VERBAL CONTROL OF VISUAL AND AUDITORY IMAGERY

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Bachelor of Arts

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Wichita, Kansas

1967

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1971

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PREFACE

During the last two decades the study of imagery has been regaining its respectability as a process worthy of study in psychology. This thesis is concerned with visual and auditory imagery; in particular, this thesis is concerned with the relative rates of abstracting information from percepts and from images and with the possible verbal control over visual and auditory images. To add greater objectivity to the study of imagery, the fact that different letters of the alphabet have different spatial and acoustical properties which can be abstracted from images and overtly signaled was used.

This method of studying imagery and a great deal more is owed to Dr. Robert J. Weber, who supplied ideas, methods, books, tape recorders, money, advice, time and a generally pleasant atmosphere both physically and psychologically in which to work; my sincere appreciation is given for his assistance.

In addition I would like to thank Dr. Robert F. Stanners and Dr. Donald K. Fromme for their early advice in the planning of the present research and for their later constructive criticisms in the analysis and writing of the research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In spite of its banishment by Watson and the behaviorists, the study of imagery appears to have been revived during the decades of the 1950's and 1960's. Before considering this revival of interest, perhaps a definition and some of the history of imagery would be appropriate; following the history are the factors responsible for this revived interest in imagery and a review of the literature. After the literature review, this thesis presents a discussion of present research problems; this present research is concerned with the relative rates of visual and auditory imagery as measured under different scanning and response conditions. The focus of this present research is on imagery as a cognitive process, i.e., while it deals with rates of imagery in particular, it deals in general with imagery as a cognitive process.

Definition of Imagery

The term image is a generic term for all subjective, conscious experiences of a quasi-sensory nature; images are present in the absence of external stimulus conditions which reliably produce the corresponding genuine sensory counterpart. Particular types of images can be defined by the conditions which arouse them. Following Richardson (1969) the major types are: after-images, which follow actual sensory stimulation; eidetic images, which are visual, differ from after-images by lasting longer, sometimes years, and in that their formation doesn't require a fixed gaze; memory images, which are the most common, may accompany thoughts concerning events of the past, present or future; and imagination images, which differ from memory images by being novel, clear in detail and vividly colored when the image is visual. Included within the imagination imagery type are hypnagogic imagery, dream imagery, perceptual isolation imagery, meditation imagery, photic stimulation imagery, pulse current imagery, sleep deprivation imagery and hallucinogenic drug imagery.

Another method of classifying different types of images is to specify the modality involved, e.g., visual images versus auditory images. The two methods of identifying imagery are not incompatible and can be combined, e.g., visual, memory imagery. In the discussion to follow the combination of the two methods will sometimes be used; when the combination is not used a particular adjective and the context will clearly indicate what type of imagery is under consideration. It is also to be noted that eidetic imagery is defined as imagery in the visual modality and that most of the research on after-imagery involves the visual modality also.

In regard to the question of the frequency of imagery in the population, it is necessary to specify the particular type. Almost everyone is capable of after-imagery, although, many individuals require some training before recognizing the after-image (Richardson, 1969).

In one of the most recent and most careful studies of eidetic imagery Haber and Haber (1964) found the frequency of eidetic imagery ability to be 8%; they also found that while the eidetic individuals could convey detailed information about the stimulus when their image was present once it faded the eidetic individuals' memory of the stimulus was not much better than that of non-eidetic individuals. It is to be noted that the 8% figure refers to children; among American adults the occurrence of eidetic imagery is near zero (Neisser, 1967). Eidetic imagery has also been found by Doob (Neisser, 1967) to be more prevalent among rural Nigerian adults than among urban Nigerian adults. Supola and Hayden (Neisser, 1967) found that eidetic imagery has a higher frequency among brain-damaged, retarded children than among normal children; this finding suggests there might be a physiological reason for the decline of eidetic imagery among American adults.

The frequency of memory imagery like that of after-imagery seems to include almost everyone; however, not everyone uses the same modality; some individuals are mainly visualizers and some are mainly verbalizers, i.e., use kinesthetic and auditory images; the majority of individuals, however, use some combination of visual and verbal images.

Specifying the frequency of imagination imagery is not as easy since this type includes many sub-types, e.g., the frequency of hypnagogic imagery, the imagery experienced immediately upon awakening and falling asleep, is estimated at 33% but the frequency of dream imagery is approximately 100% (Richardson, 1969); the frequency of other subtypes of imagination imagery cannot be specified unless several situational and subject variables are taken into account.

Holt (1964) discusses an unreported study of the relations among five types of imagery, e.g., hypnagogic, thought and perceptual deprivation imagery; the measurements of the different types of imagery were individually reliable but in relation to one another were almost completely uncorrelated.

History of Imagery

Having now provided a definition of imagery, this section contains a brief history of imagery. As early as 1860 Gustav Fechner discussed imagery in Elements of Psychophysics (Richardson, 1969). When the "new psychology" emerged in the 1890's it was a science of the mind and its instrument of study was introspection; much of what introspection yielded to these early psychologists was images. Others than the Wundtian structuralists were also interested in imagery. Francis Galton while making a natural-historical study of imagery invented the first questionnaire, his breakfast questionnaire; Galton also made the first statistical survey of imagery.

During 1901-1908 at Wurzburg Kulpe's students and associates were conducting experiments which were deleterious to introspection and the structural element, the image. "Imageless thought" was discovered as was the finding that the essential functions of laboratory associative thinking and problem solving were not fully conscious. The crux of these Wurzburg experiments was that introspection could not provide a full explanation of the mind; a different approach was needed to produce a more fruitful science of psychology.

At this point behaviorism with its dicta against imagery came into the foreground of psychological thought. As a result psychologists turned their interests from imagery with the exceptions that the clinical literature showed interest in pathological types of images, e.g., hallucinations, up until World War I and eidetic imagery was intensely studied between the two World Wars.

Reasons for Studying Imagery

Turning now to the factors which prompted and justify the rebirth of interest in the study of imagery in general and which justify the experiments of this thesis in particular it can be seen that many diverse factors are responsible for this rebirth of interest.

From a practical standpoint the confusions of percepts and images has implications for engineering psychology. There are the problems of the vivid visual images of long-distance truck drivers, radar operators monitoring radar scopes for long periods, jet pilots flying unchanging routes at high altitudes and the operators of polar exploration vehicles (Holt, 1964). In these situations serious accidents can result from the individuals mistaking their images for reality.

Another factor responsible for the revived study of imagery stems from recent research on sensory and perceptual deprivation which reports the subjects experiencing various forms of imagery (Holt, 1964). Other types of deprivation can also produce imagery, e.g., Giddan (1966) found that thirst produced imagery concerned with water.

An additional factor justifying research on imagery is the present interest in the hallucinogenic drugs. Considering the possible benefits of these hallucinogens in regard to the study of schizophrenia and considering their widespread use by the young studying the imagery involved would certainly seem worthwhile.

Another source of revived interest in imagery has been the advances made in neurology, e.g., the findings of Cajal and others (Holt, 1964) on the reticular activating system of the brain stem show efferent fibers running from the reticular formation out to the retina suggesting that the reticular activating system may be involved in imagery; the progress made in electroencephalography suggesting that visual imagery may suppress certain EEG patterns; and the findings of Penfield (1958) and others suggesting that direct stimulation of the brain may be a key to finding a permanent record of consciousness.

Studies of creativity have also revived interest in imagery, e.g., systematic differences in the use of imagery have been found for different types of scientists (Roe, 1951).

A final factor which has contributed to the revived interest in imagery is the recent interest in thinking and cognitive processes (e.g., Neisser, 1967).

Review of the Literature on Imagery

Having supplied what seems ample reason for the study of imagery, a review of the relevant literature on imagery is the next step to be taken. As will be seen this literature review is very broad but also very relevant; it ranges from the physiological mechanisms of imagery to the use of imagery in psychotherapy. While the experiments reported answer many questions it will be obvious that many other questions concerning imagery are as yet unanswered.

Physiological Mechanisms of Imagery

Many of these unanswered questions concern the anatomical and physiological basis for imagery; however, it is possible to account for some images. Almost everyone at sometime sees spots ("muscae volitantes") before his eyes; the source of stimulation has been found to be from within the eye itself (entoptic stimulation); White and Levatin (1962) found that these spots or "floaters" are often diffraction patterns of erythrocytes (red blood cells) cast upon the light sensitive cones and rods of the retina; the size of the spots is determined by the distance between the erythrocytes and the retina.

Horowitz (1964) suggests that entoptic stimulation from the ganglionic network of the retina and from anatomical bodies, e.g., erythrocytes, could be responsible for a wide range of imagery, e.g., hypnagogic, hallucinogenic drug, perceptual deprivation and schizophrenic hallucinatory imagery. Although this entoptic stimulation usually goes unnoticed, under certain conditions, e.g., perceptual deprivation, neural disinhibition or facilitation would result in this stimulation reaching higher brain centers where it would be elaborated into images. The nature of these images would depend upon the particular individual.

Entoptic stimulation would seem to be most connected with imagination imagery because of the novelty. Another source of stimulation, i.e., direct electrical stimulation of the brain, seems to be associated with memory imagery. Penfield (1958) found that direct electrical stimulation of the temporal lobes of the cerebral cortex in epileptic patients resulted in particularly vivid memory images; he assumed that somehow epilepsy sensitizes the temporal cortex. The particular memory image, usually visual or auditory, activated by the stimulating electrode seems to depend upon chance and repeated stimulation of the same point results in the same or a similar experience. Penfield believes that the stimulation of the temporal cortex results in electrical potentials being conducted to some distant unknown cortical area at which lies a permanent record of the stream of consciousness.

Another centrally-oriented physiological explanation of some types of imagery is provided by Hebb (1968); in regard to visual imagery Hebb believes eye movements play an organizing role as they do with visual perception. He considers an image to be a reinstatement of a percept and the image to be composed of different parts (cell assemblies); part-images do not directly excite other part-images but instead excite motor neurons resulting in eye movements which then excite another part-image; hence, eye movements organize the image by exciting the correct sequence of part-images.

Hebb distinquishes physiologically between memory imagery on the one hand and hypnagogic hallucinatory and eidetic on the other. Perception, according to Hebb, is the excitation by sensation of first order and higher cell assemblies; when the excitation comes from cortical events then first order cell assemblies are not necessarily excited; this provides the basis of distinquishing hallucinatory, hypnogogic and eidetic imagery which involve the excitation of first order and higher cell assemblies from memory imagery which involves the excitation of second order and higher cell assemblies. The excitation of the first order and higher cell assemblies are what gives some images their vividness and completeness.

For Hebb the image is a reinstatement of a percept that comes about in associative steps; the vividness of the image depends upon the levels of cell assemblies involved.

Hebb and Neisser have disagreed on the nature of visual perception (Neisser, 1967) and it appears that they also hold differing viewpoints concerning visual imagery. Neisser holds that both visual perception and imagery involve a visual synthesis, an active, constructive process; it should be noted that Neisser excludes after-images (where no synthesis is involved) from the other types of images created by synthesis.

For Neisser an image is not the reproduction of a percept, is not the cortical unfolding of a predetermined event but is synthesized anew each time it occurs. Eye movements are not mere associative links but are usually an integral part of this synthesis. In support of this view Neisser cites: the Habers' finding (Haber and Haber, 1964) that the eidetic individuals scanned their images; the fact that dreaming individuals move their eyes; and the fact that during memory imagery individuals move their eyes to produce the needed synthesis (Neisser, 1967). Neisser concludes that while visual synthesis might occur without eye movements the more vivid the image the higher the probability that some eye movements are involved.

Another finding which lends support to Neisser's view is that during recall of verbal material eye movements are found which are equal in frequency to those found during the actual reading (Ewert, 1933).

Neisser (1967) presents a similar argument for the formation of auditory images, i.e., that they are a product of auditory synthesis in which slight movements of the larynx play a role analagous to eye movements. Both McGuigan and Gould (Neisser, 1967) found that auditory hallucinations of schizophrenics correlated with amplified subvocal activity.

Additional comments on the Neisser-Hebb argument will be found later in an extended discussion of physiological correlates of imagery.

Physiological Correlates of Imagery

Turning then from physiological mechanisms to physiological correlates of imagery the most controversial correlate is found to be the alpha rhythm of the electroencephalogram. Memory imagery tasks have been used in studies which seek to correlate alpha rhythm responses with visual imagery. These results may be generalizable to other imagery types, i.e., to imagination and eidetic imagery.

Short (1953) classified individuals on the basis of their subjective reports as to the nature of their imagery during various tasks; he then correlated these classifications with the individual's alpha rhythm and respiratory responses obtained during the tasks. The results showed that the visualizers, who reported using visual images, had frequent alpha blocking and regular breathing patterns (alpha blocking was shown during the task and the inter-task periods); the verbalizers, who reported using kinesthetic and auditory images, had alpha persistence and irregular breathing patterns (alpha persistence was shown during both the task and inter-task periods). A third group, individuals who reported using kinesthetic, auditory and visual images, had the normal alpha rhythm pattern (i.e., blocking during the tasks when the eyes were closed and whenever the eyes were open and persistence during the inter-task periods when the eyes were closed). Short found that the verbalizers when solving tasks requiring visual images showed the physiological pattern of the visualists.

In another study on the relationship between alpha rhythm responses and imagery Barratt (1956) disregarded individuals' imagery type classification and had all subjects perform two tasks; one task encouraged the use of visual images and the other task encouraged the use of verbal processes. He found that alpha-blocking occurred in both types of tasks but more so in the visual problem task; he concluded that alpha-blocking is not, therefore, an objective indicator of the presence of visual images because it is non-specific.

Again in relating visual imagery to alpha rhythm responses, Slatter (1960) obtained results similar to those of Short, i.e., the use of visual images was associated with alpha-blocking and the non-use associated with alpha persistence. Slatter suggests that the nature of the task is very important; according to his reasoning the tasks may have been too difficult in Barrett's study, thereby, accounting for the failure of the alpha rhythm pattern to differentiate between the use and non-use of visual images. Slatter's most important finding is that alpha frequency might better identify predominately visual imagers rather than alpha amplitude; he found that a resting alpha frequency of 12 cycles/second was associated with individuals who predominately used visual images.

A final study dealing with alpha rhythm patterns showed that alpha blocking was associated with "mental multiplication" (Lorens and Darrow, 1962). Introspective reports indicated that visual images aided in the solutions; all individuals also showed increased eye movements while covertly multiplying.

Changing the discussion to a different type of imagery and a different type of EEG it was found by Berger, Olley and Oswald (1962) that there is a particular frontal EEG pattern that often precedes the rapid eye movements associated with dreaming. It was found that individuals with long standing blindness did not have rapid eye movements associated with their dreaming but other individuals blinded for only a few years did have the characteristic eye movements.

In another experiment employing covert tasks, e.g., sub-vocal counting, it was found by Novikova (1955) that as the difficulty of the task increased so did the frequency of tongue muscle potentials; in some individuals these potentials increased upon hearing the problem. These potentials also were stronger in illiterate than literate adults. A final finding was that during these covert tasks deaf-mute individuals, possessing both manual and oral speech, showed increases in both finger and tongue muscle potentials.

The results of these last three studies by Lorens and Darrow, Berger, Olley and Oswald, and Novikova all can be interpreted as supporting Neisser's concepts of synthesis: in dreaming and covert multiplication there is a visual synthesis; in other covert tasks, e.g., subvocal counting and memorizing words, there is an auditory synthesis and in special cases a kinesthetic synthesis. Unfortunately, this peripheral activity does not undeniably imply synthesis.

Another study which can be interpreted as supporting Hebb's centralist theory concerning visual imagery and eye movements is Deckert's (1964); he found that when visually imaging a beating pendulum individuals showed pursuit eye movements corresponding in frequency to the eye movements found when visualizing an actual pendulum. Deckert concluded that the presence of pursuit rather than saccadic eye movements supports a central control theory of eye movements, i.e., that cerebral images are responsible for eye movements.

In the way of a summary concerning the Neisser-Hebb argument it appears that there is evidence for both positions and only future research which tests explicit hypotheses from both positions can attest to the utility of one position over the other.

Turning now to some related research an interesting idea concerning auditory imagery arises. When amplified and channeled as input to an auditory device, i.e., earphones, the electrical activity of the laryngeal muscles can provide immediate feedback on sub-vocal activity and can serve as a cue for its elimination during silent reading (Hardyck, Petrinovich and Ellsworth, 1966). It has also been found that during silent reading as compared to resting conditions that there is increased chin and lip movement (McGuigan, Keller and Stanton, 1964). A possibility stemming from the above findings is that providing auditory feedback from the larynx, chin and lips might result in the diminution or elimination of auditory imagery in other situations, e.g., the auditory hallucinations of schizophrenics. It is to be noted that not all auditory interference may have the same effect of suppressing subvocalization; it has been found by McGuigan and Rodier (1968) that during silent reading auditory interference in the form of prose increased the amplitude of chin and tongue movements but that auditory interference in the form of white noise did not have this effect.

Before leaving the area of physiological correlates of imagery one further possibility should be mentioned. Pupillary responses have been related to visual, memory imagery (Paivio and Simpson, 1966); it has been found that pupil size does not correlate with the concreteness of the required image but pupillary response latency is shorter with the more concrete stimuli (Paivio, 1968). In this last study differing levels of visual imaging ability were not correlated with pupillary responses which suggests that cognitive activation rather than visual images per se was responsible for the observed results. Supporting this interpretation is the finding (Colman and Paivio, 1969) that the latency for the maximum galvanic skin response is longer for abstract than for concrete words; this result also points to cognitive activation as being responsible for the above pupillary response findings since it is hard to see how visual images would effect the GSR.

Functions of Imagery

As mentioned earlier all individuals do not experience some types of imagery to the same degree; with memory imagery there appears to be a continuum from the habitual abstract (verbal) encoders of stimuli to the more habitual concrete (mainly visual) encoders. The next question to be asked in this literature review is whether one point on this continuum is better than another for information processing.

Brooks (1967) has shown that reading verbal information, a message describing the spatial relationships of eight digits in a 4 x 4 matrix, conflicts with imagining the spatial referents conveyed by that information; listening to the same information did not result in such conflict. On the other hand, when the information was treated as a rote sequence of words rather than information to be imagined, then reading rather than listening produced faster verbatim reproduction from the subjects.

In another experiment Brooks (1968) was able to show that when an individual recalls visual material he more quickly conveys information concerning that material by a spoken output (saying yes/no for the presence or absence of a spatial feature) than by a spatially (e.g., visually) monitored output (checking a printed yes/no for the presence or absence of a spatial feature); but when the individual recalls a sentence, spatially monitored output is faster than speaking. From these results Brooks suggests that specific modalities are involved in the processing and recall of verbal and spatial information.

The above results suggest that performing two tasks involving the same modality is less efficient than two tasks involving different modalities. When two tasks involve the same modality the level of attention required by the tasks may affect the efficiency of performance. In regard to concurrent verbal tasks Peterson (1969) found a negative correlation between level of attention required by a task (i.e., emissive, reproductive or a problem solving task) and efficiency of performance; however, no relationship was found between the number of similar elements in the two tasks and efficiency of performance.

The results of this last study can be used to explain the results of an older study which employed a task similar to one used in the research reported in this thesis. Robinson and Bills (1926) found that 11 out of 18 subjects while naming letters visually present in front of them were also able to engage in concrete fantasies; these subjects were perhaps able to engage simultaneously in fantasy and name letters because of the low level of attention required by the letter naming task.

It is perhaps possible that the modalities discussed above are each sub-divided into a sensory modality and a memory modality; from this suggestion it would follow that there are different memory modalities, e.g., visual and auditory. Wallach and Averbach (1954) demonstrated this to be the case since when multiple memory traces, e.g., visual and auditory, were formed for a given external event (the presentation of a nonsense syllable) recognition and recall scores were enhanced. It is further suggested by Wallach and Averbach (1954) that direct recognition of an external event only takes place when the perceptual experience and the memory are of the same modality, e.g., either visual or auditory.

So far the studies reviewed have manipulated situational variables; the next study involves manipulation of a subject variable. Sheehan

(1967) used subjects who varied in their imaging ability; he found that vivid imagers showed better retentive performance for visual information than did poor imagers; he proposed that vivid imagers perceive literally, whereas, poor imagers employ some coding device.

While Sheehan's results showed better retention for vivid imagers Neisser (1967) claimed that tasks such as used in this experiment are not representative of everyday life and that a visual, memory image is not an exact replication of the previous experience and, therefore, does not help in recall.

A later study in which Sheehan and Neisser (1969) collaborated used a similar type of task. Accuracy of recall and vividness of visual imagery during recall were found for two sets of stimuli, the principal or task stimuli and the incidental or inter-task stimuli. For the principal stimuli there was a general trend for accuracy and vividness of imagery to be related. The rather difficult task involved may have prevented good imagers from out performing poor imagers; in other words imagery was difficult for the principal stimuli no matter what an individual's imaging ability might be. The incidental stimuli produced much more vivid imagery than did the principal stimuli. For the incidental stimuli there was a significant correlation between accuracy and vividness of imagery in recall. These results suggest that visual imagery may have some particular function in the recall of incidental stimuli. Sheehan and Neisser conclude that visual imagery is only one of several sources of information that may be used during recall.

There is additional evidence which must be taken into account before conclusions regarding the value of visual imagery in recall are reached.

Paivio (1969) has shown that visual, memory imagery as well as verbal processes, i.e., mediation using words or phrases, can be used as memory codes and as associative mediators in paired-associate learning; he found that the availability of visual images as associative mediators varies directly with the concreteness (visual image-evoking value) of the items to be learned in a paired-associate learning task; the availability decreases from objects to pictures to concrete words to abstract words (similar results were also obtained by Dominowski and Gadlin, 1968; Yuille and Paivio, 1967; Paivio, 1966; and Stewart, 1965). The concreteness dimension was found to have its greater effect on the stimulus items rather than on the response items. Verbal processes have been found to be independent of the concreteness of the items (Yuille and Paivio, 1967). It has also been found in paired-associate learning that if at least one of the items of a paired-associate is concrete then a visual image is the "preferred" mediator (Paivio, 1969).

Visual images have also been found to be excellent mediators in one-trial paired-associate learning in which a mnemonic device, a nursery jingle, was used to pair object names and numbers (Bugelski, Kidd and Segmen, 1968).

The concreteness dimension has also been shown to be important in a free recall situation where concrete items are recalled better than abstract items (Paivio, Rogers and Smythe, 1968; Stewart, 1965).

Visual images are not equally effective in mediating all kinds of memory tasks. Rather visual images seem to be employed in a parallel processing system (several simultaneously available items of information) as opposed to a sequential processing system (one item of information available at a time). It has been found by Paivio and Csapo

(1969) that in sequential memory tasks, i.e., in immediate memory span and serial learning, that memory for concrete items, i.e., pictures, is inferior to memory for abstract tiems, i.e., words. The material was presented at a fast rate which prevented the verbal coding of the pictures. This difference in retention was not found in non-sequential memory tasks, i.e., free recall and recognition memory.

A final study along these lines is one investigating the effects of differing abilities to form visual images. Stewart (1965) found that in paired-associate learning and in recognition tasks that good imagers did better than poor imagers where pictures were involved but that poor imagers did better where words were involved.

From the available evidence it appears that there are several informational sources which may be used in recalling previous experiences. Visual images may be one such source and, therefore, can be of value to their possessors; however, visual images are not equally useful in all kinds of memory tasks. Visual imagery appears to have its greatest value in concrete, non-sequential memory tasks and appears to be of little value in abstract, sequential memory tasks where the rate of presentation is fast enough to prevent verbal coding.

Parameters of Imagery

Having now discussed some general functional aspects of imagery the next major topic of this review concerns establishing some parameters for imagery. Before dealing with imagery memory in general will be discussed as a backdrop for considering additional aspects of imagery.

The temporal variables of memory tasks range from a brief immediate memory through a short-term memory to a long-term memory. It has been found that visual, but no auditory, confusability affects immediate visual memory; Glucksberg, Fisher and Monty (1967) found that sequences of letters rated low on visual confusability were immediately recalled better than sequences rated high; auditory confusability within the letter sequences had no effect on immediate visual memory. It has also been found that auditory confusability affects immediate auditory memory; Conrad (1964) found that lowered auditory confusability within sequences of letters correlated with an increased immediate recall of these letters. Posner and Keele (1967) established the presence of an immediate visual memory for a single letter by finding that such a letter stored in memory can be matched more rapidly with a physically identical letter, e.g., AA, than with a letter with an identical name, e.g., Aa. Immediately after the presentation of the first letter a match based upon physical identity was about 80 milliseconds faster than a match based upon name identity. The immediate visual memory for a single letter can decay in 1.5 seconds at which time the physical identity match is no faster than a name identity match. Posner, Boies, Eichelman and Taylor (1969) found that the decay of visual information from a single letter could be hastened by having an information processing task, an addition task, performed between the formation of the memory trace and the matching; the decay could be lessened by having the visual aspect of the letter become a more reliable cue for the match. It was also found in this last study that Ss could generate visual information, i.e., the auditory stimulus was converted into a visual code, upon hearing a single letter; if this recoding occurred, then the auditory-visual matching occurs as quickly as a physical match and quicker than a name match.

Returning to the temporal forms of memory, information in immediate memory, if preserved, goes into short-term memory; verbal information, even if visually presented, is preserved in an auditory form (Conrad, 1964). The short-term memory for a single item can decay within several seconds (Kendler, 1968). The information in short-term memory, if preserved, goes into long-term memory; with verbal information in long-term memory semantics become important through contextual influences.

A particular type of memory task to which imagery tasks can later be compared is that of recognition. Recognition appears to involve long lasting memory traces; nothing new is being synthesized as is, probably, in imagery. Sternberg (1967) proposes that visual recognition involves two operations: first, there is an encoding of the stimulus and next there is a comparison of the encoded information with relevant information stored in memory; second, the comparison may result in a match between the encoded item and some item from memory; the match constitutes recognition. Sternberg proposes serial, exhaustive comparisons but other evidence casts doubt upon this proposal (Morin, Derosa and Stultz, 1967). For the memory comparison process Sternberg (1966) reports an average rate of 25 to 30 items (digits) per second.

Changing the focus now to studies which have investigated the rates of imagery it has been found by Landauer (1962) that the rates for covert and overt speech are practically the same. With the numbers one through ten and the letters of the alphabet a typical rate of approximately 7 items/second was obtained.

Another study (Weber and Bach, 1969) which compared the rates of visual imagery, verbal imagery (covert speech) and overt speech supports

Landauer's results. The tasks involved processing or imagining the alphabet serially, i.e., one letter at a time; the speech conditions, covert and overt speech, showed practically identical processing times of approximately 6.5 letters/second. The visual imagery condition, however, was much slower; the required processing time showed an approximate rate of 2.5 letters/second. From these results it would appear that visual imagery is much slower than verbal imagery. However, if visual imagery could function in a parallel processing manner as it may in some instances, then perhaps it might be faster than verbal imagery. One important advantage of this approach to studying imagery is that scan rates might serve to distinquish imagery and perception (Weber, 1970a).

A similar study by Weber and Castleman (1970) replicated the above findings; in this study small but significant practice effects were found for visual imagery; the scan rate increased with practice. A final finding was that subjects thought the visual tasks to be more fatiguing than the verbal tasks.

A criticism of these last two studies is that although the subjects were forming the required verbal images, as indicated by similar covert and overt speech rates, there was no objective indication that subjects were forming the required visual images. Such an indication is needed to aid in the interpretation of the results. In another experiment Weber and Castleman (1970) provided the needed indication by adding a new task. In this task in addition to forming the required visual image of a letter subjects had to abstract from the image a spatial property, size, and signal that property overtly by saying whether the letter was large or small. Scan rates were obtained for tasks involving overt speech (5.02 letters/second), visual imagery where no properties were signaled (1.76 letters/second) and visual imagery where properties were signaled (.95 letters/second); the scan rates for the first two tasks were similar, but somewhat slower, to identical tasks in the two previous experiments; the scan rate where visual properties were signaled (two operations) was considerably slower than the scan rate where visual properties were not signaled (one operation). Again visual imagery tasks were judged more fatiguing, and there was a similar small practice effect for visual imagery. This experiment added more objectivity to the study of visual imagery; from the scan rate for visually imaging the alphabetic letters and signaling their properties, a task which involved two stages (image generation and abstraction from the image), it is possible to infer that the letters were visually imaged when no properties were signaled. The basis for this inference is the slower scan rate when signaling was involved and S's reports. The crux of this experiment is that in a serial processing task it is again found that visual imagery is slower than verbal imagery.

Introspective reports from subjects in the two preceding experiments suggested that some subjects covertly spoke each letter before visually imaging it. A final experiment by Weber (1970b) investigated the possible verbal control of visual imagery. Processing the alphabet was again the experimental task used; this experiment also employed the procedure of having subjects signal the spatial size of each visual image; this procedure appears to insure that some minimal clarity of visual images is obtained. Two modes of processing or scanning the alphabet were used, a spoken scan in which each letter was spoken aloud as the visual image was formed and a non-spoken scan in which each letter was not spoken aloud as the visual image was formed. Two response modes of signaling the size of the image were also used, a written response mode and a spoken response mode. Two forms of the alphabetic letters were also used, upper case letters and lower case letters. The results showed that the processing times for spoken scanning and non-spoken scanning were virtually the same; this result would indicate that subjects using non-spoken scanning covertly spoke each letter as the visual image was formed; this interpretation follows from a previous result, the identity of covert and overt speech rates (Landauer, 1962). It would seem that since subjects speak a letter while imaging it that there is some verbal control over visual imagery. The results also showed that using a written response mode is faster than using a spoken response mode. It appears that using the spoken response conflicts with verbal control over visual imagery, whereas, written responses do not. A final finding was that the processing rates for upper and lower case letters were practically equal; it appears that these results on visual imagery rates are generalizable to a range of visual images.

To summarize the experiments dealing with the rates of imagery, it seems possible to conclude that some visual imagery is under verbal control, e.g., the serial visual imaging of alphabetic letters; however, introspectively it is obvious that not all visual imagery, e.g., dreams, is under verbal control. It is also possible to conclude that visual imagery, even allowing for the verbal component (Weber, 1970b), is slower than verbal imagery when sequential processing tasks are used; whether the same relationship holds with parallel processing tasks remains an empirical question. In relating visual imagery (e.g., Weber and Bach, 1969) to other visual memory processes (e.g., Sternberg, 1966) it is possible to conclude that serial scanning in visual imagery is slower than scanning in visual recognition.

Learning and Imagery

The first question to be asked concerning the relationship between learning and imagery deals with conditioning, i.e., whether responses can be conditioned to various images. Representative of the answers to this question is a study by Roessler and Brogden (1943). In this study it was found possible to condition vasoconstriction to a verbal image; the image was a covertly spoken nonsense syllable. Having established that it is possible to condition a response to an image the next question concerns sensory conditioning, i.e., whether images can be conditioned to various stimuli. Leuba (1940) and Hefferline and Perera (1963) demonstrated that this is indeed possible. Hefferline and Perera conditioned a subject to report hearing a tone when the subject made an invisibly small thumb twitch. In this case the conditioned stimulus, the thumb twitch, was an actual sensation. It has also been shown (Leuba and Dunlap, 1951) that when the conditioned stimulus is itself an image that it can still elicit a "conditioned sensation", i.e., an image. Leuba and Dunlap paired a pin prick and a ringing of a doorbell. Later the auditory image of a ringing doorbell resulted in the subject reporting a sharp pain in the absence of the pin prick.

The last study where both the conditioned stimulus and conditioned response are images is similar to studies where physical skills have been learned by "mental practice". Richardson (1969) concludes that the use of imagery to practice a physical skill results in improved performance. It appears that overt muscular activity is not a necessary condition for improvement. In one study (Start and Richardson, 1964) it is suggested that the vividness and controllability of an individual's imagery is positively related to the degree of improvement a particular individual shows.

A final study (Vaughan, 1963) on this topic of imagery and learning is particularly interesting because rhesus monkeys rather than humans were used. First the monkeys were trained in the presence of various visual stimuli to avoid an electrical shock by pressing a bar; this resulted in the monkeys pressing the bar upon presentation of the visual stimuli. Later translucent corneal contact lenses were fitted to the monkeys in order to produce a non-patterned visual field. During sleep three of the four monkey subjects at times pressed the bar at rates similar to those obtained upon presentation of the visual stimuli during the training period; the explanation offered was that these monkeys experienced dream imagery which initiated the bar pressing. Two of the monkeys pressed the bar upon awakening. The explanation provided was that these monkeys experienced hypnagogic imagery upon awakening. A third monkey upon awakening engaged in various inappropriate behaviors that were possibly the result of "hallucinations". Possibly the major value of this study is in illustrating that the study of imagery is not limited to human subjects. Evidently some of the benefits of animal research can be utilized in the study of imagery.

Psychological Correlates of Imagery

The next topic of this review is the psychological correlates of imagery; this discussion will be rather brief because much of the present research on imagery is concerned with functions and parameters not with psychological correlates. It appears that intelligence and imagery are not correlated to any extent; Brower (1947) found no relationship between intelligence as measured by an intelligence test and the rated intensity of college student's images. As regards imagery and creativity Schmeidler (1965) found a low, but significant, positive correlation between visual imagery and creativity as measured by a subset of the Barron Independence of Judgment Scale. In investigating imagery among research scientists Roe (1951) found that biologists and experimental physicists expressed greater use of visual imagery while theoretical physicists, anthropologists and psychologists expressed greater use of verbal processes.

Psychotherapy and Imagery

The relationship between psychotherapy and imagery, the final topic of this review, will also be brief because there has not been much research in this area. Since many forms of psychotherapy use hypnosis it is of interest to note that vivid imagery is a necessary, but not sufficient, condition for hypnosis (Richardson, 1969); suggestibility is probably also another necessary condition.

Imagery has also been used in the behavior therapies. In desensitization therapy the client imagines the anxiety-provoking stimuli in a situation which inhibits the anxiety produced by the images. Hierarchically, all anxiety-provoking stimuli are dealt with in this manner. Later, through generalization, the actual stimuli as well as images fail to elicit anxiety. It would seem that imaging ability would play an important role in this procedure. Fortunately, Wolpe (1969) finds that 90 per cent of his South African and American clients possess the necessary imaging ability.

Imagery has also been used in another form of behavior therapy; Kolvin (1967) reports using "aversive imagery" with adolescents. The client imagines the problem-producing situation, e.g., gasoline sniffing, then in operant conditioning fashion imagines an aversive consequence; by this means the probability of the problem situation arising is reduced.

This discussion of psychotherapy and imagery concludes the review of the literature; the next section of this introductory chapter concerns the problems with which the present research of this thesis is concerned.

Statement of Problems

The research problems with which this thesis is concerned necessitate conducting three different experiments in an attempt to answer the questions involved; the major question concerns the conditions under which there is or is not verbal control over visual imagery.

Experiment I is essentially a calibration study in which response times for two different response modes are assessed. The two response modes being evaluated are a written response mode and a spoken response mode. Since writing and speaking are perhaps two of our most important types of output to the external world this seems like an important question. The results are of primary significance to Experiments II and III of this thesis.

Experiment II involves a comparison of the rates of abstracting visual properties from visually present material and from material from memory. By using two different response modes, spoken and written, this experiment will provide information concerning the extent to which visual and auditory imagery are under verbal control.

Experiment III involves a comparison of the rates of abstracting visual properties from different types of letter strings, i.e., from the alphabet and from words. By using two different scanning modes, spoken and non-spoken, and two different response modes, spoken and written, this experiment will provide information concerning possible parallel processing in visual imagery; in other words this experiment investigates visual imagery in which there may not be sequential verbal control over the components of an image.

CHAPTER II

EXPERIMENT I

Writing and speaking are two of the most important means of signalling information or communicating with our fellow men. While it seems obvious that in most instances we can speak faster than we can write, it is desirable to establish this fact experimentally as it has not been done before. Therefore in this first experiment response times for the two different response modes, speaking and writing, are measured using two different tasks, speaking and writing the alphabet and speaking and writing a 26 member series of alternating yes/nos and dash/dots, respectively.

The major reason for including this experiment at this point and for using the two different tasks and for using the two different response modes is that the results are of importance in interpreting the findings of the next two experiments which used these response modes and materials. That is, both written and spoken response modes are used in the next two experiments; these response modes are used as indicators of visual imagery; hence, this experiment establishes their temporal properties. If the results of the following two experiments differ from the results of this experiment it is possible to conclude that some factor other than the rate of responding per se is having an effect.

Method

Subjects

The subjects used in Experiment I were 10 undergraduate volunteers from an undergraduate psychology class.

Experimental Design

This experiment employed two different treatments each with two levels: the first treatment, type of task, included an alphabet task and a binary task; the second treatment, type of response mode, included a spoken response mode and a written response mode. Hence, the design was a two by two factorial with two kinds of task (alphabet list and binary list) and two kinds of response (written and spoken). In the written condition of the alphabet task the Ss were asked to write the alphabet in their normal handwriting as quickly as possible; in the spoken condition of this task the Ss were asked to speak the alphabet aloud as quickly as possible. In the spoken condition of the binary task the Ss spoke aloud a 26 member series of alternating yeses and nos, i.e., "yes, no, yes, no", etc.; in the written condition of this task the Ss wrote out a 26 member series of alternating dashes and dots, i.e., "/, ., /, .", etc.; in the later experiments the dashes will represent a "yes" response and the dots a "no" response.

Each S served in the four conditions, a within Ss design. One-half of the Ss were randomly assigned to the alphabet task as their first task and the other half to the binary task first. For each task one-half of the Ss were randomly assigned to the written condition as their first condition and the other half to the spoken condition as their first condition.

Procedure

Each S activated a remotely controlled Standard Electric clock (calibrated in .01 sec) with his free hand when he started to process the alphabet or binary series and stopped the clock when he finished. The Ss were not allowed to see the clock face. Each S was given 6 trials in each condition on each task; a trial consisted of a single processing, i.e., writing or speaking, of a particular list, i.e., alphabetic or binary. The intertrial interval was approximately 30 seconds during which the E recorded the response time on a data sheet and reset the clock. Following the 6 trials of the first condition each S was immediately given the 6 trials of the second condition. Following a one minute rest after the first task each S began the second task. The instructions given to Ss can be found in Appendix A.

Results

Response times for each task are presented in Table I. Each mean is an average based upon 10 Ss and 6 trials. The S.E. is a between Ss measure of variability based upon each S's mean over the 6 trials; that is, the S.E. is the S.E. of the means over 6 trials. The means over the 6 trials for each S can be found in Table XI in Appendix D.

As can be seen from Table I, the response time for the written response mode is greater than the response time for the spoken response mode on both the binary and alphabet tasks. An analysis of variance showed that the type of response had a significant effect ($F(1,9) = 167.36$, $p < .01$); however, the type of task did not have a significant effect ($\underline{F}(1,9) = 1.52$). A significant interaction between type of response and type of task was found ($\underline{F}(1,9) = 90.66$, $\underline{p} < .01$).

TABLE I

MEANS AND STANDARD ERRORS FOR BOTH EXPERIMENTAL TASKS

Task	Spoken Condition		Written Condition	
	Mean (Sec)	S.E.	Mean (Sec)	S.E.
Alphabet	4.63	1.30	12.87	2.07
Binary	7.50	1.80	9.37	1.55

It is also possible to compare the mean response times across Ss for the first three trials and the mean response times across Ss for the last three trials to determine the presence of practice effects. For the spoken condition of both tasks the differences are not significant; however, for the written condition of both tasks the differences are significant (binary task correlated $\underline{t} = 5.59$, d.f. = 9, $\underline{p} < .001$; alphabet task correlated $\underline{t} = 2.93$, d.f. = 9, $\underline{p} < .025$). A graph showing response times as a function of practice can be found in Figure 3 in Appendix E.

Discussion

In this experiment the increased response time for the written response mode as compared to the spoken response mode for both the binary and the alphabet experimental tasks reflect nothing more than different response times for different motor acts; the spoken response mode was the more rapid. The significant interaction between type of response and type of task can be interpreted as meaning that with written responses, _Ss_ could execute the simple straight lines required by the binary task faster than the more complex curved lines required by the alphabet task; but when spoken responses were used, _Ss_ could say the familiar alphabet faster than the novel string of 26 alternating yes/nos. There is no obvious explanation why the practice effect was obtained with the written response mode on both tasks but not with the spoken response mode on both tasks.

While this is a simple experiment the results will be useful in interpreting the results of the following two experiments.

CHAPTER III

EXPERIMENT II

In this second experiment the relative rates of abstracting visual properties and auditory properties from material visually present and from material generated from memory are measured under different response conditions. This experiment is therefore designed to answer two major questions; the first question concerns the possible verbal control over auditory and visual imagery. As mentioned earlier, images can be a source of information to an individual and it would seem to be important to understand the control over production of images. The other question concerns the possible difference in scanning rate between images and percepts. Since, as also mentioned earlier, there is presently no satisfactory objective means of differentiating between images and percepts, it is important to determine whether scan rates might do so.

Method

Subjects

The subjects used in Experiment II were 20 undergraduate college students who were selected on a voluntary basis from an undergraduate psychology class; each S was paid three dollars for his participation in this experiment. The data from a twenty-first subject were thrown out because he was unable to understand the nature of one of the tasks;

he made a substantial number of errors on every trial involving this task.

Experimental Design

The experimental tasks used in this experiment involved the use of the alphabet. In order to obtain a more objective evaluation of Ss imaging the alphabet, the fact that different letters of the alphabet have different spatial and acoustical properties was used; this is the same procedure used initially by Weber and Castleman (1970) and will now be discussed in some detail.

Individual, lower case, typed letters of the alphabet can be divided into two classes depending upon the spatial property of vertical size; for example, large letters include "b", "d", "f", "g", "h", etc. and small letters include "a", "c", "e", "i", "m", etc. By having the S visually imagine the alphabet and indicate the vertical size of the individual letters greater assurance that the Ss are, in fact, visually imaging the alphabet is obtained.

A similar situation holds for the acoustical properties of the alphabet; the individual letters can be classified into two classes depending upon whether an individual letter name has a long ē/i/sound, e.g., "b", "c", "d", "e", "g", etc. or doesn't have this long ē sound, e.g., "a", "f", "h", "i", "j", etc. By having the S aurally imagine the alphabet and indicate the presence or absence of the long ē sound of the individual letters greater assurance that the Ss are, in fact, aurally imaging the alphabet is obtained.

The following tabular example will add clarity to the above:

Imagined Letter:	a	b	c	d	e	f	g	.	.	.	z
Presence of Visual Property:	0	+	0	+	0	+	+	.	.	.	0
Presence of Acoustical Property:	0	+	+	+	+	0	+	.	.	.	+

The plus sign, +, indicates the presence of the property large size or long $\bar{e}$ sound depending upon the type of property in question, either visual or auditory; the zero, 0, the absence of the property.

The above method in addition to increasing objectivity also has the advantage of reducing the variability associated with the imagery process because the abstraction process requires some minimal clarity of the image and, therefore, a lower bound of what constitutes an image is established, reducing the variability. It has also been found that the errors involved with this method are negligible in number and, therefore, can be safely ignored (Weber and Castleman, 1970).

In the present experiment a three-factor factorial design was used: (1) to compare the rates of abstracting visual properties and auditory properties from visually presented material and from material from memory and (2) to investigate the extent to which visual and auditory imagery are under verbal control; the verbal control is investigated by manipulating the response mode of indicating visual images. The first factor, type of representation, had two within S levels, percept and image. In the percept condition the alphabet was visually present and in the image condition the alphabet was present only as a memory or image. The second factor, type of property, also had two within S levels, visual property and acoustic property. In the visual condition the alphabet was processed for visual properties (VP) and in the auditory condition the alphabet was processed for auditory properties (AP). The third factor, response mode, had two between S levels, written and spoken. Both response modes were binary. In the written condition responses were written as a vertical dash "|" or as a dot "."; these corresponded to "yes" and "no" in the spoken condition.

Hence, a given S at different times abstracted from the successive individual letters of the alphabet both visual and auditory properties from visually present material (i.e., from an 8" x 5" index card with the alphabet typed in lower case letters on it) and from material from memory (i.e., from the images which each S generated for himself). A given S used either a written response mode (he wrote dashes to indicate the presence of the property in question and dots to indicate the absence of the property in question) or a spoken response mode (he spoke aloud "yes" to indicate the presence of the property in question and spoke aloud "no" to indicate the absence of the property in question). The written response strokes were chosen because of the rapidity with which they can be executed (Weber and Castleman, 1970). The assignment of response modes was determined by the S's order of appearance at the experimental laboratory, i.e., the first and alternate S thereafter used written responses and the other Ss used spoken responses.

Procedure

Each S was given four practice trials: one for abstracting visual properties from the visually present alphabet; one for abstracting visual properties from an image of the alphabet; one for abstracting auditory properties from the visually present alphabet; and one for abstracting auditory properties from an image of the alphabet.

Each S activated a remotely controlled Standard electric clock (calibrated in .01 sec) with his free hand when he started to process the alphabet and stopped the clock when he finished; the Ss were not allowed to see the clock face; however, the Ss were given feedback in the form of time and errors for the four practice trials.

Each S processed the alphabet from perception (i.e., from a visually present alphabet) and from memory (i.e., from a non-visually present alphabet) on 6 trials for each condition; the order of the conditions was counterbalanced across Ss. Within each trial for each condition the alphabet was processed twice, once for visual properties and once for auditory properties. The order of the properties in each trial for each S was random; a total of four different random orders was used for the 20 Ss.

The E verbally indicated whether a particular trial involved memory or perception and simultaneously placed in front of the S a 5" x 8" index card indicating whether the alphabet was to be processed for visual or auditory properties; the exposure of the card was the signal for the S to begin processing the alphabet, i.e., the response interval then began. Between each processing of the alphabet there was approximately a 30 second delay during which the E recorded the response time and reset the clock. In the written response condition the Ss were not required to monitor their responses, i.e., they wrote on a blank piece of paper but were free to write anywhere on it, without looking at it. The instructions given to Ss can be found in Appendix B; Ss were told to close their eyes during the image condition.

Results

The data of this experiment were response times and for each S his mean response time across trials was calculated; these mean values (given in Table XII in Appendix D) were used in an analysis of variance; it is to be noted that for this experiment the usual F test values and the conservative F test values were the same (Winer, 1962); this was because of the equal number of degrees of freedom in both cases.

Table II presents the mean values across Ss and trials for the different conditions of the experiment.

TABLE II

MEANS AND STANDARD ERRORS FOR THE DIFFERENT CONDITIONS OF EXPERIMENT II

Response	Property	Percept Condition		Image Condition	
		Mean (Sec)	S.E.	Mean (Sec)	S.E.
Spoken	Auditory	15.78	2.29	22.41	4.16
Spoken	Visual	12.53	1.57	21.42	3.21
Written	Auditory	15.16	4.54	15.60	5.66
Written	Visual	12.35	2.90	14.86	3.51

Figure 1 graphically presents the same information contained in Table II.

As can be seen from Table II and Figure 1 the response times are

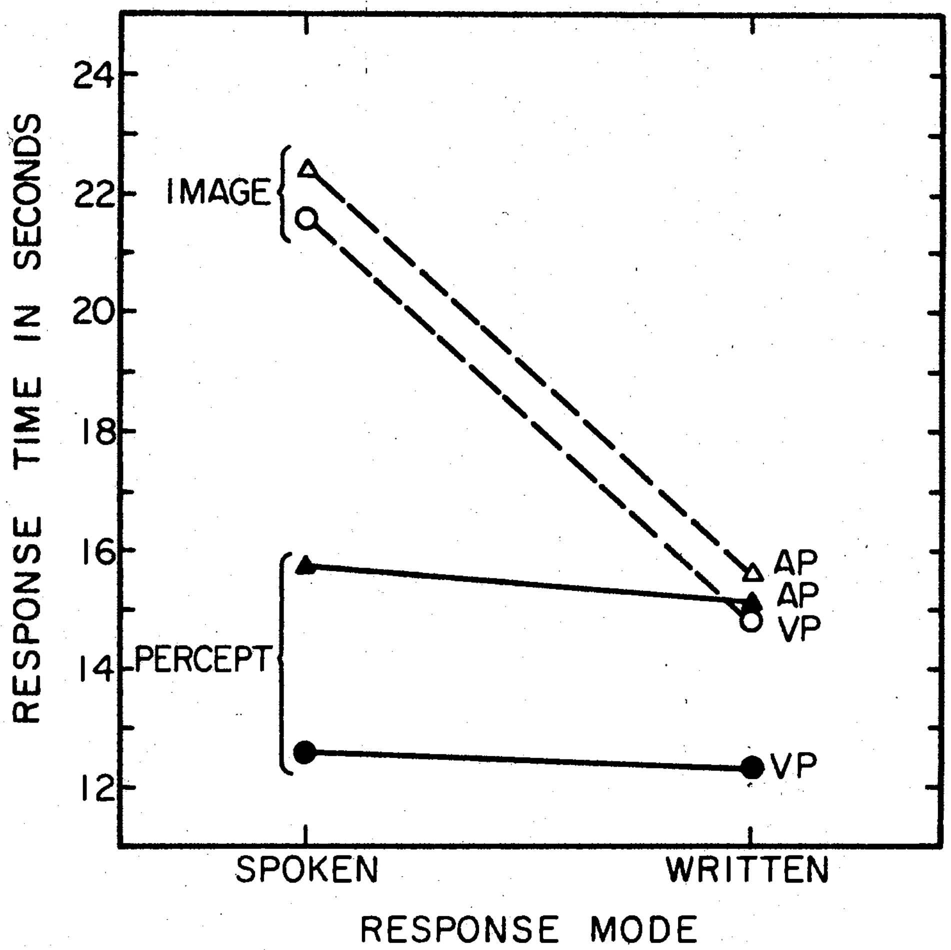

Figure 1. Experiment II - Response Time as a Function of Response Mode, With Image-Percept Representation and Acoustic-Visual Properties as the Parameters

greater in the image condition than in the percept condition; this representation effect is significant (F (1,18) = 121.84, $p < .01$); the response times are also greater in the spoken condition than in the written condition; this response effect is significant ($F(1,18) = 5.53$, $p < .05$); the response times are also greater in the acoustical property condition than in the visual property condition; this property effect is also significant ($F(1,18) = 15.85$, $p < .01$). Perhaps of most interest are the signficiant two-way interactions, response mode x representation ($F(1,18) = 56.57$, $p < .01$) and property x representation ($F(1,18) = 30.77$, $p < .01$).

Table III presents the analysis of variance values for the main and interaction effects in Experiment II.

The significant interaction between the response mode factor and the representation factor indicates the differences between spoken and written responses were much greater in the image condition than in the percept condition. The significant interaction between the property factor and the representation factor indicates that the differences between visual and auditory properties were much greater in the percept condition than in the image condition.

Table IV presents the analysis of variance values for the simple effects of Experiment II.

As can be seen from Table IV the type of response had a significant effect at both levels of the type of property, at the image level of the type of representation, on the visual property-image representation combination and on the auditory property-image representation combination. The type of property had a significant effect at both levels of the type of response and at the percept level of the type of

TABLE III

AOV OF MAIN AND INTERACTION EFFECTS IN EXPERIMENT II

Source of Variation	D.F.	S.S.	M.S.	*F*
Between Subjects	19	1066.3256		
A (Response)	1	250.7028	250.7028	5.53*
Subj. w. groups [error (a)]	18	815.6228	45.3124	
Within Subjects	60	885.4500		
B (Property)	1	75.8551	75.8551	15.85**
AB	1	.5712	.5712	.12
B x subj. w. groups [error (b)]	18	86.1416	4.7856	
C (Representation)	1	425.5031	425.5031	121.84**
AC	1	197.5690	197.5690	56.57**
C x subj. w. groups [error (c)]	18	62.8627	3.4924	
BC	1	23.2848	23.2848	30.77**
ABC	1	.0397	.0397	.05
BC x subj. w. groups [error (bc)]	18	13.6228	.7568	

*$p < .05$.

**$p < .01$.

TABLE IV

AOV OF SIMPLE EFFECTS IN EXPERIMENT II

Source of Variation	D.F.	S.S.	M.S.	$\underline{F}$
Simple Effects of A (Response)				
@ b_1 (VP)	1	113.6701	113.6701	4.5379*
@ b_2 (AP)	1	137.6039	137.6039	5.4934*
error term	36	901.7644	25.0490	
@ c_1 (Percept)	1	1.5800	1.5800	.0647
@ c_2 (Image)	1	446.6917	446.6917	18.3052**
error term	36	878.4855	24.4024	
@ b_1c_1	1	.1693	.1693	.0125
@ b_1c_2	1	215.1024	215.1024	15.8317**
@ b_2c_1	1	1.8667	1.8667	.1374
@ b_2c_2	1	231.7443	231.7443	17.0566**
error term	72	978.2499	13.5868	
Simple Effects of B (Property)				
@ a_1 (Spoken Response)	1	44.7957	44.7947	9.3605**
@ a_2 (Written Response)	1	31.6306	31.6306	6.6095*
error term	18	86.1416	4.7856	
@ c_1 (Percept)	1	91.5970	91.5970	33.0532**
@ c_2 (Image)	1	7.5429	7.5429	2.7219
error term	36	99.7644	2.7712	
Simple Effects of C (Representation)				
@ a_1 (Spoken Response)	1	601.4778	601.4778	172.2248**
@ a_2 (Written Response)	1	21.5943	21.5943	6.1832*
error term	18	62.8627	3.4924	
@ b_1 (VP)	1	323.9317	323.9317	152.4671**
@ b_2 (AP)	1	124.8562	124.8562	58.7669**
error term	36	76.4855	2.1246	

*$\underline{p} < .05$.

**$\underline{p} < .01$.

representation. The type of representation had a significant effect at both levels of the type of response and at both levels of the type of property.

Since the Ss as a group received 6 trials for each treatment combination it is also possible to analyze the data for practice effects. The mean response times across Ss and across the first three trials was compared with the mean response times across Ss and across the last three trials for the 8 different treatment combinations; all of the correlated values were significant at $p < .01$. A graph showing response time as a function of practice can be found in Figure 4 in Appendix E.

Discussion

As seen from the results of this experiment abstracting properties from material visually present is faster than from images. This result is logical since with visually present material there are probably less steps involved: in abstracting visual properties only an abstraction process is involved; in abstracting auditory properties both generating an auditory image and an abstraction process are involved. With imagined material there are probably more steps involved: in abstracting visual properties (1) generating the alphabetic sequence, (2) generating auditory images, then (3) visual images and (4) an abstraction process are involved. By generating the alphabetic sequence is meant that the S must remember the serial order of the alphabet in order to process the alphabet properly; the reason for step number 2 will become more obvious in the later discussion of the verbal control over visual imagery. In abstracting auditory properties from imagined material (1) generating the alphabetic sequence, (2) generating the auditory image and (3) an abstraction process are involved. This finding of longer response times for abstracting properties from imagined material supports Weber's (1970a) idea that scan rates might serve to distinguish imagery and perception.

It was also found that abstracting visual properties is faster than abstracting auditory properties. In the percept condition there were as mentioned above probably fewer steps involved in abstracting visual properties than in abstracting auditory properties; however, in the image condition there were probably more steps involved in abstracting visual properties than in abstracting auditory properties (this point will be elaborated in the following discussion). Therefore, the explanation of this result may be that somehow the auditory property abstraction task is harder than the visual property abstraction task; perhaps, experientially individuals have more practice sorting objects into large and small classes than sorting objects into other types of classes. An alternative explanation for the faster processing of visual properties than auditory properties is the possibility that the visual-percept condition alone is responsible for this effect, i.e., abstracting by itself is very fast as compared with all the other generation processes. Even if the first explanation is correct, i.e., auditory property abstraction tasks are harder than visual property abstraction tasks these results do not contradict earlier results (Weber and Castleman, 1970 and Weber and Bach, 1969) which showed visual imagery to be slower than auditory imagery in sequential processing tasks; the abstraction step rather than the generation of the image step may have produced the results of the present experiment.

Contrary to what might be expected from the results of Experiment I the results of this experiment show that a written response mode produced faster response times than did a spoken response mode in the image condition. This result suggests that in sequential processing tasks as used in this experiment that both auditory and visual imagery are under verbal control. By verbal control is meant that the S must speak the name of the letter in order to produce an auditory or visual image of that letter. This is, perhaps, obvious with auditory imagery; there have been few reports in the literature of auditory images without verbal components. This is not so obvious with visual imagery. However in the experimental tasks used, it appears that the name of a letter serves to retrieve its visual image representation. The evidence supporting this verbal control of auditory and visual images is that the written responses were faster than the spoken responses. It has been found previously (Brooks, 1968) that recalling verbal information and signaling that information verbally is slower than recalling verbal information and signaling it spatially. The reason for this finding might be based on some interference idea or on some limited processing capacity idea.

Written responding was also faster than spoken responding in the percept condition, although not as much faster, as in the image condition; with auditory properties in the percept condition the explanation is the same as with auditory properties in the image condition, i.e., spoken responding interfered with the verbal control of the auditory image. With visual properties in the perception condition written responding was possibly faster than spoken responding because the size of the visually present letter provided more of a direct cue as to the nature of the written response than to the nature of the spoken response, i.e., a small letter informs a S to make a dot more so than it informs him to say no.

In regard to the significant practice effects obtained for all eight treatment combinations in this experiment it is probable that with increasing trials the Ss came to associate particular responses with particular properties of alphabetic letters more rapidly. Because of the few errors committed in these types of tasks the Ss probably understood from the beginning what was required of them.

CHAPTER IV

EXPERIMENT III

In this third experiment the relative rates of abstracting visual properties from different types of letter strings, i.e., from the alphabet and from words, are measured under different scanning and response conditions. By using two different scanning modes, spoken and non-spoken, and two different response modes, written and spoken, the possibility of verbal processing in visual imagery can be investigated. It seems obvious upon introspection that there is not sequential verbal control over the components of at least some visual images, e.g., dreams. By subjecting this possibility to experimental analysis it should be possible to learn something about the organization of words in visual memory which may have implications for reading and spelling.

Method

Subjects

The subjects used in Experiment III were 40 undergraduate college students who participated in order to fulfill an introductory psychology course requirement. Two potential subjects were not used because they did not know the alphabet; one potential subject was not used because he could not learn to represent large and small lower case, typed letters of the alphabet with yeses and nos, respectively.

Experimental Design

The experimental tasks used in this experiment involved the use of the alphabet and eighteen four letter words; all words were one syllable and were high frequency usage words (defined as A or AA by Thorndike and Lorge, 1944); each of the words contained both large and small letters, e.g., back. From images of these different letter strings, i.e., the words and the alphabet, the Ss abstracted visual properties; this was done to provide more objectivity as discussed in Experiment II, i.e., having the S signal a visual property of his visual image provides greater assurance that he is in fact experiencing the required image.

To compare the rates of abstracting visual properties from the words and from the alphabet and to investigate the degree of independence of visual imagery from verbal factors in abstracting properties a three factor factorial design was used. The first factor, type of letter string, had two levels, alphabet and word. In the alphabet condition the letter string was the alphabet and in the word condition the letter strings were four letter words. The second factor, type of scan, also had two levels, spoken and non-spoken scan. In the spoken scan condition the Ss spoke aloud the name of each letter as they processed it and in the non-spoken scan condition the Ss were not required to speak aloud the name of each letter as they processed it. The third factor, type of response, likewise had two levels, written and spoken. In the written condition responses were written and in the spoken condition responses were spoken. The letter string factor was within Ss, and the other two factors were between Ss. The assignment of scan modes and response modes to the Ss was made on the basis of a predetermined random order.

Procedure

Each S was given two preliminary practice trials; one for abstracting visual properties from the letters of the alphabet and one for abstracting visual properties from the letters of a word.

The E started a remotely controlled Standard Electric Clock (calibrated in .01 sec) when the S began to process the alphabet or a word and stopped the clock when the S finished. This was a departure from the previous two experiments where the Ss controlled the clock; this departure was necessary because pilot data showed that the E was more accurate than Ss in measuring the short response times involved with words in this experiment.

The Ss were not given any feedback on their response times. To provide greater reliability of the measured response times the E also tape recorded all the S's responses; the S's responses were recorded on a Uher tape recorder. During the experiment this recorder broke down and a Wollensak tape recorder was then used. The S's spoken responses were easily recorded; to record the S's written responses the Ss wrote on an aluminum sheet; the sounds made by the S's pencil on the aluminum sheet were picked up and recorded by the tape recorder. After the experiment the E checked the measured response times by playing the tapes back at half speed.

Each S was given 10 trial blocks, each composed of six words (four letters each) and one alphabet letter string of twenty-six letters. An alphabet letter string trial began with the E saying, "Ready, the alphabet". The S then processed the individual letters of the alphabet for visual properties. A word letter string trial began with the E saying, "Ready, X", where X was a particular word. The S then processed the individual letters of the word for visual properties. A word letter string trial involved processing 6 words (6 four letter words contain almost the same number of letters as the alphabet; however, after the experiment it was pointed out that it was still possible that with the alphabet condition there could be fatigue or proactive interference effects for the alphabetic 26 letter string; these effects would be minimized with the word 4 letter strings because of the short time interval between processing separate words. The 6 words for each S were randomly selected from a pool of 18 four letter words. The same 6 words appeared in each of the 10 trials given to a particular S; however, the order of their appearance was randomized from trial to trial. The order of presentation of alphabet and word letter string trials was balanced across Ss.

Between each processing of a letter string by a S there was approximately a 30 second delay during which the E recorded the response time and reset the clock. The instructions given to the Ss can be found in Appendix C.

Results

Each S's mean response time across trials was calculated. In order to compare directly the S's responses in processing the word and the alphabet letter strings his response times in each condition were computed on a rate per letter basis; therefore, the S's processing rate per letter mean values were the units used in an analysis of variance. (These values can be found in Table XI in Appendix D). As in Experiment II the usual F test values and the conservative F test values were identical because of the equal number of degrees of freedom in both cases.

Table V presents the mean rate values across *Ss* and across trials for the different conditions of the experiment.

TABLE V

MEAN TIMES PER LETTER AND STANDARD ERRORS FOR THE DIFFERENT CONDITIONS OF EXPERIMENT III

Scan	Response	Alphabet Condition		Word Condition	
		Mean (sec/letter)	S.E.	Mean (sec/letter)	S.E.
Spoken	Written	.61	.16	.49	.12
Spoken	Spoken	1.01	.14	.91	.25
Non-Spoken	Written	.60	.15	.47	.12
Non-Spoken	Spoken	.96	.27	.53	.09

Figure 2 graphically presents the same information contained in Table V.

As can be seen from Table V and Figure 2 the processing times are faster in the non-spoken scan condition than in the spoken scan condition. This scan effect is significant ($F(1,36) = 5.74$; $p < .05$). The processing times are also faster in the word condition than in the alphabet condition; this letter string effect is significant ($F(1,36) = 63.42$; $p < .01$); the processing rates are also faster in the written response condition than in the spoken response condition; this response effect is significant ($F(1,36) = 40.55$; $p < .01$).

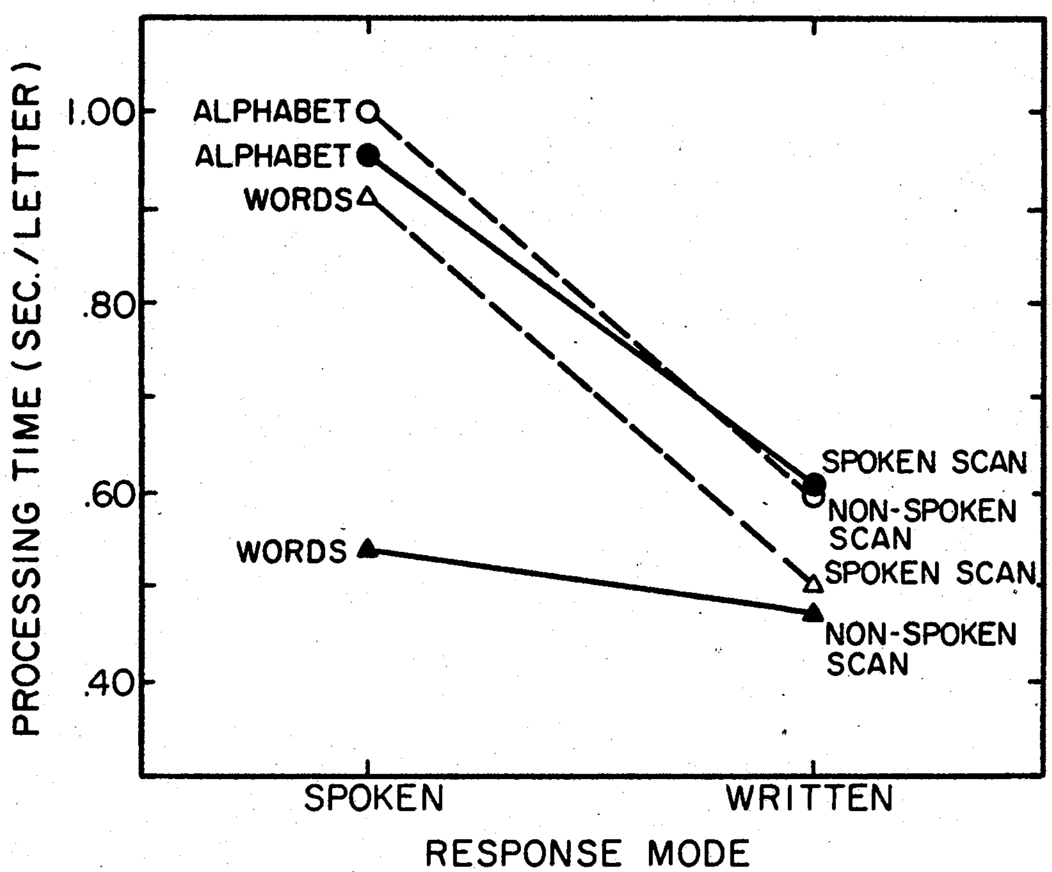

Figure 2. Experiment III - Processing Time (Secs/Letter) as a Function of Response Mode, With Alphabet-Word Letter Strings and Scanning as the Parameters

Table VI presents the analysis of variance values for the main and interaction effects in Experiment III.

TABLE VI

AOV OF MAIN AND INTERACTION EFFECTS IN EXPERIMENT III

Source of Variation	D.F.	S.S.	M.S.	*F*
Between *Ss*	39	4.1279	.1058	
A (Scan)	1	.2738	.2738	5.74*
B (Response)	1	1.9344	1.9344	40.55**
AB	1	.2000	.2000	4.19*
S w. Groups [error (between)]	36	1.7197	.0477	
Within *Ss*	40	1.6122	.0403	
C (Letter String)	1	.7801	.7801	63.42**
AC	1	.1462	.1462	11.88**
BC	1	.0966	.0966	7.85**
ABC	1	.1462	.1462	11.88**
C x *S* w. Groups [error (within)]	36	.4431	.0123	

*$p < .05$.

**$p < .01$.

As can be seen from Table VI there were significant interaction effects in this experiment; there was significant interaction ($F(1,36) = 4.19$; $p < .05$) between the response factor and the scan factor, i.e., the differences between spoken and written responses were greater in the spoken scan condition than in the non-spoken scan condition. There was also a significant interaction ($F(1,36) = 11.88$; $p < .01$) between the scan factor and the letter string factor, i.e., the differences between spoken and non-spoken scans were greater in the word condition than in the alphabet condition. There was also a significant interaction ($F(1,36) = 7.85$; $p < .01$) between the response factor and the letter string factor, i.e., the differences between spoken and written responses were greater in the alphabet condition than in the word condition. There was also a significant three factor interaction ($F(1,36) = 11.88$; $p < .01$). Table VII presents the analysis of variance values for the simple effects of Experiment III.

As can be seen from Table VII the type of scan had a significant effect at the spoken response level of the type of response and at the word level of the type of letter string. The type of response had a significant effect at both levels of the type of letter string. The type of letter string had a significant effect at both levels of the type of scan, at both levels of the type of response, on the spoken scan-written response combination, on the non-spoken scan-written response combination and on the non-spoken scan-spoken response combination. The type of scan-type of response combination had a significant effect at the word level of the type of letter string.

Although the response measure used in this experiment was response time it would have also been possible to measure response latency, i.e., the time from the E's start signal until the S began to respond. This was done to a limited extent, i.e., the response latency for one S in each of the four treatment combinations involving the word letter

TABLE VII

AOV OF SIMPLE EFFECTS IN EXPERIMENT III

Source of Variation	D.F.	S.S.	M.S.	*F*
Simple Effects of A (Scan)				
@ b_1 (Written Response)	1	.0029	.0029	.0608
@ b_2 (Spoken Response)	1	.4708	.4708	9.8700**
Error Term	36	1.7197	.0477	
@ c_1 (Words)	1	.4101	.4101	13.6700**
@ c_2 (Alphabet)	1	.0099	.0099	.3300
Error Term	72	2.1628	.0300	
Simple Effects of B (Response)				
@ a_1 (Spoken Scan)	1	1.6892	1.6892	35.4130**
@ a_2 (Non-Spoken Scan)	1	.4452	.4452	9.3333**
Error Term	36	1.7197	.0477	
@ c_1 (Words)	1	.5832	.5832	19.4400**
@ c_2 (Alphabet)	1	1.4478	1.4478	48.2600**
Error Term	72	2.1628	.0300	
Simple Effects of C (Letter String)				
@ a_1 (Spoken Scan)	1	.1255	.1255	10.2033**
@ a_2 (Non-Spoken Scan)	1	.8009	.8009	65.1138**
Error Term	36	.4431	.0123	
@ b_1 (Written Response)	1	.1638	.1638	13.3171**
@ b_2 (Spoken Response)	1	.7128	.7128	57.9512**
Error Term	36	.4431	.0123	
@ a_1b_1	1	.0819	.0819	6.6585*
@ a_1b_2	1	.0461	.0461	3.7480
@ a_2b_1	1	.0819	.0819	6.6585*
@ a_2b_2	1	.9592	.9592	77.9837**
Error Term	36	.4431	.0123	
Simple Effects of AB				
@ c_1 (Words)	1	.3441	.3441	11.4700**
@ c_2 (Alphabet)	1	.0022	.0022	.0733
Error Term	72	2.1628	.0300	

*$p < .05$.

**$p < .01$.

strings was measured. Table VIII presents the mean response latency for these four randomly selected Ss; only four Ss from the word condition were used because it seemed remotely possible that some unknown behavior on the Ss' part might differentially effect the Ss' beginning to process the word in the different conditions; e.g., in the spoken scan conditions, Ss might have spelled the word to themselves first since they had to spell it aloud. Possibilities such as this didn't seem as likely in the alphabet condition. Since it was desired first to check if such unknown effects might be present only four Ss were used.

TABLE VIII

MEAN RESPONSE LATENCY FOR FOUR RANDOMLY SELECTED Ss

Scan	Response	Letter String	Mean (Sec)
Spoken	Spoken	Word	1.55
	Written	Word	1.44
Non-Spoken	Spoken	Word	.78
	Written	Word	1.30

As can be seen from Table VIII the S in the non-spoken scan spoken-response treatment combination had a shorter mean response latency than did the three Ss representing the other three treatment combinations; however, this S was also faster than the other three Ss with the response time measure in both the word and the alphabet letter string conditions. Taking this last fact into account it appears that there would probably be no information provided by the response latency measure that is not given by the response time measure; i.e., the response latencies and response times are correlated, although this statement is somewhat hazardous based only on the data of four _Ss_.

Since the _Ss_ as a group received 10 trials for each treatment combination it is also possible to analyze the data for practice effects. The mean processing rates across _Ss_ and across the first five trials were compared with the mean processing rates across _Ss_ and across the last five trials for the eight different treatment combinations; all of the t values were significant at $p < .05$ or better. A graph showing response time as a function of practice can be found in Figure 5 in Appendix E.

In order to obtain an index of the reliability of the measurement of the _S_'s response times a correlation coefficient was computed relating a representative sample of original measurements and corresponding measurements obtained from the tape recordings. For both the word and the alphabet conditions the Pearson _rs_ were .99 indicating considerable accuracy in the original measurements. For the word condition the mean difference between the original measurements and corresponding measurements from the tape recording was +.005 sec and 92% of all test-retest differences were with $\pm$.10 secs. For the alphabet condition the mean difference was -.024 sec and 90% of all test-retest differences were within $\pm$.46 secs. When considered on a per letter basis this is an error of less than $\pm$.02 secs. From these values it can be concluded that the _E_'s measurement of the _S_'s responses was satisfactorily accurate.

Discussion

As seen from the results of this experiment abstracting visual properties from letters using a non-spoken scan mode is faster than using a spoken scan mode; however, this is true only in the word letter string condition. There is no significant difference between the spoken and non-spoken scan modes in the alphabet letter string condition; this result agrees with the findings of Weber (1970b). The explanation for this result is that the visual imaging of the individual letters of the alphabet appears to be under verbal control in the sense that each letter is implicitly spoken prior to imagining it. The evidence for this conclusion is the similarity of response times in the non-spoken and the spoken scan conditions and the previously found identical rates for covert and overt speech (Landauer, 1962 and others); the Ss evidently covertly speak each letter before visually imaging it.

Returning to the finding that with the word letter strings the non-spoken scan mode was faster than the spoken scan mode, the conclusion seems to be that the Ss did not covertly speak each letter of the words when using a non-spoken scan mode. With words, there evidently was not the same amount of verbal control over the visual imaging of the letters, i.e., the visual imagery system appears to operate more in a parallel processing manner with words than with the alphabet.

It is possible that in the non-spoken scan mode the Ss could generate the word as a whole which served to summon a visual image of the individual letters making up the word. The S could then scan for the visual properties of the simultaneously presented letters. The time advantage with non-spoken scanning lies in the implication that the name of the individual letters constituting the word need not be verbalized in order to generate the visual image of the letters constituting the word.

The evidence that Ss in the non-spoken scan mode may have spoken the word covertly in order to retrieve its visual image lies in the fact that written responses were somewhat faster than spoken responses; it has previously been found that recalling verbal information and signaling it verbally is slower than signaling it spatially (Brooks, 1968).

That less verbal control was involved in abstracting visual properties from words using a non-spoken scan mode is seen in the fact that the differences between spoken and written responses were greater with the spoken scan than with the non-spoken scan.

That less verbal control was involved in abstracting visual properties from words using a non-spoken scan mode is seen in the result that the difference between the written and spoken responses was greater in the alphabet condition than in the word condition. The fact that written responses were faster than spoken in the alphabet condition is again in agreement with Brook's findings.

A final result of Experiment III was that the processing rates were faster in the word condition than in the alphabet condition. When using a non-spoken scan the lesser amount of verbalization required, as discussed above, was probably the major factor accounting for the difference between the rates of processing words and the alphabet. However, another factor must have had an influence as shown by the finding that the rate of processing words was also faster than that of the alphabet in the spoken scan condition. This other factor may possibly have been that the Ss came to the experiment with the previously acquired ability to spell the simple four letter words faster on a per letter basis than they could repeat or spell the alphabet; this idea is supported by the fact that two Ss were not used in the experiment because they did not know the alphabet.

In regard to the significant practice effects obtained for all eight treatment combinations in this experiment it is probable that with increasing trials the Ss came to associate particular responses with particular properties of the letters of the words and the alphabet more rapidly. Because of the few errors committed in these types of tasks the Ss probably understood from the beginning what was required of them.

CHAPTER V

SUMMARY AND CONCLUSIONS

Although it seems obvious that a spoken mode of responding is faster than a written mode, it was necessary to support this idea with experimental evidence; in Experiment I it was, indeed, found that spoken responding is faster than written responding. This fact was useful in explaining the results of Experiments II and III where written responding was found to be faster than spoken responding; because of the results of Experiment I it was known that written responding is not faster than spoken responding per se; something else must account for the results of Experiments II and III.

That "something" else was verbal control over visual and auditory imagery. In Experiment II, it was found that there was verbal control over these two imagery systems when used in sequential processing tasks; although this is, perhaps, obvious with auditory imagery, it is not so obvious with visual imagery; but as the results showed, there are sequential processing tasks where there is verbal control over visual imagery. Whether this verbal control over visual imagery would also be present in parallel processing tasks remained an open question until the results of Experiment III provided an answer. In this experiment it was found that there are some tasks which permit the visual imagery system to operate in parallel; it was found that in these tasks, i.e., in processing words for spatial properties, that there was initial verbal control which served to retreive the image of the word; once this image was present, the visual imagery system could operate in a parallel processing manner; perhaps, more specifically the individual letters of a word were retrieved in parallel but were processed serially because of the serial nature of responding to the visual properties. From the results of Experiment III it appears that there are some tasks in which the amount of verbal control over visual imagery is reduced.

Whether in ordinary information recall there exist situations where there is no minimal verbal control over visual imagery is doubtful. In order to recall one visual image and not another there would appear necessarily to be some verbal control to elicit the one but not the other. Because of this minimal verbal control over most visual images it would seem that the retention of visual percepts in memory would be improved if, when the original perception occurs, there was a naming of the percept so that later the visual image could be retrieved; upon the retrieval, information might be obtained either sequentially or in parallel depending upon the nature of the image. Because of the beneficial effect which rehearsal has upon storing verbal information in memory, it would seem that after the initial naming of a visual percept, rehearsal of the name would aid in the later recovery of the visual image corresponding to the percept.

Although most visual images would appear to have some minimal amount of verbal control, there are probably some special situations where this verbal control is lacking, e.g., in schizophrenia some visual images may "spontaneously" appear as they probably do in individuals upon taking hallucinatory drugs. These visual images may appear without verbal control because of certain biochemical events within the nervous system.

One final result of the present research is the finding that information processing from a percept is faster than information processing from an image. This finding is support for Weber's (1970a) idea that scan rates might serve to differentiate images and percepts.

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APPENDIX A

INSTRUCTIONS TO Ss IN EXPERIMENT I

The purpose of this experiment is to determine the response times for two different response modes of presenting information to people; in particular, spoken and written response modes are being compared.

In this experimental task I would like you to write out a 26 member series of alternating dashes and dots. Using this ruled sheet of paper can help you keep count by forming groups of 4 with only 2 in the last column [demonstration].

Please start this electric clock when you begin the experimental task and stop the clock when you finish the task [demonstration]. Any questions?

In this experimental task I would like you to speak aloud a 26 member series of yes-nos. Using this ruled sheet of paper can help you keep count by forming groups of 4 with only two in the last column [demonstration].

Operate the clock as before. Any questions?

We will now repeat these two tasks.

In this task I would like you to speak the alphabet aloud as quickly as possible [demonstration].

Operate the clock as before. Any questions?

In this task I would like you to write the alphabet in your normal cursive handwriting as quickly as possible [demonstration]. Don't bother to dot the is and js or to cross the ts.

Operate the clock as before. Any questions?

We will now repeat these two tasks.

This completes the experiment; thank you for your time and cooperation.

APPENDIX B

INSTRUCTIONS TO Ss IN EXPERIMENT II

The purpose of this experiment is to compare the rates of abstraction processes from visually present material and from material from memory.

To begin with would you say aloud the alphabet from A to Z.

I'd like to point out that typed, lower case letters of the alphabet have different visual or spatial properties, i.e., some are vertically large and some are vertically small.

The letters of the alphabet also have different acoustical properties, i.e., some have a long $\bar{e}$ sound and some don't.

Only one-half of the Ss received the following instructions.

To indicate these different properties in the experimental tasks which follow, I would like you to say yes to indicate the presence of the visual or spatial property, large size, and say no to indicate the absence of that property [demonstration]; now you do the same thing with this list.

Also say yes to indicate the presence of the acoustical property, the long $\bar{e}$, and say no to indicate the absence of this property [demonstration]; now you do the same thing with this list.

The other half of the Ss received these instructions.

To indicate these different properties in the experimental tasks which follow, I would like you to write a vertical dash to indicate the presence of the visual or spatial property, large size, and a dot to indicate the absence of that property [demonstration]; now you do the same thing with this list.

Also write a vertical dash to indicate the presence of the acoustical property, the long $\bar{e}$, and a dot to indicate the absence of this property [demonstration]; now you do the same thing with this list.

In the experimental tasks which follow I'm going to ask you to start an electric clock when you begin the task and stop the clock when you finish. Keep your hand on the switch throughout the experimental tasks [demonstration].

In the experimental tasks which follow I would like you to process the alphabet in the manner indicated as fast as possible.

Only one-half of the Ss received the following instructions.

For the first experimental task I would like you to imagine either visually or acoustically, i.e., form a mental picture or sound of the successive letters of the alphabet beginning with A; as you imagine each letter say whether the letter has the property, either visual or acoustic, that I tell you to look for; use yeses and nos as your responses. Stop the clock when you've finished with the last letter. Any questions?

Close your eyes, when I say either visual or acoustic start the clock and process the alphabet for either visual or acoustical properties.

Ready. Visual (or Acoustic).

The next task likewise involves imagery or memory; close your eyes, ready _______.

For the next experimental task I am going to place in front of you a card with the alphabet typed on it; I would like you to look at each letter and say whether the letter has the property, either visual or acoustic, that I tell you to look for; use yeses and nos as your responses. Stop the clock when you've finished with the last letter. Any questions?

Avert your eyes to the wall; when I say either visual or acoustic start the clock, turn to the card and process the alphabet for either visual or acoustical properties.

Ready. Visual (or Acoustic).

The next task likewise involves visually present material or perception; avert your eyes _______.

The other one-half of the Ss received these instructions.

For the first experimental task I would like you to imagine either visually or acoustically, i.e., form a mental picture or sound of the successive letters of the alphabet beginning with A; as you imagine each letter write down whether the letter has the property, either visual or acoustic, that I tell you to look for; use dashes and dots as your responses. Stop the clock when you've finished the last letter. Any questions?

Position your pencil at a starting point and close your eyes; when I say either visual or acoustic start the clock and process the alphabet for either visual or acoustical properties.

Ready. Visual (or Acoustic).

The next task likewise involves imagery or memory; position your pencil, close your eyes, ready _______.

For the next experimental task I am going to place in front of you a card with the alphabet typed on it; I would like you to look at each letter and write down whether the letter has the property, either visual or acoustic, that I tell you to look for; use dashes and dots as your responses. Stop the clock when you've finished with the last letter. Any questions?

Position your pencil at a starting point and avert your eyes to the wall; when I say either visual or acoustic start the clock and turn to the card and process the alphabet for either visual or acoustical properties.

Ready. Visual (or Acoustic).

The next task likewise involves visually present material or perception; position your pencil, avert your eyes, ready _______.

All the <u>S</u>s were told: "This concludes the experiment; thank you for your time and cooperation."

APPENDIX C

INSTRUCTIONS TO Ss IN EXPERIMENT III

One-fourth of the Ss received the following instructions.

The purpose of this experiment is to compare the rates of abstraction processes from material from memory.

To begin with would you say aloud the alphabet from A through Z.

I'd like to point out that typed, lower case, letters of the alphabet have different visual or spatial properties, i.e., some are vertically large and some are vertically small [demonstration].

To indicate these different properties in the tasks which follow I would like you to write a vertical dash to indicate the presence of the visual or spatial property, large size, and write a dot to indicate the absence of that property [demonstration]. Now you do the same with this list.

In some of the tasks which follow I am going to say ready alphabet; when I say this I would like you to visually imagine, i.e., form a mental picture of the successive letters of the alphabet beginning with A.

From these mental images indicate whether the letters of the alphabet have the visual or spatial property, large size; use dashes and dots as your responses.

Speak aloud the individual letters as you process them.

We'll now have a practice trial: ready alphabet.

In some of the other tasks which follow I am going to say ready and speak a word; when I speak this word I would like you to visually imagine, i.e., form a mental picture of the successive letters of the word.

From these mental images indicate whether the letters of the word have the visual or spatial property, large size; use dashes and dots as your responses.

Speak aloud the individual letters as you process them.

We'll now have a practice trial: ready bake.

We'll now repeat these two types of tasks; please go as fast as you can without making too many errors.

Any questions?

Another one-fourth of the Ss received the following instructions.

The purpose of this experiment is to compare the rates of abstraction processes from material from memory.

To begin with would you say aloud the alphabet from A through Z.

I'd like to point out that typed, lower case, letters of the alphabet have different visual or spatial properties, i.e., some are vertically large and some are vertically small [demonstration].

To indicate these different properties in the tasks which follow I would like you to write a vertical dash to indicate the presence of the visual or spatial property, large size, and write a dot to indicate the absence of that property [demonstration]. Now you do the same with this list.

In some of the tasks which follow I am going to say ready alphabet; when I say this I would like you to visually imagine, i.e., form a mental picture of the successive letters of the alphabet beginning with A.

From these mental images indicate whether the letters of the alphabet have the visual or spatial property, large size; use dashes and dots as your responses.

Do not speak aloud the individual letters as you process them.

We'll now have a practice trial: ready alphabet.

In some of the other tasks which follow I am going to say ready and speak a word; when I speak this word I would like you to visually imagine, i.e., form a mental picture of the successive letters of the word.

From these mental images indicate whether the letters of the word have the visual or spatial property, large size; use dashes and dots as your responses.

Do not speak aloud the individual letters as you process them.

We'll now have a practice trial: ready bake.

We'll now repeat these two types of tasks; please go as fast as you can without making too many errors.

Any questions?

Another one-fourth of the Ss received the following instructions.

The purpose of this experiment is to compare the rates of abstraction processes from material from memory.

To begin with would you say aloud the alphabet from A through Z.

I'd like to point out that typed, lower case, letters of the alphabet have different visual or spatial properties, i.e., some are vertically large and some are vertically small [demonstration].

To indicate these different properties in the tasks which follow I would like you to say yes to indicate the presence of the visual or spatial property, large size, and say no to indicate the absence of that property [demonstration]. Now you do the same with this list.

In some of the tasks which follow I am going to say ready alphabet; when I say this I would like you to visually imagine, i.e., form a mental picture of the successive letters of the alphabet beginning with A.

From these mental images indicate whether the letters of the alphabet have the visual or spatial property, large size; uses yeses and nos as your responses.

Speak aloud the individual letters as you process them.

We'll now have a practice trial: ready alphabet.

In some of the other tasks which follow I am going to say ready and speak a word; when I speak this word I would like you to visually imagine, i.e., form a mental picture of the successive letters of the word.

From these mental images indicate whether the letters of the word have the visual or spatial property, large size; use yeses and nos as your responses.

Speak aloud the individual letters as you process them.

We'll now have a practice trial: ready bake.

We'll now repeat these two types of tasks; please go as fast as you can without making too many errors.

Any questions?

The final one-fourth of the Ss received these instructions.

The purpose of this experiment is to compare the rates of abstraction processes from material from memory.

To begin with would you say aloud the alphabet from A through Z.

I'd like to point out that typed, lower case, letters of the alphabet have different visual or spatial properties, i.e., some are vertically large and some are vertically small [demonstration].

To indicate these different properties in the tasks which follow I would like you to say yes to indicate the presence of the visual or spatial property, large size, and say no to indicate the absence of that property [demonstration]. Now you do the same with this list.

In some of the tasks which follow I am going to say ready alphabet; when I say this I would like you to visually imagine, i.e., form a mental picture of the successive letters of the alphabet beginning with A.

From these mental images indicate whether the letters of the alphabet have the visual or spatial property, large size; uses yeses and nos as your responses.

Do not speak aloud the individual letters as you process them.

We'll now have a practice trial: ready alphabet.

In some of the other tasks which follow I am going to say ready and speak a word; when I speak this word I would like you to visually imagine, i.e., form a mental picture of the successive letters of the word.

From these mental images indicate whether the letters of the word have the visual or spatial property, large size; use yeses and nos as your responses.

Do not speak aloud the individual letters as you process them.

We'll now have a practice trial: ready bake.

We'll now repeat these two types of tasks; please go as fast as you can without making too many errors.

Any questions?

All the Ss were told: "This concludes the experiment; thank you for your time and cooperation."

APPENDIX D

TABLES

TABLE IX

MEAN TIME (SECS) OVER THE 6 TRIALS FOR EACH S FOR THE 4 CONDITIONS OF EXPERIMENT I

S	Spoken Response		Written Response	
	Alphabet	Binary	Alphabet	Binary
1	3.75	5.87	10.93	8.25
2	3.45	5.36	11.65	10.31
3	6.88	9.27	14.48	10.26
4	4.43	6.70	11.95	7.72
5	3.26	7.56	14.05	8.73
6	4.40	9.63	14.42	10.16
7	5.35	9.24	10.50	9.30
8	6.74	9.67	17.09	12.99
9	5.00	7.16	13.39	8.32
10	3.03	4.51	10.27	7.61

TABLE X

MEAN TIME (SECS) OVER THE 6 TRIALS FOR EACH S FOR THE 8 CONDITIONS OF EXPERIMENT II

Response	S	Percept AP	Percept VP	Image AP	Image VP
Spoken	1	19.79	14.50	30.42	27.05
	2	16.31	14.49	23.61	25.27
	3	15.31	12.86	17.84	19.95
	4	13.23	12.51	22.16	22.50
	5	13.69	11.48	16.33	18.53
	6	14.73	12.39	22.13	19.32
	7	19.35	12.93	25.92	23.87
	8	14.51	10.70	20.49	18.39
	9	14.03	9.70	19.73	17.56
	10	16.82	13.81	25.46	21.72
Written	11	15.61	13.41	15.41	17.11
	12	17.57	13.25	18.77	17.69
	13	15.45	13.14	16.74	17.55
	14	18.65	14.59	16.14	13.94
	15	24.45	17.46	28.49	20.86
	16	11.17	10.98	11.93	14.21
	17	11.35	8.17	11.62	10.44
	18	15.54	12.40	17.49	13.95
	19	8.22	7.62	7.72	9.24
	20	13.65	12.51	11.70	13.58

TABLE XI

MEAN RATE/LETTER (SECS) OVER THE 10 TRIALS FOR EACH S FOR THE 8 CONDITIONS OF EXPERIMENT III

Spoken Scan						Non-Spoken Scan					
Written Response			Spoken Response			Written Response			Spoken Response		
S	Words	Alphabet	S	Words	Alphabet	S	Words	Alphabet	S	Words	Alphabet
1	.47	.53	3	1.57	1.21	2	.32	.39	4	.55	1.06
5	.41	.58	7	.72	.82	6	.51	.45	8	.54	.87
9	.50	.53	11	.80	.88	10	.55	.84	12	.41	.55
13	.41	.64	15	.94	1.21	14	.35	.56	16	.53	.72
17	.50	.57	19	.83	.84	18	.55	.70	20	.53	1.24
21	.30	.58	23	.75	1.04	22	.38	.49	24	.64	1.15
25	.59	.77	27	.95	1.03	26	.42	.53	28	.59	1.13
29	.39	.35	31	.92	1.08	30	.53	.66	32	.49	1.27
33	.74	.95	35	.92	1.09	34	.70	.80	36	.34	.56
37	.55	.64	39	.73	.89	38	.38	.55	40	.63	1.08

APPENDIX E

FIGURES

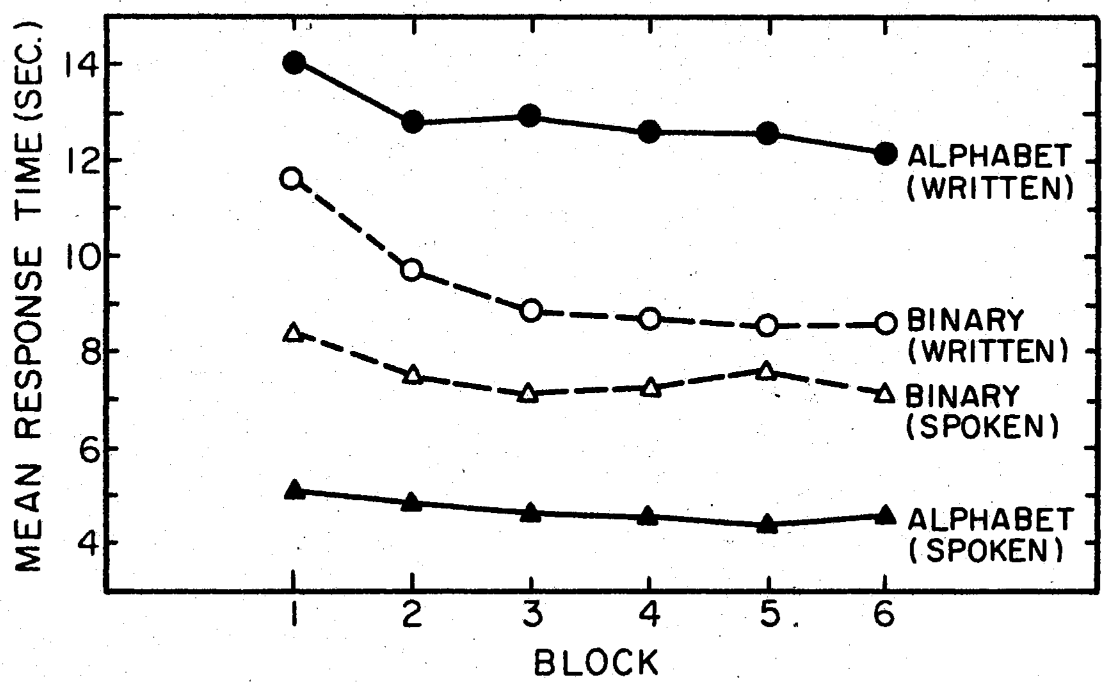

Figure 3. Response Time as a Function of Practice, With Task Type and Response Mode as the Parameters - Experiment I

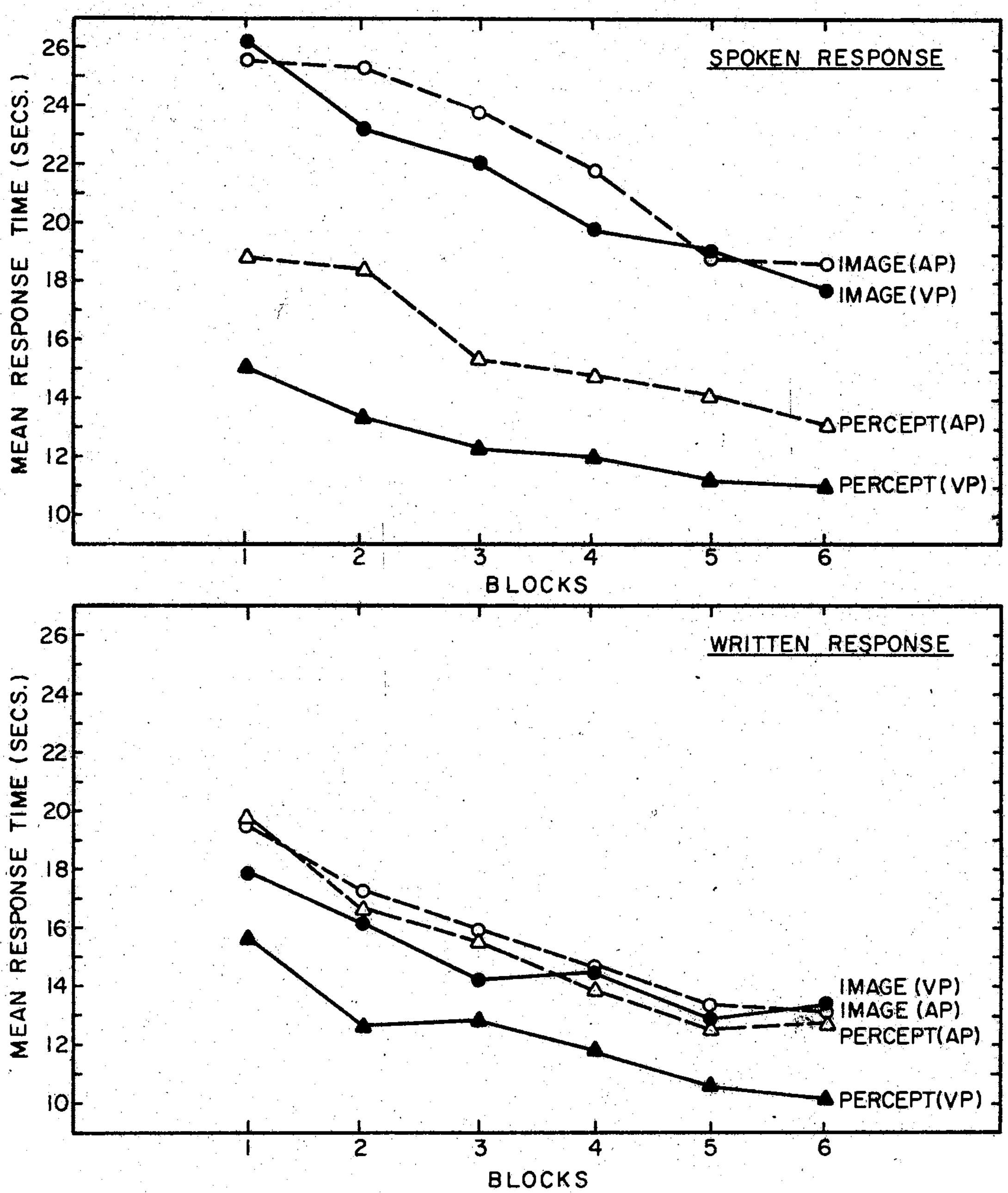

Figure 4. Response Time as a Function of Practice, With Representation Type and Letter Property as the Parameters. Spoken Responses Upper Panel and Written Responses Lower Panel - Experiment II

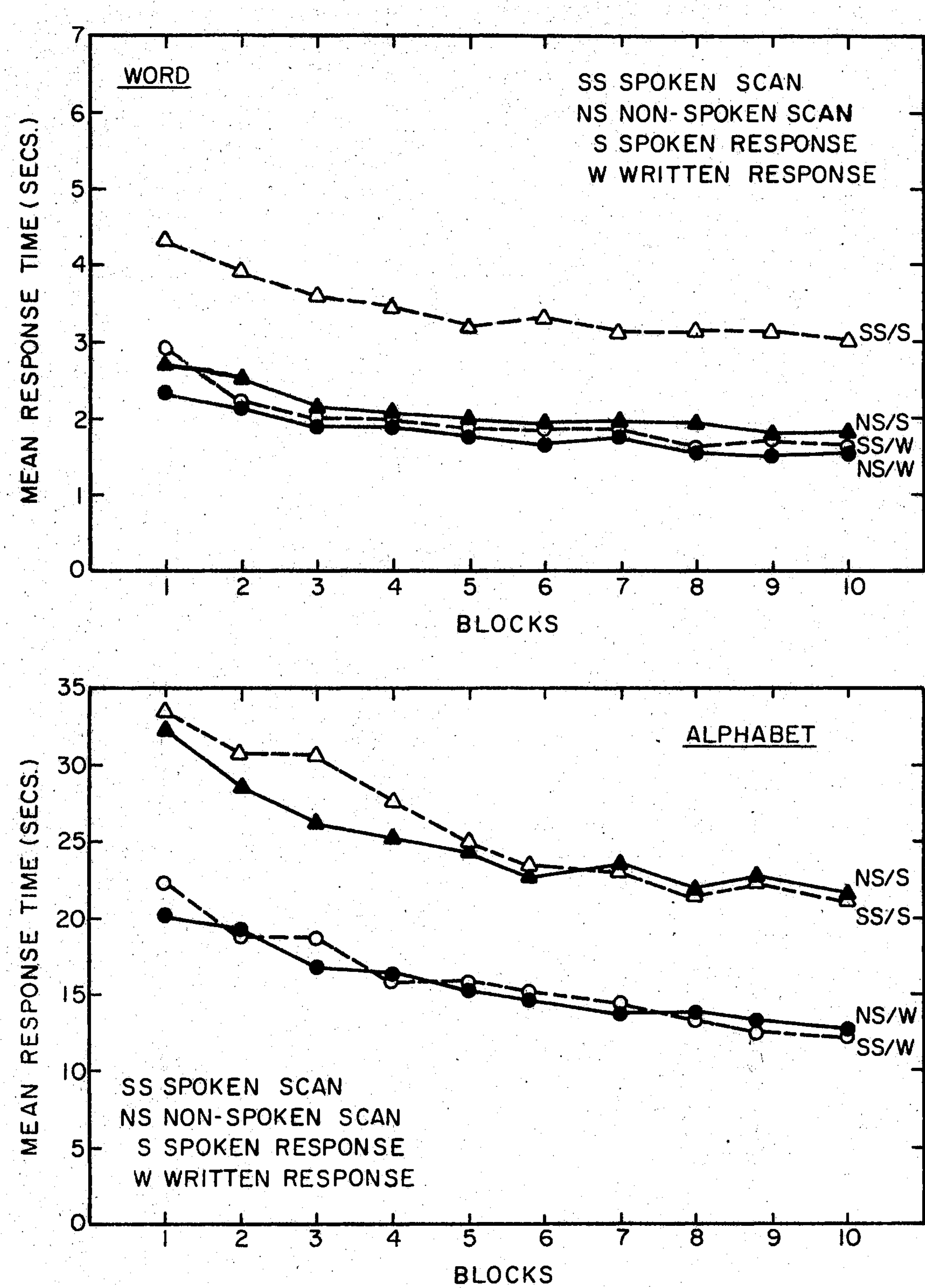

Figure 5. Response Time as a Function of Practice, With Scan Mode and Response Mode as the Parameters. Word Letter String Upper Panel and Alphabet Letter String Lower Panel - Experiment III

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