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THE EFFECT OF GUIDED IMAGERY AND INTERNAL VISUALIZATION ON LEARNING

Owen Caskey and David Meier
The Center for Accelerated Learning

for

Contracting Officer's Representative
George H. Lawrence

BASIC RESEARCH LABORATORY
Milton R. Katz, Director

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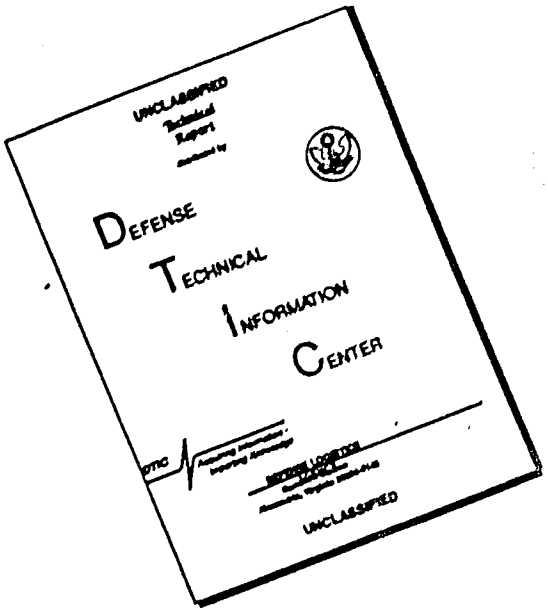

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This study examined the effects of mental imagery on short-term and long-term retention of learning material. Subjects presented with learning material through mental imagery achieved significantly higher gain scores on tests of immediate and long-term recall compared to control subjects who studied material from a traditional, lecture-based method. No significant differences were found between experimental and control groups in terms of class, major, grade point average, ethnicity, brain lateralization characteristics or

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20. Abstract (continued)

cognitive learning style preferences. The imagery group registered more positive attitudes toward the learning experience and the teaching method used than did their counterparts in the non-imagery group.

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I. INTRODUCTION

In his now famous Presidential Address to the American Psychological Association in 1962, Robert Holt (1964) refocused attention on the study of mental imagery. Since then, the field has continued to develop and expand at a rapid rate. The result has been the appearance of hundreds of articles, scores of books, dozens of conferences, several professional journals, and a number of professional associations devoted primarily or exclusively to mental imagery and related topics.

By far the greater bulk of interest, research, speculation and literature in this period has dealt with the use of imagery in therapy, particularily in handling anxiety reactions. Both the general theoretical approaches and the therapy techniques that have evolved appear, in the main, to be based on the extensive work of Lazarus (1971), Michenbaum (1974, 1977, 1983, 1984), and Wolpe (1973). While these contributions are of significance to both the understanding of basic imagery concepts and to their specific application in therapy (especially cognitive-behavior modification), they have not as yet been applied to groups or to general educational or learning topics.

Outside of specific psychotherapy areas, recent studies of imagery seem to fall into four broad categories:

1) The study of the effects of imagery on learning and memory (e.g., Bower, 1970, 1972).
2) The study of the interference effects between mental imagery and a simultaneous like-modality stimulation (e.g., Segal and Fusella, 1970).
3) The study of the types of cognitive tasks in which people spontaneously use imagery (e.g., Huttenlocker and Higgins, 1972).

4) The study of the structure of imagery per se: that is, logical, theoretical questions to be addressed prior to the study of imagery's role in cognition (e.g., Kosslyn, 1980, 1983).

Of these four, the first (imagery and memory) has received the greatest attention from researchers and is the category into which this study falls.

Imagery as a Mnemonic Mediator

There seems to be little doubt today that presenting items high in imagery value facilitates retention (Wolff and Levin, 1972). The association between imagery and memory, in fact, has been recognized for centuries (Aristotle, 1912; Levin, 1975; Rohwer, 1970, 1971; Yates, 1966).

It seems, however, that a behavioristic bias has imposed certain limitations on imagery research and that the arificial laboratory environment in which much of the research has been conducted has prevented the findings from being generalized and applied to normal everyday learning environments. Despite Pavio's turning-point analysis of the role of imagery in learning and memory (Pavio, 1972) and much subsequent research that has supported his view, there has been no rush to change teaching methods or even to explore the use of imagery in the normal, routine teaching and learning environments of our culture.

To be sure, there are unresolved theoretical problems that may await years of basic research to resolve, such as the structure of imagery, the role (or existance) of memory traces, and how retrival cues operate, to name a few. The lack of a single theory or a coherent approach has not deterred movement into direct applications in other areas, such as clinical therapy, sports performance, and advertising art. Yet in Sheikh's (1983) voluminous

review of imagery, the five chapters devoted to application contained not one review of the use of imagery in educational and training settings.

One of the conscious aims of this study was to attempt to get imagery research out of the sometimes limiting box that behavioristic methodologies and artificial laboratory environments have put it in, and test the applicability of imagery to broader, more normal learning tasks.

Anatomy of the Problem

The contemporary study of mental imagery has been dominated by Allan Paivio (1970, 1971, 1972, 1975, 1976, 1978) who has imposed a kind of neo-behavioristic bias and methodology on imagery research. He has sought for a way to study mental imagery with a methodology consistent with behaviorism in order to convince behavioral psychologists that mental imagery is indeed an area for legitimate scientific investigation (Sheikh, 1977).

Although Paivio was most instrumental in helping to get imagery back on the agenda of serious psychological researchers, in doing so, according to some commentators, he extended a now outmoded methodology to the study of imagery that precluded any significant advances in our understanding and use of it for educational purposes (Richardson, 1980, p. 8-9).

So, despite the claim of a paradigm shift in the methodology of cognitive science (Neisser, 1972) -- a shift from treating mental concepts as empirical, static phenomena to treating them in terms of the process and flow of information in the organism -- everything remained pretty much the same. This is because the terms associated with "process" were given behavioristic connotations that differed from

the normal meaning of these terms in everyday life. Mental imagery was still treated as a theoretical construct within an operational definition -- a standard notion within behavioristic methodology (Richardson, 1980, pp. 7-13).

Today we are beginning to question the ability of traditional behavioristic methodology to deal appropriately with the subject of mental imagery. Outdated or inappropriate methodologies may, in fact, retard and cloud our understanding rather than inform and expand it. Mental imagery appears to be too large and complex and interwoven a phenomenon to be contained and explained by traditional theoretical frameworks and laboratory procedures.

A Limited Framework

Behavioristic theories and approaches have imposed, it appears, serious limitations on the possibilites for imagery research and application. The bulk of the research into the mnemonic function of imagery over the past 20 years, for instance, has concentrated on the learning of unrelated lists of items or on paired associated lists of items where one group is encouraged to use imagery (simple or compound) and the other is not (Spiker, 1960; Paivio, 1968; Wollen and Lowrey, 1971). A second popular form of research has been to give no instructions whatever to the subjects to use imagery, but to vary the concreteness of the descriptions of the items to be remembered to verify the assumption that the greater the concreteness, the greater the chance that an image would be formed and an item remembered (Paivio, 1971).

As a result, educational imagery got associated with a rather simple and limited kind of mnemonic function.

And for many, that was the whole of it. Morris (1977), for instance, suggests that imagery mnemonics are of value only in learning lists of unrelated, concrete words. And Hunter (1977) has this to say on the subject:

> The Method (imagery mnemonics) has such a circumscribed range of utility that it is useless for all practical purposes of learning and remembering. Appropriate task conditions are essential. The presented items must be translatable into imaged objects; the rate of presentation must be slow, not faster than about one item every three seconds; and the Method breaks down if we try to comprehend relationships between items that are not structurally contiguous. These task conditions rarely arise in real life.

With imagery mnemonics identified with such a narrow range of application, it is no wonder that imagery research findings have had such little effect on educational philosophies and practices in our schools and traning facilities. Imagery, a basic non-linear mode of thought, has been examined through the lens of linear theories and methodologies which, it seems, have yielded seriously restricted results. Imagery has been scaled down to fit the methods for examining it. Perhaps behaviorist methodology has gone about as far as it can in studying imagery and needs to be replaced by a more appropriate approach (Richardson, 1980).

Macroscopic vs. Microscopic Research

The approach of this study has been to do its research not in the microscopic and somethimes artificial environment of the laboratory, but in an environment that more closely resembles a "normal" school learning situation. Samuel Becker (1978) commented on this approach from the point of view of research in visual communication, but his remarks are equally appropriate for the area of mental imagery research.

> As I examined the bulk of research that has been done on visual communication, it does not seem to me that it has contributed much, if anything, to

> our understanding of ways in which such meanings develop...I believe that the reason our research has not added more to our understanding of such problems is that we have concentrated too exclusively on the type of communication situations we can most tightly control and in which obtained variances in response can be attributed most reliably to particular variables. We study the response to stimuli in isolation from anything we might call a meaningful communication situation -- often even from anything we might call a meaningful message, even though there is increasing evidence that the ways in which people respond to stimuli in isolation are not generalizable to the ways in which they respond to them in various contexts. Our assumption, of couse, is that what we learn from such microscopic research will ultimately add up to or be gneralizable to the more complex situations encountered outside the laboratory. To date, though, nothing gives me enough confidence in the validity of that assumption to justify continued concentration on microscopic studies alone. We must give at least equal attention to more macroscopic approaches to understanding visual communication.

Commenting specifically on the area of imagery mnemonics, Richardson (1980, p. 80-81) says

> It is quite clear that, under the circumstances investigated by cognitive psychologists in their formal laboratory experiments, the elaboration and construction of integrative, interactive, mental images may lead to substantial and reliable improvements in the ability to remember. But what is the value and generality of these techniques, and what is their role in the development of human understanding? Human learning is of course most crucial in schools, yet nothing is really known concerning the potential value in formal education of the techniques of using mental imagery.

Of course, there are dangers in breaking out of the microscopic approach just as there are dangers in staying in it, but we believe that the rewards of getting more substantial data on the wider applicability of imagery to education are worth the risks.

This study, then, has tended toward a macroscopic approach to imagery. It has departed from traditional microscopic research in a number of ways. First, this study has sought to investigate the effects of imagery in an environment that more closely parallels a normal school learning situation for adults and young adults. Secondly, the material to be learned was not of the one-bun, two-shoe variety, but subject matter very closely aligned with normal school curriculum, particularily that encountered in the sciences. Thirdly, the type of imagery used was of a more complex nature than that typically employed in research pertaining to memory, and invited participants in the experimental group to have personal, interactive, gestalt-type, multisensory imagery experiences with the material.

Admittedly, there are still a number of theoretical and methodological questions that are unanswered regarding the most appropriate way to proceed with imagery research today. But as is the case with most scientific endeavors, the quest for theory will continue to parallel the search for practical uses. And some of the "how to" questions may be answered before many essential "how" questions are resolved.

Reese (1977) concluded that "the long-term mnemonic effectiveness of compound imagery, relative to that of verbal elaboration, has not yet been determined definitely." It is hoped that this study would contribute to that determination.

The theory espoused by many today is that that which is experienced through many senses and across many mental states will be learned faster and retained longer. This study is a test of that theory, although the study was undertaken with the following hypotheses:

1. There is no significant difference on immediate recall test scores (gain scores) between groups using a traditional lecture teaching mode and a mental imagery teaching mode.

2. There is no significant difference on long-term retention test scores (gain scores) between groups using a traditional lecture teaching mode and a mental imagery teaching mode.

3. There are no significant differences between the immediate recall and long-term retention gain scores as they are affected by age, sex, GPA, ethnicity, and student classification. . .

According to this study, Hypothesis 1 and 2 above are false and Hypothesis 3 is correct.

II. RESEARCH PROCEDURE

The sample population for this study was drawn from the student bodies of four different types of schools as follows:

- A community college catering to minorities
  (El Paso Community College, Texas)
- A state university
  (The University of Wisconsin, Whitewater)
- A technical training institute
  (Milwaukee Area Technical College)
- A private liberal arts college
  (Lake Forest College, Illinois)

Participants from these four schools were recruited through notices in their school newspapers offering them pay for participating in a research project to test "the effectiveness of television as a learning tool". Participants were unaware of the real purpose of the study, to test the effectiveness of mental imagery for learning.

Participants were directed to make application at a given location and were received on a first-come, first-served basis. In making application, participants completed a form of personal statistics (name, address, age, class, major, and ethnicity).

Applicants were then randomized into two groups, a control group and an experimental group, and were each assigned an identifying number that would track them through the project. Participants were informed that they would have to be present for two sessions, six weeks apart, to collect their full pay.

On the designated day of the first session, participants

were directed to two separate rooms depending on their randomized assignment to either the control or the experimental group. Monitors in each room handled the physical aspects such as seating, lighting, and the running of the videotape equipment. Monitors were instructed to refrain from providing the participants with any information regarding the project, the tape content, or the instructional method. All instructions were on the videotape and were common to both groups.

Once the groups were seated in their respective rooms, the monitors played the first portion of the videotape containing the common introduction to the project and the instructions on completing the pre-test. At that point, the videotape was turned off and the pre-tests distributed to the participants. When the pre-test was completed and collected, the videotape was resumed for the presentation of the learning material.

There were two videotapes prepared for this project, one for the control group and one for the experimental group. Both tapes were of the same length and covered the same learning material. But the control group's tape utilized the traditional lecture method (with external pictures and illustrations), while the experimental group's tape used mental imagery and internal visualization as the main mode of dealing with the information to be learned.

The learning task was divided into three subtasks, each designed to test a specific type of learning according to the following scheme:

Subtask 1 - The rote learning of items in sequence.

Subtask 2 - The learning of nomenclature in conjunction with positional relationships.

Subtask 3 - The learning of nomenclature in conjunction with process and function.

Neither group was permitted to take notes during the videotape presentation. Likewise, neither group was given supplemental reading material to help them with the learning. Both groups had only the videotape presentation to rely on.

At the conclusion of the videotape presentation, the monitor in each room turned off the videotape player and, without comment or without fielding questions, distributed the post-test. Upon completion of the post-test, participants were again reminded of the second session of the project that would be held six weeks later and, on leaving the room, were given partial payment for their participation.

Prior to the second session, participants were sent reminders by mail. On the day of the second session, participants were again divided into their control and experimental groups and given an identical post-test-2 to measure their long-term retention. In addition to this test, participants also completed the following:

- an instrument to measure their brain lateralization (the Loye Hemisphericity Profile)
- an instrument to measure their preferred learning style (the Kolb Learning Style Inventory)
- a questionnaire to measure their personal feelings toward the learning experience and the specific method used.

When the tests and instruments were completed and collected, the participants were thanked by the monitors and given the remainder of their pay as they left the room.

It should be pointed out that there was no review or reinforcement given to the participants between the first

and the second sessions. Likewise, the participants in the experimental group were given no prior training in the use of mental imagery for learning but confronted it "cold" in the course of watching the videotape in the first session.

Comparison of the Teaching Methods

Below is a comparison of the contents of the two teaching tapes used for this study. The tapes, of course, were stopped for the administration of the tests (shown in parentheses below).

TAPE 1 - CONTROL	TAPE 2 - EXPERIMENTAL	TIME
Common Introduction	Common Introduction	2.5 min.
(Administration of Pre-Test)	(Administration of Pre-Test)	10 min.
Common Overview of Planets	Common Overview of Planets	2.5 min.
Verbal Pictorial Elaboration	Mental Imagery Elaboration	4.5 min.
Common Overview of Brain Lobes	Common Overview of Brain Lobes	5.0 min.
Verbal Pictorial Elaboration	Mental Imagery Elaboration	9.0 min.
Common Overview of Neuron	Common Overview of Neuron	7.5 min.
Verbal Pictorial Elaboration	Mental Imagery Elaboration	9.5 min.
Common Closing Remarks	Common Closing remarks	0.5 min.
(Administration of Post-Test-1)	(Administration of Post-Test-1)	10 min.

Note that there were common, identical segments on both tapes: the general introduction, the overviews to the three separate learning segments, and the closing remarks. Where the tapes differed was in the elaboration of the learning material, the control group being exposed to a verbal/pictorial elaboration and the experimental group being directed in a mental imagery elaboration. The elaborations for each segment were for an identical length of time and covered the identical learning material.

What follows now is a further description of the teaching content and methodology used for the two types of elaborations on the videotapes -- first, that used for the control group for all three segments, and then that used by the experimental group.

Control Group Elaborations

1) The Planets. A list of the planets in our solar system was displayed with the instructor on the videotape reviewing the list several times. For one of the reviews, individual photographs or paintings of the planets were displayed. The list of planets was then left on the screen for about a minute and a half with instructions for the participants to use any method they wanted to for remembering them. (The planets were, of course, always presented in the order of distance from the Sun.) A final review was made two times by the instructor.

2) Brain Lobes. The learning assignment here was to learn the four major lobes of the cerebral cortex and a brain function associated with each as follows:

Frontal Lobe - forward planning
Parietal Lobe - touch
Occipital Lobe - vision
Temporal Lobe - hearing

In addition, the participants were taught the location and function of the motor cortex and the sensory cortex. The format of the instruction was a lecture accompanied by two large full-color drawings of the brain as it appears on the tests and pointed to by the instructor as he taught. One drawing contained the names of the lobes, the other contained the functions. Several iterations of the material were made, the final one being a presentation of the lobe names one by one on the screen to the accompanyment of music.

3) The Neuron. The task here was to teach the participants the general architecture and function of a typical brain neuron. Eight separate full-color drawings were used to illustrate the verbal elaborations of the instructor. The drawings were labeled with the appropriate words and functions to be learned. The specific items, functions, and concepts covered are those represented in Appendix C for Subtest 3 and do not have to be repeated here. Each item, concept, and function to be learned was reiterated at least four times on the videotape, and in some cases more. The instructor used a pointer to refer to the pictures as he taught.

Experimental Group Elaborations

1) The Planets. The participants were asked to take several refreshing breaths, close their eyes, and use their imaginations to create a vivid experience with an episode that the instructor was about to relate. What follows is a capsule summary of the script. There were, of course, frequent pauses to allow the participants to form and experience the various multisensory images.

> You are in a meadow on a beautiful summer's day. In the middle of the meadow is a new Mercury car. Touch it, feel it, smell it, kick the tires. What color is it? Go back, sit under a tree and watch what happens. From stage left comes the beautiful goddess of love, Venus. Watch her walk to the car and get behind the steering wheel. Next enters the entertainer Eartha Kitt, mumbling and grumbling and dragging a heavy package behind her. Notice what she's wearing, how she looks. She gets into the back seat of the Mercury and pulls the package in after her. She opens the package, removes a 50 lb. Mars bar, and begins to devour it ravenously. Go over to the car. Smell the Mars bar. Take a bite. Slowly chew it and swallow it. Go back and sit down. Now feel the earth tremble under you as if a giant were approaching. Then see a 12-foot giant enter from the left -- the god Jupiter. See him and feel him walk to the Mercury. He wants to hitch a ride to Mt Olympus, but is obviously too

> big to get in the car. So have him get on top in some fashion. Now Venus starts the Mercury and it begins to pull away from you (Eartha still ravaging her Mars bar and Jupiter holding on for dear life on top). Then you notice the license plate, glowing in beautiful, unearthly colors with one word on it -- SUN. You sense that that stands for Saturn, Uranus, and Neptune. Burn the word on the license plate into your head. As the Mercury pulls away, the cartoon dog Pluto comes over to you and licks your hand. Now pet Pluto. What does his coat feel like? Pluto spots the car, and, being true to his genetics, takes off after it, yelping at the back tires. Let the car and Pluto slowly disappear around a bend in the road and slowly open your eyes and return to this time and this place.

It should be noted that, while the elaborations for both the control and experimental groups took the identical amount of time, the control group had several iterations of the material while the experimental group had only one.

2) The Brain Lobes. After the common introduction in which the names and functions of the brain lobes under consideration were presented, the participants were again asked to relax, close their eyes, and to use their imaginations to have a vivid, multi-sensory, internal experience under the guidance of the instructor. They were asked to imagine themselves in front of a house with the shape and appearance of a huge brain. They were going to take a walking tour through various rooms in it. They were asked to walk up the steps to a room in the top front of the brain house called the Frontal Lobe - the room set aside for forward planning activites. They could observe people in the room planning -- a trip, next semester's academic schedule, etc. The back wall was stacked with motors of all kinds (the Motor Cortex) which the participants were invited to touch, smell, and thoroughly examine.

Next, the participants were invited to walk past the wall of motors into a large room behind the Frontal Lobe called

the Parietal Lobe. Its front wall was covered with living hands gently reaching out to them (the Sensory Cortex) which they were asked to communicate with by touching, enjoying the sensations of touch. Next, they were lead down a stairway to a smaller room in the back of the brain house on the lower level (the Occipital Lobe) where the wallpaper of various colored eyes and a collection of glass eyes spilled on the floor suggested that this was a room associated with vision. Finally, they were led forward to a long, squat room on the lower floor (the Temporal Lobe) filled with audio equipment where they were invited to listen to various realistic sounds like a jumbo jet taking off over their heads and the sounds of an orchestra or band playing some of their favorite music. The point, of course, was to help them associate this lobe with hearing. As a quick review, they were led back through the various rooms they had visited, leaving the brain house where they had originally entered.

3) The Neuron. Again, after the common introduction in which all the concepts, names, and functions of the neuron to be learned were presented, participants were invited once again to enter the world of mental imagery. They now found themselves floating in the warm cytoplasm in the soma of a giant neuron. They were asked to observe the tree-like dendrites branching out from the soma and the activity inside the soma, particularily the manufacture of vesicles filled with neurotransmitter substance. They were then invited to ride one of the vesicles on a journey down the axon to the synapse. On the trip they encountered neurofibrils, glial cells, the myelin sheath, and Schwann cells, and they experienced the process of the exchange of potassium and sodium ions as an electrical charge passed them in the axon. Finally, they entered the huge shipping dock of the neuron, the synapse, where they experienced the electrical, calcium-assisted process

of having the vesicle they had been riding on pushed against a small opening in the synaptic membrane until it erupted and spilled its content (the neurotransmitter substance) out on to a kind of street. They were then asked to see the spilled substance being quickly absorbed through little openings in the wall of another synapse "across the street". Throughout this journey, the participants were invited to see, hear, feel, touch, and experience objects and events in the environment as vividly as they could.

During all the imagery elaborations for the experimental group, the TV screen was blank except for a symbolic drawing of a pair of closed eyes.

It should be noted that the same instructor was used on both the control and the experimental video tapes.

III. THE INSTRUMENTS

Pre-Test, Post-Test-1, Post-Test-2

These are identical instruments that were administered to both the control and experimental groups at appropriate times in the research project. These tests were used as the sole measure of knowledge gain both for immediate recall (Post-Test-1) and for long-term retention (Post-Test-2).. A sample of the test is in the appendix.

The test was composed of three subtests as follows:

Subtest	Content	Main Learning Task	Max. Score
1	Order of the Planets	Items in Sequence	9
2	Anatomy of the Cerebral Cortex	Nomenclature in conjunction with spatial relationships	10
3	The Function of The Neuron	Nomenclature in conjunction with process and function	17

The score for the total test had a possible range of from 0 to 36. The Pre-Test was used at the start of the project to measure the participants' prior knowlege of the learning material used in the study. Post-Test-1 was administered immediately after the videotape presentation of the learning material. Post-Test-2 was administered six weeks later.

The Kolb Learning Style Inventory (LSI)

This instrument, developed by David Kolb in 1975, is a standardized, forced-rank, self-report instrument that measures a learner's preferred learning strategy.

Using both split-half and test-retest reliability procedures, this instrument yields reliability coefficients that range from .40 to .80. Research using this instrument indicates that it measures learning style preferences consistently over time.

The Kolb LSI measures cognitive learning style preference in four discrete dimensions according to the following scheme:

Dimension	Score Range	A high score here indicates a Preference for...
Concrete Experience	7-22	A receptive, experience-based approach to learning.
Reflective Observation	6-22	A tentative, impartial, and reflective approach to learning.
Abstract Conceptualization	9-24	An analytical, conceptual and rational approach to learning.
Active Experimentation	8-24	An active, learn-by-doing approach to learning.

Two additional measurements are derived from these scores by subtracting the Concrete Experience score from the Abstract Conceptualization score (AC - CE) and by subtracting the Reflective Observation score from the Active Experimentation score (AE - RO). The AC - CE score has a range from -12 to +18. The AE - RO score

has a range of -11 to +17. These two scores are used to place the learner somewhere in one of four quadrants, which further illuminates that person's preferred learning style and strategy.

The Loye Hemisphericity Profile

This is a simple, self-report brain lateralization profile developed by David Loye that measures hemispheric dominance (left, balanced, right). Left-brain dominance, according to this instrument, indicates a personal preference for logical structure, rational analysis, and verbal stimulus. Right-brain dominance, according to this instrument, indicates a personal preference for intuitive thinking, holistic perception, and visual stimuli. A balanced score on this instrument indicates a complementary interplay between left-brain and right-brain skills. The instrument is scored along a continuum that ranges from 1 to 20.

Participant's Application

The demographic data derived from the application completed by each participant included age, sex, college classification, academic major and minor, grade point average (self-reported) and ethnicity. A copy of the application form is in the appendix.

Participant's Evaluation

Participants were asked to evaluate the learning experience in terms of their attitudes toward the teaching

method used on the videotape. In addition, they indicated their visual and auditory acuity during the videotape session and their prior familiarization with the learning content used in the study. A copy of the evaluation form is in the appendix.

IV. DESCRIPTIVE STATISTICS

The following tables describe the charactaristics of the students who participated in this study.

TABLE 1
Number of Participants by Campus

Campus	Control	Experimental	% of Total
El Paso Community College	41	44	31.7
University of Wisconsin	37	32	25.7
Milwaukee Area Technical College	24	24	18.0
Lake Forest College	32	34	24.6
TOTALS	134	134	100.0

TABLE 2
Classification

Class	Number	% of Total
Freshman	101	37.7
Sophomore	92	34.3
Junior	37	13.8
Senior	29	10.8
Graduate	9	3.4
TOTAL	268	100.0

TABLE 3
Age Group

Age	Number	% of Total
17-19	104	38.8
20-22	99	36.9
23-25	30	11.3
26-29	15	5.5
30-39	13	4.9
40-54	7	2.7
TOTAL	268	100.0

TABLE 4
Grade Point Average

G.P.A.	% of Total
1.5	3.4
1.6 - 2.0	16.0
2.1 - 2.5	23.1
2.6 - 3.0	29.5
3.1 - 3.5	20.1
3.6 - 4.0	7.9

TABLE 5
Academic Major

Major	Number	% of Total
Humanities, Liberal Arts	19	7.0
Social Sciences	35	13.0
Allied Health	23	8.6
Business/Mktng./Mgt.	81	30.2
Industrial	5	1.9
Engineering	2	.7
Architecture	1	.4
Computer Science	18	6.7
Technical	13	4.9
Education	24	9.0
Math & Science	8	3.0
Communications	15	5.6
Law Enforcement	8	3.0
Undeclared	16	6.0
TOTAL	268	100.0

TABLE 6
Ethnicity

Ethnicity	Number	% of Total
American Indian	2	.7
Black (Non-Hispanic)	13	4.9
Hispanic	57	21.3
Oriental	3	1.1
White	192	71.6
Other	1	.4
TOTAL	268	100.0

TABLE 7
Sex

Sex	Number	% of Total
Male	120	44.8
Female	148	55.2
TOTAL	268	100.0

V. RESULTS OF THE STUDY

As mentioned earlier, the variable that differed in this study was the use of imagery for presenting the learning material to the experimental group. Both the control and the experimental groups were presented with the identical material through the same medium of videotape for the same length of time. The control group received the learning material by the lecture method (with many pictorial illustrations), while the experimental group received the information through the use of mental imagery.

Statistical analysis, therefore, was designed to evaluate the significance of differences between the control and experimental groups based on both immediate recall and long-term retention of the learning material. Immediate recall was measured by comparing the scores of the pre-test and the post-test-1 for each participant. Long-term retention was measured by comparing the pre-test with the post-test-2 scores.

Statistics were also gathered to measure the effect of other factors on immediate recall and long-term retention, such as hemisphericity (brain lateralization), college major, ethnicity, native ability (as measured by self-reported grade point averages), sex, and prior familiarization with the learning material.

Mean Scores

What follows on the next page is a comparison of the mean test scores for the control group (Group 1) and the experimental group (Group 2). The first chart compares the means for the total scores for the pre-test, the post-test-1, and the post-test-2. The second chart compares the means for the subtest scores for each of the three tests.

RAW SCORE TOTALS BY GROUP

(Highest Possible Score = 36)

	Pre-Test		Post-Test-1		Post-Test-2	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
GROUP 1	5.84	4.04	25.60	6.50	14.96	6.54
GROUP 2	5.09	3.72	27.51	5.78	17.40	6.42

SUBTEST RAW SCORES BY GROUP

Highest Scores Possible:

Planets = 9
Brain Lobes = 10
Neuron = 17

PRE-TEST

	GROUP 1		GROUP 2	
	Mean	Std Dev	Mean	Std Dev
Planets	3.06	2.93	2.56	2.84
Brain Lobes	.59	1.02	.55	1.21
Neuron	2.19	2.11	1.98	1.96

POST-TEST-1

	GROUP 1		GROUP 2	
	Mean	Std Dev	Mean	Std Dev
Planets	8.33	1.51	8.50	1.30
Brain Lobes	8.65	2.27	9.02	2.19
Neuron	8.62	4.13	10.15	3.72

POST-TEST-2

	GROUP 1		GROUP 2	
	Mean	Std Dev	Mean	Std Dev
Planets	6.54	2.86	7.39	2.57
Brain Lobes	3.69	2.86	4.72	2.97
Neuron	4.81	2.91	5.13	3.03

The following two tables show the comparative gain scores for both the test of immediate recall and the test of long-term retention. The pre-test, of course, is the base.

TABLE 8

A) Pre-Test to Post-Test-1 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	19.76	5.74
Experimental (Group 2)	134	22.42	5.72

B) Analysis of Variance: Pre-Test to Post-Test-1 Gain

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	472.89	1	472.89	14.41	.001
Residual	8730.95	266	32.82		
Total	9203.84	267	34.47		

TABLE 9

A) Pre-Test to Post-Test-2 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	9.12	5.42
Experimental (Group 2)	134	12.31	6.12

B) Analysis of Variance: Pre-Test to Post-Test-2 Gain

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	683.52	1	683.52	20.41	.001
Residual	8908.92	266	33.49		
Total	9592.44	267	35.927		

As mentioned earlier, the learning material was designed to test three types of learning according to this scheme:

Subtask 1 - The rote learning of items in sequence

Subtask 2 - The learning of nomenclature in conjunction with spatial relationships.

Subtask 3 - The learning of nomenclature in conjunction with process and function.

The immediate recall and long-term retention gains of the experimental group on Subtask 1 were higher than those of the control group at the significance level of .05 for immediate recall and .001 for long-term retention as seen in Table 10 and Table 11.

TABLE 10

SUBTASK 1
A) Pre-Test to Post-Test-1 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	5.26	2.76
Experimental (Group 2)	134	5.95	2.82

SUBTASK 1
B) One-Way Anal. of Var.: Pre-Test to Post-Test-1 Gain by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	30.89	1	30.89	3.96	.05
Residual	2072.96	266	7.79		
Total	2103.85	267	7.88		

TABLE 11

SUBTASK 1
A) Pre-Test to Post-Test-2 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	3.48	3.07
Experimental (Group 2)	134	4.83	3.23

SUBTASK 1
B) One-Way Anal. of Var.: Pre-Test to Post-Test-2 Gain by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	120.89	1	120.89	12.16	.001
Residual	2644.52	266	9.94		
Total	2765.41	267	10.35		

The immediate recall mean for the two groups on Subtask 2, while somewhat higher for the experimental group, did not reach statistical significance. The long-term retention for Subtask 2, however, was found to be higher for the experimental group at the .01 level of significance as noted in Table 12 and Table 13.

TABLE 12

SUBTASK 2

A) Pre-Test to Post-Test-1 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	8.05	2.27
Experimental (Group 2)	134	8.47	2.37

SUBTASK 2

B) One-Way Anal. of Var.: Pre-Test to Post-Test-2 Gain by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	11.70	1	11.70	2.16	NS
Residual	1438.01	266	5.40		
Total	1449.71	267	5.43		

TABLE 13

SUBTASK 2

A) Pre-Test to Post-Test-2 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	3.09	2.65
Experimental (Group 2)	134	4.16	2.90

SUBTASK 2

B) One-Way Anal. of Var.: Pre-Test to Post-Test-2 Gain by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	77.37	1	77.37	10.01	.01
Residual	2055.31	266	7.72		
Total	2132.68	267	7.98		

The Subtask 3 means in Table 14 and Table 15 show that the experimental group did significantly better than the control group in immediate recall. But, although the long-term mean of the experimental group was higher for this subtask, it only approached statistical significance.

TABLE 14

SUBTASK 3
A) Pre-Test to Post-Test-1 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	6.42	3.93
Experimental (Group 2)	134	8.17	3.68

SUBTASK 3
B) One-Way Anal. of Var.: Pre-Test to Post-Test-1 Gain by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	204.31	1	204.31	14.05	.001
Residual	3867.80	266	14.54		
Total	4072.11	267	15.25		

TABLE 15

SUBTASK 3
A) Pre-Test to Post-Test-2 Gain

	Number	Mean	Std. Dev.
Control (Group 1)	134	2.61	2.58
Experimental (Group 2)	134	3.16	2.71

SUBTASK 3
B) One-Way Anal. of Var.: Pre-Test to Post-Test 2 Gain by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Control/ Experimental Group	19.88	1	19.88	2.82	NS
Residual	1869.53	266	7.02		
Total	1889.41	267	7.07		

Comparison of the control and experimental groups, therefore, shows that the experimental group consistently achieved higher immediate recall gains as well as higher long-term retention gains as compared to the control group. Further, these gains are statistically significant for the total test scores as well as for immediate recall on two of the subtasks, and for long-term retention on two of the subtasks.

Effects of Variables Other Than Imagery

The decision to conduct the research on four differing campuses with varying types of students was made to insure a heterogeneous sampling and to prevent limited generalizations of the results. The descriptive statistics presented earlier in this report show the wide range of the sample. It was expected that some differences among the campuses would be evident. Tables 16 and 17 show the means for both groups by campus for immediate recall and long-term retention. Experimental groups on all campuses achieved higher gain scores, with gains atatistically significant.

TABLE 16

A) Pre-Test to Post-Test-1 Gain by Campus

Campus	Mean		Std. Dev.	
	Control	Experim.	Control	Experim.
El Paso Community College	19.90	20.29	4.97	5.72
University of Wisconsin	20.54	24.97	4.73	4.81
Milwaukee Area Technical College	16.75	21.71	5.99	6.14
Lake Forest College	20.94	23.26	6.91	5.24

B) Two-Way Anal. of Var.: Pre-Test to Post-Test-1 Gain by Campus

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Group	496.40	1	496.40	16.12	.001
Campus	500.42	3	166.81	5.42	.01
Two-Way Interaction					
Group/ Campus	227.66	3	75.89	2.47	NS
Residual	8002.88	260	30.78		
Total	9227.36	267	34.47		

TABLE 17

A) Pre-Test to Post-Test-2 Gain by Campus

Campus	Mean		Std. Dev.	
	Control	Experim.	Control	Experim.
El Paso Community College	9.19	9.89	6.04	6.70
University of Wisconsin	10.35	15.19	4.63	5.62
Milwaukee Area Technical College	8.16	13.42	4.79	4.14
Lake Forest College	8.31	11.97	5.84	5.84

B) Two-Way Anal. of Var.: Pre-Test to Post-Test Gain by Campus

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Group	730.14	1	730.14	23.00	.001
Campus	423.06	3	141.02	4.44	NS
Two-Way Interaction					
Group/ Campus	232.67	3	77.56	2.44	NS
Residual	8253.19	260	31.74		
Total	9639.06	267	35.93		

Loye's Brain Lateralization Profile categorized subjects as to preferred approach to hemispheric processing. No significant difference between the control and experimental group occured for either immediate recall or long-term retention as a result of hemisphericity. Tables 18 and 19 indicate significant gains in both Post-Test-1 (immediate recall) and Post-Test-2 (long-term retention) for the experimental group. But analysis of the effects of hemisphericity and the interaction effects between the groups and hemisphericity were not found to be statistically significant.

TABLE 18

A) Pre-Test to Post-Test-1 Gain by Hemisphericity

Hemisphericity	Mean		Std. Dev.	
	Control	Experim.	Control	Experim.
Left Hemisphere	20.72	22.46	5.44	5.44
Balanced	19.73	23.45	6.02	5.60
Right Hemisphere	18.46	21.72	5.88	6.12

B) Two-Way Anal.of Var.: Pre-Test to Post-Test-1 Gain by Hemis.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Group	458.10	1	458.10	14.06	.001
Hemisphericity	149.65	2	74.82	2.29	NS
Two-Way Interaction					
Group / Hemisphericity	47.31	2	23.65	.72	NS
Residual	8533.98	262	32.57		
Total	9189.04	267	34.47		

TABLE 19

A) Pre-Test to Post-Test-2 Gain by Hemisphericity

Hemisphericity	Mean		Std. Dev.	
	Control	Experim.	Control	Experim.
Left Hemisphere	9.83	12.33	5.24	5.43
Balanced	6.94	12.93	5.20	5.91
Right Hemisphere	9.00	11.92	5.62	7.09

B) Two-Way Anal. of Var.: Pre-Test to Post-Test-2 Gain by Hemis.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Group	700.78	1	700.78	20.94	.001
Hemisphericity	36.40	2	18.20	.54	NS
Two-Way Interaction					
Group / Hemisphrericity	106.10	2	53.05	1.58	NS
Residual	8766.41	262	33.46		
Total	9609.69	267	35.92		

Since individuals comprising the sample were enrolled in some type of post-secondary education or training program, their classifications and major areas of study were analyzed to determine the effects of these variables on learning. As shown in Table 20, no statistically significant differences occurred as a result of classification or the interaction between groups and classification for either immediate recall or long-term retention.

TABLE 20

A) Two-Way Analysis of Variance: Pre-Test to Post-Test-1 Gain

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Group	563.28	1	563.28	17.68	.001
Classification	481.05	4	120.26	3.77	.01
Two-Way Interaction					
Group / Classification	32.05	4	8.01	.25	NS
Residual	8217.84	258	31.85		
Total	9294.22	267	34.47		

B) Two-Way Analysis of Variance: Pre-Test to Post-Test-2 Gain

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Main Effects					
Group	719.97	1	719.97	21.53	.001
Classification	234.54	4	58.63	1.75	NS
Two-Way Interaction					
Group / Classification	49.05	4	12.26	.36	NS
Residual	8625.32	258	33.43		
Total	9628.88	267	35.92		

Table 21 indicates that the academic majors of the participating individuals did not exert a significant interaction effect on immediate recall or long-term retention.

TABLE 21

A) Two-Way Analysis of Variance: Pre-Test to Post-Test-1 Gain

Source of Variation	Sum of Squares	Degrees of Freedom *	Mean Square	F	Sig.
Main Effects					
Group	440.11	1	440.11	13.54	.001
Major	271.89	8	33.98	1.04	NS
Two-Way Interaction					
Group/Major	65.43	6	10.90	.34	NS
Residual	5882.43	181	32.50		
Total	6659.86	196	34.02		

B) Two-Way Analysis of Variance: Pre-Test to Post-Test-2 Gain

Source of Variation	Sum of Squares	Degrees of Freedom *	Mean Square	F	Sig.
Main Effects					
Group	506.09	1	506.09	14.45	.001
Major	148.39	8	18.55	.53	NS
Two-Way Interaction					
Group/Major	74.08	6	12.34	.35	NS
Residual	6336.50	181	35.00		
Total	7065.06	196	36.48		

* The SPSS program will occasionally collapse a cell on a two-way interaction when the number of cases in that cell is small.

Finally, ethnicity as an influencing variable was evaluated and found not to contribute to either a main effect or an interaction effect between groups, as shown in Table 22 on the next page.

TABLE 22

A) Two-Way Analysis of Variance: Pre-Test to Post-Test-1 Gain

Source of Variation	Sum of Squares	Degrees of Freedom *	Mean Square	F	Sig.
Main Effects					
Group	407.30	1	407.30	13.06	.001
Ethnicity	408.39	4	102.09	3.27	.05
Two-Way Interaction					
Group/ Ethnicity	164.12	3	54.70	1.75	NS
Residual	8041.76	258	31.17		
Total	9021.57	266	34.04		

B) Two-Way Analysis of Variance: Pre-Test to Post-Test-2 Gain

Source of Variation	Sum of Squares	Degrees of Freedom *	Mean Square	F	Sig.
Main Effects					
Group	670.57	1	670.57	20.55	.001
Ethnicity	299.22	4	74.80	2.29	NS
Two-Way Interaction					
Group/ Ethnicity	165.00	3	55.00	1.68	NS
Residual	8418.29	258	32.62		
Total	9553.08	266	35.892		

* The SPSS program will occasionally collapse a cell on a two-way interaction when the number of cases in that cell is small.

Analysis of Covariance

As pointed out earlier, subject were assigned to control and experimental groups randomly with the assumption of normalcy for both measured and unmeasured traits and charactaristics. The factor of ability or achievement, which might have influenced the outcome of this study, was not a factor in random assignment.

Likewise, prior knowledge of the content of the learning was not an assignment consideration.

Randomized assignment to control and experimental groups should assure normal distribution of ability and pre-test knowledge of contents. Nevertheless, analysis of covariance was applied to the data to assure that normal distribution was indeed the case. Although analysis of covariance is most often used in research where conditions prevent randomization or experimental control (i.e., intact groups), its use here served the same purpose -- that is, to statistically equate all individuals in the control and experimental groups on important quantitative variables.

For comparison purposes, therefore, all subjects were statistically given the sames scores on grade point average and on the pre-test.

Table 23 uses the GPA (Grade Point Average) as the covariate to compare the immediate recall and the long-term retention of the groups. It is seen that there continues to be a statistically significant difference between the control and experimental groups with GPA held constant for all subjects.

Using Post-Test-1 as the covariate, Table 24 (on Page 31) verifies that a statistically significant difference between the groups exists for both immediate recall and long-term retention with all subjects assigned the same pre-test score. The fact that these differences are significant at the .001 level provides further evidence of the validity of the random selection. And it further strengthens the findings of this study regarding the effectivness of imagery for learning.

TABLE 23

A) Analysis of Covariance: Post-Test-1 by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Covariate GPA	1201.91	1	1201.91	36.01	.001
Main Effects					
Control/ Experimental Group	275.96	1	275.96	8.27	.01
Residual	8836.28	265	33.34		
Total	10,314.15	267	38.63		

B) Analysis of Covariance: Post-Test-2 by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Covariate GPA	207.87	1	207.87	5.03	.05
Main Effects					
Control/ Experimental Group	416.62	1	416.62	10.07	.01
Residual	10,959.54	265	41.357		
Total	11,584.03	267	43.386		

TABLE 24

A) Analysis of Covariance: Post-Test-1 by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Covariate Pre-Test	1643.45	1	1643.45	52.56	.001
Main Effects Control/ Experimental Group	384.15	1	384.15	12.28	.001
Residual	8286.56	265	31.27		
Total	10,314.16	267	38.63		

B) Analysis of Covariance: Post-Test-2 by Group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Covariate Pre-Test	2252.89	1	2252.89	68.45	.001
Main Effects Control/ Experimental Group	609.75	1	609.75	18.52	.001
Residual	8721.39	265	32.91		
Total	11,584.03	267	43.38		

Cognitive Learning Style

There is evidence that a person's preferred cognitive learning style has a bearing on which teaching techniques will be most effective for that individual. This study measured the effect of individual learning style on the learning performance of both the control and the experimental groups.

The learning styles of the participants were measured using Kolb's Learning Style Inventory (LSI). The LSI, fully described in Section III, plots one's preferred learning style according to four basic dimensions (1 through 4 below) and two ranges (5 and 6 below) as follows:

1. Concrete Experience
2. Reflective Observation
3. Abstract Conceptualization
4. Active Experimentation
5. AC - CE
6. AE - RO

A high score on any of the dimensions (1 through 4) indicates a strong bias toward that particular learning/thinking style. The differences between the control and experimental groups on the six learning style variables are shown in Table 25 on the following page.

The control group was somewhat higher than the experimental group in preferring a logical, analytic approach to learning and fell more on the abstract end of the abstract-concrete continuum. The experimental group preferred a more experience-based approach and fell more toward the concrete end of the abstract-concrete continuum.

TABLE 25

LSI Score Comparisons by Group

	Mean	Std. Dev.	Sig.
Concrete Experience			
Control	14.41	3.01	.05
Experimental	15.28	3.00	
Reflective Observation			
Control	14.37	3.63	NS
Experimental	14.82	3.39	
Abstract Conceptualization			
Control	16.81	3.21	.05
Experimental	15.79	3.51	
Active Experimentation			
Control	16.19	3.23	NS
Experimental	15.78	3.03	
AC - CE			
Control	2.28	5.41	.01
Experimental	.46	5.75	
AE - RO			
Control	1.82	5.88	NS
Experimental	.98	5.60	

The overall interaction of cognitive styles with groups, however, was not found to be a significant one as shown in Table 26 on the following page.

TABLE 26

Multivariate Analysis of Variance
The Effect of Groups on Cognitive Style

Dependent Variable	Sum of Squares	F	Significance
Individual Dimensions of Cognitive Style			
Concrete Experience	51.08	5.65	.05
Reflective Observation	13.88	1.12	NS
Abstract Conceptualization	68.00	5.99	.05
Active Experimentation	11.28	1.15	NS
AC - CE	220.33	7.06	.01
AE - RO	169.29	2.23	NS
Overall Dimension of Cognitive Style			
Pillais Trace		1.96	NS
Hotelling-Lawley Trace		1.96	NS
Wilk's Criteria		1.96	NS

The geographically seperated schools used for this study reflected differing ethnic proportions and a wide variety of academic majors. Yet, as Table 27 and Table 28 indicate, no significant differences were found on any of these measures.

TABLE 27

Multivariate Analysis of Variance
The Effects of Ethnicity on Cognitive Style

Dependent Variable	Sum of Squares	F	Significance
Individual Dimensions of Cognitive Style			
Concrete Experience	48.72	1.06	NS
Reflective Observation	134.42	2.22	NS
Abstract Conceptualization	102.23	1.79	NS
Active Experimentation	55.11	1.12	NS
AC - CE	90.40	.56	NS
AE - RO	205.86	.53	NS
Overall Dimension of Cognitive Style			
Pillais Trace		1.34	NS
Hotelling-Lawley Trace		1.36	NS
Wilk's Criteria		1.35	NS

TABLE 28

Multivariate Analysis of Variance
The Effects of Major on Cognitive Style

Dependent Variable	Sum of Squares	F	Significance
Individual Dimensions of Cognitive Style			
Concrete Experience	107.62	.89	NS
Reflective Observation	157.98	.98	NS
Abstract Conceptualization	241.51	1.65	NS
Active Experimentation	113.46	.88	NS
AC - CE	486.54	1.18	NS
AE - RO	445.04	.43	NS
Overall Dimension of Cognitive Style			
Pillais Trace		.86	NS
Hotelling-Lawley Trace		.86	NS
Wilk's Criteria		.86	NS

Table 29 indicates that there are some differences between campuses on the learning style dimensions of Reflective Observation and Abstract Conceptualization. There is, however, no significant overall interaction on cognitive style as a result of campus location. The metropolitan community college and urban technical institute students were more reflective and less analytical than those enrolled in the state university and the private college.

TABLE 29

Multivariate Analysis of Variance
The Effects of Campus on Cognitive Style

	Individual Dimensions of Cognitive Style		
Dependent Variable	Sum of Squares	F	Significance
Concrete Experience	112.52	1.78	NS
Reflective Observation	217.37	2.61	.05
Abstract Conceptualization	183.58	2.35	.05
Active Experimentation	36.88	.52	NS
AC - CE	424.41	1.94	NS
AE - RO	665.32	1.25	NS
	Overall Dimension of Cognitive Style		
Pillais Trace		1.63	NS
Hotelling-Lawley Trace		1.63	NS
Wilk's Criteria		1.63	NS

The class of the students, which quite likely reflects an increase in age as well as in educational experience, shows a major difference in Reflective Observation and the Active-Reflective Continuum, with an increasing preference for the role of observer and an impartial approach to learning as the class increases. Again,

however, no significant overall effect of class on cognitive style was found, as reported in Table 30.

TABLE 30

Multivariate Analysis of Variance
The Effects of Class on Cognitive Style

Dependent Variable	Sum of Squares	F	Significance
Individual Dimensions of Cognitive Style			
Concrete Experience	20.96	.56	NS
Reflective Observation	244.01	5.24	.001
Abstract Conceptualization	52.62	1.14	NS
Active Experimentation	68.60	1.76	NS
AC - CE	103.11	.80	NS
AE - RO	1378.48	4.78	.001
Overall Dimension of Cognitive Style			
Pillais Trace		1.62	NS
Hotelling-Lawley Trace		1.66	NS
Wilk's Criteria		1.64	NS

A significant relationship was found between the measure of brain laterality (hemisphericity) and the dimensions of cognitive style. Subjects who were more right-hemisphere oriented or balanced tended to use a more feeling-based approach to learning (CE) and were less logical and analytical (AC) while falling more toward the concrete end of the abstract-concrete continuum.

Table 31 (on the following page) reports these differences in cognitive style mean scores, while Table 32 indicates that there was a significant overall effect of hemisphericity on cognitive style scores.

TABLE 31

Cognitive Style and Hemisphericity

Laterality	Mean	Std. Dev.	Sig.
Concrete Experience			
Left Hemisphere	14.23	2.95	.01
Balanced	15.71	3.36	
Right Hemisphere	15.21	2.83	
Reflective Observation			
Left Hemisphere	14.54	3.36	NS
Balanced	14.15	4.00	
Right Hemisphere	14.88	4.47	
Abstract Conceptualization			
Left Hemisphere	17.05	3.27	.01
Balanced	16.12	3.74	
Right Hemisphere	15.43	3.19	
Active Experimentation			
Left Hemisphere	16.02	3.01	NS
Balanced	16.35	2.88	
Right Hemisphere	15.74	3.41	
AC - CE			
Left Hemisphere	2.69	5.43	.001
Balanced	.62	6.35	
Right Hemisphere	.03	5.21	
AE - RO			
Left Hemisphere	1.52	5.49	NS
Balanced	2.15	6.05	
Right Hemisphere	.88	5.93	

TABLE 32

Multivariate Analysis of Variance
The Effects of Hemisphericity on Cognitive Style

Dependent Variable	Sum of Squares	F	Significance
	Individual Dimensions of Cognitive Style		
Concrete Experience	94.75	5.32	.01
Reflective Observation	18.15	.73	NS
Abstract Conceptualization	144.07	6.49	.01
Active Experimentation	12.51	.63	NS
AC - CE	415.92	6.80	.001
AE - RO	16.83	.10	NS
	Overall Dimension of Cognitive Style		
Pillais Trace		2.24	.01
Hotelling-Lawley Trace		2.23	.01
Wilk's Criteria		2.24	.01

Participant's Evaluation

Participants were asked to evaluate the learning experience in terms of their attitudes toward the teaching method used. The experimental group was significantly more positive toward imagery than the control group was toward the lecture method. The experimental group had a greater desire to have their method used in school, and they felt that they learned significantly more from the imagery methodology than the control group felt they learned from the lecture. These attitudinal differences between the control and experimental group are shown in Table 33 on the next two pages.

TABLE 33

Student Response to Evauation Questions by Percentage

1. Question: What was your impression of the teaching method used on the videotape?

		Control	Experimental
Ineffective	1	3.7%	1.5%
	2	17.2%	1.5%
to	3	32.1%	17.2%
	4	36.6%	38.8%
Effective	5	10.4%	41.0%

2. Question: How well was it able to hold your attention?

		Control	Experimental
Boring	1	23.1%	2.2%
	2	29.1%	9.0%
to	3	28.4%	17.9%
	4	14.2%	30.6%
Interesting	5	5.2%	40.3%

3. Question: Would you like to see this teaching method of the videotape applied to the courses you are taking now?

		Control	Experimental
No	1	37.3%	5.2%
	2	17.9%	10.4%
to	3	18.7%	23.1%
	4	12.7%	24.6%
Yes	5	13.4%	36.6%

4. Question: How well were you able to see the TV screen?

		Control	Experimental
Not Well	1	2.2%	1.5%
	2	6.7%	0.7%
to	3	15.7%	14.9%
	4	20.9%	20.1%
Perfectly Well	5	54.5%	62.7%

TABLE 33 (Continued)

5. Question: How well were you able to hear what was said?

		Control	Experimental
Not Well	1	0.0%	0.0%
	2	3.7%	0.0%
to	3	5.2%	3.7%
	4	20.1%	6.7%
Perfectly Well	5	70.9%	89.6%

6. Question: Do you wear glasses?

	Control	Experimental
Yes	53.0%	51.5%
No	47.0%	48.5%

7. Question: How familiar were you with the content of the video presentation before the session?

		Control	Experimental
No Familiarity	1	35.8%	28.4%
	2	28.4%	35.1%
to	3	26.1%	32.1%
	4	9.7%	4.5%
Complete Familiarity	5	0.0%	0.0%

What do you feel you learned from the TV presentation?

		Control	Experimental
Nothing	1	1.5%	0.7%
	2	11.9%	3.0%
to	3	35.8%	20.1%
	4	36.6%	38.1%
A Great Deal	5	14.2%	38.1%

VI. CONCLUSIONS

Students in the experimental group who experienced the presentation of learning material through mental imagery achieved significantly higher gain scores than the control group on both the test of immediate recall and the test of long-term retention.

As a whole, imagery groups achieved gain scores that were 12% above the control group on immediate recall and 26% above the control group on long-term retention.

Specific types of gains varied from a low of 4% for the experimental group on immediate recall of information relating to process and function (Subtask 3) to a 31% gain over the control group for information emphasizing the rote memory of sequential data (Subtask 1).

Overall, the experimental group had its most significant gain over the control group in the rote memorization of sequential data (Subtask 1), although there were noticeable gains in the long-term retention of material related to process and function (Subtask 3), as well as significantly higher immediate recall gains in areas requiring the understanding of spatial relationships (Subtask 2).

Although there were many common charactaristics among the total student sample, the four types of schools involved in the study did reflect some major differences in ethnicity, academic major, and age levels. As such, there were score variations among the four schools. Regardless of the differences, however, the experimental group at each school exceeded the performance of the control group by a significant degree in both immediate recall and long-term retention.

Mental imagery, in recent years, has been identified as a dominant right hemispheric function by much of the research. This would suggest that those with a preference for or tendency toward right hemispheric thinking skills would be at an advantage in an environment requiring the use of imagery for learning. Analysis of the data of this study, however, reveals that hemisphericity did not serve as a significant influence on the results, either for immediate recall or long-term retention.

In similar fashion, the classification and academic major of students might be thought to exert an influence on learning by favoring those of a higher class with more learning experience, or those whose academic major was closely related to the content of the learning tasks. Again, in this study such was not the case. Neither class nor academic major provided a significant interaction effect on immediate recall or long-term retention.

Likewise, one might suspect that the outcome of a learning task might be influenced by the native ability of the learner (as reflected in grade point average), or by prior knowledge of the content of the learning task (as reflected by high scores on the pre-test). This would be particularily true had randomized assignment to the groups not produced equally normalized distributions of the critical variables of GPA and high pre-test scores. Analysis of the differences in immediate recall and long-term retention in this study found higher significant differences in favor of the experimental group when ability and achievement (GPA) and prior knowledge (pre-test scores) were held constant.

The learning style inventory found no differences in cognitive style preferences as a function of ethnicity or academic major, and only selected differences as a

result of classification and campus. Students from the community college and the technical institute showed a slight preference for impartial observation in learning and were less likely to rely on logical analysis and rational evaluation than their counterparts at the state university and the private college.

It was also discovered that the higher the class of the participant, the more the tendency existed for that participant to prefer impartial observation and personal reflection in learning.

As might be suspected, hemisphericity exerted the major influence on cognitive style of all the variables in this study. Those with left-brain preferences were inclined toward a more logical, rational approach to learning and preferred more structured, authority-directed learning settings. Right hemisphere and balanced hemisphere students preferred to be personally and emotionally involved in learning, preferably with peers, and to learn through concrete examples rather than abstract theory.

Finally, although some differences between the control and the experimental groups were found (the experimental group tending to be slightly more concrete and less analytical) no significant overall interaction between groups and the measures of cognitive style were found.

VII. SOME IMMEDIATE APPLICATIONS TO ARMY TRAINING

Based on our findings that mental imagery is an aid to learning and recall, a number of applications suggest themselves for immediate Army use.

1. Army trainers could be informed about mental imagery, how it affects learning, and the conditions under which it can be most appropriately used.

2. Army trainers could be formally trained in the use of mental imagery for training.

3. Existing training programs could be analyzed to find those content areas where mental imagery might be most effectively applied to enhance the learning.

4. New curriculum development activities could take mental imagery into account as an integral part of the curriculum design where applicable.

VIII. RECOMMENDATIONS FOR FURTHER STUDY

1. The effects of mental imagery on learning need to be studied in a setting where there is a real need to know. Although this study was conducted not in an isolated laboratory environment, but in normal classrooms, we suspect that there was little apparent incentive on the part of the subjects other than receiving monetary payment. What needs to be researched is this: Is imagery an even more effective learning tool where a genuine motivation to learn exists?

2. This study confined itself to the effects of imagery on knowledge acquisition. Research is needed on the effects of imagery on skill acquisition as well.

3. For this study, participants in the experimental group received no prior training in how to use imagery for learning. A study is needed to determine how prior training in the use of mental imagery affects one's ability to learn using imagery. Also needed is research into the most effective and accelerated ways of developing one's skills in educational imagery.

4. In this study there was no review or spaced reinforcement of the learning material between Post-Test-1 and Post-Test-2. A study is needed to determine the effects on learning and recall of review using mental imagery as opposed to traditional methods.

5. More research is needed regarding the effects on learning of self-directed vs. other-directed imagery.

6. More research is needed in the use of imagery for helping people identify and overcome learning barriers. In connection with this, research is also needed in the effects on learning and recall of using mental imagery for positive mindsetting and for helping people become more personally and emotionally involved in learning.

7. Significantly more research is needed into the most effective ways of using mental imagery and other non-linear mental skills in conjunction with computer-based and machine-driven learning. How can we, in other words, build computer-based environments that appeal most effectively to the whole mind, the whole personality, in a multi-sensory, holistic way?

8. A "total system" approach to educational research appears to be increasingly appropriate for today's research needs. A study is needed into the combined effect of orchestrating into one system the major elements that show evidence of contributing to more accelerated and effective learning (such as: mental imagery, positive suggestion, mind/body relaxation, training in right-brain and whole-brain learning skills, cooperative and team-based learning approaches, multi-modal and whole-brain presentation of material, conscious/paraconscious coordination, etc.). Separate elements could then be backed out to test their negative effectiveness. Also, the most effective combination of elements could be determined.

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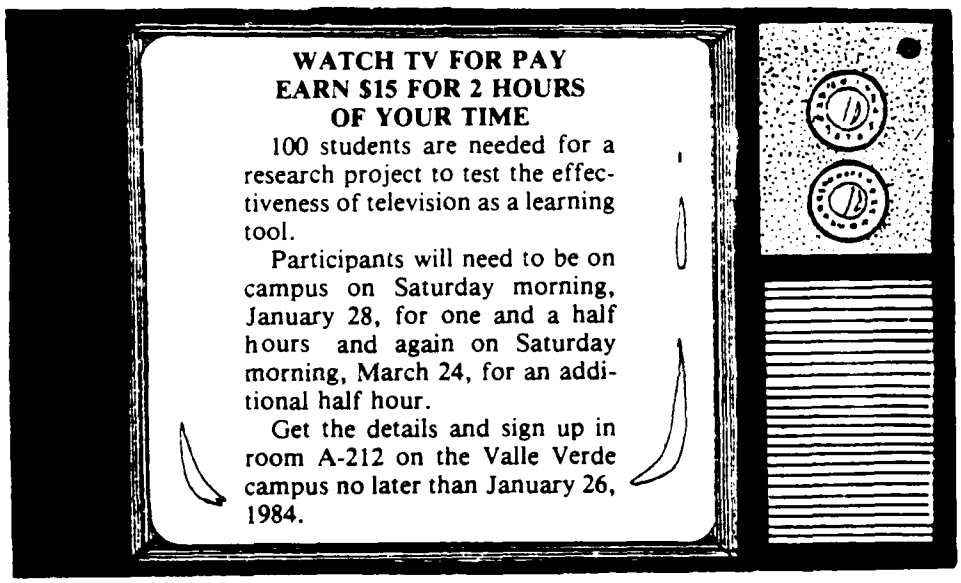
SAMPLE AD FOR PARTICIPANTS



MATC

TV LEARNING RESEARCH PROJECT

Participant's Application

The following questions may be answered on a stricly voluntary basis and are only to help researchers understand the characteristics of the group as a whole. The information is confidential and will not be used in any way outside the scope of this study.

Name (please print) _____

Mailing Address _____
street city zip

Year: Freshman ___ Age _____ Major _____
Sophomore ___ Sex _____ Minor _____
Junior ___
Senior ___
Other ___

Ethnicity: ___ American Indian ___ Oriental
___ Black (non-Hispanic) ___ White
___ Hispanic ___ Other

Circle the letter on the right that roughly corresponds to your grade point average so far in college.

A A- B+ B B- C+
C C- D+ D D-

So that we might assign you to a group for watching the TV presentation, please check **ALL** the time periods below when you will be free:

Monday, Feb. 27 - 10:40 a.m. - 11:50 a.m. ___
12:10 p.m. - 1:20 p.m. ___

Wednesday, Feb. 29 - 10:40 a.m. - 11:50 a.m. ___
12:10 p.m. - 1:20 p.m. ___

Please deposit this application in its sealed envelope before February 21 at the Office of Student Affairs, Room 222 in the Main Building. If your application is accepted, you will be informed by mail when you should be present in Room 220 of the Main Building for the first phase of the project.

SAMPLE TEST

Participant Number _____

Television as a Learning Tool

IMPORTANT - PLEASE READ THIS BEFORE STARTING

1. This is not a test of your intelligence or general academic ability, but a test of the effectiveness of certain teaching methods.

2. The results of this test will be kept absolutely confidential and will in no way whatever affect your academic career at this school.

3. If you honestly do not know the answer to any question, don't guess. Just leave it blank.

4. If you are unsure of how to spell any word on this test, spell it phonetically. Other than that, don't worry about spelling.

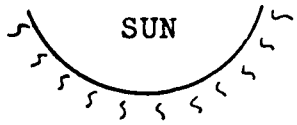
5. When a written answer is called for, please **PRINT** it legibly.

(SUBTEST 1)

THE PLANETS

List the planets of our solar system in order by their distance from the sun.

(Note: there are more blank lines than you will need)



_____

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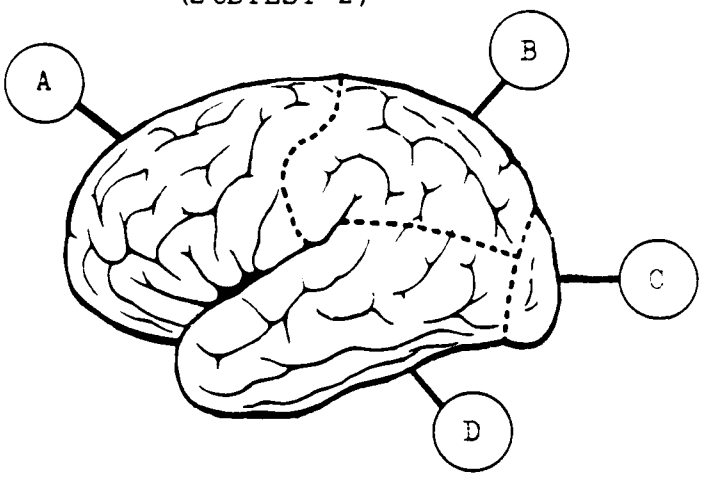
(SUBTEST 2)



BRAIN ANATOMY

1. Name the general areas pointed to in the brain diagram above.

   A _____

   B _____

   C _____

   D _____

2. What is the name of the area at the back of A?

   _____

3. What is the name of the area at the front of B?

   _____

4. Name a sense or a brain activity associated with each of the brain areas above.

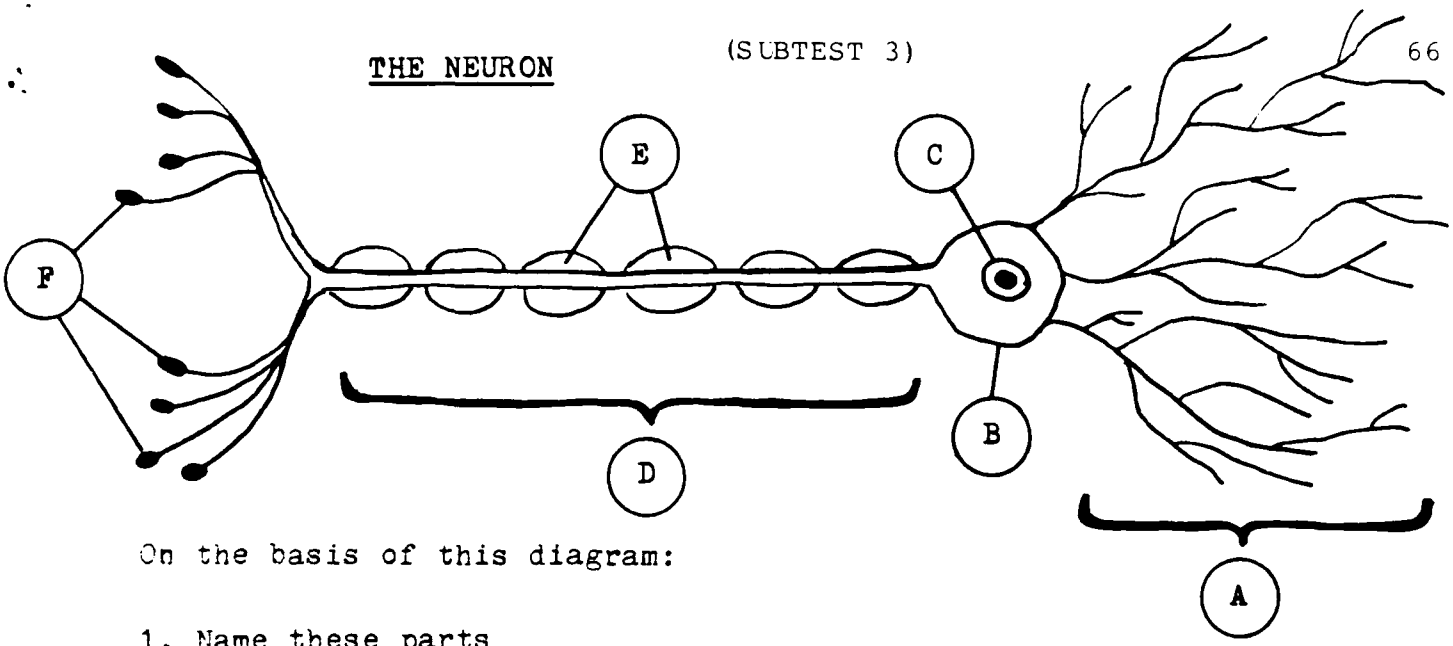
   A _____

   B _____

   C _____

   D _____

THE NEURON



On the basis of this diagram:

1. Name these parts of the neuron:

   A _____

   B _____

   C _____

   D _____

   E _____

   F _____

2. Electro-chemical information comes into the neuron through (check one): ____ A ____ D

3. Electro-chemical information is sent out of the neuron through: ____ A ____ D

4. The sacks filled with neuro-transmitter substance are called _____

5. In a normal resting state there is a relative abundance of _____ ions <u>outside</u> the neuron's membrane.

6. In a normal resting state there is a relative abundance of _____ ions <u>inside</u> the neuron's membrane.

7. What substance within the neuron plays an active part in the initiation of a nerve impulse and helps get the process of ion exchange going? Check one:

_____ Calcium Chloride
_____ Acetylcholine
_____ ATP
_____ Phosphorus
_____ Magnesium
_____ Sodium Phosphate
_____ Adrenalin
_____ _____ (other)

8. In a resting state the inside of a neuron's membrane has (check one):
____ a negative charge
____ a positive charge

9. In a resting state the outside of a neuron's membrane has (check one):
____ a negative charge
____ a positive charge

10. When a nerve impulse reaches F (in the diagram of the neuron above) what substance rushes into F from the outside to cause the sacks of neurotransmitter substance to merge with the membrane and erupt?

_____

11. The billions of non-neuron cells in the brain that provide structural support for the neurons and the brain's blood vessels are called

_____

12. An internal component of the neuron that some researchers believe plays a role in transporting the sacks of neurotransmitter substance is known by the name of (check one):

____ Mitochondrion
____ Neurotransport Mechanism
____ Golgi Apparatus
____ Neurofibrils
____ ATP
____ Acetylcholine
____ Rough Endoplasmic Reticulum
____ Schwann Cells
____ _____ (other)

PARTICIPANT'S EVALUATION

Please circle the appropriate numbers on the scales below.

1. What was your impression of the teaching method used on the videotape?

   Ineffective 1 2 3 4 5 Effective

2. What did you think of it in terms of interest?

   Boring 1 2 3 4 5 Interesting

3. How would you like to see the teaching method of the videotape applied to the courses you are taking now?

   No 1 2 3 4 5 Yes

4. How well were you able to see the TV screen?

   Not well at all 1 2 3 4 5 Perfectly well

5. How well were you able to hear what was said?

   Not well at all 1 2 3 4 5 Perfectly well

6. Do you wear glasses? (check one) ___yes ___no

7. How familiar were you with the content of the video presentation before the session?

   No familiarity 1 2 3 4 5 Complete familiarity

8. What do you feel you learned from the TV presentation?

   Learned nothing 1 2 3 4 5 Learned a great deal

9. Any general comments about the TV presentation and your participation in it? (Use the reverse side.)

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