will be most effective. Again, it remains important that you are sensitive to specifically what type of learning you are trying to do and what the intended use is.

Reading — A few general guidelines for reading may be helpful.
1. Divide your reading up into small meaningful units. Chapters are intended to be such units. Smaller units may be desirable. For most people more than an hour of continuous reading (especially of textbooks) is too much.
2. Make sure you are prepared to learn what you are reading before you start. Look over what you are about to read. Ask yourself some questions about what you expect to learn from it, what it is about, what it’s relationship is to other things that you know about or are interested in. Pick out the terms you see underlined or italicised and look them up in the glossary or a dictionary before you start.
3. Read — looking for answers to your questions, looking for things that you didn’t expect to find, looking for surprising information. As you read, write down words or concepts or ideas that you don’t understand. Underline, if you want, but keep it to a minimum.
4. When you finish reading think back over what you have read. Summarize it. Review your questions. Make sure you can answer them. Note those things that you learned that you were especially interested by or that were surprising or you didn’t understand. Go back and make sure that you understand all the things you wrote down — words, concepts, ideas that you didn’t know. You may also want to go back over lists you make of important names and date or other terms that might be pertinent.
5. A few days and/or a week or two later, go back over what you read. Review it, your underlinings and your notes. Refresh your memory and re-ask your questions in light of what has happened since.
Never read when you are having trouble concentrating. Always stop and do something else until you are ready to read with concentration or have figured out what you need to do to get ready to read. If you read when you are doing it inefficiently, not only do you learn little from your reading, but you learn how to read inefficiently and it will be easier to read that way in the future.

It may be particularly helpful to discuss your reading with another person who has read the same thing. Make sure that the discussion is an attempt to understand the material and not an attempt to guess what the professor will ask on a test or to show up the person you are studying with.

Writing - Some rare individuals may stumble blindly into becoming good writers, but for virtually all of us writing well is hard work. You can only become a good writer if you write and work very hard at improving the quality of what you have written. That means writing second and third and fourth drafts of your writing (you are reading a fourth draft). It means having people read what you have written and criticize it. It means spending the time to learn grammar, spelling and punctuation and using them in your writing. And it also means reading the writing of people who write well and noticing what they do. Much of what we learn we learn by imitating others - parents, friends, etc. The same is true of learning to write.

Note Taking - Note taking is an attempt to provide yourself with an aid to your memory. You can't learn something if you don't do it at least once. The danger in note taking is that it will interfere with your participating in the event the first time. In note taking less is generally better than more. There are three things that one can hope to accomplish by note taking. First, the act of writing down and looking at something that you have heard someone say or have read puts that thing into another sensory system and forces you to actively process in and convert it into your own words. The mere act of writing it down will tend to improve your memory of it, even if you never look at it again. This will be less true if you write verbatim and more true if you write it down in your own words. Second, there will be specific names, dates, terms, definitions, etc. that you will want to remember exactly. There should be one column of your notes in which you list these things along with the minimum verbatim detail necessary to assist your memory. Third, usually the hardest and most important part of a lecture or a piece of text is to keep the whole picture in focus. As you listen or read you want to try to convert what you are exposed to into an organized framework that makes sense to you. Your job is to provide the organization that will make the material meaningful. This should be one of the major things that appears in your notes - a framework which will allow you to recall the important elements of the reading or the lecture and their relationships. This can be done in a number of ways. The most common, and for most purposes probably the best is to make an outline. You should do this with the minimum of words - avoiding like the plague writing whole sentences. For material which is not well organized
when you are first exposed to it, an outline may work poorly. You may want to take note in a treelike fashion, where you add branches as new topics emerge from the material and add them to the appropriate part of the tree to make the whole thing most meaningful. Drawing diagrams or designs or pictures may help. Most importantly you should find a method of note taking which is comfortable to you and which is minimally intrusive in your listening or reading - your time is best spent understanding what is there, not just trying to write it down. You need to remember that the intent of notes is to act as cues for your memory - external memory. Those notes are best which will, with the least written, trigger the greatest and most accurate memory of the material that you are trying to learn. Since memory depends on organization, notes should be used to help organize learning and to trigger the systematic recall of that material later.

Efficient Use of Time - It is not so important how much time you spend studying as it is that you spend your time well. Some guidelines should be apparent from the preceding. Small blocks of time spread evenly over a long period of time are most efficient. Never try to study when you find you are doing it inefficiently. Study in a place where there will be a minimum of distractions (too quiet could be as much a distraction as too noisy). Have a set of cues (stimuli) which are discriminative stimuli for studying (preferably ones you create inside yourself). When they are there study, when they aren't get them there before starting to study. Always be prepared for studying before you start. If you are lacking motivation, solve that problem before you start.

Perhaps most important is to make a schedule for the use of your time and stick to it. Plan ahead! Nothing produces inefficient use of time as readily as a deadline that is too close. When you know what you have to do and what your deadlines are, plan an even distribution of your time which will spread out your work and give you plenty of time to complete the task.

There have been a number of studies of people who study at regular intervals spread evenly through school terms as opposed to people who do little until exam time and cram all their studying into a short intense period right before the exam. The performance of these two groups on exams is usually about the same. However, if they are tested a year later those who crammed know little if anything of what they learned, while those who spread out their studying tend to have retrained most of what they learned. If you only goal is to get a good grade, cramming may work. If you want to learn something that you can retain, you should more evenly distribute your study time.

Memory Improvement - As mentioned before there are a number of strategies for memory improvement. They can work. They all take work. A portion of what one learns in studying is material that is to be learned by rote - i.e. learned so that you can repeat it at the appropriate time, without necessarily understanding much about it. This is the sort of material most amenable to the use of mnemonic devices. Memory strategies work well with specific factual material, they tend to work less well, if at all, when the learning is
conceptual — general understanding. All of the memory devices have the following things in common. First, they attempt to make sure that you really pay attention to what you are learning by having you do something active with it — encoding. Second, they attempt to convert something that is essentially without associations to things you know into something which is intimately tied to something you know well. Third, they try to convert isolated things into parts of whole things that are more easily remembered — e.g. visual images, sentences, etc. Fourth, they all work only to the degree that they provide you with a means of searching for the memory and finding it — provide order to the learned material. The strategies are mostly attempts to get you to store things in your memory in such a way that you will have easy access to them in the future. There are a number of books that describe various memory improvement systems in detail. All will work. All will take considerable effort and practice to be mastered. I would recommend either of the following:

Cermak, Laird, Improving Your Memory
Lorayne, Harry and Lucas, Jerry, The Memory Book

Both are readily available in bookstores and in paperback.
Appendix B

Psych 100 - Protocol

Disk 1

FPT Run
1. Eyes Open
2. Eyes Open
3. Eyes Closed
4. Eyes Closed
5. Counting Backward by 3s from 462
6. Recall a Pleasant Experience
7. Solving a Maze - (page 37 - Scrambled Exits) - Do Not Write in Book
8. Draw a Face
9. Read - (Start page 21 - The Brain)
10. Read Aloud - Continue from wherever they got to

ERP Run
1. AEP P300 Ratio 4:1 Maximum Stimuli #2 = 30 #1 #2 #projects
2. AEP P300 Ratio 4:1 Maximum Stimuli #2 = 30 #1 #2 #projects
3. AEP - Baseline Staring Ahead - Maximum Stimuli = 100
   Make sure to hit A (allocate banks) and 1 after finishing
   the P300 and before doing run 3.
4. Learn a list using an Auditory Code - Maximum Stimuli = 50 #projects
5. Learn a list using Categories - Maximum Stimuli = 50 #projects
6. Learn a list using visual imagery - Maximum Stimuli = 50 #projects
7. Learn a list making a story of words - Maximum Stimuli = 50 #projects
8. Learn a list in order - recall in order - maximum stimuli = 50 #projects
9. Learn Free Recall List - any strategy - Maximum Stimuli = 100 #projects

Disk 2

ERP Run
1. Consensed Figures (Closure Flexibility) Test - Max = 100
   Record # 5 Given # Rejects # Total
   # 5 Averaged # Rejects # Total
2. Mental Rotations
   # 3 Averaged # Rejects # Total
3. Card Rotations
   # 3 Averaged # Rejects # Total
4. Figure Rotations
   # 3 Averaged # Rejects # Total
5. Read Passage for Gist
   # 3 Averaged # Rejects # Total
6. Read Passage for Main Idea
   # 3 Averaged # Rejects # Total
7. Read Passage for Facts
   # 3 Averaged # Rejects # Total
8. Read Passage for Analysis
   # 3 Averaged # Rejects # Total
9. Read Passage for Run
   # 3 Averaged # Rejects # Total
10. No Probe - Baseline Starring
    Type of Stimuli - None
    Max = 100,
11. No Probe - Reading Silently
    Max = 100
<Action of the Review Committee>

With regard to the employment of human subjects in the proposed research protocol:

85B0143 NEUROCOGNITIVE STUDY OF LEARNING, Marlin L. Langus, Educational Theory & Practice

The Behavioral and Social Sciences Review Committee has taken the following action:

- **Approved with conditions**
- **Waiver of Written Consent Granted**

* Conditions stated by the Committee have been met by the Investigator and, therefore, the protocol is APPROVED.

It is the responsibility of the principal investigator to retain a copy of each signed consent form for at least four (4) years beyond the termination of the subject's participation in the proposed activity. Should the principal investigator leave the University, signed consent forms are to be transferred to the Human Subject Review Committee for the required retention period. This application has been approved for the period of one year. You are reminded that you must promptly report any problems to the Review Committee, and that no procedural changes may be made without prior review and approval. You are also reminded that the identity of the research participants must be kept confidential.

Date: December 6, 1985
Signed: Theodore J. Kaule
(Chairperson)
Appendix C

BIOMEDICAL SCIENCES
HUMAN SUBJECT REVIEW COMMITTEE
THE OHIO STATE UNIVERSITY

Meeting Date: November 18, 1985

RESEARCH PROTOCOL:

81110312 OSU MULTIDISCIPLINARY TEAM FOR RESEARCH IN LEARNING AND HUMAN DEVELOPMENT - COGNITIVE PATTERNS AMONG DEAF, LEARNING DISABLED, EDUCABLE MENTALLY RETARDED AND NORMAL PERSONS: AN EEG AND EYE MOVEMENT PATTERN STUDY - (NEUROCOGNITIVE STUDIES IN LEARNING), Martin L. Languis, Educational Theory & Practice

presented for review by the Biomedical Sciences, Human Subject Review Committee to ensure the proper protection of rights and welfare of the individuals involved with consideration of the methods used to obtain informed consent and the justification of risks in terms of potential benefits to be gained. The Committee action was:

Protocol was unanimously APPROVED WITH THE FOLLOWING STIPULATION:

Provide an updated progress report to the Committee.

Your approval is contingent upon your agreement to comply with the above stipulations. Please SIGN this form in the space(s) provided and RETURN WITH ANY ADDITIONAL INFORMATION REQUESTED TO ROOM 205, THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION, 1314 KINNEAR ROAD, "CAMPUS," within one week. Upon such compliance, the approval form will be mailed to you. In the case of a deferred protocol, please submit the requested information at your earliest convenience.

Date____________________________ Signature(s)____________________________

HS-105 (3/85)
Stipulations/Comments

(Principal Investigators)
Appendix D

PROPOSED RESEARCH AT ____ MIDDLE SCHOOL

DAVID B. ANDREWS
College of Education
Dept. of Theory and Practice
The Ohio State University

Purpose: Explore the use of neurocognitive information as an adjunct to the teaching of generalizable learning skills in middle school students

Subjects: 8th graders from ____ Middle School, __________, Ohio

6 students will be selected who are having difficulty in performing successfully in school

6 students will be selected who are performing successfully

Plan: Each of the six students who is experiencing difficulty will be given a complete neurocognitive assessment in the Brain Behavior Laboratory, 488 Nisonger Center, McCampbell Hall, The Ohio State University. This assessment will consist of an EEG using the Bio-logic System Corporation, Brain Atlas for Topographic mapping of brain electrical activity while involved in tasks requiring various educationally relevant cognitive skills. In addition, each of these individuals will be evaluated using experimenter develop assessments of concept of self as learner, knowledge and utilization of learning strategies, self-monitoring, metacognitive knowledge and actual learning performance. Standardized test scores for each individual will be collected from the Guidance Office personnel. Second grading period grades will be collected. Teachers will be requested to complete an evaluation of student attitudes, strengths and weaknesses.

During the third nine week grading period, each of these individuals will be given both group and individual instruction on learning skills and strategies which are appropriate, based on the pre-tests and the neurocognitive assessment. This instruction will involve direct exposure to the information gained from the neurocognitive assessment and the active utilization of that information in the development of metacognitive knowledge and learning skills appropriate to each individual’s identified strengths and abilities. Instruction will be given in specific school related learning skills such as reading, writing, notetaking,
memorization and comprehension strategies. More central to
the instruction will be the development in each student of
the nature of learning as they do it and a set of
generalizable self-knowledges and skills which will produce
more effective utilization of the abilities of each student.

At the end of the third nine week grading period, each of these
students will have a second neurocognitive assessment at the
Brain Behavior Laboratory and a post-test of the other
assessments, including learning performance. In addition,
the grades from the third grading period will be collected,
as well as teacher evaluations of changes in student
performance and attitude.

During the third grading period, the 6 other students will be
given neurocognitive assessments and performance tests.
These tests will be solely for comparison with the
experimental group. There will be no instruction in learning
skills for this group. This approach is based on the
assumption that those who are successfully have found means
of effectively using their strengths while those who are not
performing effectively have been unable to develop skills and
strategies which most effectively utilize their abilities or
compensate for their weaknesses.

Consultation with the School: This proposed research has been fully
presented to Mr. Grawen, Principal, and Dr. Quaranta, 8th
grade guidance counselor at _____ Middle School. They were
enthusiastic about the research and what it could offer to
both the students and to them in working toward developing
improved learning skills in all of their students. Both
offered to be of whatever assistance they could in expediting
this project. In addition, a presentation of some of the
neurocognitive assessment to be used in this research was
given to approximately one third of the eighth graders at
_____ Middle School. Both their teachers and the students
were very interested in further participation in this
research and information about it.
Appendix E

Dear Parent,

Your child has been selected for participation in the project described in the attached materials. Please read the materials carefully. If you have any questions about the project or your child’s participation, please feel free to contract me for further information. If you are willing to have your child participate in this project, please sign the enclosed participation form and return it to Dr. Quaranta at ______ Middle School.

One of your questions may be, "why was my child selected?" The answer to that question will vary from child to child. The goal of the project is the development of procedures to assist all individuals in improving their learning by helping them to understand their learning better. All of the children being asked to participate have been selected with the assistance of the Guidance staff at ______. The general guiding principle has been to identify individuals who, for any one of a number of reasons, are perceived as capable of learning better than they are currently. It should be emphasized that this judgment may not be correct in all cases, it was a judgment used in the selection of children. Beyond that judgment, selection was made at random. It is the intent of this program to develop programs which can be of use for all learners, not those with any particular strength or weakness.

The scheduling of the project will be worked out with those who agree to participate. As much as possible activities will be conducted during school time. If other times are necessary, I will assume responsibility for transportation of your child as may be necessary or convenient. The assessment of brain activity at the Brain Behavior Laboratory at OSU will almost certainly have to occur by individual arrangement at mutually convenient times. All arrangements will be worked out with you, at your convenience, and in advance.

I look forward to your child’s participation.

Sincerely,

David B. Andrews
2532 Scioto View Lane
Columbus, OH
43221
488-3962 - home
422-1717 - work
Appendix F

Brain Behavior Laboratory - Cognitive Neuropsychological Assessment

Brain Behavior Laboratory
488 McCampbell Hall - Nisonger Center
The Ohio State University
Marlin Languis, Director

The Brain Behavior Lab is a multidisciplinary research center investigating the relationship of nervous system activity and the cognitive processes of individuals. The research program of the lab seeks an understanding of the neural basis of various personal and psychological characteristics from which programs can be developed to improve individual adaptation and learning. At present there are research programs underway or beginning which deal with: identification of early signs of learning disabilities and the development of programs to head off learning and reading problems in schools; studies of individuals who have abused substances to attempt to gain a better understanding of the problem and the appropriate way to assist each individual in recovery, studies of writing which can lead to programs for improved composition, studies of college learning disabled students to assist them in identifying their learning strengths, studies of individuals who have difficulty with math, studies of the effects of different strategies on individual reading, learning and comprehension, a study of depressed individuals, studies of various types of learning and the brain processes which underlie them, among many others.

The general goal of the activities is to gain an understanding of brain processes which can help the individual understand him/herself and develop effective methods of utilizing personal strengths.

Our major research tool is the Bio-logic Systems Corporations Brain Atlas II. This instrument permits the recording of electrical activity of the nervous system and the conversion of that information into color coded brain maps. These maps may be used to look directly at the types of brain activity that an individual has in a wide variety of tasks. While this technology is rather new, early work has shown that it is possible to show substantial differences in these brain maps with very slight differences in the ability, strategy or attitude of an individual. These differences are useful in gaining insights into the basis of individual action. The maps are dramatic and can easily be used with people who have virtually no technical knowledge to increase their understanding of their own thought processes and the basis for their actions. Thus, they gain added potential for self-control.

An assessment session at the Brain Behavior Lab takes between 2 and 3 hours. Each session consists of a familiarization with the research and the equipment that will be used in the assessment. The attachment of 19 small sensors used to record the electrical
activity of the brain. Only electrical activity coming out of the brain is recorded, none is put in. Each sensor is placed at a measured spot on the scalp using an electrically conductive paste. A variety of stimuli will be presented to each participant - tones through earphones, various visual displays, etc. - to some of which the individual is to make responses - e.g. pushing buttons. The electrical activity of the brain during these tasks is stored for further analysis. The recorded data is reviewed with the individual at the completion of the session. Each participant will be given a brain map to take home.

At this point in the research we are looking for possible brain factors related to specific patterns which can help individuals in best adapting their abilities to the situations at hand. It is not possible, yet, to give definite diagnoses and prescriptions for individuals. Assessed individuals will be contributing, both with their brain activity and with their personal insights to the improved understanding of human thought and action. All individuals who are assessed are free to remain in touch with the Brain Behavior Laboratory for further information as it becomes available or to continue participation in the research program.
Appendix G

Information for Parents on Participation in Learning to Learn Research

The following information is to help you understand the research project in which your child is being asked to participate. It should be understood that your child's participation is entirely voluntary and may be discontinued by you or your child at any time without question. This research is being conducted in the hope of developing better learning skills in your child and to gain knowledge of ways to produce the same results in other students. While your child will be asked to take some tests as a part of this project, the main thrust of the research will be a 9-week long course of learning skills improvement designed to identify individual strengths and weaknesses and teach all participating children strategies for understanding and utilizing their strengths effectively.

Experimenter: David B. Andrews  Parent of Ethan Andrews-8th grader at

2552 Scioto View Lane
Columbus, OH 43221
488-3962 (home)
422-1712 (office) - The Brain Behavior Lab at OSU

I am a native of Columbus who has been teaching psychology at Keene State College in Keene, New Hampshire for 16 years. I am currently completing a PhD in the College of Education at Ohio State.

Goal of the Research: There are many approaches in use which attempt to improve learning. This project seeks to see if the use of direct information about the brain activity of individuals, collected during various learning tasks, can provide a more effective basis of instruction, and produce a more positive response of each individual to the instruction by their direct participation.

Schedule: The research will begin in January and be completed by early April. It will correspond roughly with the third grading period.

Participants: 6-10 eighth grade students from Jones Middle School. Brain assessment may be conducted with other individuals, but the course in learning skills will be for just this group.

Specific Activities: This project will be both a research project and a course designed to teach improved learning skills to the students who participate. The specific thrust will be to explore the utilization of information about the electrical activity of the brain of the individual as a piece of the instructional program. It is often the case that more effective learners better utilize their
strengths in adapting to the situation and task at hand. It is possible to directly assess brain activity of an individual during various learning tasks and to utilize that information to assist each learner in gaining understanding of their own learning strengths and thus a better attitude toward them and adaptation of them in their own learning.

1. Each individual participating in this project will be scheduled to come to the Brain Behavior Laboratory at Ohio State for a neurocognitive assessment—see attached sheet for information on this assessment.

2. Each individual will be given a number of paper and pencil tests—some group and some individual—assessing their cognitive style, their attitudes toward themselves as learners, their knowledge of learning and effective use of it, and some brief tests of learning. Records of standardized test performance will be obtained along with 2nd grading period grades.

3. A program of learning skills development will be conducted for all participants—partly in a group, partly individual—during the entirety of the 3rd grading period. This program will be conducted by the experimenter and will include:
   a. some discussion of general principles of learning and memory
   b. discussion of learning styles—including the variety of ways in which effective learning occurs
   c. group discussions of different approaches to learning
   d. individualized instruction in specific learning strategies and skills
   e. group and individual instruction in specific skills appropriate for school success
   f. examination of their brain assessment and paper and pencil tests and use of this information in the development of appropriate individual learning approaches

4. A post test will be given on the various paper and pencil tests used at the beginning of the course. Third grading period grades will be collected.

5. A second assessment will be conducted at the Brain Behavior Laboratory to look for changes in brain functions resulting from the specific instruction.
6. A specific set of proposals for continued work and improved learning will be drawn up for each individual with a copy given to the parents and to the administration at ____.

7. A proposal for a program of learning skills instruction for Jones Middle School will be given to the ____ Administration.

8. Results of the research will be made available when data analysis has been completed.

Participation of your children in this project will be greatly appreciated. If you have any observations, thoughts, suggestions, criticisms or questions at any time during this project do not hesitate to get in touch with the experimenter directly or through the staff at ____.
Appendix H

Parental Permission for Participation in the Learning to Learn Project

The attached slip should be signed and returned to Dr. Quaranta at your earliest convenience. If you have any questions about this project or your child's participation in it please feel free to call David Andrews 422-1712 (days), 488-3962 (evenings or weekends).

_________________________ has my permission to participate fully in the Learning to Learn Project. I understand that my child will be scheduled at a mutually convenient time for two trips to the Brain Behavior Laboratory at OSU for neurocognitive assessment using an EEG (electroencephalogram); that the experimenter will be given access to my child's school records, including grades, standardized test scores, and any individualized testing which may have been done for diagnostic purposes; that the student will receive a series of additional testing at the beginning and at the end of the project; that the project will include both individual and group activities teaching learning skills over a period of 9 weeks. I understand and agree that my consent and the participation of my child is entirely voluntary and may be discontinued without question at any time.

_________________________ (parent)
Appendix I

Learning Skills Program

This program is intended to help you understand how you learn so that you can do it better. You will have an opportunity to learn more about learning, learning ways to improve learning in the places where you want to, and learn about what your brain does while you are learning.

Schedule of Activities

Meeting One: Group meeting with David Andrews to discuss the Program, answer questions and fill out a brief questionnaire.

Meeting Two: Individual Meetings with David Andrews to discuss your personal learning habits, strengths and weaknesses - find out what you would like to change.

Meeting Three: Trip to the Brain Behavior Lab at Ohio State for measurement of brain electricity during learning and other tasks. Time will be available to go over brain maps at the end of that session.

During the remainder of the third grading period we will try to have one group meeting and one individual meeting. The group meetings will be to talk about learning and different general techniques to improve it. The individual meetings will be to work on things that are specific interests of each person.

At the end of the third grading period a second trip to the Brain Behavior Lab will be scheduled. There will be some brief questionnaires at the end to assist in evaluating this program.

A report will be prepared for each individual on what the brain assessments show and suggestions for learning improvement.
Appendix J

Learning Skills Questionnaire

What subjects do you think you learn best?

Why do you think you learn these best?

What subjects do you think you learn worst?

Why do you think you learn these best?

About how much time do you spend on homework each night?

When you are having a hard time understand something or finishing a homework assignment what do you do to try to help?

Rate each of the following:

How easy is it for you to pay attention in class?

1 2 3 4 5 6 7
very hard very easy

Overall, how good a learner do you think you are?

1 2 3 4 5 6 7
very poor very good

How well do you think you organize your study time

1 2 3 4 5 6 6
very poorly very well
What kinds of things in school do you find most interesting?

When you have free time, what things do you like to do the best?
Appendix K

NAME__________________________

LOCUS OF CONTROL SCALE

1. Do you believe that most problems will solve themselves if you just don't fool with them?  Yes No
2. Do you believe that you can stop yourself from catching a cold?  Yes No
3. Are some kids just born lucky?  Yes No
4. Most of the time do you feel that getting good grades means a great deal to you?  Yes No
5. Are you often blamed for things that just aren't your fault?  Yes No
6. Do you believe that if somebody studies hard enough he or she can pass any subject?  Yes No
7. Do you feel that most of the time it doesn't pay to try hard because things never turn out right anyway?  Yes No
8. Do you feel that if things start out well in the morning that it's going to be a good day no matter what you do?  Yes No
9. Do you feel that most of the time parents listen to what their children have to say?  Yes No
10. Do you believe that wishing can make good things happen?  Yes No
11. When you get punished does it usually seem it's for no good reason at all?  Yes No
12. Most of the time do you find it hard to change a friend's (mind) opinion?  Yes No
13. Do you thing that cheering more than luck helps a team to win?  Yes No
14. Do you feel that it's nearly impossible to change your parent's mind about anything?  Yes No
15. Do you believe that your parents should allow you to make most of your own decisions?  Yes No
16. Do you feel that when you do something wrong there's very little you can do to make it right?  
Yes No

17. Do you believe that most kids are just born good at sports?  
Yes No

18. Are most of the other kids your age stronger than you are? Yes No

19. Do you feel that one of the best ways to handle most problems is just not to think about them? Yes No

20. Do you feel that you have a lot of choice in deciding who your friends are? Yes No

21. If you find a four leaf clover do you believe that it might bring you good luck? Yes No

22. Do you often feel that whether you do your homework has much to do with what kind of grades you get? Yes No

23. Do you feel that when a kid your age decides to hit you, there's little you can do to stop him or her? Yes No

24. Have you ever had a good luck charm? Yes No

25. Do you believe that whether or not people like you depends on how you act? Yes No

26. Will your parents usually help you if you ask them to? Yes No

27. Have you felt that when people were mean to you it was usually for no reason at all? Yes No

28. Most of the time, do you feel that you can change what might happen tomorrow by what you do today? Yes No

29. Do you believe that when bad things are going to happen they just are going to happen no matter what you try to do to stop them? Yes No

30. Do you think that kids can get their own way if they just keep trying? Yes No

31. Most of the time do you find it useless to try to get your own way at home? Yes No

32. Do you feel that when good things happen they happen because of hard work? Yes No
33. Do you feel that when somebody your age wants to be your enemy there's little you can do to change matters? Yes No

34. Do you feel that it's easy to get friends to do what you want them to? Yes No

35. Do you usually feel that you have little to say about what you get to eat at home? Yes No

36. Do you feel that when someone doesn't like you there's little you can do about it? Yes No

37. Do you usually feel that it's almost useless to try in school because most other children are just plain smarter than you are? Yes No

38. Are you the kind of person who believes that planning ahead makes things turn out better? Yes No

39. Most of the time, do you feel that you have little to say about what your family decides to do? Yes No

40. Do you think it's better to be smart than to be lucky? Yes No
Appendix L

School Locus of Control

Pick a school assignment in which you got a good grade

For each pair below, pick one and circle it

I got a good grade because
1. I tried hard or I was lucky
2. I was lucky or I was clever
3. It was easy or I tried hard
4. I was clever or It was easy
5. It was easy or I was lucky
6. I tried hard or I was clever

Pick a school assignment on which you got a poor grade

For each pair below pick one and circle it

I got a poor grade because
1. I didn’t try hard or I was unlucky
2. I was unlucky or I wasn’t clever
3. It was hard or I didn’t try hard
4. I wasn’t clever or It was hard
5. It was hard or I was unlucky
6. I didn’t try hard or I wasn’t clever
### Appendix M

<table>
<thead>
<tr>
<th>Free Recall List</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folk</td>
<td>Car</td>
</tr>
<tr>
<td>Blade</td>
<td>Huron</td>
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<tr>
<td>Spoon</td>
<td>Basketball</td>
</tr>
<tr>
<td>Cut</td>
<td>Door</td>
</tr>
<tr>
<td>Sharp</td>
<td>March</td>
</tr>
<tr>
<td>Slash</td>
<td>Bus</td>
</tr>
<tr>
<td>Stab</td>
<td>Erie</td>
</tr>
<tr>
<td>Slices</td>
<td>House</td>
</tr>
<tr>
<td>Blood</td>
<td>February</td>
</tr>
<tr>
<td>Horse</td>
<td>Lock</td>
</tr>
<tr>
<td>September</td>
<td>Coat</td>
</tr>
<tr>
<td>Table</td>
<td>West</td>
</tr>
<tr>
<td>Golf</td>
<td>Bus</td>
</tr>
<tr>
<td>Table</td>
<td>Squash</td>
</tr>
<tr>
<td>North</td>
<td>June</td>
</tr>
<tr>
<td>Log</td>
<td>Smoke</td>
</tr>
<tr>
<td>Night</td>
<td>Key</td>
</tr>
<tr>
<td>Superior</td>
<td>Lock</td>
</tr>
<tr>
<td>Pig</td>
<td>Sheep</td>
</tr>
<tr>
<td>Desk</td>
<td>December</td>
</tr>
<tr>
<td>Tennis</td>
<td>Ping Pong</td>
</tr>
<tr>
<td>Hot</td>
<td>Lion</td>
</tr>
<tr>
<td>January</td>
<td>Saw</td>
</tr>
<tr>
<td>Desk</td>
<td>Paint</td>
</tr>
<tr>
<td>Grass</td>
<td>Pin</td>
</tr>
<tr>
<td>South</td>
<td>Thimble</td>
</tr>
<tr>
<td>Michigan</td>
<td>Syringe</td>
</tr>
<tr>
<td>Handball</td>
<td>Haystack</td>
</tr>
<tr>
<td>April</td>
<td>Thread</td>
</tr>
<tr>
<td>Cow</td>
<td></td>
</tr>
</tbody>
</table>
INTERNATIONAL (10-20) ELECTRODE PLACEMENT

LEFT SIDE OF HEAD

RIGHT SIDE OF HEAD

Bio-Logic Channels

HEAD DIAGRAM

INTERPOLATED CHANNELS ARE DISPLAYED IN GREEN
Appendix 0 - Brain Behavior Lab Log Form

Name:
Phone:
Sex:
Age:
Major:
Easy Subjects:
Hard Subjects:

Information Location:  Consent From:
Handedness Test:
History:
Debriefing:
Test Results:
Ink Record:
Protocol:

Comments:
Brain Behavior Laboratory

Edinburgh Handedness Inventory (modified)

Family handedness (left handed relatives)

Father    Mother
Brother/sister Sibling(s)

1. (back side) write your name
2. (back side) draw a happy face
3. open this box
4. show me how you would throw this ball
5. show me how you would use these scissors
6. show me how you would use this toothbrush
7. show me how you would cut cheese with this knife
8. show me how you would use this spoon
9. show me how you would strike this match
10. show me how you would open this jar
11. show me how you would use this tube if it were a telescope
12. show me how you would look through the hole at this "X"
13. I'm going to whisper something to you softly; close your eyes, you may turn your head to hear better if you like, repeat what I whisper
14. use this broom
15. kick a football (simulate)
16. step on a bug (simulate)

PERSONAL INFORMATION

A. State of well being ( ) excellent ( ) average ( ) fair record any current illness

B. Sleep last night _____ hours

C. Food Intake last 24 hours ( ) average ( ) unusual record unusual eating

D. Smoking ( ) yes ( ) no record type and extent

E. Alcohol consumed ( ) yes ( ) no in last 24 hrs. record type and amount

F. Drugs, medication ( ) yes ( ) no record type and amount, when last taken
<table>
<thead>
<tr>
<th><strong>Appendix Q</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BRAIN ATLAS WORKSHEET - NORMATIVE STUDY</strong></td>
</tr>
<tr>
<td><strong>TODAY'S DATE:</strong> <em><strong>/</strong></em>/___ (month/day/year)</td>
</tr>
<tr>
<td><strong>TEST CENTER:</strong> ___________________ <strong>TECH:</strong> ___________________</td>
</tr>
<tr>
<td><strong>EEG MACHINE USED WITH B.A.:</strong> CRASS NIKON KODEN OTHER</td>
</tr>
<tr>
<td><strong>NO. OF CHANNELS:</strong> ________</td>
</tr>
<tr>
<td><strong>PATIENT CODE:</strong> X X Y Y Z  (test site keeps record for name)</td>
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<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>DATE OF BIRTH:</strong> <em><strong>/</strong></em>/___ (month/day/year)</td>
</tr>
<tr>
<td><strong>HANDEDNESS:</strong> (Left = L; Right = R) _______ <strong>GENDER:</strong> M F</td>
</tr>
<tr>
<td><strong>INDEX</strong></td>
</tr>
<tr>
<td><strong>MEDICATION:</strong> ___________________</td>
</tr>
<tr>
<td><strong>DOSAGE:</strong> name _______ _______ MG od bid tid qid</td>
</tr>
<tr>
<td><strong>ALLERGIES:</strong></td>
</tr>
<tr>
<td><strong>SPECIAL TREATMENTS:</strong> DIET (special nutrition)</td>
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<td></td>
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</tbody>
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### Appendix Q

**HISTORY**

The presence of any of the following conditions may disqualify the subject from being in the normative study, but the data may still be collected if desired.

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PATIENT</th>
<th>FAMILY MEMBERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diabetes:</td>
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<td></td>
</tr>
<tr>
<td>2. Head Trauma:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severity?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cerebral Vascular Disease:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Skull Fracture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Neurosurgery:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Intraventricular Shunt:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
<td></td>
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<tr>
<td>7. Seizures:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Febrile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afebrile</td>
<td></td>
<td></td>
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<tr>
<td>8. Migraine:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Meningitis (including spinal):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Encephalitis:</td>
<td></td>
<td></td>
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<tr>
<td>11. Visual Impairment (Specify):</td>
<td></td>
<td></td>
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<tr>
<td>Poor Visual Perception</td>
<td></td>
<td></td>
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<tr>
<td>Visual Occlusion (Episodic)</td>
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<td></td>
</tr>
<tr>
<td>(Cataracts/Glaucoma/Retinitis)</td>
<td></td>
<td></td>
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<tr>
<td>12. Mental Retardation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Learning Disabilities:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Dyslexia:</td>
<td></td>
<td></td>
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<tr>
<td>15. Psychiatric Conditions:</td>
<td></td>
<td></td>
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<tr>
<td>16. Drug Dependence:</td>
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<td></td>
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<tr>
<td>17. Blood Pressure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(actual value or Hi/Lo/Normal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Other Illnesses:</td>
<td></td>
<td>(and neurologic/psychiatric relevance)</td>
</tr>
</tbody>
</table>
Appendix R

Brain Atlas Protocol-II

Subject________________________

File #________________________

Disks________________________

Disk #
1. EO
2. ED
3. EC
4. EC
5. Imagine Learning Well
6. Imagine Learning Poorly
7. Recall High School Friends
   (names, faces, locations, activities)
8. Solve a Maze
9. Draw a Person
10. Imagine Listening to Favorite Music
11. Free Write - Generate Words
12. Serial Subtraction
13. Memorization
14. Memorization
15. Oral Recall
16. Written Recall
17. Phonetic Spelling List
18. Non-Phonetic Spelling List

Disk #
1. AEP P300 with no Stimulus 1 #1 #2 Subject #R
2. AEP P300 Oddball #1 #2 Subject #R
3. AEP Baseline (S=100) #R

4. Reading - Probe
5. Reading - FFT
6. Reading Test - FFT
7. CFT - Probe
8. CFT - FFT
9. SM - Probe
10. SM - FFT
11. List Learning - Auditory - Probe
12. List Learning - Categories - Probe
13. List Learning - Visual Imagery - Probe
14. List Learning - Order - Probe
15. Stroop
Serial Subtraction

793
- 27
-- 72
-- 18
-- 61
-- 9
-- 188
-- 17
-- 39
-- 92
-- 44
-- 6
-- 77
-- 23
-- 11
-- 36
-- 58
-- 17
-- 35
-- 28
Appendix T

Memorization Passage

A Subject receiving a good bit of thought these days is something we might refer to as the people explosion. The number of us who now inhabit the globe has passed the four billion mark. At present growth rates, it will climb two billion more by the end of the century.

In all of our millions of years on earth, this number was not half that size until about sixty years ago. That is within the lifetimes of many who are still living. Experts say that a quarter of all the persons who ever lived on this planet are still alive today.

While estimates vary, of course, we know that a great many of these people do not receive enough of the right kinds of food to function at their best. Because of this fact, a great debate now rages as to how many people the resources of the earth can support.
Appendix U

Phonetic Spelling List

astronomy
democrate
frequent
quotasion
publesher
charitie
handecap
nevertheless
representative
ravenge
badje
dictionary
entertainment
industry
varnesh
atheletic
monumant
photographe
population
respekful
Appendix V

Non-Phonetic Spelling List

douteful
hasten
jugement
napsack
liquer
aknowledge
cruze
scientefic
sargeant
thoroogh
bureau
climbate
foriegn
justece
lifegard
incourage
honorable
poltry
sorce
riters
Appendix W

List Learning Word - List # 1

Dog
Tree
Book
Hair
House
Pen
Dress
Window
Hand
Horse
Paper
Chair
Ear
Door
Hat
Foot
Flower
Grass
Ice
Boat
Appendix W

List Learning Words - List # 2

Paper
Show
Car
Cup
Tree
Book
Light
Ball
Food
Pin
Grass
Shirt
Fork
Window
Sock
Stick
Road
Rug
Watch
Scissors
Appendix W

List Learning Words - List # 3

Lip
Beach
Perfume
Pain
Flower
Smoke
Blood
Friend
Dive
Smile
Gun
Cat
Bed
Shower
Birthday
Warm
Dog
Mom
Snake
Punch
List Learning Words - List #4

House
Ear
Horse
Plate
Toe
Desk
Phone
Shrub
Plum
Fence
Pencil
Head
Chair
Tooth
Letter
Ring
Piano
Apple
Cloud
Lock
Appendix X

Model of What Happens When You Learn

1. Inputs - The things you want to learn about have to get into your nervous system. That includes attention to those things. They can get there through:
   a. vision
   b. hearing
   c. movements
   d. touch
   e. smell
   f. taste
   g. language
   h. thoughts
Attention can be good or not so good for each one of these. Each individual has channels he prefers to use and is better at using - that includes attention in that channel.

2. Representations - There has to be some kind of model of what you are trying to learn that is stored in your head. This is the record of what you think happened - not necessarily what actually happened. These representations can be:
   a. auditory
   b. visual
   c. kinesthetic
   d. spatial
   e. emotional
   f. linguistic
   g. logical
   h. symbolic
   i. many others - or combinations of any of them
Each person has some ways that they represent things more and better than others.

3. Transformations - These representations can be transformed from one type to another. This can be done to make them correspond to plans you have or goals or the types of things that you are supposed to do. If you have no plans or goals you are likely to have no transformations and very little usable learning. Transformations can occur from any form of representation to any other. Individuals will have preferred forms of transformations. Difficulty in learning often results from an inability, or unwillingness, to transform what you have learned into a form which allows it to be used in the way you are supposed to.
4. Outputs - What you have learned needs to be used. This can occur in many forms:
   a. speech
   b. writing
   c. thoughts - which are mostly further transformations
   d. movements
   e. constructions
   f. combinations of these
Each individual will have preferred forms of using what they have learned. Weak areas can be strengthened. Strong areas can be used to compensate for weaknesses.

5. Controls - We make decisions about how to try to use all of the processes. These include:
   a. setting goals
   b. monitoring our progress toward our goals
   c. deciding when, and if, to do something
   d. Deciding what strategy to use
   e. Deciding if this situation is like one we have experienced in the past and how best to approach it
   f. changing strategies
   g. combinations of the above
Controls are what determines how we use the resources we have in the other four areas. Controls can all be learned. Good learners are those who learn the controls that allow them to get the most from their resources. This is where effort to improve learning is most likely to pay off.
Appendix Y

Skilled Learner Techniques
Adapted from Simon, 1979

1. Seeking knowledge vs. avoiding failure - positive motivation

2. Perform preliminary task overview - advanced organizers
   a. perform componential analysis
   b. perform relational analysis
   c. define the goal - form an image of the final product and work from that rather than the immediate stimulation

3. Hindsight analysis
   a. verification
   b. mastery
   c. self-teaching

4. Self-monitoring
   a. periodic progress assessment
      discrepancy minimization - by task components

5. Have and apply a varied arsenal of learning strategies

6. Realistic assessment of personal strengths and weaknesses
   Task orientation - use strengths and learn compensations for weaknesses

7. Identify and learn from observing good learning models
   Teachers as learning models
   Peers as learning models

8. Spontaneous covert rehearsal - Zeigarnik Effect

9. Deep processing - semantic

10. Elaborative rehearsal

11. Use context, self-cueing, generalize readily (analogical thinking), make precise discriminations (feature analysis)
13 Preparatory Steps to Successful Self-Directed Learning

From Allan Tough, The Adult's Learning Projects

1. Deciding on the detailed knowledge and skill sought
   Specifically, what do you want to learn?

2. Deciding on the activities, materials, resources and equipment needed
   Must be specific to the type and goal of the learner and may need the help of an expert

3. Deciding where to learn
   Dependent on the equipment and facilities as well as the learner's style

4. Setting specific deadlines or intermediate goals
   Must be realistic - guidance is often needed

5. Deciding when to learn
   Learner specific - capture the moment!

6. Deciding the pace
   Must coordinate with goals and have checks to allow for readjustment of the goals and pace

7. Estimating the level of progress
   Deciding where you are so you know where to start

8. Detecting blocks and inefficiencies.
   Need to know where you will have trouble and how to deal with it

9. Obtaining resources and equipment
   Need the aggressiveness (motivation) to get what you need to succeed

10. Preparing a room or other physical conditions
    Must be specific to the learner

11. Obtaining the money

12. Finding the time for the learning
    Need organizational skills for other things as well as for learning
13. Increasing motivation or dealing with motivational blocks. These are specific to the learner. Need constant feedback and self-correction. Often need outside help — maybe professional. Motivational problems are often wrapped up in the topic and/or goal choice — redefinition may be needed.
Appendix A: Personal Learning Questionnaire

Name_________________________

School Learning Item_____________________________________
Non-School Learning Item_____________________________________

1. Inputs - School

Non-School

2. Representations - School

Non-School

3. Transformations - School

Non-School

4. Outputs - School

Non-School

5. Controls - School

Non-School
List anything else you can think of which is important in determining whether you learn well. How does it relate to any of the above?

How does the knowledge you already have about something affect your ability to learn something new about it? Give an example.
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