7921234

GOURLEY, JAMES EARL
DIFFERENTIAL PROCESSING OF AUDITORY AND VISUAL INFORMATION IN LINGUISTIC AND NON-LINGUISTIC FORMS.

THE UNIVERSITY OF OKLAHOMA, PH.D., 1979

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

# DIFFERENTIAL PROCESSING OF AUDITORY AND VISUAL INFORMATION IN LINGUISTIC AND NON-LINGUISTIC FORMS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

JAMES E. GOURLEY

Norman, Oklahoma

1979

DIFFERENTIAL PROCESSING OF AUDITORY AND VISUAL INFORMATION IN LINGUISTIC AND NON-LINGUISTIC FORMS

APPROVED BY

[signatures]

DISSERTATION COMMITTEE

## ACKNOWLEDGEMENTS

I would like to express my greatest appreciation to Dr. Blaine Goss for his unfailing support and guidance. In his role as chairman of my dissertation committee he was always ready, able, and eager to assist and encourage.

Also I have been grateful for the criticism and guidance provided by Dr. Wayland Cummings, Dr. Richard Talbott, and Dr. Edmund Nuttall. The assistance from Dr. Michelle Mondani and Dr. Roger Mellgren is also gratefully acknowledged.

My research assistants, Miss Janet Cunningham, Miss Marsha Kolinek, Miss Cheryl Nickell, Miss Diana Schulz, and Mrs. Peggy Slack made the data gathering more interesting and efficient. Thanks also goes to Mr. Shane Simon for the art work that I used as stimulus material.

Among all of the graduate students to whom I owe thanks, Mrs. Millie Thompson Scarberry deserves the greatest accolades as a scholar and friend.

TABLE OF CONTENTS

LIST OF TABLES

## LIST OF ILLUSTRATIONS

# DIFFERENTIAL PROCESSING OF AUDITORY AND VISUAL INFORMATION IN LINGUISTIC AND NON-LINGUISTIC FORMS

## CHAPTER I

### Introduction

The human mind responds to the world as if it were an orderly and patterned series of events. That process intrigues many minds and instigates vast amounts of research. Unfortunately, men are only beginning to fathom the processes through which our minds are able to gather information. The nature of the information processing that does occur is very much a matter of debate and research by both philosophers and scientists.

Of all the categories of information available to our minds, one has special significance because it may be an activity particularly characteristic of human intelligence. That activity is, of course, language. We are able to understand a great deal about our environment without language, however, it is through language that we establish culture and build civilization. Most of us deal with the world in terms of linguistic information. Education, culture, business, and most of what we call living depends on linguistic processing. Linguistic processing here refers to the use of arbitrarily assigned symbols to convey meaning in an organized, planned system such as language. Given the curiosity that surrounds information processing and the pervasiveness of linguistic information in our everyday affairs, one might ask: Does the human mind receive linguistic information in a way different from that used for other types of information? Do we process words and sentences in the same manner as we process sights and sounds which are non-linguistic? If language is as important to man as some think, then answers to these questions could teach us much about ourselves as well as our language.

Another natural distinction between categories of available information is that of sensory modality. One could assume that visual information and aural information were simultaneous processes, as though these two modes of receiving information were really just separate mail slots that led to the same sorting process. Is there any characterisitc difference between the manner in which aural information is processed as compared with visual stimuli? For example, the written word _cat_ and the spoken word _cat_ could be assumed to trigger the same mental functioning just as the mail receives similar treatment without regard to what means it used to reach the post office. However, this need not be the case. The real question is whether these different systems remain significantly separate as the information is processed by the brain.

One phenomenon that makes this distinction more understandable is silent speech. Silent speech is that process of saying words to ourselves as if we were speaking without actually articulating the words. As one reads this manuscript he might be aware of saying the words to himself silently as he reads. Thus when receiving visual information we translate that image into a silent speech experience, but when we receive aural information the translation is not necessary. The two modes are processed differently.

Combining the Categories

By combining the categories of linguistic versus non-linguistic information with visual versus auditory information, four categories of information are produced:

1. linguistic/visual: writing
2. non-linguistic/visual: pictures
3. linguistic/auditory: speech
4. non-linguistic/auditory: sounds

This research will attempt to sort out the differences that exist between these four categories. Since we are able to recognize these categories, they must represent at least a surface level distinction by the brain. The depth and scope of these differences will be the telling difference. For instance, are spoken words processed separately from pictures in the mind? Or is there a point in processing after which these two different modalities are treated similarly? If, as suggested, the brain processes some information differently based on its linguistic and modal characteristics, how far along the processing path is that difference maintained? For example, if the information is just processed for quick retrieval, like repeating words as they are said or taking dictation, is the difference as strong or stronger than if the information is memorized for later recall, like a friend's telephone number or address? Just how differently are the types of information processed as they are received?

## LITERATURE REVIEW

To answer these questions, several areas of research were reviewed. First, there is the nature of the brain as the main processing location. Next, the two gathering systems of vision and audition will be described and evaluated as they work together. The literature that describes how these modes interact will be explained to take advantage of pertinent data. The third area is that of memory and how it can be used to measure the depth of information processing. That section will include descriptions of both short and long-term memory. The final section is the presentation of the dual-coding hypothesis which suggests how pictures, sounds, and words might be coded for retrieval and processing. Once each of these sections has been completed, a series of hypotheses relating the four main categories with three distinct levels of processing will be presented and explained.

The intended outcome of this research is a statement that not only relates non-linguistic to linguistic information, and visual to auditory information, but one that will explain how the mind handles each of these types of information at surface levels and deeper levels of processing.

## The Nature of the Brain

The human brain is the object of continuing research. Over the past two hundred years, several theories of how the brain accomplishes its many functions have been offered. Current research reveals that the brain is differentiated into specialized areas like most of the human body. Each area is still linked to other areas and maintains the potential for at least some change or adaptation. The stroke victim is a good example of the ability of the brain tissue to adapt to new functions. Once a stroke has damaged a region of the brain, other brain tissue may begin to learn the former functions of the damaged area. This process is slow but it often occurs. Of course, the brain has limits to this ability but the potential exists. The result is a view of the brain in which special areas each perform separate functions, and to a limited extent they may learn closely related functions under pressure such as injury.

Cerebral anatomists (Prosser, 1973) also are able to trace vast networks of interconnections among the various specialized regions of the brain. While some specialization occurs, it is necessary for the parts to remain in constant communication with each other. The auditory and visual centers, for example, as separate as these two systems seem, have a large number of nerve fibers that transmit information between them. The exact nature of this information is still unidentified, yet the need for and existence of contact between regions is documented.

The structure and function of the brain determine how we process incoming stimuli. Though psychological research sometimes ignores the physical limits of the body, studying the physical systems often sheds light on the psychological phenomena as well. The interactions among the regions of the brain indicate that the sensory modalities do not function independently. The information that is processed by the ears also may affect visual images and conversely, images available to the eyes may arouse or affect auditory experiences. Certainly there is more to be known, however, it is clear that the various activities of the brain are interdependent.

## The Auditory and Visual Systems

One common activity that depends on two sensory systems is language. Words appear both as visual and auditory stimuli. Often in the psychological literature, the difference between the spoken and written word is ignored. Certainly within our everyday experience, we feel that we are able to assume that if one sees or hears a word, the effect is the same; the receiver reacts to the word regardless of the mode of presentation. Undoubtedly the similarity of response to stimuli in differing modes is great, nonetheless there are reasons to expect that one might observe differences as well.

Recently several researchers (Murdock, 1966; Thompson and Clayton, 1974) have begun to delineate the degree of differentiation between visual and auditory modes as they appear in short-term memory tasks. This research must recognize the oral-aural nature and usage of language. The symbolic nature of language is an auditory invention. While we have hundreds of different languages on the Earth, nearly all have had an oral-aural origin within a culture. There still exist some languages which have not yet been fully systematized into a written symbol code. These languages remain, nonetheless, the means by which people communicate. This dependency on the auditory sense is part of the nature of the languages. The gradual transition from the sole use of oral language to the intermixed usage of oral and written language can be observed in children. During ages one to six the normal child learns the vocabulary, syntax, and grammar of his oral language to a functionally adequate level (Smith, 1975). Then, usually in school, the child begins to translate his oral-aural competence into the written symbols of literacy. The learning of a written language generally takes several years to catch up to the child's oral-aural competence.

The written language that one eventually learns in school in most Western countries is a visual, written code for the oral-aural language that was previously mastered. As a normal, healthy child learns to read, he first learns the symbols that represent the sounds that he hears. Finally, he puts together the letters in the correct order to correspond to the sounds of a word. The product is a visual stimulus that represents the aural experience. In fact, the early learning of reading is done by reading aloud. Reading aloud is nothing more than translating words, one at a time, into the familiar oral-aural system of sounds that the child had previously learned. Thus written language may not constitute a directly visual experience, but rather an indirect stimulus for the oral-aural language that we have previously mastered.

This may correspond to the phenomenon that Vygotsky (1962) refers to as inner speech in children. Early in development as Piaget (1934) also reports, the child will talk to himself as he goes about his play. This is overt speech, but it is apparently not intended for others. Often the child will describe his actions or intended actions as an accompaniment to his play. At about six years of age this behavior begins to taper off. Vygotsky suggests that this is because the child had learned to maintain this same monologue in his head using words without having to use overt speech. Everything is the same except that the actual use of the voice had been eliminated and inner or silent speech replaces the overt speech. The child maintains this behavior through adulthood using inner speech to comment on his actions and interests.

The decline of overt speech does not mean that the processing in the language centers of the brain is also declining. With written language, the visual stimulus may be partially processed by the visual region and then continued in the speech center where the experience of saying it to oneself occurs. This might even suggest certain advantages of aural presentation of words which will be explained later by the Murdock experiments.

The Complementarity of Audition and Vision

An appreciation of the oral-aural nature of language could help researchers predict the outcome of various modal difference investigations. Certainly, if one is given a choice of an oral or written word as a stimulus for recall, one could predict from the literature that the oral stimulus would produce better recall. Other factors need to be considered, though, in the type of research being conducted. The research has focused on short-term memory tasks of several types. The subjects were asked to recall or recognize some previous oral or written words. The subjects undoubtedly have had more experience with the short-term recall of oral rather than written stimului. A greater percentage of our daily communication is oral, and written messages are usually more available for review than are oral messages. Thus we get far more practice at trying to remember oral messages.

Another important factor in modal recall differences is our ability to rehearse an auditory message orally when we often rehearse a written message orally as well. In memory tasks, the subject only sees or hears the stimulus once, but as he seeks to rehearse the word or stimulus he must do so in the oral-aural mode. Therefore, even if written words were easier to process, the subject would be likely to translate the visual stimulus into an oral one for rehearsal.

Further investigations into the role of the visual and auditory modes might recognize the complementary relationship of these modes of information gathering. Among the current theoretical interpretations that deal with mode, however, most seem to view the auditory and visual modes as parallel and independent means of information gathering. One such model is that of Kausler (1974). Kausler argues for a model of memory that includes pre-sensory storage areas with information coming via separate, parallel modal channels, such as auditory, visual, tactile, gustatory, etc.. This is a model that views the modal channels as mail slots wherein each gathers a type of stimulus, begins to process it and then offers signals from each modal channel that are similar for further processing. It implies that the product of each modal channel is the same and that the modal differences fail to show up after this initial pre-sensory processing. He states that modal inputs are parallel and are processed simultaneously and independently, that is without interaction. This does not explicitly exclude the complementary nature of the modes, but it does fail to note the possibility. For instance, Kausler's view could not explain the increased performance of audition in warning (Posner, Nissen, and Klein, 1976) nor the superiority of vision for sheer amount of information gathered.

Another view of modal processing as expressed by Penney (1975) in a lengthy review of the modal literature, recommends that the parallel view of modal input be extended beyond the pre-sensory level. This view, as Kausler's, fails to recognize the complementary nature of modes. The short-term memory research alone does not contradict her view that the modal inputs are entirely parallel. However, the physiology of the modes and the psychological literature both support a view of vision and audition as complementary modes of information gathering.

To simplify the explanation of the complementary relationship of audition and vision, a description of each of the systems will follow. Each system will be described in terms of: (a) continuity of activity, (b) amount of information, (c) perceptual field, and (d) ability to alert. These are all physiological descriptions of the systems, but they explain the relationships and are quite consistent with the psychological data for these modes. The two systems, audition and vision, work together at separate but similar tasks that serve each other and the total organism to promote survival.

Auditory Modality The ears are a mechanism that are able to scan the environment. The ear does not have the ability to close or stop the continual input of stimulation. Certainly the level of listening can vary, but even in sleep the ear remains on duty to warn the organism of any unusual sounds. Anatomically, the ear is heavily tied to the reticular formation (Posner, 1976) which is responsible for general body arousal. Thus the ear, upon receiving a particularly unusual, threatening, or intense signal may even disturb sleep. The ear then, is a sentinel on guard at all times.

The amount of information supplied by the ear is relatively small (Prosser, 1973). It is able to register only frequency, intensity and duration and to some degree direction (but that may be a combination of other dimensions). The further characteristics of sound such as timbre are actually various codings of pitch and intensity. The ability of the ear to locate the source of a sound is only approximate. The ear cannot pinpoint a sound source in three-dimensional space as well as the eye can.

The field of the ear by contrast to the eye is very large. Regardless of head orientation the ear can perceive sound anywhere in three-dimensional space. Thus the ear is truly omnidirectional in its receptivity.

The ear as explained by Posner et al (1976) is particularly able to alert the organism. The experience of being awakened from sleep by a sudden noise is common, but Posner also cites some experimental evidence of the ear's superior capabilities for alerting the organism. In one study, subjects were given directions to respond to given visual and aural stimuli by pushing a button. The aural and visual stimuli were then preceded by aural and visual warnings. The subjects were always aware of the location of the visual stimuli so that the experimenter was certain that they attended to the visual stimuli. The results of the study show that the auditory system was superior to the visual warning system. In many cases the visual warnings did not increase the response time at all. Consistently, the auditory mode for warning helped the subjects achieve a shorter response time.

Visual Modality The eye provides an interesting contrast to the ear in its perceptual limitations. The eye cannot constantly monitor the environment. The eye blinks frequently, and may spend eight or ten hours per day closed and therefore not able to gather data. As a warning sentinel its function is severely limited. The eye, then, is often dependent on some other signal to be alerted of where and when to scan.

The amount of information that the eye provides as compared to the ear is immense. Within the retina are four different sensors, three for color, and one for general intensity. In addition to these four dimensions, studies (Goldsmith, 1973) have shown that fields of receptors within the retina may function as specific movement and/or shape detectors, thus allowing many new dimensions to be available to the eye. The complexity of visual signals with capabilities for many simultaneous inputs makes the ear appear to be relatively simple.

The field of the eyes and the alerting ability are severely limited. Unlike the ear with its omnidirectionality, the eye, has a restricted field (Moray, 1970). The stationary field of the fixed eye is less than one third of the environment, while even the addition of eye and head movements do not make the eye omnidirectional. As reported in the ear description, the studies reported by Posner (1976) reveal the eye to be slower in its ability to alert the total organism.

When inspected along these four dimensions, the eye and ear compose a very facile, complementary system for information gathering. First, the ear with its omnidirectionality and constant scanning perceives a signal which alerts the organism. The instinctual head-turn response adjusts the head and eye position to put the source of the sound within the field of vision. Then the eye with its superior information gathering ability proceeds to analyze further the target for information unavailable to the ears.

The problems of the deaf and blind reiterate the differing roles of audition and vision. One of the chief problems of deaf persons is the need for non-aural warning devices. Alarm clocks, telephone bells, door bells, and fire alarms are all useless to the deaf person who cannot take advantage of the warning function of the auditory mode. While most people express a greater fear of the loss of vision, it is the loss of hearing that is more immediately dangerous. Once asleep the deaf person must rely only on tactile stimulation, whereas the blind person is as aware as the sighted while asleep.

The combined system is both effective and efficient. Its efficiency comes in the use of the ear as a constantly scanning, large field, alerting device. Since the ear perceives relatively less information of a non-symbolic nature, the ear makes an efficient monitor. If the eyes were to be the constant monitor, the organism would be receiving far more information to process, most of which would be of low value. Therefore, the eye surveys only the fields that are more likely to have information relevant to survival. Like all systems, an organism needs to have the best information at the lowest total energy price.

## Modal Processing Literature

Modal processing literature includes the discussion of the divergent roles of audition and vision. These two complementary and interacting systems provide an efficient and effective information gathering system. The function of these modes for language usage is not equal nor is it independent as will be discussed later. The development of language is and was an oral-aural process, that is only coded in a written form. The preference and superior performance of subjects in short-term memory tasks with words as auditory stimuli could have been predicted by the oral-aural nature of language.

One simple scheme that might help the reader visualize the processing system can be described in just three points.

Point A represents the entry point of information into one of the modal systems. From Point A to Point B each of the modal systems moves information relatively directly and in a parallel manner. That is, the different systems do not interact significantly between points A and B. Then from Point B to Point C the systems do interact significantly and one can expect to see changes in the information processing. It is likely that Point B represents some significant process such as rehearsal and this likelihood will be discussed later. Thus this scheme suggests that information processing is parallel for some defined interval and then interactive after that interval.

The modal literature will be reviewed by considering five basic topics. First of these is the documentation of a modal difference in short-term memory. This concern is fundamental to this research and will be handled in the next section as an introduction to the modal literature. Since the research suggests that the appearance of modal differences seem to depend on presentation rate, this too, is a topic to be considered. The third topic area, that of modal differences in long-term memory is not clearly discussed in the literature, but still deserves attention in this account. The role of rehearsal in memory also impacts on the modal differences and the differences in recall and is therefore an area of interest. The final area, that of recall, is a necessary investigation for the measurement of modal differences thus will be included as the last section in the review.

Two fundamental views of information processing have been articulated in the literature. The first, as presented by Birch (1963), argues for the integration of separate sensory modalities. Each sensory system, he suggests, gathers information that is subsequently processed without regard to modality. Gibson (1969) also emphasizes an amodal view of information processing wherein all modalities are expected to perform equally. Counter to these positions is that of Freides (1974) who presents the concept of modal adeptness. Essentially this is an awareness of the special abilities of each mode for processing certain types of data. Freides presents the following summary of what others have done with respect to the different capabilities of each mode. "Visual memory for words favored the early inputs of a sequence (primacy), whereas auditory memory favored the later inputs (recency); simultaneous visual inputs were preferentially recalled in simultaneous orders whereas simultaneous auditory inputs were recalled in successive orders; retrieval of information increased with faster auditory inputs and slower visual inputs; auditory memory showed serial position interference effects, visual memory did not; visual mnemonic capacity was extensive; auditory mnemonic capacity was limited" (Freides, 1974, p. 301). He concludes that modalities are different systems for information processing each of which possesses special capabilities.

Various models and discussions of short-term memory demonstrate the debate on how visual and acoustic stimuli are processed. Many researchers (Fisk, 1974; Blackburn, 1974; Lowe, 1973; Ternes, 1974; Bosshardt, 1975) seem to agree with Freides that the processing of visual and acoustic material does vary enough to indicate the possibility of separate short-term retrieval systems.

The work of Blackburn (1974), for example, concludes that since shifts in modality relieve proactive inhibition, modal information must be stored separately or at least have different encoding categories. His rationale stated that proactive inhibition in short-term memory was quickly built up unless there was a shift to a new type of stimulus material. Proactive inhibition is the tendency for performance to decrease due to interference (defined as the build-up of inhibition) from the continued input of material of one type or class. By using ten trials of trigrams (three letter sequences) with modal shifts on the fourth, seventh, and tenth, he was able to show significant recall improvement on those trigrams that represented modality shifts as compared to the other trials that represented no change in the type or class of stimulus material. Thus the subjects were presented with a series of ten trigrams. The first three trigrams were in one particular mode (say auditory, for example) then the next three were in a different mode (say visual) so that the fourth trigram represented a shift to a different modality. After trigram six the seventh shifted back to auditory and stayed there for trigrams eight and nine. The final trigram was again a shift (in this example a shift back to visual). Consequently trigrams four, seven, and ten represent shifts in the modality. Apparently the modality shifts were a sufficient change in the stimulus material to constitute a new encoding category thus relieving the proactive inhibition.

Some researchers such as Sperling (1967) argue that all short-term memory is acoustically coded, however, more recent work disputes this claim. Thompson and Clayton (1974) among others (Pellegrino, 1976; Reeve, 1976) argue that separate facilities process visual and acoustic material providing modality specific encoding again supporting the notion of modality adeptness. These conclusions are supported by the work of Reeve (1976) who found that visual short-term memory for non-linguistic material was very limited. Once this limit had been reached any extra material was coded linguistically. While effort is still underway to determine the exact nature of the interplay of these systems, the conclusion that visual and acoustic processing are, to some significant degree, separate seems reasonable and useful.

Among the first to cite the modality differences as a subject of repeated research concern was Murdock (1966; 1967). In these studies he demonstrated that with serial and paired-associate material, the auditory mode as compared with the visual mode produced superior retention. Both experiments used a probe technique to allow the subjects who were college students to report their recall without having to record all of the stimulus material. A probe technique provides a cue (the probe) as to which of the stimulus items is to be retrieved. This allows for testing of recall without the problem of the recall of the first items interfering with the last items recalled. The experimenter can choose a representative set of the items without having the subject recite all of them each time. The content of both modal stimuli was the same except that one was an oral presentation on recorded magnetic tape while the other was visual presentation on slide transparencies. Common English words were used as stimuli to control for the type of information. The presentation of the words was at a relatively fast rate of two words-per-second which prevented rehearsal. In later experiments, Murdock asked whether the modal differences that he had previously encountered were located in storage or retrieval (Murdock, 1968). His design compared the results of retention of identical lists in recall and recognition tasks. The essential issue was one of availability (storage) versus accessibility (retrieval) as put forth by Mandler (1967). Murdock argued that differences in storage would be apparent in recall and recognition, while differences in retrieval would appear only in recall. The conclusive finding was that modality effects represent differences in storage and not in retrieval due to clear modal differences in both recall and recognition in serial and non-serial tasks. These storage differences are the result of how information is processed according to mode of acquisition (vision or audition). And as Murdock indicated the means of retrieval did not affect performance. This view supports the argument that mode of presentation is a significant variable in determining how information is processed by the mind.

For what appear to be pedagogical reasons, modal research has also been reported in educational journals. Cooper and Gaeth (1967) used middle-class school children in Detroit as subjects for a modality difference task that sought to show effects across age groups. While their findings indicated that visual presentation produced superior results for early grades, there are several confounding factors that make any interpretation of the data rather difficult. All of their subjects were from middle-class schools with similar skill levels and the youngest subjects were fourth graders whose skills have already reached an advanced level. The superior retention by high school students to auditory stimuli might be due to the lengthened attention span of older students for messages that are only acoustic, or there may be a developmental effect that had not yet been clearly described by this or other research. Further research could control for the attention span variability. Thus, as suggested , interpretation of these findings might better wait for further study.

Research shows that the youngsters in the Cooper and Gaeth research were not the only subjects to exhibit poor retention of auditory stimuli. Gadzella and Whitehead (1975) used college students as subjects when investigating recall techniques with modality differences. Although Gadzella and Whitehead were also looking at plural modal situations, they did test the retention of common English words after exposure to both oral and written lists. Unlike the Murdock research, the presentation rate used was a slow, one word every five seconds allowing ample time for rehearsal between the presentation of each word. This rate is ten times slower than Murdock's 0.5 seconds-per-word. Their subjects exhibited no significant differences in retention of auditory or visual stimuli. If Murdock's findings are correct, the slower presentation rate of Gadzella and Whitehead may have made it easier for retention of oral and written stimuli.

Work by Dornbush (1968) also described this same phenomenon. She found that the slower administration of the stimulus items aided the visual inputs whereas the faster rate aided the auditory inputs. Experiments designed to study presentation rates have been reported by Laughery and Fell (1969) and by Miscik and Diffenbach (1974). Laughery and Fell varied the rate of presentation of stimuli using rates of 0.5, 0.75, 1.0, 2.0, and 3.0 seconds-per-word. Their stimuli were not words but nonsense syllables made up of five to eight letters presented in lists of fifteen groups. At the end of the presentation sequence the subjects were instructed to write down any items they could remember (free recall). The interaction of presentation rate and stimulus retention clearly coincided with the Murdock, and the Gadzella and Whitehead studies. At 0.5, 0.75, and 1.0 seconds-per-word the subjects in the oral presentation condition performed significantly better on the free recall. But when the rate reached 2.0 and 3.0 seconds-per-word, the auditory superiority was no longer present. It is necessary to note, though, that there never occurred a superiority in the visual performance even in the Gadzella and Whitehead study with a rate of 5.0 seconds-per-word. This is interpreted to mean that rehearsal negates the inherent superiority of auditory stimuli for the introduction of memory material.

<u>Modality in Long-term Memory</u>

Research has not yet explored the potential for modality differences in long-term memory (Penney, 1975). If, as Murdock argues, the modal differences do occur in storage and not retrieval, it could be that the time of retrieval would be irrelevant to the degree of modality effects. More likely, though, the extensive rehearsal that occurs before long-term memory would negate any modal effects. Other evidence that supports this expectation was presented by Murray (1974) who noted increased performance in short-term memory but not in long-term memory due to vocalization of stimulus material. Apparently the advantage gained by vocalization in short-term memory is lost when the subject must process the material for long-term memory.

Cermak (1972) defines a long-term memory task as one in which the subjects master the material until they have achieved one hundred percent recall before the recall measure is taken at some later point in time. The Laughery and Fell (1969) results indicated that slow presentation rates decrease the magnitude of modality differences. Apparently the slower presentation rate provides an opportunity for the subjects to rehearse the stimulus as it is presented and this rehearsal improves retention for visual stimuli. Provided that the slower presentation rate does promote rehearsal, it is reasonable to expect that retention on a long-term task would not exhibit the degree of modality effect that is common in short-term tests. The modal research points up the consequences of the differences between auditory and visual information processing. The appearance of increased effectiveness of auditory stimuli for short-term memory confirms the modal difference hypothesis. An answer to the question of differences in long-term memory would help to explain the type of difference.

## Rehearsal

The topic of rehearsal, perhaps surprisingly, also is addressed in the literature on reading. Research into the reading process begs the question of modal disparity. As one reads, his eyes receive visual stimuli, but one also experiences what is called silent speech simultaneously. Silent speech is that experience of saying words to oneself while reading. The phenomenon of silent speech will help elucidate the difference between visual and aural processing. Through silent speech we are able to rehearse some of the auditory and visual stimuli that we receive. Words, in particular, are readily available for this type of rehearsal.

The work of Corcoran (1967) sheds some light on this issue. He had subjects scan written prose for the letter e. His results emphasized that a smaller percentage of silent e's were found than e's that were articulated in normal speech. He argued, as does Conrad (1972), that the reader was reading silently to himself as he scanned the prose, and thus 'heard' the articulated e's but missed those that were unarticulated. Corcoran's subjects did not miss all of the silent e's; they were still able to detect sixty percent of them, indicating the use of visual strategies. Thus, the investigators support the conclusion that, under normal reading conditions, subjects will go to considerable effort to re-code visual input phonologically. The subjects were rehearsing the stimuli through silent speech and the silent speech appears to be a form of auditory rehearsal in that the errors were phonological. These results also confirm the concept of modal adeptness. These subjects may have been re-coding the stimuli into a more adept modality (re-coding written into aural) in order to process the task. The subjects chose the re-coding strategy to solve the problem in spite of errors probably because they are used to re-coding written prose into aural stimulation and do so habitually.

Another study that supports both the notion of an auditory rehearsal through silent speech and the concept of modality adeptness was reported by Conrad (1971). The young subjects preferred using a phonological code when given the opportunity of recall visually presented sound-alike and non-sound-alike items. The subjects ranged in mental age, (as measured by the English Picture Vocabulary Test), from three to eleven years. They were presented sets of pictures that were either sound-alike words (cat, bat, rat, etc.) or non-sound-alike words (train, clock, spoon, etc.). The results illustrated a clear trend for increasingly superior performance for the non-sound-alike words as the age of the subjects increased. At ages three through five there were no differences in performance between sound-alike and non-sound-alike sets. However, a steady trend developed that ended with subjects of mental age eight to eleven years exhibiting fifty percent better performance with the non-sound-alike sets. These results support the claim that children under six years of age use a visual code for short-term memory, and that as the subjects increase in age they prefer to use a phonological code for short-term memory. The subjects' choice of modality changes as they learn to re-code visual language stimuli into aural stimuli.

This explanation emphasizes the use of silent speech for rehearsal. The subjects at ages four to six are seeing the pictures and later attempting to remember the pictures. The older subjects, though, are attaching verbal labels to the pictures that they are seeing and then recalling the verbal labels. The superior performance for non-sound-alike pictures is explained by the confusion resulting from verbal labels for sound-alike pictures that are not distinct. Thus, the rehearsal of the stimulus items that was necessary for recall was of an apparently aural nature.

## Recall as a Measure of Processing Differences

The areas investigated so far (the brain, the ear and eye, and the use of silent speech for rehearsal) indicate that auditory and visual processing differ. Each type of study suggests in its own way that further differences can be expected. But when investigating differences in information processing, one central issue is the question of how to measure qualitative differences in processing. As one alternative memory may provide some clue as to the differences under question. Certainly other researchers have made this assumption (Murdock, 1966; Crowder, 1972; Bosshardt, 1975), perhaps because it is an easy one for which to argue.

This assumption requires that one accept that memory is dependent on the amount and quality of information available. That is to say that one will remember more of a given stimulus set if there are more items in that set, up to the limits of that memory system. Additionally, the accuracy of the memory

will also depend on the clarity of the stimulus image. If one cannot clearly perceive the stimulus items then the likelihood of remembering them decreases. The logic being pursued here suggests that if two sets of stimuli are equally easy to process and perceive, they ought to be equally easy to remember. Thus, differences in the reported remembering ought to indicate differences in the ease of perception and/or processing. Since processing is the variable of concern, stimulus clarity should be held constant.
One developed example of this vein of research is the Precategorical Acoustic Storage (PAS) theorized by Crowder and Morton (1969). In this model it is hypothesized that the auditory sensory system provides extra information about liguistic stimuli that are stored in the PAS, giving the subject time to recheck his categorization based on new incoming information. The actual processing of the information and the storage are concurrent event. This suggests that memory and processing of information are not really separate at all. The linear view that stimulus items are received, then processed, then stored, is naive.

Reading is a good example of a task that requires some memory for processing. We cannot read by perceiving words one at a time, then storing them (Conrad, 1972). Instead, we must hear words and store them long enough to attach meaning to a whole phrase or sentence. This processing occurs after some form of storage or memory. The interplay of these systems is undoubtedly complex, but offers a means of measuring processing differences.

Recall provides an excellent measure of the differences in auditory and visual processing that have been reviewed here. Through the study of reading these differences have been further clarified. The memory process that is responsible for coding these stimuli has also been investigated. These studies, explained below, characterize the types of coding that are used for verbal material.

## The Dual-Coding Hypothesis

The dual-coding hypothesis as presented by Paivio (1971) postulates the existence of two types of memory processing. The first type is the verbal code which uses words in a serial fashion (one after the other) as both stimuli and response. The second type is the image code, and involves a type of spatial image that is both stored and retrieved. As will be explained below, these two types of codes each have individual advantages and disadvantages but they can also be used jointly. The assumption is made that two codes are better than one. That is, a subject who is able to code material in both verbal and an image code is more likely to recall that material than if it is stored in only one of the codes.

The dual-coding hypothesis assumes a distinction between abstract words, concrete words, and pictures. The ease with which a subject can produce mental images increases across these three levels. This is in contrast to the verbal coding process which is readily available for both abstract words and concrete words, but somewhat less available for pictures.

Experimentation by Paivio and Csapo (1969) bears out predictions of the dual-coding hypothesis. From the model one would predict that "since words can be read faster than objects can be named, the arousal of the verbal memory code can be prevented during input in the case of pictorial stimuli without eliminating it in the case of words by using a sufficiently fast rate of presentation" (Paivio, 1971, p. 234). That means that a subject can read a word more quickly than he can perceive and label an image or picture. A sufficiently fast rate of presentation would interfere with a subject's ability to associate images with concrete and abstract words.

The research of Paivio and Csapo used four memory tasks (memory span, serial learning, free recall, and recognition) with two rates of presentation (fast - 5.3 items per second; slow - 2 items per second). As expected, recall for pictures was poorer than recall for words at a fast rate of presentation. At a slow rate for these same tasks, however, pictures did not differ from words because subjects were able to supply verbal labels for the images and thus were able to use both codes. For the recognition and free recall tasks, the pictures were easier to remember than words at a slow rate because subjects were able to have ready access to both codes. At the fast rate, though, labeling was prevented and memory for pictures did not exceed the concrete or abstract words.

In the proposed research, a rate of two items per second will be employed which is the same as the slowest rate used by Paivio. Therefore, the list of picture stimuli ought to be more easily recalled than the words because the subjects will have the opportunity to use both the image code and the verbal code as the pictures are presented by attaching labels to the images as they see them. What ought to occur is that subjects will see each picture, store an image, and then also store a label for the picture. In effect, they will store the verbal label and an image. Consequently, on retrieval the subjects will have two coding systems, verbal and image, from which to draw. This prediction leads to the generation of three hypotheses.

## An Extension of the Dual-Coding Hypothesis

Since Paivio argues that pictures can be remembered by storing either an image and/or a word label, it is reasonable that sounds might also be stored in both of these processes. Of course, a sound image (or replay) is certainly different from the label for that sound. For example, the sound of a typewriter at work might be stored as an auditory experience and also as "the sound of typing" which is a label or verbal code for the auditory experience. Again like pictures, a sufficiently fast rate of presentation could prevent the dual-coding of both auditory experience and verbal label. Instead, only the auditory coding would be stored.

Little research has been published in regard to the nature of sounds as stimuli as compared with linguistic stimuli of the auditory and visual modes. Except for the work of Warren, Obusek, Farmer, and Warren (1969) that emphasizes the relatively poor ability of short-term memory to handle sequential tasks for non-linguistic sounds, the dual-coding hypothesis addresses the role of sounds in short-term memory better than any statement. Unfortunately, the Warren et al results have no bearing on any memory situations other than those that employ the sequential use of short-term memory. In research on free recall with slow rates of presentation, auditory experiences could be readily coded with verbal labels in addition to auditory "images". Therefore, subjects would be able to retrieve from two coding systems and should be able to more easily remember sounds than linguistic material under similar conditions. Since auditory stimuli are apparently handled more easily than image material, one could guess that sounds might also be more easily remembered than pictures, but this question has not been addressed by the literature.

An overview of the literature provides three basic topics that will be addressed by this research. The first area is that of modal adeptness and disparity. The differing capabilities and performance of the auditory and visual modes, while documented in the literature have yet to be fully understood and explained. Yet it is clear that the auditory modality ought to perform better at a recall task than the visual modality if the presentation rate is sufficiently fast. One attempt to explain this disparity suggests that rehearsal will negate these differences because it requires additional processing beyond the point at which modal stimuli remain separated. As in the model of Points A,B, and C presented earlier, the segment AB represents parallel modal processing whereas segment BC represents an interaction between the modes being processed. Thus the modal differences that are reported for short-term memory would not be expected to occur in long-term memory. The third topic is that of linguistic versus non-linguistic stimuli. When these categories are combined as explained earlier, four new categories emerge which are: speech, writing, sounds and pictures. The two non-linguistic categories, sounds and pictures, ought to be more easily recalled than linguistic stimuli, if presented slowly enough to allow for the dual-coding of both experience and labels to be made. (A presentation rate of 0.5 seconds per word is both fast enough to prevent rehearsal and slow enough to allow for dual-coding.) These three areas of concern can be summarized by the following propositions.

1. Auditory input ought to be more easily recalled than visual in short-term memory.

2. In long-term memory these modal differences will not occur despite their appearance in short-term memory.

3. Non-linguistic material ought to be more easily recalled than linguistic material if presented at a rate that will allow dual-coding regardless of the mode of presentation.

One of the goals of this research is to provide one setting that will test all of these variables in a unified manner. This approach seeks to avoid the previous "piecemeal account of human variation" and offer "a more rational choice of information processing characteristics to test for in making predictions concerning behavior" (Freides, 1974, p. 305).

## Hypotheses

The available literature, as reviewed above, leads to the generation of the following hypotheses. In general, non-linguistic stimuli will be more readily recalled from both short-term and long-term memory than will linguistic material. This main effect is explained by Paivio's dual-coding hypothesis and suggests the following hypotheses.

$H_1$: Subjects who are exposed to non-linguistic stimulus items will recall significantly more of the stimulus items than subjects who are exposed to linguistic stimuli.

The dimension of mode will be affected by the type of memory causing an interaction effect. In the short-term memory task the auditory stimuli will surpass the visual stimuli in the number of items recalled. Thus hypothesis two is offered:

$H_2$: Subjects who are exposed to auditory stimulus items will recall significantly more of the stimulus items for the short-term memory task than subjects who are exposed to visual stimuli.

The issue of linguistic material suggests that the linguistic auditory stimuli will surpass the linguistic visual items for the short-term recall because the rate of presentation will prevent rehearsal as cited above. Thus hypothesis three is suggested:

$H_3$: Subjects who are exposed to auditory linguistic stimuli will recall significantly more of the stimulus items than subjects who are exposed to visual linguistic stimuli for the short-term memory task.

In the long-term memory tasks the auditory stimuli will not show the superior retention that occurred in short-term memory and therefore the cells with sounds will not differ from those with pictures. The dual-coding hypothesis provides a rationale for hypotheses four and five as they appear below:

$H_4$: Subjects who are exposed to visual non-linguistic stimulus items will recall significantly more of the stimulus items than subjects who are exposed to visual linguistic stimuli.

$H_5$: Subjects who are exposed to auditory non-linguistic stimuli will recall significantly more of the stimulus items than subjects who are exposed to auditory linguistic stimuli.

The superiority of sounds to pictures as memory stimulus items will be affected by mode and length of memory. As with the linguistic material, it is predicted that the auditory stimulus will surpass the visual stimulus for the short-term memory task, however, this effect will fail to appear for the long-term memory tasks. This is again due to the rehearsal that is available in preparation for the long-term memory task. Hypothesis six reads:

$H_6$: Subjects who are exposed to auditory non-linguistic stimuli will recall significantly more of the stimulus items for the short-term memory task than subjects who are exposed to visual non-linguistic stimuli.

## CHAPTER II

## METHOD OF ANALYSIS

### Subjects

Two hundred eighty-eight subjects were selected randomly from the undergraduate population of Southwest Texas State University. They were drafted from each of four sections of Speech 1310. Speech 1310 is a required course for every student on the university campus and therefore, as a cross-section of the university, it represents a random sample.[1]

### Design

As Illustration I shows, a total of four independent variables were manipulated. The three experimental variables were mode (auditory versus visual), type (linguistic versus non-linguistic), and length of memory (short-term, long-term at ten minutes, and long-term at forty-eight hours). One repeated measure, that of concept, was a design variable. Each of four groups of subjects was presented with twelve stimulus items in appropriate type, mode, and length of memory. These items were tested for interactions with the other three independent variables. The design was a 2 x 2 x 3 x 12

ILLUSTRATION 1

EXPERIMENTAL DESIGN

| | MODE: | Auditory | | Visual | |
|---|---|---|---|---|---|
| | TYPE: | Ling. | Non-ling. | Ling. | Non-ling. |
| LENGTH OF MEMORY | Short-term Memory | I (24)[a] | IV (24) | VII (24) | X (24) |
| | Long-term 10 min. | II (24) | V (24) | VIII (24) | XI (24) |
| | Long-term 48 hour | III (24) | VI (24) | IX (24) | XII (24) |

CONCEPT: 1 2 3 4 5 6 7 8 9 10 11 12

Note. Total N size is 288.

[a]Numbers in parentheses indicate the number of subjects in that cell.

which produced one hundred forty-four cells. Of those one hundred forty-four cells, twelve large cells (ignoring the dimension of concept) are of particular interest because they represent the three experimental variables.

Twenty-four students were randomly assigned to each of twelve experimental groups. Groups ALST, $ALLT_{10}$, and $ALLT_{48}$ received auditory linguistic stimuli (speech). Groups ANLST, $ANLLT_{10}$, and $ANLLT_{48}$ received auditory non-linguistic stimuli (sounds). Groups VLST, $VLLT_{10}$, and $VLLT_{48}$ received visual linguistic stimuli (written language) and groups VNLST, $VNLLT_{10}$, and $VNLLT_{48}$ received visual non-linguistic stimuli (pictures). Thus, each of the four types of stimulus sets (auditory linguistic, auditory non-linguistic, visual linguistic, and visual non-linguistic) were presented to three independent groups of subjects.

Procedure

Each of the twelve groups was exposed to a set of twelve stimulus items. All of the stimulus sets were presented at the rate of one item per half second (twelve items in six seconds). This fast rate was chosen to prevent rehearsal of the items as they were presented (Laughery and Fell, 1969). The data were gathered during the students' usual class meeting time in their usual lecture auditorium. Each section (of four sections) usually contains about seventy-five students. All of the students that were present for that day's class were drafted as experimental subjects except those who chose to leave after they were informed of the experimental nature of the day's activities (only three subjects were observed taking this opportunity to leave). The sections met at 8:00 AM, 10:00 AM, 12 NOON, and 2:00 PM on the same day for fifty minutes each. In order to accomplish the forty-eight hour long-term memory test, the same sections were reconvened during their next scheduled class meeting which was forty-eight hours later. Thus the four stimulus sets were prepared to be given at four separate times but under as nearly similar conditions (same room, same day, same instructions) as possible.

Groups ALST, $ALLT_{10}$, and $ALLT_{48}$ heard a tape recording of corresponding words read at .5 seconds per word. Groups ANLST, $ANLLT_{10}$, and $ANLLT_{48}$ heard a tape recording of sounds that corresponded to the words at the same rate. Groups VLST, $VLLT_{10}$, and $VLLT_{48}$ were shown slide transparencies of words on a screen at the same rate. Finally, groups VNLST, $VNLLT_{10}$, and $VNLLT_{48}$ were presented slide transparencies of twelve simple pictures that corresponded to the other stimuli at the same .5 items per second rate.

Immediately following the stimulus sets presentation, groups ALST, ANLST, VLST, and VNLST were instructed to write down on supplied forms, all stimulus items that they were able to recall. Subjects were given four minutes to complete this task. After these groups had completed their task, all the groups had their stimulus sets re-presented with written recall trials each time until all of the subjects were able to recall all of their respective stimulus items. The total number of trials required to reach one hundred percent recall was recorded for each subject. Ten minutes after all the members of each group had reached one hundred percent recall, groups $ALLT_{10}$, $ANLLT_{10}$, $VLLT_{10}$, and $VNLLT_{10}$ were instructed to write down all of the stimulus items that they were able to recall from their stimulus sets on the proper forms. Forty-eight hours after the achievement of one hundred percent recall, groups $ALLT_{48}$, $ANLLT_{48}$, $VLLT_{48}$, and $VNLLT_{48}$ were asked to write down all of the stimulus items that they were able to recall.

The actual collection of the data followed this procedure. First, the four sets of stimulus items were presented separately to the three appropriate groups. All four stimulus sets were presented in the same facility. Subjects were introduced to the research situation and were given the chance to practice seeing or hearing an abbreviated stimulus set in order to practice. This was done to prevent any startle effect when the actual stimulus set was presented. Subjects were instructed not to speak to each other during the data collection, nor to discuss the experiment with anyone until after the following day's class. Subjects were not informed of the purpose of the research until after the forty-eight hour session was completed.

Each desk in the data collection room contained these items: (a) a sheet of colored paper in one of three colors, (b) twenty-one blank sheets of paper on which recall lists were to be written, and (c) a pencil. The sheets of colored paper which were randomly distributed on the desks were used to assign the subjects to their length of memory group. All subjects having red paper were asked to recall from short-term memory. All subjects with yellow paper participated in the long-term for ten minutes task. The subjects with blue paper were asked to recall only at forty-eight hours. This method allowed the subjects to identify themselves readily without being aware of any group label other than a color name.

Once the stimulus sets had been presented, all "reds" (groups ALST, ANLST, VLST, and VNLST) recorded their data and were excused from the study. The other groups then proceeded to repeat recall attempts after re-viewing the stimulus sets as many times as was necessary to attain one hundred percent recall on the part of every subject. A pilot study conducted by the author ascertained that twelve items was a reasonable number to expect college students to memorize in this fashion. At this point all the "blues" ($ALLT_{48}$, $ANLLT_{48}$, $VLLT_{48}$, and $VNLLT_{48}$) were excused after being cautioned to return for Part II of the study in forty-eight hours. They were not informed of the nature of Part II of the study. Their instructions (see Appendix D) implied, but did not state, that Part II was separate and not related to Part I, thus avoiding the likelihood of further rehearsal of the items. Once the "blues" had been excused and ten minutes following one hundred percent recall had past, all the "yellows" ($ALLT_{10}$, $ANLLT_{10}$, $VLLT_{10}$, and $VNLLT_{10}$) were asked to recall as many stimulus items as possible for the long-term for ten minutes trial. Then all of the subjects were excused for the day.

Forty-eight hours later, all of the subjects were re-convened. Once settled, the ones with blue cards ($ALLT_{48}$, $ANLLT_{48}$, $VLLT_{48}$, and $VNLLT_{48}$) were asked to recall as many of the previous stimulus items as possible. After all the blue carded subjects had recalled as many as they could of the stimulus items, all of the subjects were excused. At this point a written explanation of the intent of the study was distributed to all of the participants.

Due to the possibility of experimenter bias, the author of this research did not participate directly in the data collection process. Instead, research assistants who were naive about the hypotheses and research questions, directed the subjects through the data collection procedure. The research assistants were provided with a set of written instructions (see Appendix D) to read to the subjects to help avoid any possibility of demand effects or other experimental contamination.

Material

The twelve stimulus sets were composed of matched items. For example, set one for the auditory linguistic group might have contained the word heart and eleven other words. The subjects heard the word heart spoken on a tape recording. Set two would then contain the corresponding sound, which in this example would be the sound of a heart beating also on a tape recording. The third set was slide transparencies of the written words including in this example the word heart projected on a screen. Set four would contain a simple line drawing of a heart along with drawings of the other items all of which were projected on a screen. Each of the twelve stimulus items was correspondingly matched across all four sets of stimuli (see Appendix A).

The twelve items that were used have been selected from a list of twenty-four that were tested in the pilot study for ease of recognition and agreement among the subjects (see Appendix B). The pilot subjects were asked to identify possible sounds and pictures with words. The items chosen were those items most easily and frequently labelled with the correct word.

## Statistical Analysis

The recall scores (number of items successfully recalled) were submitted to analyses of variance to test for main effects of mode, type, and memory length. (The concept variable is a design variable that is included as a check on internal consistency) Certain interaction effects were also scrutinized in this study. The interaction of mode/type is particularly of interest as indicated in the review. In addition, *t* tests were run on cells ALST versus VLST (for $H_3$), ALST and ANLST versus VLST and VNLST (for $H_2$), VNLST, $VNLLT_{10}$, and $VNLLT_{48}$ versus VLST, $VLLT_{10}$, and $VLLT_{48}$ (for $H_4$), ALST, $ALLT_{10}$, and $ALLT_{48}$ versus ANLST, $ANLLT_{10}$, and $ANLLT_{48}$ (for $H_5$), and finally ANLST versus VNLST (for $H_6$). A significance level of .05 was required for significance in all analyses.

## CHAPTER III

## RESULTS OF ANALYSIS

The results of this experiment can be viewed in Table 1 where the means of the twelve cells are displayed. Each mean represents the average percentage of items recalled by the twenty subjects in that cell. Cell ALST, for example, represents the twenty subjects in the auditory linguistic short-term condition and it indicates that they recalled 40.5% of the words on the average. This percentage is found by dividing the actual number of words recalled by the total number of words available for recall. Note that the reported n-size was twenty for all twelve cells. Actually the n-size varied from twenty to twenty-four due to chance variation and attrition. Because equal n-size is easier to process, a random number technique was used to delete subjects from each cell as necessary to bring each total to twenty.

### General Findings

A quick overview of the means in Table 1 shows that the short-term recall tasks varied greatly from the long-term conditions. Also within the short-term row the variation is greater than within either of the long-term rows. The greater variation among the short-term means is an indication that the mode and/or type effects were more pronounced in the short-term condition than in either long-term condition. An analysis of variance bears out the significance of these simple observations.

The results of the 2 x 2 x 3 x 12 analysis of variance can be seen below in Table 2. As explained earlier, only the first three variables, mode, type, and length of memory are experimental variables. The fourth variable is a design variable that will be discussed later. Each of the three main effects produced a significant alpha level above the required .05. The modal effect, auditory versus visual conditions, produced an F ratio of 61.43 which at 1 degree of freedom is significant at greater than .001. This significant F ratio indicates that it is reasonable to assume that mode was a determiner of some of the variation among the means. The type effect, referring to linguistic versus non-linguistic stimuli produced an F of only 19.62 but this is still significant at greater than .001 with one degree of freedom. Thus the type of information was also responsible for some of the variation among the means in each row. The length of memory variable, which tested recall for short-term versus long-term memory, produced the highest F ratio, 354.71, which even at two degrees of freedom easily exceeds the .001 significance level. This finding is due to the variation among the rows of means (see Table 1) and can be explained by an analysis of the experimental technique. Thus all three main effects produced significant results.

Of the three first-order interactions, only two had significant differences. These were mode by length of memory and type by length of memory. Mode by length of memory had an F ratio of 29.67 which at two degrees of freedom produced an alpha level of greater than .001. This important interaction is seen easily by noting that the auditory means were higher than the corresponding visual means in every case. Type by length of memory showed an F ratio of 4.07 which at two degrees of freedom was significant at greater than .025. This interaction demonstrated the greater variation between the short-term means than between the long-term means with respect to type. The third first-order interaction, mode by type, was not significant producing an F ratio of only .19.

The only second-order interaction, mode by type by length of memory , was not significant as expected with an F ratio of .00. The .00 F ratio indicates that all of the variation was accounted for by the previous effects leaving none.

## Hypothesized Findings

The review of the literature and the rationale of this study suggested six hypotheses for testing, one of which coincided with a main effect in the analysis of variance. The results of these comparisons can be seen in Table 3. The first hypothesis, $H_1$, stated that subjects exposed to non-linguistic stimuli would recall more items than subjects exposed to linguistic items. The main effect for type tests exactly this condition. The non-linguistic items were more frequently recalled than the linguistic items in nearly every case. The significant F ratio of 19.62 for the type main effect supports $H_1$.

Hypothesis two compares only four cells from the study, which were ALST and ANLST versus VLST and VNLST. They represent all of the subjects in the auditory conditions in short-term memory categories versus all in the visual short-term memory category. To test these cells a Student's _t_ test was incorporated. The _t_ test value was 2.34 which exceeds the significance level of 1.67 for 78 degrees of freedom in a one-tailed test at a .05 alpha level. These means clearly demonstrate that the auditory conditions provided better recall than the two visual conditions.

Hypothesis three tests only cells ALST and VLST and is thus a refinement of $H_2$. The _t_ test yielded a value of 2.69 which exceeds the necessary 1.68 given 38 degrees of freedom in a one-tailed test at a level of significance of .05. Thus, $H_3$, which stated that subjects exposed to auditory linguistic stimuli will recall more items from short-term memory than will subjects exposed to visual linguistic stimuli, was supported.

The fourth hypothesis which compares recall of visual non-linguistic stimuli to recall of visual linguistic stimuli did not yield a significant t test value. The value of .55 is much less than the 1.66 that was required for significance with 118 degrees of freedom in a one-tailed test. Note that cell $VLLT_{10}$ is greater than cell $VNLLT_{10}$ which is the only case in this study in which a linguistic cell is greater than a non-linguistic cell.

Hypothesis five compares recall for auditory non-linguistic versus recall for auditory linguistic stimuli. The non-significant t test value of .37 is below the necessary value for significance of 1.66 for 118 degrees of freedom in a one-tailed test. Again the lack of variation in long-term memory at ten minutes is the exception in this comparison which may make the difference.

The final hypothesis, number six, compares only two cells, cell ANLST versus cell VNLST. It suggests that recall for auditory non-linguistic stimuli (sounds) would exceed recall for visual non-linguistic stimuli (pictures) in short-term memory. The t test value of 2.49 for 38 degrees of freedom exceeds the necessary value of 1.68 to achieve significance indicating that sounds were recalled more successfully than corresponding pictures. Thus, as Table 3 illustrates, hypotheses one, two, three, and six exceeded the significance level for one-tailed tests and hypotheses four and five did not.

The interpretation of these results along with some speculations and testing of a posteriori comparisons will appear in the following chapter.

TABLE 1

MEAN RECALL

| | Auditory | | Visual | |
|---|---|---|---|---|
| | Ling. | Non-ling. | Ling. | Non-ling. |
| Short-term | 40.5% | 44.3% | 25.3% | 32.6% |
| Long-term 10 min. | 98.2% | 98.7% | 97.9% | 93.0% |
| Long-term 48 hr. | 82.0% | 91.2% | 72.0% | 88.3% |

Total N=240

N per cell=20

TABLE 2

ANALYSIS OF VARIANCE

| SOURCE | SS | dF | MS | F | P |
|---|---|---|---|---|---|
| Between Subjects | 228.57 | 239 | | | |
| M (Mode) | 12.90 | 1 | 12.90 | 61.43 | .001 |
| T (Type) | 4.12 | 1 | 4.12 | 19.62 | .001 |
| L (Length of Memory) | 148.98 | 2 | 74.49 | 354.71 | .001 |
| MT | .04 | 1 | .04 | .19 | N.S. |
| TL | 1.91 | 2 | .86 | 4.07 | .025 |
| ML | 12.45 | 2 | 6.23 | 29.67 | .001 |
| MTL | .00 | 2 | .00 | .00 | N.S. |
| Error (Between) | 48.17 | 228 | .21 | | |
| Within Subjects | 409.75 | 2560 | | | |
| C (Concept) | 8.17 | 11 | .74 | 9.74 | .001 |
| CM | 6.90 | 11 | .63 | 8.25 | .001 |
| CT | 1.23 | 11 | .11 | 1.45 | N.S. |
| CL | 2.94 | 22 | .13 | 1.71 | .025 |
| CMT | 8.57 | 11 | .78 | 10.26 | .001 |
| CML | .00 | 22 | .00 | .00 | N.S. |
| CTL | 17.87 | 22 | .81 | 10.66 | .001 |
| CMTL | 1.04 | 22 | .05 | .62 | N.S. |
| Error (Within) | 183.67 | 2428 | .08 | | |

TABLE 3

RESULTS OF T TESTS OF HYPOTHESES

| Hypo. | Cells | Type Test | Test Value | dF | Alpha |
|---|---|---|---|---|---|
| 1 | NL v. L | ANOVA | F=19.62 | 1 | .001 |
| 2 | AST v. VST | *t* test | *t*=2.34 | 78 | .05 |
| 3 | ALST v. VLST | *t* test | *t*=2.70 | 38 | .05 |
| 4 | VNL v. VL | *t* test | *t*=0.55 | 78 | N.S. |
| 5 | ANL v. AL | *t* test | *t*=0.37 | 118 | N.S. |
| 6 | ANLST v. VNLST | *t* test | *t*=2.49 | 38 | .05 |

A= auditory
V= visual
L= linguistic
NL= non-linguistic
ST= short-term

TABLE 4

RESULTS OF A POSTERIORI TESTS

| Cells | Type test | Test value | dF | Alpha level |
|---|---|---|---|---|
| ANLST v. ALST | *t* test | *t*=0.79 | 38 | N.S. |
| VNLST v. VLST | *t* test | *t*=1.68 | 38 | $p < .05$ |

TABLE 5

DESIGN VARIABLE (CONCEPT) DATA

| | Heart | Car | Door | Clock | Horse | Dog | Type writer | Bird | Tele | Gun | Saw | Bowl ing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALST | 0 | 6 | 5 | 16 | 9 | 14 | 13 | 10 | 7 | 2 | 9 | 5 |
| $ALLT_{10}$ | 17 | 18 | 18 | 18 | 20 | 19 | 20 | 19 | 20 | 19 | 19 | 18 |
| $ALLT_{48}$ | 10 | 15 | 14 | 14 | 12 | 19 | 19 | 14 | 18 | 13 | 19 | 12 |
| ANLST | 6 | 12 | 7 | 7 | 12 | 15 | 9 | 11 | 5 | 8 | 8 | 6 |
| $ANLLT_{10}$ | 20 | 18 | 20 | 20 | 20 | 20 | 20 | 19 | 20 | 19 | 20 | 20 |
| $ANLLT_{48}$ | 17 | 16 | 20 | 18 | 20 | 19 | 18 | 19 | 19 | 19 | 13 | 18 |
| VLST | 7 | 8 | 3 | 8 | 5 | 11 | 6 | 3 | 2 | 4 | 2 | 2 |
| $VLLT_{10}$ | 19 | 20 | 19 | 19 | 19 | 19 | 20 | 19 | 20 | 20 | 19 | 20 |
| $VLLT_{48}$ | 12 | 13 | 18 | 9 | 10 | 17 | 16 | 14 | 17 | 12 | 11 | 16 |
| VNLST | 5 | 9 | 9 | 3 | 4 | 7 | 3 | 6 | 6 | 8 | 11 | 7 |
| $VNLLT_{10}$ | 12 | 16 | 20 | 12 | 11 | 16 | 11 | 11 | 18 | 12 | 14 | 14 |
| $VNLLT_{48}$ | 12 | 12 | 18 | 10 | 14 | 15 | 11 | 12 | 14 | 14 | 15 | 15 |
| | | | | | | TOTALS | | | | | | |
| AL | 27** | 39 | 37 | 48 | 41 | 52* | 52* | 43 | 45 | 34 | 47 | 35 |
| ANL | 43 | 46 | 47 | 45 | 52 | 54* | 47 | 49 | 44 | 46 | 41** | 44 |
| A | 70** | 85 | 84 | 93 | 93 | 106* | 99 | 92 | 89 | 80 | 88 | 79 |
| VL | 38 | 41 | 40 | 36 | 34 | 47* | 42 | 36 | 39 | 36 | 32** | 38 |
| VNL | 29 | 37 | 47* | 25** | 29 | 38 | 25** | 29 | 38 | 34 | 40 | 36 |
| V | 67 | 78 | 87* | 61** | 63 | 85 | 67 | 65 | 77 | 70 | 72 | 74 |
| L | 65** | 80 | 77 | 84 | 75 | 99* | 94 | 79 | 84 | 70 | 79 | 73 |
| NL | 72 | 83 | 94* | 70** | 81 | 92 | 72 | 78 | 82 | 80 | 81 | 80 |
| Grand | 137** | 163 | 171 | 154 | 156 | 191* | 171 | 155 | 166 | 150 | 160 | 153 |

* highest recall for row ** lowest recall for row

# CHAPTER IV

# DISCUSSION

This chapter discusses the interpretations of the data presented earlier. First is the discussion of the modal effect along with the significance of rehearsal to this variable. Next is the type effect which includes a discussion of linguistic and non-linguistic information, the lack of interaction effects with mode, and the role of rehearsal and rate of presentation in these data. The third section looks at the interplay of length of memory with both of the previous independent variables, and concludes the experimental data interpretations. The fourth section is a discussion with comments on the research questions given the various interpretations of the data offered in the previous sections. A fifth section is devoted to a lengthy discussion of the design variable, concept, including patterns of interest to the modal and type data. This chapter concludes with suggestions for further study and a brief summary of the entire study.

## Mode

The main effect of auditory versus visual information showed a significant overall effect ($\underline{F}$=61.43, p<.001) as predicted in the literature. The real importance of this finding, though, lies in the difference between the variation in the short-term memory cells and the long-term memory cells. As Table 1 shows there is a great deal more variation among the short-term cells than there is among the long-term cells. The results of testing hypothesis two help to understand this difference. Hypothesis two was stated:

$H_2$: Subjects who are exposed to auditory stimulus items will recall significantly more of the stimulus items for the short-term memory task than subjects who are exposed to visual stimuli.

The significant results ($t=2.34$, $p<.05$) indicate that there was a pronounced advantage for subjects who were played auditory stimulus items over those subjects who were shown visual stimulus items for immediate recall. The lack of significant differences among the long-term cells indicates that the auditory versus visual advantage does not continue when the subjects attempt long-term recall.

Hypotheses three and six also lend support to this conclusion. They were stated as:

$H_3$: Subjects who are exposed to auditory linguistic stimuli will recall significantly more of the stimulus items than subjects who are exposed to visual linguistic stimuli for the short-term memory task.

$H_4$: Subjects who are exposed to auditory non-linguistic stimuli will recall significantly more of the stimulus

> items for the short-term memory task than subjects who are exposed to visual non-linguistic stimuli.

Since both of these hypotheses yielded significant results ($H_3$: $\underline{t}$=2.70, p .05; $H_6$: $\underline{t}$=2.49, p<.05) one can see that the auditory advantage for short-term recall carried over for both linguistic and non-linguistic items. Clearly, the reported advantage for auditory versus visual stimuli is supported by these data.

The impact of these findings is on the notion of how information is processed. If one can assume that long-term memory takes more processing than short-term memory, then it appears that this additional processing somehow negates the modal difference. While we are still uncertain as to the exact nature of the memory process, the use of the experimental technique lends support to the idea that long-term memory demands more processing than does short-term memory. The repeated rehearsal of items is an indication of this additional processing that occurs before long-term memory.

The issue of rehearsal as discussed earlier has a very important impact on this investigation. Rehearsal of the stimulus items provides the additional processing that accounts for the disappearance of the modal effect between short-term and long-term memory. The subjects received their stimuli at a rate of two-per-second which is fast enough to prevent rehearsal during the presentation (Laughery and Fell, 1969). This rate assured the experimenter that the subjects who were tested for short-term memory could not rehearse the items except possibly after the entire list had been presented. The long-term memory subjects on the other hand, had the items presented at the same rate but with numerous trials to allow them to rehearse the items repeatedly to assure the additional processing that is involved through rehearsal.

Rehearsal, though, cannot account for the modal differences that are suggested by the significant results in hypotheses two, three, and six. In all three hypothesized cases the auditory stimuli were more often recalled than were the visual stimuli. Since the items were presented so quickly as to prevent immediate rehearsal through silent speech, the auditory stimuli had no advantage over the visual stimuli. For example, if a subject heard the word gun he could not say it repeatedly to himself because another stimulus word was already being presented. The tentative conclusion is that there must be some type of inherent advantage for auditory stimuli over visual stimuli for accuracy of recall.

The results of hypothesis six can also be interpreted in light of the extension of the dual-coding hypothesis (Paivio, 1971) that was offered in an earlier chapter. This explanation suggested that since linguistic auditory stimuli are apparently recalled more often than image material (confirmed by $H_2$ and $H_3$), sounds (which are auditory stimuli) might also be more easily remembered than pictures (visual stimuli). The rate of presentation is an issue in this case as well, because Paivio (1971) reports that the rate of 5.3 items-per-second can prevent dual-coding of items. Subjects who were presented items at that rate could not label the sound that they heard. In light of Paivio's findings, the experiment reported here was designed with a rate of presentation of only two words-per-second, the subjects could easily attach a verbal label to each sound and picture (image) that was presented before the next stimulus item was presented.

The results clearly indicate that auditory items, both linguistic and non-linguistic, prove to be superior stimuli for short-term recall than do visual stimuli representing the same concepts. The only apparent explanation is an inherent ability of the mind for processing auditory information and making it available for immediate recall. While this immediate recall is superior for auditory stimuli, the subsequent processing involved in making information available for long-term recall diminishes this advantage to the point that auditory and visual items are recalled equally well.

## Type

The significant main effect shown in Table 2 for linguistic versus non-linguistic stimuli suggests that non-linguistic stimuli are more easily recalled than are linguistic stimuli. These are the results predicted in hypothesis one which stated:

$H_1$: Subjects who are exposed to non-linguistic stimulus items will recall significantly more of the stimulus items that subjects who are exposed to linguistic stimuli.

The explanation for these results lies in Paivio's (1971) dual-coding hypothesis. The dual-coding hypothesis states that stimulus items that can be coded for memory in two forms are more likely to be recalled than are items coded in only one form. For example, a subject seeing a picture of a telephone can recall either the pictorial image as he saw it or the verbal label telephone whereas a subject seeing the word telephone had only the verbal label to recall. Of course, a sufficiently fast rate of presentation can block this dual-coding process by presenting pictures faster than the subject can label them. However, Paivio indicated that rates approaching five items per second were necessary for that to occur. In this study items were presented at only two items per second which was definitely slow enough to allow for dual-coding to occur.

The non-significant results of both hypotheses four and five ($H_4$: $\underline{t}$=.55; $H_5$: $\underline{t}$=.37) seem to indicate that the main effect of type is not an artifact of a strong effect in either mode but rather an effect in their union. Hypotheses four and five were stated as:

$H_4$: Subjects who are exposed to visual non-linguistic stimulus items will recall significantly more of the stimulus items than subjects who are exposed to visual linguistic stimuli.

$H_5$: Subjects who are exposed to auditory non-linguistic stimuli will recall significantly more of the stimulus items than subjects who are exposed to auditory linguistic stimuli.

Thus there does not seem to be an interaction effect of mode and type. The analysis of variance also bears out this prediction (see Table 2) with an $\underline{F}$ of .19 which is not significant for the mode by type interaction.

Two a posteriori tests help to explain these data further (see Table 4). It may be that subjects who are exposed to visual non-linguistic stimuli will recall more of the stimulus items for the short-term memory task than subjects who are exposed to visual linguistic stimuli. To test this possibility cells VNLST and VLST were compared ($\underline{t}$=1.68, $p<.05$) which indicated that the improved recall while not better for visual non-linguistic items ($H_4$) was significantly better for visual non-linguistic items in short-term memory. This could be interpreted as another advantage that diminishes with the opportunity for further processing but these results remain not easily interpreted.

Another comparison might be that auditory non-linguistic stimuli will be recalled better than auditory linguistic stimuli for the short-term memory task. The results of this comparison were not significant ($\underline{t}$=.79) thus showing no preference for auditory non-linguistic stimuli in short-term memory. The one fairly certain set of results was that of hypothesis six which stated:

$H_6$: Subjects who are exposed to auditory non-linguistic stimuli will recall significantly more of the stimulus items for the short-term memory task than subjects who are exposed to visual non-linguistic stimuli.

Here, the significant data ($t$=2.49, $p$<.05) show that the auditory stimuli are clearly more easily recalled than the visual stimuli in short-term memory for all non-linguistic groups.

Interpretation of these data calls for a recognition of the availability of non-linguistic stimuli for dual-coding whereas linguistic data are coded only linguistically making recall less likely. The lack of an interaction effect with mode probably means that the modality of the stimulus does not affect its availability for dual-coding. The presence, though, of an interaction with length of memory ($F$=4.07, $p$<.025) and the significant $t$ value for the first comparison, indicate that in short-term memory the pictures (visual non-linguistic items) were more readily recalled than the written words (visual linguistic items) but this increased recall did not hold true for the long-term conditions. The effect is diminished by additional processing.

Length of Memory

The highly significant main effect for length of memory ($F$=354.71, $p$<.001) was expected because of the design of the experiment. The psychological literature suggests that long-term recall is tested by allowing subjects to rehearse to one hundred percent recall before recording recall. Therefore, subjects are very likely to recall more items during long-term memory than during short-term memory which provided only one opportunity to learn the stimulus items. The significance of the recall variable lies in its interactions with the mode and the type variables as discussed above. The interaction with mode suggests that auditory stimulus items are more easily recalled than visual stimulus items only in short-term memory and not in long-term memory. Apparently the additional processing that is required for long-term memory washes out the superior auditory performance.

The interaction with type ($F=4.07$, $p<.025$) is not so clearly explained since only the visual stimuli seemed to show any significant differences here. Again, though, note that it is the short-term recall conditions that show a performance difference and the long-term recall conditions that do not, which are results that support the importance of the additional processing as a factor which diminishes other effects.

## Interpretations

During the introduction to this research endeavor two statements of purpose were made. The first indicated that the auditory and visual modalities were to some degree independent processing systems, that each handled information separately and simultaneously and then combined all information for further processing. The data from this study support that notion. The subjects' proclivity to recall auditory information over visual information is an indication that these auditory stimuli are somehow processed more easily and therefore at least to some degree separately from the visual stimuli. These results concur with the conclusions made by Murdock, Bosshardt, and Freides. The auditory mode provides a superior stimulus for recall in short-term memory, most likely because the auditory system is expecially adept at processing these stimuli. The lack of a modal effect in long-term memory lends support to this idea in that the information is ultimately processed similarly and thus the modal differences are no longer apparent. The model of information processing that fits here is one that sees processing as a modal task only to a certain point (from Point A to Point B), past which all information is treated similarly regardless of mode of entry (from Point B to Point C). In Gibson's work (1969) she emphasizes the amodal characteristics of processing which may not be incorrect after the information has been sufficiently processed.

This description presents differences as levels of processing. As a surface level the stimuli are processed differently in each mode. Not only are there modal differences but each mode is adept at handling certain tasks as described earlier. Thus within each mode there are certain characteristics and/or limitations. However, after a certain point all information is treated similarly by the brain regardless of the mode of entry. The lack of modal disparity in long-term memory would lend support to this idea.

The role of rehearsal is underlined by the data presented here. The additional processing that rehearsal requires completely changes the nature of the data. The long-term means do not differ as do the short-term means which is largely due to the effects of rehearsal. Certainly this study and its cited precursors cannot absolutely define the limits of the processing. Yet these data do indicate a respect for the idea of discreteness for some time during the information processing and lend insight into the likely nature of the process. As with nearly all studies, further investigation is necessary to help define the exact nature of the limits and usefulness of this model of information processing.

## Design Variable: Concept

A variable labelled concept was included as a design variable in this study to serve as a check for the use of a repeated measure. The repeated measure was the choice of twelve stimulus items for each of the four experimental conditions. The same twelve concepts were used in each of the four experimental conditions (see Appendix A) with a corresponding type and mode for that condition as explained earlier. Even though a pilot study was conducted (see Appendix B), the choice of concepts was difficult and a probable source of error.

The significant main effect for concept ($F$=9.74, $p<.001$)

indicates that there was a significant variation between the twelve stimulus items used in the study. Table 5 shows the actual number of times each stimulus item was recalled by the subjects in the experiment. The totals for each experimental variable show the highest and lowest totals for each column. A quick overview reveals certain patterns in the data that may help to explain this significant main effect.

The single concept most frequently recalled was dog (191 out of 240). This was the case not only in both of the auditory cases but in the visual linguistic case as well, thus it received the highest overall total. The only category in which it was not the highest was visual non-linguistic, the condition in which the subjects saw a picture of the concept. (Note: in the visual non-linguistic condition the recall for dog was well above average.) The most likely explanation for this phenomenon is the frequency of use of the word and concept. Dog is a word of very high usage frequency and one that is readily identified.

The concept least frequently remembered was heart (137 out of 240). In every case it was the lowest or next to lowest. This effect did not appear to be due to either mode or type since the effect was so consistent across conditions. This seems a difficult result to explain. It is possible that the relative vagueness of heart lead to this result. As compared to concepts like dog, gun, telephone, and horse the concept heart can refer to both an anatomical object or a romantic ideal. Perhaps this ambiguity is the explanation of its poor performance as a stimulus for recall. Or perhaps the stimulus heart was not sufficiently clear to provide a stimulus equal in strength to the other items. If this were the case it could not have provided as good a stimulation for recall as the other items.

The recall frequency for the concept door was extremely high in one category, that of visual non-linguistic, with a frequency well above the mean (47). Because this category was so unusually high, this concept also had the highest frequency in visual and non-linguistic totals, but this is largely due to its extreme performance in the visual, non-linguistic condition. The high totals in visual and non-linguistic are both only two higher than the next highest, showing the likelihood of these totals being artifacts of the one exceptional case (visual non-linguistic). This result apparently means that the pictorial representation of door was most easily remembered and is likely due simply to the unusual simplicity of this picture. (see Appendix E).

In contrast to the concept door, the concept clock performed poorly in the visual linguistic conditon and also pulled down the totals for visual and linguistic separately. A close look though, shows that clock performed near the mean or above in the other three conditions. The probable explanation is that the picture (see Appendix E) of an alarm clock was unduly vague or ambiguous. If the image caused the subjects to respond with words other than <u>clock</u> the scores would be unusually low as seen here.

The most anomalous concept was <u>typewriter</u>. This concept was the most frequently recalled in the auditory linguistic condition and the least frequently recalled in the visual non-linguistic condition. This is not an easy phenomenon to explain. One explanation is from the subjects in the auditory linguistic condition who reported that if they remembered <u>telephone</u> they were likely to also recall <u>type-writer</u> because of the similarity in the words. If this were the case, then the <u>typewriter</u> totals would be artificially high. The uniqueness of the word, it being three syllables when only one other was that long (nine of the twelve were only one syllable) and having the most letters may have also aided its recall in this condition. On the other hand, the picture of the typewriter for the visual non-linguistic condition (see Appendix E) was one of the most complex pictures in the stimulus set perhaps making it difficult to identify. If it werehard to identify, then one would expect the recall scores to be low in that condition.

The variation among the twelve stimulus items is too great to be explained well by chance variation. Certainly the significant analysis of variance results indicate that chance is not a likely reason for the differences. More likely is that these items do vary in familiarity, length, abstractness, and ambiguity. These variations may well affect how easily they are recalled thus providing variation other than that explained by the hypotheses.

A general overview of the concept data reveals a number of peculiar patterns that interact with mode and type, but few if any consistent patterns that account for either the mode effect or the type effect. The significant main effect for this variable is not a desirable outcome in this study, however, there does not appear to be any reason to doubt the findings based on this look at the concept data.

## Suggestions for Further Study

The results of this study lead to further questions about the nature of information processing. These fall into three types of issues that will be discussed in order in the following paragraphs. First are the simple issues of intervening variables. What additional variables might be controlled or systematically varied to produce more meaningful results? Second are the questions of re-operationalizing these variables to gain new and perhaps greater insight into these issues. The last is the investigation of tangential issues related to the questions pursued by this study.

### Intervening Variables

The use of a presentation rate of two items-per-second in this study limits the interpretation of the data for two reasons.

1. The two per second rate is sufficiently fast to prevent rehearsal during presentation.

2. The two per second rate is sufficiently slow to allow labeling of non-linguistic stimuli for dual-coding. This study could be repeated using the rate of presentation as an additional variable. In this instance the suggested rates would be 5.3 items per second, 3 items per second, 2 items per second, 1.5 items per second, and 1 items per second. This would allow one to test the assumptions made that two items per second blocked rehearsal yet allowed dual-coding. For instance, if this interpretation is correct, the faster rate of 5.3 items per second (see Paivio, 1971) would prevent dual-coding and should therefore eliminate the type (linguistic versus non-linguistic) main effect. The slower rates of two per second and slower would bring about the re-appearance of a type effect as seen in this study. The slower rates, those of 1.5 per second and 1 per second should result in the disappearance of the mode main effect (auditory versus visual). This would be due to the opportunity for rehearsal between items as suggested in the study by Laughery and Fell (1969). The regulation of this rate variable would provide a tight control on both of these variables (mode and type).

Re-operationalization

The use of recall as a dependent measure assumes that information processing deals only with the ability of the mind to recall previous stimuli. The mind accomplishes more than just recall when processing information. One frequently studied dimension of processing is comprehension. Comprehension suggests more than just the ability to re-state a stimulus at a later point in time. It involves the ability to re-code and use the recalled information, and the ability to fit this information into the subject's pre-existing categories and sets. Therefore, the use of comprehension as a measure of modal and type differences might produce even more knowledge about the way the information is processed.

One possibility for this type of research might be to have subjects try to solve syllogisms or answer questions about short anecdotes to indicate their comprehension of the material. The material could easily be presented to half of the group orally and to half of the group in a written or visual mode. Since comprehension likely depends at least partially on recall, the subjects could be pre-tested for recall ability. The results of this type of study would be very useful for all kinds of learning situations in which teachers must decide which mode to use. In addition, differences in comprehension might indicate inherent differences in the mind's ability to handle and process information.

Tangential Issues

The actual structure of the human brain is being investigated constantly by neurophysiologists and neuroanatomists. The psychologist and the communication researcher probe only into conceptualizations of the human mind that may or may not correspond with the physical brain. Nonetheless, this type of study tries to explain how the mind handles information in accordance with psychological models and the physical realities. The recognition of the possibility of inherent differences and limitations on the mind will provide significant insight into human information processing. The establishment of modal discrepancies and/or special abilities to process certain types of information (e.g. linguistic and non-linguistic) promises to reveal a great deal about the workings of the mind.

This study indicates that the brain must provide for separate processing of modal inputs. Given the view of the brain described earlier, this is not a difficult situation to imagine. The brain has well-defined areas that process speech coding and vision, and while there are interconnections these areas do maintain a degree of autonomy. The notion, too, of modal adeptness fits the model of physical complementarity presented earlier. The systems each provide certain capabilities that together best serve the organism. Thus the physiological and the psychological models do coincide in their perception of the brain.

## Summary

This experimental study investigated the relationship among mode, type, and length of memory in information processing. The subjects were two hundred forty undergraduates who were randomly assigned to the twelve experimental groups. Mode was defined as either the auditory or visual sensory system. Type referred to the presentation of either linguistic or non-linguistic stimuli. Length of memory was operationalized as one of three conditions. Short-term memory was the immediate recall of the stimulus item. Long-term at ten minutes was recall after the subjects had mastered the list to one hundred percent recall and waited for ten minutes. Long-term memory at forty-eight hours was recall forty-eight hours after the subjects had mastered the list to one hundred percent recall. These twelve conditions were tested with an analysis of variance technique with a design variable called concept as a repeated measure. The final design was a 2 x 2 x 3 x 12 analysis of variance.

The results of this studv indicated that there were significant differences in both mode and type using recall as a dependent measure. The main effects were statistically significant at or above the .05 level. Six hypotheses were tested in addition to the analysis of variance with significant results in four of the six cases.

The conclusions made from this study were:

1. The auditory stimuli were more easily remembered in short-term memory.

2. Non-linguistic stimuli were more readily remembered than were linguistic stimuli.

3. Most modal and type differences that appear in short-term memory are diminished in long-term memory.

These three statements are the foundation of a model of information processing that suggests that information is processed independently by each modal system thus providing certain modal characteristics. Further processing, though, does not involve any modal independence and results in information being treated without regard for modality.

BIBLIOGRAPHY


Baddeley, A. D. Short-term memory for word sequences as a function of acoustic, semantic and formal similarity. Quarterly Journal of Experimental Psychology, 1966, 18, 362-365.

Birch, H. G., & Belmont, L. Perceptual analysis and sensory integration in brain-damaged persons. Journal of Genetic Psychology, 1964, 105, 173-179.

Blackburn, D. L. Stimulus modality as an encoding category in short-term memory (Doctoral dissertation, Northern Illinois University, 1973). Dissertation Abstracts Inernational, 1974, 34, 4071B. (University Microfilms No. 74-2788)

Bosshardt, H. G. The influence of visual and auditory images on the recall of items of visual and auditory presentation modes. Psychology Research, 1975, 37, 211-227.

Cermak, L. S. Human memory: Research and theory. New York: Ronald Press, 1972.

Conrad, R. Acoustic confusions and memory span for words. Nature, 1963, 197, 1029-1030.

__________. The chronology of the development of covert speech in children. Developmental Psychology, 1971, 5, 398-405.

__________. Speech and reading. In J. F. Kavanagh & I. G. Mattingly (Eds.), Language by ear and by eye. Cambridge, Massachusetts: The MIT Press, 1972.

Conrad, R. & Hull, A. J. The role of the interpolated task in short-term retention. Quarterly Journal of Experimental Psychology, 1966, 18, 266-269.

Cooper, J. C. & Gaeth, J. H. Interactions of modality with age and with meaningfulness in verbal learning. Journal of Educational Psychology, 1967, 58, 41-44.

Corcoran, D. W. J. An acoustic factor in proof reading. Nature, 1967, 214, 851-852.

Crowder, R. G. Visual and auditory memory. In J. F. Kavanagh & I. G. Mattingly (Eds.), Language by ear and by eye. Cambridge, Massachusetts: The MIT Press, 1972.

Crowder, R. G. & Morton, J. Precategorical acoustic storage (PAS). Perception and Psychophysics, 1969, 5, 365-373.

Curtis, H. S. Automatic movements of the larynx. American Journal of Psychology, 1900, 11, 237-239.

Dornbush, R. L. Input variables in bisensory memory. Perception and Psychophysics, 1968, 4, 41-44.

Fisk, L. W. Modality effects and release of proactive interference in short-term memory (Doctoral dissertation, University of California, Irvine, 1973). Dissertation Abstracts International, 1974, 34, 3525B-3526B. (University Microfilms No. 73-30, 811)

Freides, D. Human information processing and sensory modality: cross-modal functions, information complexity, memory, and deficit. Psychological Bulletin, 1974, 5, 284-310.

Gadzella, B. M. & Whitehead, D. A. Effects of auditory and visual modalities in recall of words. Perception and Motor Skills, 1975, 40, 255-260.

Gesell, A. & Ilg, F. L. The child from five to ten. London: Hamish Hamilton, 1946.

Gibson, E. J. Principles of perceptual learning and development. New York: Appleton-Century-Crofts, 1969.

Goldsmith, T. H. Photoreception and vision. In C. L. Prosser (Ed.), Comparative animal physiology (3rd Ed.). Phildelphia: W. B. Saunders Company, 1973.

Kausler, D. H. Psychology of verbal learning and memory. New York: Academic Press, 1974.

Laughery, K. R. & Fell, J. C. Subjects preferences and the nature of information storage in short term memory. Journal of Experimental Psychology, 1969, 82, 193-197.

Locke, J. L. & Feh, F. S. Young children's use of the speech code in learning. Journal of Experimental Child Psychology, 1976, 10(3), 367-373.

Lovell, K. Educational psychology in children. London: University of London Press, 1968.

Lowe, D. G. Components of memory for brief visual displays (Doctoral dissertation, University of Waterloo, 1972). Dissertation Abstracts International, 1973, 34, 397B-398B.

Mandler, G. Organization and memory. In K. W. Spence & J. A. Spence (Eds.), The psychology of learning and motivation (Vol. 1). New York: Academic Press, 1967.

McGuigan, F. J. Covert oral behavior during the silent performance of language tasks. Psychological Bulletin, 1970, 74, 309-326.

Miscik, J. G. & Deffenbacher, K. A. Short-term retention of visual sequences as a function of stimulus duration and encoding technique. Journal of Experimental Psychology, 1974, 103, 188-190.

Moray, N. Attention: Selective processes in vision and hearing. New York: Academic Press, 1970.

Murdock, B. B. Visual and auditory stores in short term memory. Quarterly Journal of Experimental Psychology, 1966, 18, 206-211.

__________. Visual and auitory stores in short term memory. Acta Psychologica, 1967, 27, 316-324.

__________. Modality effects in short term memory: storage or retrieval. Journal of Experimental Psychology, 1968, 77, 79-86.

Murray, D. J. The role of speech responses in short-term memory. Canadian Journal of Psychology, 1967, 21, 263-276.

__________. Vocalization, primary memory and secondary memory. British Journal of Psychology, 1974, 65(3), 430-443.

Paivio, A. Imagery and verbal processes. New York: Holt, Rinehart and Winston, Inc. 1971.

Paivio, A. & Csapo, K. Concrete-image and verbal memory codes. Journal of Experimental Psychology, 1969, 80, 279-285.

Pellegrino, J. W. Short-term retention of pictures and words as a function of type of distractions and length of delay interval. Memory and Cognition, 1976, 4(1), 11-15.

Penney, C. G. Modality effects in short term memory. Psychological Bulletin, 1975, 82, 68-84.

Piaget, J. The language and thought of the child, E. Hanfmann & G. Vakar (Ed. and Trans.). London: Routledge and K. Paul Limited, 1934.

Pintner, R. Inner speech during silent reading. Psychological Review, 1913, 20, 129-153.

Posner, M. I., Nissen, M. J., & Klein, R. M. Visual dominance: an information-processing account of its origins and significance. Psychological Review, 1976, 83(2), 171-175.

Prosser, C. L. Comparative animal physiology, (3rd Ed.). Philadelphia: W. B Saunders Company, 1973.

Reeve, R. A. & Hull, R. The storage of physical and name properties in short-term visual memory. Memory and Cognition, 1976, 4(1), 6-10.

Smith, F. Comprehension and learning. New York: Holt, Rinehart and Winston, 1975.

Sperling, G. A model for visual memory tasks. Human Factors, 1963, 5, 19-31.

__________. Successive approximations to a model for short term memory. Acta Psychologica, 1967, 27, 285-292.

Ternes, W. Interference and coding processes in verbal and visual short-term memory (Doctoral dissertation, University of British Columbia, 1973). Dissertation Abstracts International, 1974, 34, 6252B-6253B.

Thompson, J. T. & Clayton, K. N. Presentation modality, rehearsal-prevention conditions, and auditory confusions in tests of short-term memory. Memory and Cognition, 1974, 2(3), 426-430.

Vygotsky, L. S. Thought and Language. Cambridge, Massachusetts: The MIT Press, 1962.

Warren, R. M., Obusek, C. J., Farmer, R. M., & Warren, R. P. Auditory sequence: Confusion of patterns other than speech or music. Science, 1969, 164, 586-587.

FOOTNOTES

[1]Data to support the assumption that Speech 1310 at Southwest Texas State University does represent a random sample of the students on campus has been assembled by Dr. M. Lee Williams of the Speech Department. For several semesters including the Spring semester 1978, when these data were drawn, he has compared the students enrolled in Speech 1310 to the entire student body. Speech 1310 is a required course for every major on campus and typically contains students from all departments and of a breakdown of school years. The male-female ratio is the same as the total campus. Also the ACT scores of the students in Speech 1310 do not differ significantly from the scores of the entire campus. Essentially there does not seem to be any reason to believe that any significant variation exists between the sample selected and the general campus population.

# APPENDICES

## APPENDIX A

## TWELVE STIMULUS ITEMS

| | |
|---|---|
| Gun | Typewriter |
| Car | Bird |
| Door | Heart |
| Clock | Telephone |
| Saw | Horse |
| Dog | Bowling |

APPENDIX B

PILOTED STIMULUS ITEMS

| | | |
|---|---|---|
| Heart | Gun | Crying |
| Typewriter | Car | Clock |
| Helicopter | Saw | Bowling |
| Horse | Rain | Train |
| Dog | Laughing | Door |
| Bird | Piano | Guitar |
| Telephone | Sneezing | Teapot |
| Siren | Sheep | Steamboat |

APPENDIX C

RAW DATA

CELL ALST

AUDITORY
LINGUISTIC
SHORT-TERM

Mean = .405

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | x | | x | | x | x | x | x | | | x |
| $S_2$ | | x | | x | x | | x | x | | | x | x |
| $S_3$ | | x | | x | | x | x | | x | | x | x |
| $S_4$ | x | x | | x | | x | x | | x | | | |
| $S_5$ | | | | x | x | x | x | x | | | x | |
| $S_6$ | | x | x | x | | x | | x | x | | | |
| $S_7$ | | | | x | x | x | x | x | | | x | |
| $S_8$ | | | x | x | x | x | | x | | | | |
| $S_9$ | | | | x | x | | x | x | | | x | |
| $S_{10}$ | | | x | | | x | x | | x | | | x |
| $S_{11}$ | | | | x | x | x | x | | | | x | |
| $S_{12}$ | | | | x | x | x | x | x | | | | |
| $S_{13}$ | | | | | | x | x | x | | | x | |
| $S_{14}$ | x | | x | x | x | x | x | x | x | | x | |
| $S_{15}$ | | | | | x | x | | | | | x | |
| $S_{16}$ | | | | x | | x | | | | | | x |
| $S_{17}$ | | | | x | | | x | | | | | |
| $S_{18}$ | | | | x | | | | | x | | | |
| $S_{19}$ | | x | x | | | | | | | | | |
| $S_{20}$ | | | | x | | x | | | | | | |

CELL $ALLT_{10}$

AUDITORY
LINGUISTIC
LONG-TERM 10 MIN

Mean = .982

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | x | | x | x | x | x | x | x | x | x | x |
| $S_2$ | x | x | | x | x | x | x | | x | x | x | x |
| $S_3$ | x | | x | x | x | x | x | x | x | | x | x |
| $S_4$ | x | x | x | | x | x | x | x | x | x | x | x |
| $S_5$ | x | x | x | x | | x | x | x | x | x | x | x |
| $S_6$ | x | x | x | x | x | | x | x | x | x | x | x |
| $S_7$ | x | x | x | x | x | x | x | x | x | | x | x |
| $S_8$ | x | x | x | x | x | x | x | x | x | x | x | |
| $S_9$ | x | x | x | x | x | x | x | x | x | | x | |
| $S_{10}$ | | x | x | x | x | x | x | x | x | x | x | x |
| $S_{11}$ | x | | x | | x | x | x | x | x | x | x | x |
| $S_{12}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{13}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{14}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{15}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{16}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{17}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{18}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{19}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{20}$ | x | x | x | x | x | x | x | x | x | x | x | x |

CELL $ALLT_{48}$

AUDITORY
LINGUISTIC
LONG-TERM 48 HRS.

Mean = .82

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | x | x | x | x | x | x | x | x | x | x | |
| $S_2$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_3$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_4$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_5$ | x | x | x | x | x | x | x | | x | | x | x |
| $S_6$ | x | x | | x | x | x | x | x | x | x | | x |
| $S_7$ | x | x | x | x | x | x | x | x | x | x | x | |
| $S_8$ | x | x | x | x | x | x | x | x | x | | | x |
| $S_9$ | x | x | x | x | x | x | x | x | x | | | x |
| $S_{10}$ | x | | x | x | x | x | x | x | x | x | x | x |
| $S_{11}$ | x | x | x | x | x | x | x | | x | x | x | x |
| $S_{12}$ | | x | x | x | x | x | x | x | x | x | | x |
| $S_{13}$ | | x | | | x | x | x | | x | | | |
| $S_{14}$ | x | | x | x | x | x | x | | x | | x | |
| $S_{15}$ | | | x | | x | x | x | x | x | x | x | |
| $S_{16}$ | x | x | x | | x | x | x | x | | | | x |
| $S_{17}$ | | | | | x | x | | | x | | | x |
| $S_{18}$ | | x | | | x | x | x | x | x | | | |
| $S_{19}$ | | x | | | x | x | x | | | | x | x |
| $S_{20}$ | | | | x | | | x | x | x | | x | x |

CELL ANLST

AUDITORY
NON -LINGUISTIC
SHORT - TERM

Mean = .443

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | | | x | | | | x | x | x | | x | |
| $S_2$ | x | x | | | | x | x | | | | x | |
| $S_3$ | | x | | | x | x | | x | | | | x |
| $S_4$ | | x | | | | x | | | | x | x | |
| $S_5$ | | x | x | | x | x | x | x | | | | x |
| $S_6$ | x | x | | | | x | | | x | | x | |
| $S_7$ | | | | | | | x | x | | | x | |
| $S_8$ | | x | | | | x | x | x | | | | x |
| $S_9$ | x | | | x | x | x | | | x | x | x | |
| $S_{10}$ | | x | x | | | x | x | | | x | | |
| $S_{11}$ | x | x | x | x | x | x | | x | | | | |
| $S_{12}$ | x | | | x | | x | | x | | | x | |
| $S_{13}$ | x | | x | x | x | | | x | | | x | |
| $S_{14}$ | x | x | | | | x | x | | x | x | | |
| $S_{15}$ | | x | | | x | x | | x | | x | | x |
| $S_{16}$ | | x | x | x | x | | | x | | | x | |
| $S_{17}$ | | | | x | | x | x | | | | x | |
| $S_{18}$ | x | x | | | | x | | | | | | |
| $S_{19}$ | | | x | | x | x | | x | | x | x | x |
| $S_{20}$ | | | | x | | | x | | x | | x | x |

CELL ANLLT$_{10}$

AUDITORY
NON-LINGUISTIC
LONG-TERM 10 MIN

Mean = .987

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | | | x | x | x | x | x | x | x | x | x | x |
| $S_2$ | x | | x | x | x | x | x | | x | x | x | x |
| $S_3$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_4$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_5$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_6$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_7$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_8$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_9$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{10}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{11}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{12}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{13}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{14}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{15}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{16}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{17}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{18}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{19}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{20}$ | x | x | x | x | x | x | x | x | x | x | x | x |

CELL ANLLT$_{48}$

AUDITORY
NON-LINGUISTIC
LONG-TERM 48 HR

MEAN = .912

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | | x | | | x | | x | x | x | x | x |
| $S_2$ | x | x | x | x | | x | | x | | | x | x |
| $S_3$ | x | | x | x | | x | x | | x | x | x | x |
| $S_4$ | x | x | x | | | | x | x | x | x | x | x |
| $S_5$ | | x | x | x | x | x | x | x | x | | x | x |
| $S_6$ | x | x | x | x | x | x | x | x | x | x | x | |
| $S_7$ | x | x | x | x | x | x | x | x | x | x | x | |
| $S_8$ | x | x | x | x | | x | x | x | x | x | x | x |
| $S_9$ | x | | x | x | x | x | x | x | x | x | x | x |
| $S_{10}$ | x | x | x | x | x | x | x | x | x | | x | x |
| $S_{11}$ | x | | x | x | x | x | x | x | x | x | x | x |
| $S_{12}$ | x | x | x | x | | x | x | x | x | x | x | x |
| $S_{13}$ | x | x | x | x | | x | x | x | x | x | x | x |
| $S_{14}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{15}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{16}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{17}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{18}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{19}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{20}$ | x | x | x | x | x | x | x | x | x | x | x | x |

CELL VLST

VISUAL
LINGUISTIC
SHORT-TERM

Mean = .253

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | | | | x | x | x | | x | x | x | |
| $S_2$ | | | | | | | | | | | | |
| $S_3$ | | | | | | | | | | | | |
| $S_4$ | | | | | | | | | x | | | |
| $S_5$ | | x | x | | | | | | | | | |
| $S_6$ | x | | | | | | | | | x | | |
| $S_7$ | | | | x | | | x | | | | | |
| $S_8$ | | | | | | x | | | | x | | |
| $S_9$ | | | | | | x | x | | | | x | |
| $S_{10}$ | | x | | x | | | | x | | | | |
| $S_{11}$ | x | x | | x | | | | | | | | |
| $S_{12}$ | | x | x | | | x | | | | | | |
| $S_{13}$ | x | x | | x | | x | | | | x | | |
| $S_{14}$ | | x | | | | x | | | | x | x | |
| $S_{15}$ | | | | | | x | x | x | | x | | |
| $S_{16}$ | x | | | | x | x | | | | | | |
| $S_{17}$ | | | | x | | x | | | | x | x | |
| $S_{18}$ | | x | | x | | x | | | | | | x |
| $S_{19}$ | | | x | x | | | x | x | | | | |
| $S_{20}$ | | | | x | | x | x | | | | x | |

CELL $VLLT_{10}$

VISUAL
LINGUISTIC
LONG-TERM 10 MIN

Mean = .979

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | x | x | x | | x | x | | x | x | x | x |
| $S_2$ | x | x | x | x | x | x | x | x | x | | x | x |
| $S_3$ | x | x | x | x | x | | x | x | x | x | x | x |
| $S_4$ | x | x | | x | x | x | x | x | x | x | x | x |
| $S_5$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_6$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_7$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_8$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_9$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{10}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{11}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{12}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{13}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{14}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{15}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{16}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{17}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{18}$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_{19}$ | x | x | x | | x | x | x | x | x | x | x | x |
| $S_{20}$ | x | x | x | x | x | x | x | x | x | x | | x |

CELL $VLLT_{48}$

VISUAL
LINGUISTIC
LONG-TERM 48 HR

Mean = .718

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | x | | x | x | x | x | x | x | x | | |
| $S_2$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_3$ | x | | x | | x | x | | x | x | | x | x |
| $S_4$ | x | | x | | x | | x | x | x | x | | |
| $S_5$ | | x | x | x | | x | x | x | x | x | x | x |
| $S_6$ | x | x | x | | | x | x | | x | x | x | x |
| $S_7$ | x | x | x | x | x | x | x | x | x | x | x | x |
| $S_8$ | x | | x | x | x | x | x | x | x | | x | x |
| $S_9$ | x | x | x | | x | x | x | x | x | x | | x |
| $S_{10}$ | | x | | | | | | x | | | x | x |
| $S_{11}$ | | | x | | | x | x | x | x | x | | x |
| $S_{12}$ | x | x | x | x | x | x | x | x | x | x | | x |
| $S_{13}$ | x | x | x | | | x | x | x | | x | x | x |
| $S_{14}$ | | x | x | | | | | | x | | | x |
| $S_{15}$ | | x | x | x | | x | | | | | | x |
| $S_{16}$ | | x | x | | x | x | x | x | x | | x | |
| $S_{17}$ | x | x | x | | x | x | x | | x | x | x | x |
| $S_{18}$ | x | | x | | | x | | x | x | | | |
| $S_{19}$ | | | x | x | | x | x | | x | x | | x |
| $S_{20}$ | | | x | x | x | x | x | x | x | | | x |

CELL VNLST

VISUAL
NON-LINGUISTIC
SHORT-TERM

Mean = .326

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | | | | | x | | | x | | | | |
| $S_2$ | | | | | x | | | x | | | | |
| $S_3$ | x | | x | x | | x | | x | x | | x | x |
| $S_4$ | | x | | | x | | x | | x | x | | |
| $S_5$ | x | x | x | | x | x | | | | | | |
| $S_6$ | | | | | | x | | | x | x | x | x |
| $S_7$ | x | | | | x | | | x | x | | | x |
| $S_8$ | x | x | x | | x | x | | | | | | |
| $S_9$ | | x | x | | | x | | x | | | x | |
| $S_{10}$ | x | x | | | | x | | | | | | x |
| $S_{11}$ | | | | | x | | | | | | | |
| $S_{12}$ | | x | x | | | | | | | x | | x |
| $S_{13}$ | | | | | x | | | | x | x | x | |
| $S_{14}$ | | x | | x | | | | | x | | | x |
| $S_{15}$ | | x | | | | x | | x | | | | x |
| $S_{16}$ | x | | x | | x | | | | | | | |
| $S_{17}$ | x | | x | | x | | | | | | | |
| $S_{18}$ | x | | x | | | | x | | | | | |
| $S_{19}$ | | x | x | x | x | | x | | | x | | |
| $S_{20}$ | | | | | | | | | | | | |

CELL $VNLLT_{10}$

VISUAL
NON-LINGUISTIC
LONG-TERM 10 MIN

Mean = .930

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | | x | | x | x | x | | x | | | x |
| $S_2$ | x | x | x | x | x | x | | | x | | | |
| $S_3$ | | x | x | x | | x | x | | | x | x | x |
| $S_4$ | x | | x | x | x | x | | x | x | | | x |
| $S_5$ | | x | x | | x | x | x | x | x | | | x |
| $S_6$ | | x | x | | x | | | | x | x | | x |
| $S_7$ | | x | x | | x | | | | x | | | x |
| $S_8$ | | x | x | | x | x | x | | x | x | | |
| $S_9$ | x | x | x | | | x | | | x | x | x | |
| $S_{10}$ | | x | x | x | x | x | x | x | x | x | x | x |
| $S_{11}$ | x | | x | x | x | x | x | x | x | x | x | x |
| $S_{12}$ | | x | x | x | x | x | | x | | x | x | x |
| $S_{13}$ | x | x | x | x | | x | x | | x | x | x | x |
| $S_{14}$ | x | x | x | | | x | x | x | x | x | x | x |
| $S_{15}$ | x | x | x | x | x | | x | x | x | x | x | |
| $S_{16}$ | x | | x | x | x | | x | | x | x | x | |
| $S_{17}$ | x | x | x | | x | x | | x | x | | x | |
| $S_{18}$ | | x | x | x | | x | | x | x | | | x |
| $S_{19}$ | x | x | x | x | | x | | x | x | | | x |
| $S_{20}$ | x | x | x | x | x | x | x | x | x | x | x | x |

CELL $VNLLT_{48}$

VISUAL
NON-LINGUISTIC
LONG-TERM 48 HR

Mean = .883

| | Gun | Car | Door | Clock | Saw | Dog | Typewriter | Bird | Telephone | Heart | Horse | Bowling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | x | | x | x | x | x | | x | | x | x | x |
| $S_2$ | | | x | x | x | x | x | x | x | x | x | x |
| $S_3$ | x | | x | x | x | | x | | | x | x | |
| $S_4$ | | x | x | | x | x | x | x | | x | | |
| $S_5$ | x | x | x | x | x | | | | x | | | x |
| $S_6$ | | x | x | | | x | | x | x | | x | x |
| $S_7$ | x | | | x | x | x | | x | x | | x | |
| $S_8$ | | | | | x | x | | | | | | x |
| $S_9$ | x | x | x | x | | x | | x | x | x | | x |
| $S_{10}$ | x | x | x | | | x | x | x | x | x | | x |
| $S_{11}$ | x | x | x | | x | x | x | | x | x | x | x |
| $S_{12}$ | x | x | x | x | | x | x | x | x | x | x | |
| $S_{13}$ | | | x | | x | | x | x | | x | x | x |
| $S_{14}$ | x | x | x | | x | x | | x | x | x | x | x |
| $S_{15}$ | x | | x | x | x | | | | x | | x | x |
| $S_{16}$ | x | x | x | | | x | x | | x | | x | x |
| $S_{17}$ | x | x | | | x | | x | x | | | x | |
| $S_{18}$ | | x | x | | x | x | | x | x | x | x | x |
| $S_{19}$ | x | | x | x | x | x | x | | x | | x | x |
| $S_{20}$ | x | x | x | x | x | x | x | | x | x | | x |

## APPENDIX D

## RESEARCH ASSISTANTS' INSTRUCTIONS

TO BE READ BY THE RESEARCH ASSISTANT:

Good morning (afternoon). The reason that we have asked you to be here today is to participate in some research on human communication. On your desk will find a waiver form that we would like you to read carefully and sign. This form certifies that you are participating in this experiment as a volunteer. It is not required that you participate. There is no reason to believe that this research is harmful in any way. Please pass your forms to the left after you have signed them.

I'm sorry but I will not be able to answer any questions during the next 50 minutes, so you must listen especially carefully to the instructions that I give you the first time to be certain that you understand what is required of you. I repeat! I cannot answer any questions so please listen unusually carefully. Thank you.

Do not speak to anyone else in this room until we dismiss you from this room. It is mandatory that we maintain silence during the entire session.

On your desk you will find a sheet of colored paper. Leave it on your desk. The color of your paper, red, yellow, or blue, identifies you as a member of a particular group. We will refer to those groups later. Remember your color; it is important.

Now watch (listen) very carefully.

(Signal for slides (tapes)).

That was a sample of what you will be seeing (hearing) in a few minutes. Please raise your hand if you could not see (hear). Thank you.

Now watch (listen) again very carefully.

(Signal for slides (tapes)).

Will everyone with a red sheet, blues and yellows will please remain quiet, I repeat, everyone with a RED sheet please write down all the words (sounds, pictures) that you can recall on the white sheet of paper. Do not look around you.

(Wait 2 minutes)

I wish to remind you to attend class on Wednesday. After you are dismissed from class today, you are requested not to descuss anything that occurred here with anyone until Friday of this week. Please wait until Friday to discuss this research.

Now all of those with red sheets may leave the room and wait in the hall until asked to return to class today. Only those with red sheets are to leave. Be careful to leave all of your materials on your desk. Please leave quickly and quietly.

(Once all have left, resume)

A: Now, will all those here please watch (listen) closely.

(Signal for slides (tapes)).

Everyone please write down on the paper before you all the words (sounds, pictures) that you can recall.

(Wait 1 minute)

Now turn over your recall sheet so that you have a new, clean one before you.

(Repeat Sequence A)

(Repeat Sequence A adding Sequence B)

B: Will those who have not recalled all of the items please raise your hand?

(Continue to repeat Sequence A with Sequence B until 100% reach 100% recall.)

(Once the 100% goal has been reached NOTE THE EXACT TIME!)

I wish to remind you to attend class on Wednesday. After you are dismissed from class today, you are requested not to discuss anything that occurred here until Friday of this week. Please wait until Friday to discuss this research.

Now all those with yellow sheets please leave quickly and quietly leaving all of your materials on your desk. Wait in the hall until you are asked to return to class. Those with blue sheets are to remain here quietly. Yellows please leave.

(After 10 minutes have passed since you noted the time say...)

Will you all please write the word "READY" on the top of the clean sheet in front of you.

Now write all of the words (sounds, pictures) that you can recall on the same sheet.

(Wait 2 minutes)

I would like to remind you to be certain to attend class on Wednesday. Also DO NOT discuss what we have done here with anyone until after class on Friday at which time you will be briefed as to the purposes of the experimentation. I repeat. Please do not discuss this research until that time. Please leave all of the research materials on your desk and leave quickly and quietly. Thank you. You are dismissed.

---

All-purpose phrases that may be inserted anywhere.

1. Will everyone please be quiet.
2. I repeat.
3. Do not look around you.

---

INSTRUCTIONS FOR THE SECOND DAY

Good morning (afternoon). Will everyone please become quiet and give me your full attention. Anyone who was not here Monday, please wait quietly for the next few minutes until we are finished. I am sorry but I will not be able to answer any questions for the next few minutes, so please be careful to listen very intently.

(Wait until it is quiet)

Thank you.

Now will everyone who had a yellow sheet on Maonday please raise your hand.

(Pass out sheets)

Will these people please write the word "YELLOW" on the page in front of you. Thank you.

Everyone who had a yellow sheet on Monday will you please write down on the sheet with the word "YELLOW" all the words (sounds, pictures) that you can recall from the list you learned on Monday.

(Wait 1½ minutes)

Now everyone pass your sheets of paper to your left. Please remain quiet.

(Collect all the sheets)

At this time we would like to Thank You for your participation and urge you not to discuss this research until Fricay. Thank you. We are finished.

## APPENDIX E

PICTURES FOR SLIDE TRANSPARENCIES