

HEMISPHERIC SPECIALIZATION AND
VISUAL MASKING OF PERCEPTION
AND IMAGERY

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PREFACE

Imagery offers a stimulating and important area of investigation to the behavioral scientist. New findings from related areas of research, new questions and new techniques for the objective study of imagery have recently combined to give new validity to its investigation. This thesis combines literature from the areas of imagery, blinking, visual masking and hemispheric specialization in order to deal with the issue of the nature of imagery. Specifically, the thesis deals with the question of whether imagery can be visually masked like perception.

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CHAPTER I

INTRODUCTION

Visual imagery is perhaps best known to most people through their dreams and daydreams. As research into the area has grown, however, imagery has been shown to have important functions in many other aspects of man's life. Cooper and Shepard (1972), for instance, have related their work with mental rotation of images to such everyday activities as

assembling the pieces of a jigsaw puzzle; rearranging furniture in a room; finding and fitting together the variously-shaped parts of a complicated mechanical device; and (at a much more abstract, theoretical level) working out a creative solution to a problem in geometry, electrical engineering, stereochemistry, or theoretical physics (Cooper and Shepard, 1972, p. 98).

Other spatial transformations which occur mentally may play a role in such areas as "choreography, gymnastics, modeling in clay, or solving problems in topography" (Cooper and Shepard, 1972, p. 98). The insurance investigator "reconstructing" an accident, the seamstress matching fabric to pattern, and the professional tennis player mentally practicing her swing are all instances of the everyday uses of imagery. Almost anyone can add to the list from his or her own experiences.

Downs and Stea (1973) deal with the image in terms of man's cognitive mapping of his environment. Their work combines contributions from such diverse areas as neurophysiology, cognitive psychology,

animal learning, urban sociology and psychophysics in an attempt to gain insight into how imagery aids man in knowing where things are in his environment and how he can get from one place to another.

Another of the diverse fields in which research in imagery is now taking place is that of the psychology of motivation. Klinger (1969), for instance, reports on the connections between play and fantasy, which he finds resemble each other in both content and structure at important points in development. Imagery is discussed because, as Klinger reports, fantasy can be defined as "imagining a complex object or event in concrete symbols as images, whether or not the object or event exists; or the symbols or images themselves: e.g., a daydream" (English and English, 1958, p. 203). The use of images in fantasy is unique because the images are not evaluated by the individual in terms of gaining any immediate goal other than the imagery (fantasy) itself.

There has been increased interest also in imagery in clinical settings (Jacobs, 1971; Jacobs and Wolpin, 1971) using behavior modification techniques and systematic desensitization procedures patterned after Wolpe (Hall and Lindzey, 1970; Vetter and Smith, 1971). In its original application Wolpe treated human neuroses by first training the patient to relax his major muscle groups at will. Next the patient and the therapist ranked a series of situations according to the degree of anxiety they aroused in the patient. Finally, the patient maintained relaxation while imagining, in turn, the series of situations. Extinction of anxiety reactions occurs at each level and generalizes to the next level until the most anxiety producing situation is no longer a problem to the patient.

Bugelski (1971) addresses himself to the relatively new area of animal language acquisition when he reports on the chimpanzee Washoe's acquisition of sign language. When Washoe hears the bark of a dog, she can make the sign for a dog, even though she cannot see the other animal. In making such a communication about an absent object, the chimpanzee is nevertheless indicating that she does have something to talk about. That something, according to Bugelski, is an image. Such interpretations of Washoe's behavior have obvious implications for interpretations of human language acquisition.

A more mundane area of research on imagery is that involved in memorization. Indeed, the use of imagery to aid memory has long been a well known technique. Cicero told the story of how Simonides invented the art of memory by devising the method of loci (Norman, 1969). As summarized by Bower (1970), the method consists of memorizing a list of mental pictures of locations arranged in their familiar order, making up images which are in some way symbolic of the information to be remembered, and associating the images with the imaginary locations. Then all that one must do to remember the information is to trace his footsteps through the imaginary locations. As he proceeds from one location to another, he will find the symbols of the items he is to recall. Another memory technique, the numeric pegword system, makes similar use of imagery. The memory pegwords are images of unrelated concrete objects associated in a one-to-one manner with integers (usually by rhyme, e.g., one-bun, two-shoe). Then connections are made between the imagery pegs and the images symbolic of information to be remembered. Recall of a specific integer brings to

mind the associated pegword and the information to be remembered (Bower, 1970).

As is clearly evident in the above, imagery plays an important role in many areas of man's life. The research and theoretical considerations presented thus far, however, have dealt with only one aspect of imagery, the functional aspect. Of more importance to the present study is the nature (i.e., the internal structure) of imagery.

CHAPTER II

STATEMENT OF PURPOSE

As imagery is such an integral part of man's life, it is not surprising that it has long been a topic of investigation. The ancient Greeks wrestled with the phenomenon philosophically. Plato's impressions on a "wax tablet" were equivalent to the image; perceptions and thoughts impressed in such a way upon the mind were remembered for as long as the image lasted (Paivio, 1971). Images were also the basis of memory for Aristotle (Watson, 1971). Indeed, Aristotle also insisted that thinking takes place in images and can never occur without them (a belief which was held until the investigations of the Wurzburg school nearly two thousand two hundred and fifty years later).

Imagery came under scientific study with the pioneering efforts of Sir Francis Galton in the late nineteenth century. While his initial work generated much interest and numerous empirical studies, subjective concepts (such as imagery) and the introspective method used to study them soon fell into disrepute. Contributing heavily to this change in Zeitgeist was Watson's view that imagery was devoid of any functional significance (Paivio, 1971).

More recently, however, there has been a renewed interest in the study of imagery. The current revival of work in investigating imagery has led to several different theories concerning the nature of imagery. The theories appear to lie along a continuum, with the

extremes depicting imagery as being either very much like perception (i.e., pictorial) or very different from perception. Neisser (1967, 1968, 1970), for instance, considers imagery and perception both to be the result of the same underlying process of "analysis-by-synthesis." As a result he argues that visual imagery is very much like perception. Pylyshyn (1973), on the other hand, suggests that imagery is represented in the brain by fundamental propositions which are not sensory or pictorial in any way. Imagery, according to this theory, is not at all like perception.

The renewed interest in imagery has also generated new techniques for studying imagery which do not involve introspective reports from subjects about the nature of their images. Shepard and Feng (1972), for example, measured response times for subjects to make decisions about patterns of squares which, when folded, would result in a cube. The subjects had to decide whether two arrows, each positioned on one side of two different squares, would meet when the squares were folded to produce the cube. Cooper and Shepard (1972) have measured reaction times of subjects required to decide whether a letter is presented correctly or as its mirror image when it is presented at a tilted angle. Weber and Castleman (1970) also used letters of the alphabet in their development of an objective technique to study imagery. They had subjects classify imagined, lowercase, typed letters of the alphabet into two groups based on vertical height. One group consisted of the small letters (i.e., a, c, e, i, m, n, o, r, s, u, v, w, x, z) and the other consisted of the large letters (i.e., b, d, f, g, h, j, k, l, p, q, t, and y). Weber and Kelly's (1972) subjects also classified letters into two groups. In this instance, however, the subjects were working with imagined, uppercase, typed letters, and the two groups consisted of

those letters with vertical straight lines (i.e., B, D, E, F, H, I, J, K, L, M, N, P, R, T, U, and Y) and those without vertical straight lines (i.e., A, C, G, O, Q, S, V, W, X, and Z).

These new techniques for studying imagery objectively and the empirical questions suggested by basic differences between theories about the nature of imagery (i.e., that images are or are not like perceptions) represent the rationale behind the present study. The present study will deal with the question of whether imagery is like perception (i.e., is at least to some extent pictorial). If, indeed, imagery is in some way like perception, it may be expected to be affected by some of the same variables which affect perception.

One potentially important aspect of the visual system (i.e., of visual perception and perhaps of visual imagery) is the eyeblink (Ponder and Kennedy, 1927; Hall, 1945). Holland and Tarlow (1972) have noted that one characteristic of mental activity (of which imagery is one example) is a reduction of blinking activity. They hypothesized that blinking disrupts certain cognitive processes and that inhibition of blinking during such processing serves to protect the mental activity from interference.

The rapid closing and opening of the eye as in the blink strongly suggests the phenomenon of visual masking using flashes of light or "visual noise" as the source of this interference with the visual image. Visual masking is a broad term which "covers the class of situations in which some measure of the effectiveness of a visual stimulus (the test stimulus, TS) is reduced by the presentation of another (the masking stimulus, MS) in close temporal contiguity to it" (Kahneman, 1968, p. 404). Thus, the eyeblink seems analogous to the

masking paradigm in the sense that it seems to disrupt image formation.

The reader may experience this disruption for himself in the following demonstration. With eyes open, imagine a word (e.g., "toy") printed in black type appearing on a piece of blank white paper. After having the image firmly in mind, blink one time. For most people the image will be gone and it will take some time to regenerate it. It is as if both images (the original image and the regenerated image) have in some way been masked by the "field of visual noise" produced by the eyeblink. An image formed with the eyes closed can be disrupted similarly by rapid opening and closing of the eyes one time. Again the reader may demonstrate the effect to himself by imagining a word with eyes closed. After having the image firmly in mind, open and close both eyes rapidly one time. Some people, at least, will report that the image is gone, and it will take some time before a second image can be generated (i.e., the images will have been masked by the flash of light).

Recently a new dimension has been added to the study of imagery as research in hemispheric specialization (also called cerebral lateralization, hemispheric asymmetry, or, less specifically, the "split-brain" phenomenon) has come into prominence. Some of the most exciting work in psychology is taking place within this area of research. Indeed research with the split-brain holds promise of new insights into even some of the oldest problems in psychology. Hebb (1974), for instance, has stated,

Today, no one, psychologist, philosopher, neurologist, or humanist, is entitled to an opinion on the mind-body

question if he is unfamiliar with the split-brain procedure and its results in human patients (Hebb, 1974, p. 76).

The research techniques used in studies of hemispheric specialization in normal subjects were developed as a result of an early investigation into the function of the great nerve fiber bundles (i.e., commissures) which connect the left and right hemispheres of the brain (Sperry, 1967). It was found that the commissures, of which the largest and most discrete is the corpus callosum, transmit information between the two hemispheres. The many resulting hemispheric specialization studies have shown that the right and left hemispheres of the higher primate brain are specialized for processing different kinds of information (Sperry, 1967, 1968; Gazzaniga, 1970; Gibson, Filbey and Gazzaniga, 1970; Rizzolatti, Umiltà and Berlucchi, 1971; Klatzky, 1970; Kimura, 1966, for example). In the human brain (for most individuals) the left hemisphere is specialized for processing verbal information and the right hemisphere is specialized for processing spatial information (Gazzaniga, 1970). Paivio and Ernest (1971) suggest that "the theoretical and operational definition of imagery in terms of figural ability suggests a relationship only between imagery ability and the recognition of nonverbal stimuli" (p. 429) (as opposed to there being a relationship between imagery ability and the recognition of any type of material). Thus, for these investigators, imagery ability is equated with spatial or figural-transformational ability. Specialization for imagery processing should be located in the right hemisphere, according to this reasoning.

The earliest studies in hemispheric specialization in human subjects were done with patients who had had their corpus callosum cut

surgically (usually in an attempt to control epileptic seizures). Such subjects are rare, however, and necessarily represent a unique subgroup of the general population. More recent work has been aimed at investigating hemispheric specialization in normal subjects.

In normal subjects, of course, the corpus callosum is still intact, and the problem becomes one of developing a methodology to study hemispheric specialization even though information is being transferred across the commissures. Filbey and Gazzaniga (1969) were the first researchers to suggest "splitting the normal brain with reaction time" (p. 335).

With normal subjects the split-brain technique developed by these researchers involves presentation of material to either side of a midline in the visual field, i.e., to the left visual field (LVF) or right visual field (RVF). Directing stimulus material to either specific hemisphere is possible because of the neural organization of the optic nerves. According to Gazzaniga's (1970) findings, "the visual midline represents nothing but the abutment of the two visual fields. The visual fields were found to stop exactly on the midline, with no overlap . . . evident" (p. 92). (See also Sperry, 1968.) Thus, when a subject is focusing with both eyes on a midpoint in his total visual field, stimuli presented from the LVF are projected to the right hemiretinas of his eyes. Conversely, presentation from the RVF is to the left hemiretina of each eye. The optic nerve fibers from each hemiretina project to the corresponding lateral geniculate body of the thalamus, i.e., nerve fibers from the left half of the retinas project to the left lateral geniculate body and nerve fibers from the right half of the retinas project to the right lateral

geniculate body. The crossing of the nerve fibers (see Figure 1) occurs at the optic chiasm, the point where the two optic nerves meet (Thompson, 1967). From the lateral geniculate bodies information falling on the right hemiretinas goes directly to the right hemisphere and information falling on the left hemiretinas goes directly to the left hemisphere.

If the material to be processed is verbal in nature and is presented via the LVF, it is projected to the right hemisphere and must cross to the left hemisphere before it can be processed. This processing takes fractions of a second longer than if the material had been presented via the RVF and had gone directly to the left hemisphere. The opposite is true for information to be processed spatially. Thus, by comparing reaction times for different (verbal and spatial) tasks, one can split the brain with reaction time.

In terms of the present study, the split-brain paradigm (as used with normal subjects) is valuable in enabling a more precise investigation of imagery processing. Hemispheric asymmetry for imagery perhaps suggests, for instance, that in some cases perception and imagery may indeed be processed "differently" and, thus, that imagery may be quite different from perception. McKeever and Gill (1972) have used the paradigm in a preliminary study of masking effects on perception. Using alphabetic letters as stimuli, they predicted that masking effects would be greater for the LVF than for the RVF because the ability to retain temporal patterning of letter input varies "inversely with the transmission pathway length and complexity" (McKeever and Gill, 1972, p. 112). Their results showed this for right-handed, but not for left-handed subjects. Specifically, "initial right visual

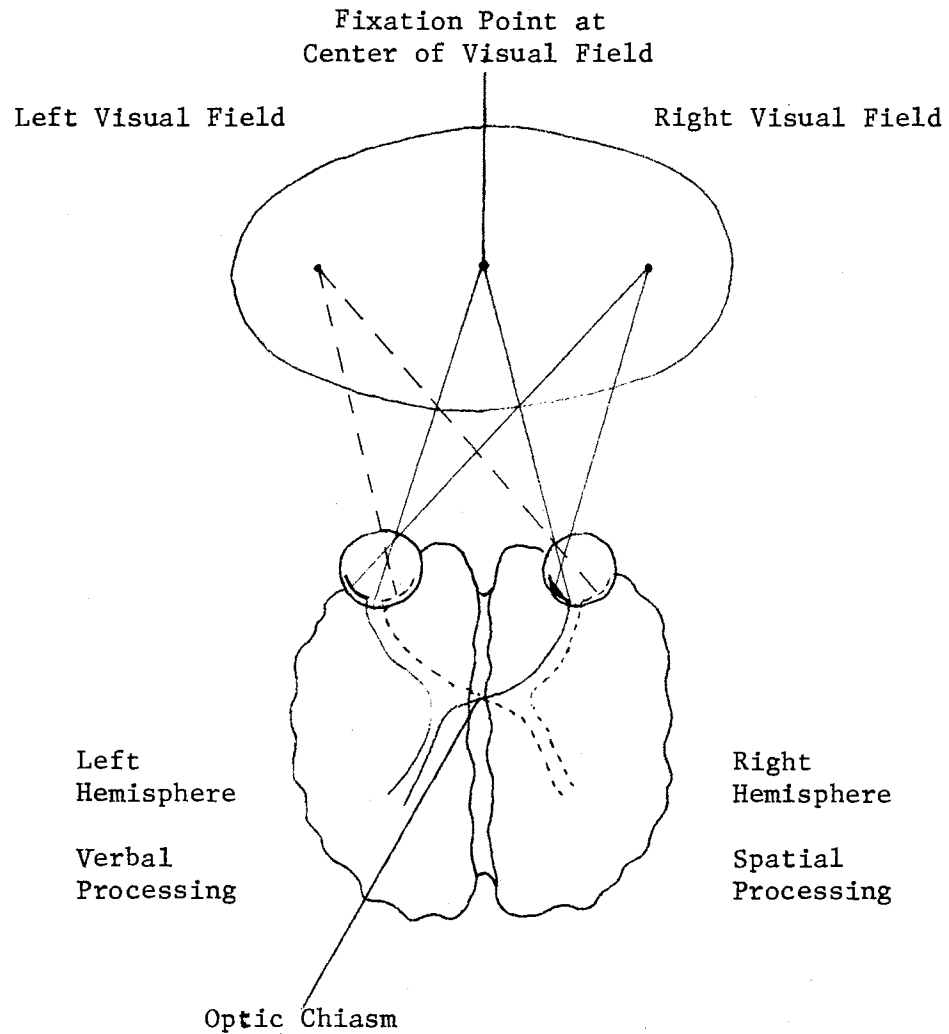


Figure 1. The Relationship of Visual Presentation Fields, Left and Right Hemiretinas and the Informational Pathways to Left and Right Hemispheres

field letters escaped heavy masking by subsequent stimuli in right handers while initial left visual field letters escaped heavy masking in left handers" (McKeever and Gill, 1972, p. 115). Since backward masking studies show that there is interference in the recognition of an initial stimulus if it is closely followed by a second stimulus delivered to the same retinal area (because the initial stimulus is not completely processed prior to interference by the second stimulus), the ability to preserve temporal patterning of letter input might help to reduce masking effects.

Seamon and Gazzaniga (1973) have investigated cerebral laterality effects using coding strategies (relational imagery and verbal rehearsal) for a short-term recognition memory task. They found that imagery coding appeared to be specialized in the right hemisphere while verbal rehearsal was specialized in the left hemisphere. In conclusion, they argue for "the inclusion of imagery, or generated visual information, as part of the visual processing system" (Seamon and Gazzaniga, 1973, p. 255).

The purpose of the present study was to investigate the nature of imagery. If imagery is like perception, (i.e., pictorial) it should be affected by some of the same variables which affect visual perception. As suggested by the eyeblink, one such variable may be masking effects. Specifically, then, the study incorporated an objective technique for studying imagery with the "split-brain" procedures used with normal subjects to define imagery precisely. Tachistoscopic presentation of stimuli with dark and light pre- and post-exposure fields was used to compare the effects of masking on perception and imagery when the subject was engaged in a spatial task.

CHAPTER III

REVIEW OF LITERATURE

Imagery

In 1880 when Galton published the results of his questionnaire studies in imagery, he made no effort to present a theory of either the function or the nature of imagery. Rather, he meant only "to define the different degrees of vividness with which different persons have the faculty of recalling familiar scenes under the form of mental pictures, and the peculiarities of the mental visions of different persons" (Galton, 1880, p. 21). His results, which revealed a wide variety of individual differences in ability to produce "mental images," were a fascinating beginning to the study of imagery, but they did little to increase man's knowledge concerning the structure of the image itself.

Bower (1970) admits that we have not come much further since Galton in agreeing on what an image is. According to him, however, scientists need not get involved in "philosophical problems" when dealing with imagery. For Bower, all that is needed for research in imagery to be valid is the agreement that something is subjectively present to the subject which enables him to experience some of the structural information which was available to him perceptually in an earlier perception of the object. While this viewpoint may apply to the memory

image, it is a rather limited position considering the wide range of images used by man.

Other investigators have expanded their work to theorizing about the nature of that "something" (Bower, 1970) which is present to the subject. Four such theorists include Neisser (1967, 1968, 1970), Hebb (1966), Shepard (Shepard and Chipman, 1970; Shepard and Feng, 1972; Cooper and Shepard, 1972) and Pylyshyn (1973). Their theories concerning the nature of imagery appear to lie along a continuum, ranging from the position that images and percepts have highly similar representation within the mind to the position that images and percepts have highly dissimilar representations within the mind.

The first of these theorists to be discussed is Neisser (1967, 1968, 1970), for whom imagery is a manifestation of the "analysis-by-synthesis" of perceptions. As he presents the idea, the process of visual cognition consists of two stages. The first is a pre-attentive stage which is wholistic in nature and results in iconic storage of the visual object for a period just long enough to make it available for further analysis. Detailed aspects of the object are not automatically present as a result of processing in this stage, but must be selected for the second stage (that of focal attention) and then must be subjected to further processing. If focal attention is drawn to the object (or some aspect of the object), there is a synthesis of a percept of the object. This synthesis is based upon not only the stimulus information, but also past experience, expectations and preferences. Thus, both the object being "observed" and the nature of the analysis performed upon its stimulus information may vary from time to time and from person to person. The important point made by Neisser

(1967) is that once an object has been thus constructed perceptually, it can be reconstructed in the form of a visual memory image. Neisser also accounts for other than memory images when he suggests that "Perhaps we experience familiarity to the extent that the present act of visual synthesis is identical to an earlier one" (Neisser, 1967, p. 98).

Hebb (1966) defines imagery as "the occurrence of perceptual processes in the absence of the stimulation which normally gives rise to the perception" (Hebb, 1966, p. 41) when the subject realizes that he is not actually perceiving an external event. Based on the fact that persons cannot read backwards words represented as images in their minds, he feels that the memory image is not like "having a picture in your mind" (Hebb, 1966, p. 43). Instead, he explains the memory image as being analogous to sensation in a phantom limb or to the presence of negative after-images to the extent that they are re-occurrences of some of the same processes which occurred during prior perception of the object. The ability of a person to read an imagined word faster in left to right order is taken as evidence that some of the same processes are being reinstated as when one originally read the printed external stimulus word. The image is a series of events which occur in particular order (as perception did); it is not a picture that can be scanned in any order.

In attempting to analyze the image in physiological terms, Hebb proposes that the image is the result of a "short-circuiting of the sensory-perceptual pathway" (Hebb, 1968, p. 467). Hence, the images are either produced by excitation of the central processes through spontaneous firing of afferent neurons or through associations with

other excited cell assemblies. Citing the work of Hubel and Wiesel (1968), Hebb describes how the different levels of cell assemblies can account for the different degrees of vividness in imagery.

A "simple cell" in the cortex responds to a specific retinal stimulation, its receptive field permitting little variation; but "complex cells" respond to stimulation in any part of their larger receptive fields . . . A sub-assembly made up of simple cells, or controlled by them, will thus be representative of a very specific sensory event, but one made up of complex cells will incorporate in itself some degree of generalization or abstraction. Assembly activities accordingly may be more or less specific as perceptual or imaginal events (Hebb, 1968, p. 471).

This explanation of the differences in vividness of imagery puts Hebb in agreement with Neisser's (1967) explanation of unusual or unfamiliar imagery. Neisser suggests that such imagery may be the result of a serial reconstruction of the perceptual process which has been terminated before it was complete. Unlike Galton (1880), who interpreted his results to mean that men possessed different abilities to imagine, Hebb feels that at least some imagery is simply so "fleeting and unobtrusive" (Hebb, 1968, p. 476) that people fail to report it. Thus, for Hebb, the difference between people who have much imagery and those who have little is "not a difference of the mechanism of thinking, but a difference in the retrievability of the image" (Hebb, 1968, p. 476).

Shepard has noted that there is a temptation to suppose that there is a structural isomorphism between the external object and its internal representation. Such a "first-order" isomorphism could even lead to the insistence that Hebb's cell assemblies be spatially arranged in the form of a square when the subject was perceiving a square. Such a first-order concept of isomorphism has been, of

course, discredited if for no other reason than the fact that "we learn the appropriate use of such words as 'square' from a verbal community that has access only to the public object and not to any such private image" (Shepard and Chipman, 1970, p. 1). Shepard proposes instead a "second-order" isomorphism between "(a) the relations among alternative external objects, and (b) the relations among their corresponding internal representations" (Shepard and Chipman, 1970, p. 2). Shepard interprets his results from several experiments (in which S's mentally folded connected squares into the shape of a cube) to mean that the S's mental processing was analagous to the physical process. He interprets this to mean that

whatever neurophysiological events are taking place while one is merely imagining the external process in question--these events have much in common with the internal events that occur when one is actually perceiving the external process itself (Shepard and Feng, 1972, p. 242).

Thus, when his subjects did the mental folding task, they had to decide whether two arrows placed on the sides of two of six squares would touch when the six squares were folded to form a cube. The S's response times to make the decision increased linearly with the sum of the number of squares which would have been involved (to make the arrows touch), if the folding had actually been done.

As a corollary to his basic principle of second-order isomorphism, Shepard suggests that "while one is in the course of imagining the external process--one passes through an ordered set of internal states of special relation to or readiness for the successive states of the external process" (Shepard and Feng, 1972, p. 242). To test this corollary, Cooper and Shepard (1972) did two chronometric studies of the rotation of mental images. Using asymmetrical alphanumeric

characters as their stimuli, they measured response times to make a decision of whether the stimulus was in its normal or mirror-image position when it was presented in different tilted angles from the normal upright position. Their empirical findings as interpreted theoretically show, in part,

Mental rotation is an analog process with a serial structure bearing a one-to-one relationship to the corresponding physical rotation. The time required (mentally) to rotate from an orientation A to an orientation C is just the sum of the times required to rotate from A to some intermediate orientation B, and to rotate from B to C . . . Moreover, in mentally rotating an object between any two widely separated orientations, A and C, the internal process passes through the mental image corresponding to that same object in some intermediate orientation, . . . Consequently, the orientation at which the subject is most prepared for the appearance of that object at each moment is actually rotating with respect to the external world (Cooper and Shepard, 1972, pp. 95-96).

Cooper and Shepard (1972) conclude that their work has shown several things about the nature of the image. They state that the internal representation of an external object (i.e., the image)

has an internal structure that is itself to some extent analogically related to the structure of its corresponding external object. For, during the process of rotation, the parts and the relationships among the parts must be transformed in very constrained ways in order to enable the kind of rapid, template-like match against an ensuing visual stimulus that we have demonstrated here.

Clearly, the internal representation cannot adequately be regarded either as an undifferentiated neural event (such as the activation of a particular neuron or population of mutually interchangeable neurons) at the neurophysiological level, or simply as an unanalyzable symbol at the information-processing level (Cooper and Shepard, 1972, p. 99).

Pylyshyn (1973) attacks the use of "mental image" as a theoretical construct used to describe one form of memory representation. Rather, he suggests that unconscious underlying mental structures (which are conceptual and propositional and not in any way sensory or

pictorial) are what give characterization to stored knowledge (Pylyshyn, 1973). Pylyshyn sees knowledge as propositional. Such knowledge is derived from language (sentences) and pictures (perceptions).

Yet,

[j]ust as cognition requires propositions which stand in a type-token relation to sentences, so also does it require something which stands in a type-token relation to pictures or sensory patterns. This something is best characterized as a descriptive symbol structure containing perceptual concepts and relations, but having the abstract qualities of propositions rather than the particular qualities of pictorial images. Furthermore, to refer to a representation arising from sensory stimulation as being propositional, as we have been advocating, is to imply (a) that it does not correspond to a raw sensory pattern, but rather, is already highly abstracted and interpreted, (b) that it is not different in principle from the kind of knowledge asserted by a sentence, or potentially assertable by some sentence, (c) that it depends on the classification of sensory events into a finite set of concepts and relations, so that what we know about some event or object is formally equivalent to (i.e., can be reduced to) a finite (and, in fact, relatively small) number of logically independent descriptive propositions (Pylyshyn, 1973, p. 7).

Hence, Pylyshyn differs from Neisser's and Hebb's view that images are comparable to perceptions. He argues, instead, that for images

the functional mental representation is not to be identified with the input to a perceptual stage but rather with the output of such a stage, inasmuch as it must already contain, in some explicit manner, those cognitive products which perception normally provides. If we could think of functional (rather than phenomenal) "images" in this sense, we would have removed the disturbing duality of "image" and "mind's eye," while, at the same time, we would have answered some of the puzzling classical questions referred to earlier: An image qua representation in our sense can certainly be selective, generic, abstract, and even unconscious inasmuch as the cognitive products of perception can be all of these (Pylyshyn, 1973, p. 12).

The four theories discussed above, then, seem to lie on a continuum. Neisser (1967, 1968, 1970) describes images to be very much

like pictorial perceptions. In fact, he sees them as being the end result of the same basic process: percepts are synthesized from sensory stimulation and images are reconstructions of the original synthesis. Hebb (1966, 1968) equates the image to a series of neurological events which occur in the same serial order as did the neurological events which produced the perception. Shepard's work (Shepard and Chipman, 1970; Shepard and Feng, 1972; Cooper and Shepard, 1972) is meant to show that the image does not stand in a one-to-one relationship with the percept, but rather, that the relationships between the parts of the image and the relationships between the parts of the percept are in this type of one-to-one relationship. Pylyshyn (1973), on the other hand, extends this basic concept to propose that the image is not like the percept, but is a product of the propositional system in which percepts are represented. Thus, the image is not sensory or pictorial, but is a mental representation of the underlying "logically independent descriptive propositions" (Pylyshyn, 1973, p. 7). It appears, then, that the empirical question suggested by these theories involves the relationship between an image and a percept.

The relationship between an image and a percept was investigated directly by Segal and Gordon (1969) when they successfully blocked visual signals with visual imagery. The study was a re-evaluation and further investigation of the Perky effect. Perky (1910) had discovered that an image may be used to mask perception of an ordinarily supraliminal stimulus and that an image may pick up aspects of an unreported stimulus. Segal and Gordon (1969) hypothesized that the imagined object represents a source of internal noise which effectively reduces the signal-to-noise ratio of the neural activity and thus

interferes with the detection of the visual signal during the imagery tasks.

Segal and Fusella (1970) investigated the Perky effect and included tasks (imagining and detecting percepts) in different and same modalities (auditory and visual), and found the greatest disruption when the tasks were in the same modalities. Thus, imagery does not cut down on general attention, but has the specific effect of interfering with the perception in the same modality. In a related study, Segal and Fusella (1971) also found that imagery in the auditory, gustatory, tactile and kinesthetic modes all have an effect (though much slighter than that of visual imagery) on the detection of the visual signal.

When imagery is in the same mode (i.e., visual), Segal (1971) feels that the visual stimulus may be assimilated to the image (i.e., the visual signal is processed only to the extent that it relates to the visual image) and that, therefore, it is unavailable for detection as an external stimulus. He thus seems to be in agreement with Neisser (1967) as to the selective nature of perception.

Segal and Glicksman (1967) found that body position will influence the critical ability of the S to notice the stimulus in the Perky paradigm. Thus, when relaxed, the S's imagery influences his perceptions, while when he is alert, the S's imagery is influenced by his perceptions. When the body is in a supine position (a position associated with relaxation), Segal and Glicksman found that the S failed to notice the stimulus. In a sitting position (a position more associated with alertness), however, they found that the S was more likely to notice the stimulus. Finally, while standing (a body

position even more associated with activity and alertness) the S had the lowest threshold and detected the greatest number of stimuli. According to Segal (1971) the supine body position allows relaxation, and a sensory signal in the same mode as the image is assimilated into the image. Hence, the unique qualities of the stimulus are lost since the stimulus is processed only as it is related to the S's image. The more upright body position, on the other hand, alerts the S to a signal detection situation and the image itself is accommodated by the stimulus. In this instance, then, the properties of the stimulus suggest the properties of the image.

Segal combines results from her own work with evidence from other research and concludes that images, in general, differ from percepts in that they are less vivid, smaller, less clearly defined and less stable (Segal, 1971). Thus, her work supports Neisser's (1967) contention that an image is a weaker reconstruction of a visual percept. Further, Neisser (1967) would also agree that the expectations set up by the image could influence the percept. Conversely, since images are reconstructions of perceptions, the percepts in the Perky paradigm (as when S was in the alert positions in the Segal and Glicksman [1967] study) could influence the image. It is difficult to see how such influences can be explained by Pylyshyn's (1973) notion of the underlying proposition. While the perception can be seen to be capable of influencing images in his theory, the manner in which an image might influence a perception does not appear to be clear.

Brooks (1967, 1968) also found interference between visual perception and visual imagery. He presented S's with instructions to place digits in certain positions in a matrix. The instructions were

given either verbally or verbally and in written form. The results of his experiments showed that reading the instructions interferes with the "internal representation of the spatial information" (Brooks, 1967, p. 298). When the S's responded in a manner which involved reading (the S's had to underline the word which had been given to them in the instructions) as opposed to just saying the words given in the instructions, the reading again interfered with the image of the matrix. In another study (Brooks, 1968) subjects were instructed to form an image of a letter (in block form) and classified the corners in the letter as an extreme corner (top or bottom of the letter) or an intermediate corner. Another condition had S's classify parts of speech in sentences. Subjects thus worked in either a spatial or a verbal mode. When their response to the task was in the same mode, there was again interference in the response (i.e., the response time to complete the task was longer). The fact that Brooks found interference even though "only two subjects reported anything which could correspond to a clear image" (Brooks, 1967, p. 298) substantiates the claim that visualization of an image involves the visual system whether or not the individual claims to have vivid imagery, much as suggested by Hebb (1967) when he proposed that the difference in "having" or "not having" imagery was actually only a difference in the ability to retrieve the image.

Seamon and Gazzaniga (1973) have shown that verbal and imagery coding strategies have been specialized in the left and right hemispheres, respectively. In their task, which involved short-term recognition rather than concurrent activities, S's did match a visual image with a pictorial probe presented in the left visual field faster

than if presented in the right visual field. The authors conclude that imagery (i.e., generated visual information) should be included as part of the visual processing system. Their work, then, can be interpreted as arguing for the position that images, like perceptions, are pictorial.

Weber and Harnish (1974) tested Hebb's "picture theory" of visually imagining words. Hebb had concluded that a subject's inability to spell a word, such as "university," as rapidly backwards as forwards was proof that having an image is not like having a picture in the mind at which another part of the mind can look (Weber and Harnish, 1974). Weber and Harnish suggested, however, that a long word such as "university" might overtax the visual imagery system. They suggested instead that a test with a shorter word, e.g., "toy," would be just as valid a test of the theory and would not tax the visual imagery system. Using three and five letter words, they used a probe technique to test objectively the subjects' images of the words. In some conditions they found that imagery and perceptual representations were comparable in the response time required for processing. They suggested that

there exists a visual image operating memory with a fixed letter capacity for parallel processing that is less than that of the visual percept system. When the image capacity of the operating memory is strained or exceeded, differences in processing time between percept and image systems become apparent (Weber and Harnish, p. 30).

Thus, visual imagery does seem from the above evidence (Segal and Gordon, 1969; Segal and Fusella, 1970; Segal and Glicksman, 1967; Brooks, 1967; Seamon and Gazzaniga, 1973) to involve the visual system. Indeed, while Pylyshyn would disagree, visual imagery has been

called "generated visual information" (Seamon and Gazzaniga, 1973, p. 255). Logically one would hypothesize, then, that phenomena which affect visual perception might also act to affect visual imagery. As blinking is one manner in which humans control perceptual input, it might also play a part in controlling imagery. The next section will explore this hypothesis.

Blinking as a Visual Mask

Ponder and Kennedy (1927) concluded from their investigations into the causation of blinking that such movements were centrally originated (although they could also be influenced along certain secondary paths such as the optic and auditory nerves). This central control of blinking was reflected in the fact that a change in rate of blinking would result from a change in the general level of attention of the individual. They employed some fascinating naturalistic observations to come to this conclusion. Observing witnesses in a court of law, for example, they discovered that the rate of blinking increased remarkably when the witness was under cross-examination as opposed to being questioned under direct examination. Other evidence was gathered from observations of men and women passengers on street cars and in the reading rooms of libraries. Different results were found for both men and women in the two different situations. On the street cars women were observed to have much lower blink rates than the men supposedly because the women were much more introspective in their attention, while the men were much more engaged in attending to their external environment. The investigators had much more difficulty in gathering data from the reading rooms and in this instance, the

results were exactly the opposite. That is, the blink rates of the men were much lower blink rates than those of the women. This finding was explained by the greater tendency of the men to study, while the women's attention wandered around the room. Ponder and Kennedy's experiments lead them to the general conclusion that blinking is related to mental tension. Another conclusion, however, might be that the cause of blinking is not so much mental tension as it is the amount and kind of attention the person is paying to his surroundings.

Similar evidence is presented in Hall's (1945) discussion of blinking. This researcher saw blinks as being of two types: voluntary and reflex. Reflexive blinks include automatic blinks for the protection and efficient action of the eyes, blinks for the preservation of the organism (which according to Hall are the most frequent kind of everyday blinks), and blinks of technique such as those which occur during the act of reading aloud.

In preface to his discussion of the blinks involved in the preservation of the organism, Hall (1945) points out that blinks (and absence of blinks) are the result of inherited reflexes of aggression and self-preservation. The carnivora or hunting animals represent characteristics of aggression as their sole means of getting food is through attack on other animals which are usually far away, highly mobile and highly resistant (Hall, 1945). The herbivora (the animals which are hunted) represent the opposite in food gathering aspects. Their food supply is usually nearby, stationary and non-resisting. These animals are often prey to the carnivora, however, and thus, self-preservation is manifested in nearly constant vigilance. These

two basic reflexes (of "aggression" and "self-preservation") meet as opposites in the eye and the eyeblink.

The manifestations of these two reflexes are displayed in the blinking behaviors of animals. Blount (1927) observed animals in the Edinburgh Zoo and found the average blink rates of several species of animals. Carnivora blinked much less frequently (on the average 2.0 times per minute) than did the herbivora (on the average 10.5 times per minute). Hall concludes from this data that blinking is highly correlated with the relative importance of the self-preservation and aggression reflexes in the two groups of animals. Blount found an even higher average rate of blinking (24 per minute) in aboreal primates. He attributes the increase not to a greater need for self-preservation (having taken to the trees the animals are "safer" than the herbivora still on the ground), but rather he attributes it to dependence on a new and ever changing use of the fixation reflex. Fixation has changed from the prolonged fixation at stalked prey to the rapid adjustment to and ever constant interest in looking-about an ever changing environment (Hall, 1945).

Blinking in man has been found to vary greatly under different circumstances (Ponder and Kennedy's [1927] data show a range of 3.29 per minute to 25.4 per minute). Yet, the human blink rate is, on the whole, greater than that of lower animals and is somewhat comparable to the primates of Blount's study. While man shows the same responsiveness to the self-preservation reflexes (the acoustic reflex and the menace reflex) as do the lower animals, he also reacts to imaginary threats arising from emotional or nervous causes. Thus, these

blinks allow for a cutting short of the fixation reflex without causing an interruption in the continuity of vision.

Blinks of technique, on the other hand, are meant to interrupt the visual input signal. Thus, Hall (1945) found that when reading aloud, the accomplished reader blinks at appropriate places (usually at punctuation marks) and for appropriate duration (depending on the type of punctuation mark) in order to delay the outflow of the text in his speech. There is no change of fixation and reading picks up again at the same point.

Telford and Thompson (1932) measured blink rates of subjects under three conditions. When blink rate during conversation is taken as normal, reading was found to retard blink rate and mental arithmetic was found to increase blink rate. The authors do not attribute the drop in blink rate during reading to mental activity, but rather suggest several other factors which may be responsible for it. Among the other factors is the fact that "excessive winking interferes with the process of reading" (Telford and Thompson, 1932, p. 536). Telford and Thompson's (1932) evidence is again indicative of the fact that increased attention to the individual's surroundings is accompanied by an increase in blink rate.

Baumstimler and Parrot (1971) investigated the relationship between spontaneous blinking and a voluntary motor task. They found that their subjects' (S's) blinks occurred in the time period after the onset of the motor response had occurred and before the onset of the next stimulus. The blinks were inhibited in the time period between onset of the stimulus and the beginning of the response. The active process was hypothesized to be the inhibition of blinking during the

period between the S's first expectancy of the stimulus and when the response is given. The inhibition of blinking, then, occurs when the S is monitoring a numerical indicator three feet in front of him, awaiting a visual signal. In a previous study the mean blink rates of subjects involved in reading and in fixation upon a nearby object were found to be "practically equal" (Peterson and Allison, 1931, p. 147). The results are interpreted as meaning that blinking can be voluntarily monitored so as not to interfere with task demands. Stated in another way, the results can be interpreted as showing that blinking can be inhibited when the individual is fixating on or closely monitoring an object in his environment.

Broadbent (1958) agrees that man can monitor his environment in order to know when to blink and when not to blink. Blinks cut off information to the nervous system instantaneously. This does little harm, however, since man can suspend blinking and he can control his blinks so that he will blink only when he is relatively sure that no new information will be arriving at that time. He can also continue to act even though he is not taking in information at that precise point in time.

Several investigators have noted that blinking is related in some way to various mental states. Collins (1962), for instance, suggested that the blinking rate is higher during emotional excitement and that it is lower during daydreaming. Antrobus, Antrobus and Singer (1964) found that S's who were asked to generate a wish blinked less often than S's asked to suppress a wish. Holland and Tarlow (1972) hypothesized that blinking disrupts certain cognitive processes and that blinks therefore occur in gaps between processes. Increased

mental load would decrease the availability of such gaps and therefore the opportunity for blinking would be decreased.

In the first part of Holland and Tarlow's (1972) experiment, the subjects were seated facing a wall on which was a large black patch located at eye level. The S's were auditorially presented a series of numbers randomly varied in length (4, 6, or 8 digits). The "S's task was to look at the black patch and visualize (italics added) the series of numbers they had just heard, until a signal tone sounded 70 seconds later. At this signal, S was asked to repeat the original digits out loud in the same order as they were presented" (Holland and Tarlow, 1972, p. 121). As the digit span increased (an event which Holland and Tarlow took to represent an increase in mental load), the number of errors increased. The fewer digits being visualized (i.e., the smaller the mental load) the higher was the blink rate. These results may also be interpreted (contrary to Holland and Tarlow) as being indicative of the fact that the subjects could maintain a few digits easily, but that they had to concentrate more heavily on internal processes in order to maintain larger numbers of digits. To do this, fewer blinks could be tolerated.

In the second part of this study, subjects were involved in a mental arithmetic task in which they were instructed "to keep a running total of the numbers by visualizing (italics added) the addition on the black patch and to respond with the cumulative total at the sound of the signal tone" (Holland and Tarlow, 1972, p. 121). In this part of the experiment S's made more errors on addition not involving zeros and on addition involving two-digit numbers. The S's also blinked more on trials containing zeros than on those not containing

zeros. Again, the results seem to show that the more concentration required for the mental visualization task, the less interference from the effects of blinking could be tolerated.

Indeed, in both parts of the study there were more blinks preceding incorrect trials than there were preceding correct ones. The authors conclude that the results indicate that when mental load is reduced, the rate of blinking will increase. Moreover, they further suggest, "It would be adaptive to inhibit blinks during mental activities if blinks disrupted certain cognitive processes" (Holland and Tarlow, 1972, p. 127). If vision and visual imagery share the same processing channels and if blinks tend to bring external stimuli into brighter focus, which in turn masks the visual image (either by light or patterns), then it would, indeed, be quite adaptive to inhibit blinking when engaged in such an act of visual imagery.

Along these lines, Weitzenhoffer (1969) tested the "unblinking stare" as being a characteristic of hypnosis. His results showed that subjects considered to be "appreciably" hypnotized did "show a markedly decreased rate of spontaneous blinking" (Weitzenhoffer, 1969, p. 674). In seeking to explain his findings, Weitzenhoffer offers the same type of "selective attention" hypothesis suggested above. As he suggests,

Speaking only in somewhat of a clinical manner at this time, it has seemed to this investigator after watching many individuals strongly attending to various stimuli, particularly those calling for an inward turning of attention, that attending is often accompanied by reduced blinking, or at least by the appearance of short bursts of blinking with relatively long intervals free of blinking. If so, and if hypnosis is a form of concentrated or selective attention, as has been proposed many times, one might expect a reduction in blink rate with hypnosis (Weitzenhoffer, 1969, p. 675).

The importance of selective attention has been noticed in other studies. The concentration (attending to one thought or goal) as found in many cognitive tasks and in some emotional arousal is associated with reduced blink rates. General emotional arousal not associated with a specific goal, shifts in attention, and, perhaps thought suppression, on the other hand, are associated with increased frequency in blinking (Barron, 1973). As discussed above, blinking has also been shown to be associated with disruption of a cognitive task involving visualization (i.e., imagery) (Holland and Tarlow, 1972). Further investigation is needed to examine whether blinking itself disrupts the visual imagery process and, if it does, in what manner.

As was suggested earlier, the act of blinking suggests some of the elements present in the masking paradigms. Kahneman's (1968) review of the masking literature defines "visual masking" as "the class of situations in which some measure of the effectiveness of a visual stimulus (the test stimulus, TS) is reduced by the presentation of another (the masking stimulus, MS) in close temporal contiguity to it" (p. 404). Backward masking occurs when the MS follows the TS; forward masking occurs when the TS follows the MS. Masking can be by light (in which a flash of homogeneous illumination is used) or by pattern (in which regular or random arrays of white and dark areas are used). Masking using random patterns is sometimes termed "masking by visual noise" (Kahneman, 1968, p. 405). When the MS and TS are not spatially overlapping, backward masking is termed "metacontrast" and forward masking is termed "paracontrast" although, as Kahneman (1968, p. 405) points out, the term metacontrast is generally applied to both situations.

Using these terms, then, the situation in which an individual has an image and then blinks (rapidly closes and opens his eyes once) can be seen as an instance of forward masking (if the blink actually causes a delay in the formation of the next image) and of backward masking (if the blink actually causes an "erasure" of the preceding image). Indeed, two characteristics of masking with light which have been confirmed repeatedly are: (1) the masking flash interferes with TS, both when it precedes the TS (forward masking) and when it follows the TS (backward masking) and (2) the forward and backward masking effects are both most severe when the TS and the MS follow one another immediately (Kahneman, 1968) as they do in the blinking situation.

In discussing theories of visual masking, Kahneman (1968) reports,

All current theories of backward masking share a central idea: the visual response to a brief stimulus lasts longer than did the stimulus that caused it; consequently, the responses to two successive stimuli may overlap in time (Kahneman, 1968, p. 419).

Thus, backward masking is not really a retroactive event, but rather it is caused by an interaction between responses which are at least partly concurrent. With this in mind, the author presents two general groups of theories concerning the interaction effect which occurs when the TS and MS overlap. The integration theories basically assume that the TS and the MS are linearly summed so that any response to "their presentation in sequence is the same as would be evoked by their joint simultaneous presentation" (Kahneman, 1968, p. 420). Thus, if the system is being overloaded by massive stimulation of the MS, it "is less capable of conveying information about TS" (Kahneman, 1968, p. 420). In the interruption theories, on the other hand, the idea

emphasized is that "the normal perception of a TS requires time and that the process may be stopped by a stimulus presented during that time" (Kahneman, 1968, p. 420).

Turvey (1973) also discusses the integration and interruption theories of masking. This researcher has investigated the peripheral and central processes of vision involved in masking in terms of an information processing model. In the visual information processing system information goes first to iconic memory and then is recoded into a categorical form before representation in response and/or short-term storage.

The interruption hypothesis localizes the effect of backward masking by pattern subsequent to iconic storage. It is assumed that a clear icon is established and that an 'after-coming' pattern interferes with the translation into categorical form. The time needed to effect that translation is cut short by the after-coming stimulus. The integration hypothesis on the other hand, proposes that target material and mask are dealt with as a composite, resulting in an unintelligible icon. For the integration hypothesis, the effect of an after-coming pattern is on the formation of the target iconic representation so that it never achieves the acuity, contrast or clarity that it would have attained in the absence of the mask (Turvey, 1973, p. 3).

In a long series of experiments in which the TS and MS were presented to the same hemiretina of one eye or to different hemiretinas (one in each eye), Turvey was able to direct the TS and MS through one channel or to the same hemisphere through separate channels. Thus, the author was able to control for masking occurring peripherally or centrally.

He found,

In short, there are two possible loci for the perceptual impairment resulting when two visual stimuli follow in rapid succession. The impairment may have its locus in the transmission channel or in a central processor. Impairment localized in the transmission channel is best viewed as the effect one stimulus exerts on the other.

Impairment localized in a central processor can be of two sorts: an interaction between the stimuli, similar in kind to that occurring in the transmission channel, or a distortion induced in the operation of a central processing mechanism (Turvey, 1973, p. 18).

Turvey proposes instead a concurrent-contingent model of visual masking. In the model, central and peripheral processing act concurrently and are overlapping in time. The central processes are, however, contingent upon the output of the peripheral processes. In particular, Turvey's experiments resulted in his drawing several conclusions about masking in the peripheral and central systems. He concluded, for instance, that in the peripheral system both forward and backward masking can occur. The masking in the peripheral system depends upon the energy levels of the two competing stimuli so that the stimulus of greater energy is the one most likely to be perceived. In the central processing situation, on the other hand, energy is not important in the competition of two stimuli. Rather the competition is resolved by the later stimulus being most completely identified. Thus, backward masking occurs to the greatest degree in central processing, while forward masking is relatively weak.

Several of Turvey's (1973) findings have implications for the suggestion that masking in the imagery-blink-imagery situation might occur centrally. These include the effectiveness of backward masking, the fact that forward masking has been observed which delayed rather than impaired the recognition of a test item and the wide range of individual differences found in central masking. Further, while "peripheral" and "central" are not fully defined in Turvey's model, imagery itself occurs centrally and thus could not be masked peripherally.

Thus, as Raab has concluded, the findings of forward and backward masking studies have shown that "unhindered perception of a target requires that it be 'surrounded in time'--i.e., preceded and followed--by zones devoid of masking energy" (Raab, 1963, p. 125). It is suggested here that the eyeblink acts in some manner to introduce such a masking energy.

Hemispheric Specialization

The earliest suggestions of human hemispheric specialization were the result of "experiments of Nature" in which patients suffering from aphasic symptoms due to hemiplegia or hemiparesis resulting from brain injuries were studied (Satz, Achenbach, and Fennell, 1967). Much of the recent interest in this area, however, has come from the research by Sperry and Meyers in the 1950s. Their initial work involved an investigation into the functioning of the commissures (discrete bundles of nerve fibers which link the two cerebral hemispheres) and more specifically, of the corpus callosum (the most prominent of these links). The commissures "form reciprocal connections between parallel centers in the two hemispheres" (Sperry, 1967, p. 240). Thus, both the size and the location of the commissures suggested the importance of their functioning.

One of Sperry's graduate students, Ronald E. Myers, subsequently developed a technique of "splitting-the-brain" of a cat by surgically cutting the corpus callosum (and, in the initial study, the optic chiasm). Through post-operative testing, Myers learned that the actual function of the great cerebral commissure (the corpus callosum) was to transmit information between the two hemispheres of the brain.

Testing the performance of the two brain halves separately, he found that when the corpus callosum was cut, what was learned by one side of the brain was not transferred to the other side. In fact, the two sides could learn diametrically opposed solutions to the same experimental problem, so that the animal's response in a given situation depended on which side of the brain was receiving the triggering stimulus. It was as though each hemisphere were a separate mental domain operating with complete disregard--indeed, with a complete lack of awareness--of what went on in the other. The split-brain animal behaved in the test situation as if it had two entirely separate brains (Sperry, 1967, p. 241).

Post-operative testing techniques developed by Sperry and his colleagues for use on human patients whose corpus callosum had intentionally been surgically severed (usually in an attempt to control epileptic seizures) later gave more specific information about hemispheric specialization (Sperry, 1967, 1968; Gazzaniga, 1970). Sperry (1967) gives numerous examples of tests given such patients and the deficiencies in performance shown by them. In testing the patients a special testing set-up is used. It allows the experimenters to do lateralized testing for right and left visual fields (separately or together) and to do lateralized testing of right and left arms and legs with vision excluded (Sperry, 1967, 1968; Gazzaniga, 1970).

Handedness and footedness are aspects of cerebral lateralization which are readily apparent to most people. There has been much controversy over the connection between this aspect of hemispheric specialization and other aspects such as speech and language specialization (Milner, Branch and Rasmussen, 1973). The question revolves around the relationship of handedness to the location of speech lateralization. That is, since it is overwhelmingly accepted that right handed individuals have speech specialization in the left hemisphere, does it follow that left handers have speech lateralization in the



right hemisphere? Further, is speech lateralization always completely lateralized? These questions become quite important in situations in which left-handed, ambidextrous and sometimes right-handed patients are candidates for neurosurgery. The Wada test was developed for quick and precise determination of speech specialization so that speech abilities would not be disturbed during neurosurgery. The test consists of blocking processing in one hemisphere at a time (one side on each of two days) with an intracarotid artery injection of sodium amytal (Milner, Branch and Rasmussen, 1973; Satz, Achenbach and Fennel, 1967) and then testing patients with verbal processing tasks. Milner, Branch and Rasmussen report the results of tests of 119 patients which showed that ninety percent of right-handed patients (and these were patients suspected for some reason not to have speech specialization in the left hemisphere) did show speech specialization in the left hemisphere. Of the left-handed patients, on the other hand, over twenty percent of the patients in each of two groups (those with and those without early left brain damage) also had speech specialization in the left hemisphere. Furthermore, all instances of bilateral speech representation were in the left-handed groups. These results present further evidence that while language specialization is relatively distinct in right handers, it is not distinct in left handers. Of course, since use of the test is limited to candidates for neurosurgery, its results are often criticized as coming from non-normal subjects (Satz, Achenbach and Fennel, 1967).

Levy (1969) has presented an hypothesis concerning the evolutionary basis of lateral specialization of the human brain. Based on the fact that there is some evidence for minimal right hemisphere

ability for language processing which is overshadowed by the stronger control of the left hemisphere over motor mechanisms for speech production, he proposed that specialization was "an adaptation permitting control of the unique vocal apparatus, uncomplicated by competitive antagonism between hemispheres" (Levy, 1969, p. 615). Levy-Agresti and Sperry (1968) showed that the right hemisphere is superior in its ability to visualize in three dimensions. Further, in such a task the left hemisphere seemed to analyze the stimulus properties as if to process the information in a manner so as to be described in language, while the right hemisphere seemed to process in a manner so as to grasp the stimulus Gestalt (i.e., an integrated whole of the stimulus). This researcher suggests, then, "During the evolution of the hominids Gestalt perception may have lateralized into the mute hemisphere as a consequence of an antagonism between functions of language and perception" (Levy, 1969, p. 615). Testing left- and right-handed graduate science students on the verbal and performance scales of the Wechsler Adult Intelligence Scale (WAIS), he found the antagonistic hypothesis confirmed. That is, the left-handers (S's taken to have bilateral language centers or partial language competence in both hemispheres) did more poorly than right-handers (S's with dominant language ability in the left hemisphere alone) on the performance scales, while there was no difference between the two groups on the verbal scales.

Filbey and Gazzaniga (1969) were among the first researchers to suggest splitting the normal brain with reaction time. Their first experiment involved having S's give either verbal or manual responses to either the presence or absence of a dot or a blank field in right

or left visual fields. Since verbal responses restrict responses to the left hemisphere, a dot presented in the RVF should result in a faster reaction time than a dot in the LVF. Further, since there must be callosal transmission of information between left and right hemispheres before a totally blank field may be indicated (S must check both sides for "no dot"), responding to a blank field should also take longer. The results showed that discrimination of a left dot and of a blank field took 30-40 msec. longer than discrimination of a right dot. Similarly, in a motor response both hemispheres can have access to the response. Thus, there should be no left-right difference in detecting dots, but detection of a blank field should again necessitate callosal transmission of information across the hemispheres and thus result in longer reaction times. Again, these results were found with the blank field detection taking 30-40 msec. longer than either left or right dot detection.

Gibson, Filbey and Gazzaniga (1970) presented a dot to either left or right visual fields and required a simple verbal response ("e" = "yes," "c" = "no"), and replicated the finding that the dot presented to the left visual field takes 30 msec. longer in which to respond. This result is obtained because information presented to the silent (right) hemisphere must be transferred to the speaking (left) hemisphere before the subject can respond. In addition, the researchers used a mental rotation task which required rotation and matching of two figures (e.g.,  - "yes,"  - "no"). It was expected that such a task presented to the left hemisphere would require transfer to the right hemisphere for processing and then transfer back to the left hemisphere for the verbal response. Ten of twelve subject's showed a

RVF superiority on the first task, and eleven showed a LVF superiority on the second task.

Geffen, Bradshaw and Wallace (1971) suggest that in using response time measures with normal subjects, visual field differences could be due either to time needed to cross from non-dominant hemisphere to the dominant hemisphere (for specialized processing of a particular type) or to merely better efficiency of one hemisphere in processing of that particular type or to both (i.e., to both hemispheric asymmetry and to interhemispheric transmission times).

Dimond, Gibson and Gazzaniga (1972) tested subjects on their ability to match words presented either in one visual field or simultaneously in both left and right visual fields. They found that when the stimuli was presented in both visual fields there was an increase in errors (as compared to presentation in either left or right field alone). The results were interpreted as suggesting that "combining of information from both visual fields require its transmission across the corpus callosum," and that "information is lost during this process" (Dimond, Gibson and Gazzaniga, 1972, p. 379).

Kinsbourne (1970), on the other hand, proposes that asymmetries in processing information from visual fields arise "when preponderant cerebral activation of one hemisphere biases attention to the contralateral side" (Kinsbourne, 1970, p. 193). As a vestige of earlier biological adaptation, Kinsbourne suggests,

Expectancy of a briefly exposed word or letter induces preparatory left hemisphere activation, and thus biases attention somewhat to the right of the fixation point, even though central fixation be strictly maintained. When the display actually appears on that side, more processing time is available than when it appears on the other side,

necessitating a shift of attention. This, like any biological process, is not instantaneous (Kinsbourne, 1970, p. 196).

Hemispheric specialization has also been found for nonverbal stimuli. Doreen Kimura (1966) showed the verbal superiority of the left hemisphere (i.e., right visual field superiority for recognition of letters) and a right hemisphere superiority for nonverbal material (i.e., left visual field superiority for dots, though not for nonsense forms). Kimura (1969), in a series of seven experiments, found that dots can be more accurately located when presented in the left visual field. She further found that this difference could not be attributed simply to differences in the ease in which a dot can be seen in the left visual field. She suggests a spatial co-ordinate system in the right hemisphere which mediates the representation of external space.

Rizzolatti, Umiltà, and Berlucchi (1971) compared left and right visual field presentations of verbal (capital letters) and nonverbal (pictures of unknown persons) stimuli. They found the expected right visual field superiority for letters and left visual field superiority for the pictures. Evidence that task requirements are very important is found when it is noticed that in previous work (Rizzolatti *et al.*, 1971) no visual field superiority was found for pictures of faces. In the earlier study, however, the pictures used were sketches of faces of famous persons. This fact may have provided a "verbal loop" as subjects named the faces.

Muscovitch (1972) also found differences in the manner in which alphabetic letters can be processed. Using response times as his dependent variable, he presented letters (one or six) binaurally to his

subjects and had them report (with a manual response) whether a test letter (presented visually in left or right visual fields) matched a letter in the memory set. When the memory set contained only one letter, there was a left visual field superiority. When the memory set contained six letters, however, there was a right visual field superiority. This led Moscovitch to conclude that when the subjects had only one letter in the memory set, they matched the test letter to it visually (in accordance to the right hemisphere's ability to process visual information); when the subjects had six letters in the memory set, they matched the test letter verbally (in accordance with the left hemisphere's ability to process verbal information).

Klatzky (1970) compared nonverbal and verbal stimuli in a matching task. In this experiment, however, letters were considered to be nonverbal because they were treated as spatial objects and were compared to the memory set in terms of their physical configurations. Pictures of common objects served as the verbal stimuli because S's made the memory comparisons between verbal labels for the pictures. Stimuli were presented to either left or right visual fields, and the subjects responded if the stimulus matched one of a previously presented set (or, in the case of the pictures, if the first letter of the name of the pictured object matched a letter in the memory set). The results of the experiment showed the expected left visual field superiority for nonverbal processing of letters and the right visual field superiority for verbal processing of letters. Klatzky also included memory set size (of 2 to 5 letters) as one variable. She found left visual field superiority for all set sizes in processing of letters. However, in the processing of pictures, there was RVF superiority in

small memory set size (two letters) and LVF superiority for large memory sets (three to five letters). This shows a shift from verbal to nonverbal processing as memory set size increased. Klatzky suggests that one possibility is that

the transfer of information from the right to the left hemisphere has a facilitative effect on the comparison process. It is also possible that presenting a picture to the left hemisphere, where comparisons are supposed to take place, makes the comparison process more difficult. A third possibility is that some picture could be equated with its corresponding letter without the aid of verbalization, enabling the right hemisphere to perform spatial comparisons when it receives a picture stimulus (Klatzky, 1970, p. 203).

Harnish (1974) further suggests that imagery might have been used in some way in the larger memory set. Seamon and Gazzaniga (1973), for instance, found that imagery coding produced faster latencies for probes to the right hemisphere in a short-term recognition memory task.

As White (1971) reported, the evidence showing a right visual field superiority for alphabetic letters, the fact that stimuli presented in the right visual field are transmitted directly to the left hemisphere, and the fact that the left hemisphere is dominant for mediation of languages "have led to the proposition that cerebral language dominance can account for certain aspects of visual laterality differences" (White, 1971, p. 207). He presented subjects letters in right and left visual fields and found a RVF superiority. In a second experiment, however, subjects had to discriminate the orientations of straight lines presented to them. In this instance, White also found a RVF superiority. These results suggested to him that there is something in common about discriminating line orientations and the

perception of letters. He suggests, "A commonality is the correct discrimination of contours; what distinguishes an A from an H is the orientation of the two side elements" (White, 1971, p. 210). He suggests that his results are "explicable in terms of a selective contour-tuning apparatus" (White, 1971, p. 210), such as described by Hubel and Wiesel (1965, 1968). One problem with his work, however, is that he used a vocal response in each case, and thus may have biased his results.

Geffen, Bradshaw and Nettleson (1972) found hemispheric asymmetry for differential encoding (verbal and spatial) of visual stimuli. Letters presented tachistoscopically were to be responded to as same or different according to physical properties (e.g., "A-A") or according to their name (e.g., "A-a"). Letters similar in name were found to have a right visual superiority (i.e., were processed faster in the left, language, hemisphere) while letters having identical physical properties were found to have left visual field superiority (i.e., were processed faster in the right, spatial hemisphere). The authors conclude,

The finding of faster processing of physically identical stimuli when these are directed to the right hemisphere suggests that the type of task is more important than the type of stimulus in determining hemispheric asymmetry. When analysis of visual patterns is required, the right hemisphere is better (Geffen *et al.*, 1972, p. 30).

Gibson, Dimond and Gazzaniga (1972) first presented words to their subjects in a spatial matching task and later in a verbal task, i.e., reading the word. Their results indicated a left visual field superiority for the matching test (contrary to most findings involving words as stimuli). Further, they suggest that word recognition is a

multistage process and thus cannot be invariably handled better by one or the other hemispheres. Rather, they conclude, "Treating a word as a verbal stimulus would seem to be justified only when the task stressed language related properties. Whether or not a right field superiority will manifest itself is not dictated by the stimulus alone but also depends upon the interaction of task and stimulus" (Gibson *et al.*, 1972, p. 465).

Seamon and Gazzaniga (1973) had subjects engage in a short-term memory task. The S's saw two simple nouns (e.g., HAT, DUCK), on a rear projection screen. Then they were probed in one hemisphere by presentation of a line drawing of a pictorial representation of one of the two study items. Both positive (a drawing of one of the objects) and negative (a drawing of an unrelated object) probes were used. Subjects used either a verbal rehearsal code or an imagery code. Thus, subjects "were told to rehearse the two study words subvocally and continually during their presentation and the blank period preceding the probe" or they "were instructed to generate an imaginal representation of each of the study words, and to put the two images together into a single interactive scene so that one image was always touching the other image" (Seamon and Gazzaniga, 1973, p. 251). The S's in the verbal rehearsal condition were to indicate if the picture probe represented one of the two study items, while the S's in the imagery condition were to indicate if the picture represented one of the objects imagined in the scene. The results indicated that "cerebral laterality effects are functionally related to coding strategies" (Seamon and Gazzaniga, 1973, p. 253). Thus, faster reaction times were found for probes to the left hemisphere when S's were using the

verbal rehearsal strategy. Similarly, faster reactions were found for probes to the right hemisphere when S's were using the imagery code.

The authors state,

In summary, these data support the original hypothesis that varying coding strategies can produce cerebral laterality effects consistent with the model of separate processing systems, and argue for the inclusion of imagery, or generated visual information, as part of the visual processing system. As such, generated visual information may be viewed as a coding alternative to verbal mediation. (Seamon and Gazzaniga, 1973, p. 255).

Paivio and Ernest (1971) reasoned that if S's with high imagery ability have an overall ability to process visual material at a perceptual level, then they should show greater tachistoscopic recognition accuracy for any type stimuli presented. If, however, the theoretical and operational definition of imagery identify it in terms of figural ability, then there should only be greater tachistoscopic recognition of nonverbal stimuli. They tested the specific hypothesis that

superiority on spatial or figural transformational ability tests (i.e., high imagery ability) reflects superior right hemisphere functioning. If true, high imagers should be more accurate than low imagers, specifically in identifying nonverbal stimuli presented to the left visual field. No imagery differences should result when such materials are presented to the right visual field nor when verbal stimuli are presented to either visual field (Paivio and Ernest, 1971, p. 429).

The task involved recognition of and verbal naming of letters, pictures and geometric forms. The results of the study showed that overall, the high imagers did better and showed a right hemisphere superiority for the task. Low imagers, on the other hand, showed a left hemisphere superiority for the task. The authors suggest two reasons for this difficulty of the right hemisphere:

It could be right-hemisphere deficiency in the processing of visual information concerning forms or relative inefficiency in the transmission of appropriate information from the right hemisphere to language control systems in the left hemisphere, such information being necessary for the initiation of the verbal response that identifies the form (Paivio and Ernest, 1971, p. 432).

The authors concluded, in part, that

imagery ability is apparently unrelated to letter recognition, but high imagers clearly surpass low imagers in picture recognition. These data suggest strongly that the superiority of high imagers is specific to nonverbal stimuli, although in themselves they do not rule out a verbal-processing component in the effect. It could be argued, for example, that high imagers may surpass low imagers in their ability to code pictures verbally and that this ability plays a part in recognition accuracy (Paivio and Ernest, 1971, p. 431).

Use of a verbal response (thus biasing the left hemisphere) and possible confounding by inclusion of left handed S's make clear interpretation of the results in this study difficult, however.

Harnish (1974) also studied imagery processing. He presented typed uppercase capital letters one at a time in either the LVF or RVF. Subjects were to classify the equivalent lowercase letter as to its vertical height as in Weber and Kelley (1972). Responding with a bimanual response, the S's response latencies showed faster processing in the right hemisphere for this imagery task.

Thus, the split brain paradigm may offer a technique to better isolate visual imagery for study without confounding by verbal processing of report information and without confounding through loss of information caused by callosal transmission. As suggested by Turvey (1973) the neural pathways which allow the split-brain testing of normal subjects to be done also present unique opportunities for testing central and peripheral masking effects. Thus, the situation

is potentially adaptable for testing masking effects on imagery and perception.

CHAPTER IV

METHOD

Subjects

Twenty-four undergraduate student volunteers enrolled in lower division psychology courses were used as subjects (S's). They received course extra credit for their participation. Twelve S's were randomly assigned to each between group condition. All S's had filled out the Handedness Questionnaire (Appendix A) adapted from Harnish (1974) and their answers indicated that they were right handed (i.e., that they had checked "left-hand" or "either hand" no more than twice on the questionnaire) and that they had no known left-handedness in their immediate family (mother, father, grandparents, brothers, or sisters). Since the size of the viewing hood of the tachistoscope prohibited the use of S's who wore glasses, the questionnaire also screened for this condition. While none of the S's wore glasses, contact lenses were permitted.

Design

The design was a Type SPF = 2.224 design (Kirk, 1968, p. 308). The between-S treatment was mode of processing (perception and imagery). The within-S treatments were type of pre- and post-exposure field (dark and light), visual presentation field (left and right),

and letter position in a stimulus word (one, two, three, and four). The dependent variable was response latency measured to one millisecond.

Apparatus

A two channel Scientific Prototype tachistoscope Model 800 E was used. The experimenter presented the stimulus for 150 msec. by throwing a two way toggle switch. Throwing the toggle switch simultaneously started a Hunter Model 120 A Series D Klockounter (by opening a circuit in a Gerbrands Electronic Voice Key Model 130). The S's bimanual finger response was made by pushing two of four (central or peripheral) Electro-Snap Model E4-3 micro-switches located directly in front of the S. The response (measured by the one switch pressed first) stopped the clock by advancing one of two counters, the noise of which closed a circuit in a Lafayette 6602A Voice Response time control relay and thus closed the circuit in the Gerbrands voice key. Each set of micro-switches (central and peripheral) advanced separate counters. Thus, the two appropriately labeled counters indicated to E which response S had made and, hence, whether the response was correct or incorrect. The experiment required the use of two experimenters. E₁ gave instructions, presented the trials, recorded correct and incorrect responses, recorded response latencies, and reset the Klockounter, and both voice relays after each trial. E₂ changed the stimulus cards after each trial and changed the tachistoscope settings after each block of trials. This latter change consisted of setting the light intensity for the pre- and post-exposure field for the light

condition at the highest setting (and equal to the stimulus field) and for the dark condition at the lowest setting.

Stimuli

The stimuli were eight high frequency four letter words (AA in the Thorndike and Lorge [1944] word count): blue, edge, half, page, show, spot, trip, and wild. Half of the total number of letters within the set of eight words were vertically small (a, e, i, o, r, s, u, w, with some letters repeated) and half of the total number of letters were vertically large (b, d, f, g, h, l, p, t, with some letters repeated) when printed as lowercase letters. In each of the four letter positions four letters were large and four were not large. The words were presented in blocks of eight (each word represented once). Within each block each letter position (one per word) occurred as the test letter twice, once as a large letter and once as a letter which was not large. Further, within each block each letter position appeared once in the LVF and once in the RVF. Four groupings (Table I) of the resulting four blocks (Figure 2) were determined in which each block appeared once in each presentation position (one through four). The order of presentation of these groupings was randomly chosen. Two such groupings made up the first half of the trials and the other two made up the second half of the trials. The order of presentation of the words within each block was randomly chosen for each presentation of the block with the limitation that no more than three words in a row be presented from the same visual field. In each half of the trials, if a letter position and letter height appeared in the LVF in the first presentation of a block of eight words, they appeared in the

TABLE I
GROUPINGS OF THE FOUR BLOCKS OF STIMULUS WORDS

First Half of Trials		Second Half of Trials	
Group 1	Group 2	Group 3	Group 4
1	3	4	2
3	1	2	4
4	2	3	1
2	4	1	3

Block 1
Letter Position

1	2	3	4	Visual Field
e	d	g		L
s		o	t	R
t	r		p	R
p	a		e	L
h		l	f	L
	h	o	w	R
w	i	l		R
	i	v	e	L

Block 3
Letter Position

1	2	3	4	Visual Field
e	d		e	L
s	p		t	R
t	r	i		R
p		g	e	L
	a	l	f	L
s		o	w	R
	i	l	d	R
b	i	v		L

Block 2
Letter Position

1	2	3	4	Visual Field
	d	g	e	R
s	p	o		L
	r	i	p	L
p	a	g		R
h	a		f	R
s	h		w	L
w		l	d	L
b		v	e	R

Block 4
Letter Position

1	2	3	4	Visual Field
e		g	e	R
	p	o	t	L
t		i	p	L
	a	g	e	R
h	a	l		R
s	h	o		L
w	i		d	L
b	i		e	R

Figure 2. Four Blocks of the Eight Stimulus Words Shown as Presented in Imagery Condition

RVF in the second presentation of the block and vice versa. There were a total of 128 trials. Half the S's were randomly chosen to begin with one set of 64 trials and half were chosen to begin with the other set of 64 trials.

In the percept condition each word contained a bar marker over one of the letters (Figure 4). In the imagery task there was one letter missing in each of the words and there was a bar marker over the space where the letter would normally have appeared (Figure 4). Thus, in this condition the S's had to use imagery in order to respond to the height of the missing letter.

Percept

■
/blue/

Imagery

■
/bl e/

Figure 3. Examples of the Stimuli for the Percept and Imagery Conditions

The letters were presented (within words) on four by five inch cards. The words were typed in lowercase pica letters on an IBM electric typewriter with carbon ribbon. The visual angle subtended by the words was 42 min. at a viewing distance of 33 inches (83 cm.). The words began 10 min. out from the midpoint of the visual field and the complete word was included in less than one degree of visual angle. Each letter subtended .10 minutes of viewing angle. Since Miskin and Forgays (1951) found recognition differences in the left and right

visual fields in a region between $1^{\circ}11'$ and $4^{\circ}46'$ from fixation, the distances were chosen to be within one degree of visual angle from the midpoint.

When the S's looked through the viewing hood of the tachistoscope they saw a viewing field of approximately $2\frac{1}{2}$ by $2\frac{3}{4}$ inches for both the pre- and post-exposure fields and the stimulus field. In the dark pre- and post-exposure field the S's saw darkness which was created by placing dark construction paper in the auxiliary stimulus holders (preceding the light source). A small hole was made in the paper through which a pin point of light marking the midpoint was visible. The light source intensity was turned to its lowest setting for presentation of the dark pre- and post-exposure fields.

In the light pre- and post-exposure field the light intensity was the same as that for the stimulus field (the highest setting). The S's saw a white ground with the midpoint marked by a black dot. The pre- and post-exposure fields alternated between dark and light for half the S's and between light and dark for the other half of the S's. The starting field (dark or light) was randomly selected for each S with the restraint that half of the S's chosen to begin with a particular set of 64 trials began with the dark pre- and post-exposure fields and half began with the light pre- and post-exposure fields.

Procedure

The exact instructions given the S's are given in Appendix B. The S's were shown a card on which was typed, in lowercase letters, the alphabet. They were shown how the letters could be divided into

two classes according to vertical height and were given practice in doing so.

Subjects were then shown two examples of marked words such as they would see in the test situation. They were told that their task would be to decide as quickly as they could whether the letter which was indicated by the bar marker was large (a "yes" letter) or not large (a "no" letter). Subjects in the imagery condition were, in addition, told that since the actual letter would be missing, they would have to visually imagine the missing letter in order to make their decision concerning its height. These S's were told that visually imagining something is like picturing it in one's mind.

The S's were then shown the midpoint of the viewing field. They saw both the dark condition (a pinpoint of light on a black background marking the midpoint) and the light condition (a black dot on a white background marking the midpoint). The S's were instructed to try to fixate on the dot before each word was shown.

The S's were then given instruction in the bimanual response task. A bimanual task was used to prevent the biasing of one hemisphere over the other. Half of the S's were told to press the outer two switches to indicate a large letter and the inner two switches to indicate a letter which was not large. The other half of the S's used the inner switches to indicate large letters and the outer switches to indicate letters which were not large. The two inner switches were pressed with the two index fingers and the outer two switches were pressed with the two middle fingers. The S's were told to press with the corresponding fingers from both hands each time a response was made.

The S's were then shown two practice words and were given four practice trials. The practice trials gave the S's experience with left and right visual fields, "yes" and "no" responses, and dark and light pre- and post-exposure fields. No feedback was given as to the correctness or incorrectness of the S's responses.

The S's were next given a list of the eight stimulus words. After studying the list the S was given a written spelling test on the eight words. This served as a final check on handedness and also showed that the S's did indeed know how to spell the words (and thus, that they knew which letters would be used as the test letters).

During the testing session the S viewed the pre-exposure field, E₁ said "set," and the word was presented to the S for 150 msec. The procedure is depicted in Figure 4. If a response was incorrect, this was noted and the trial was repeated at the end of the block. Hence, all response latencies were for correct responses only. After the experiment, the S's were debriefed as to the nature of the experiment.

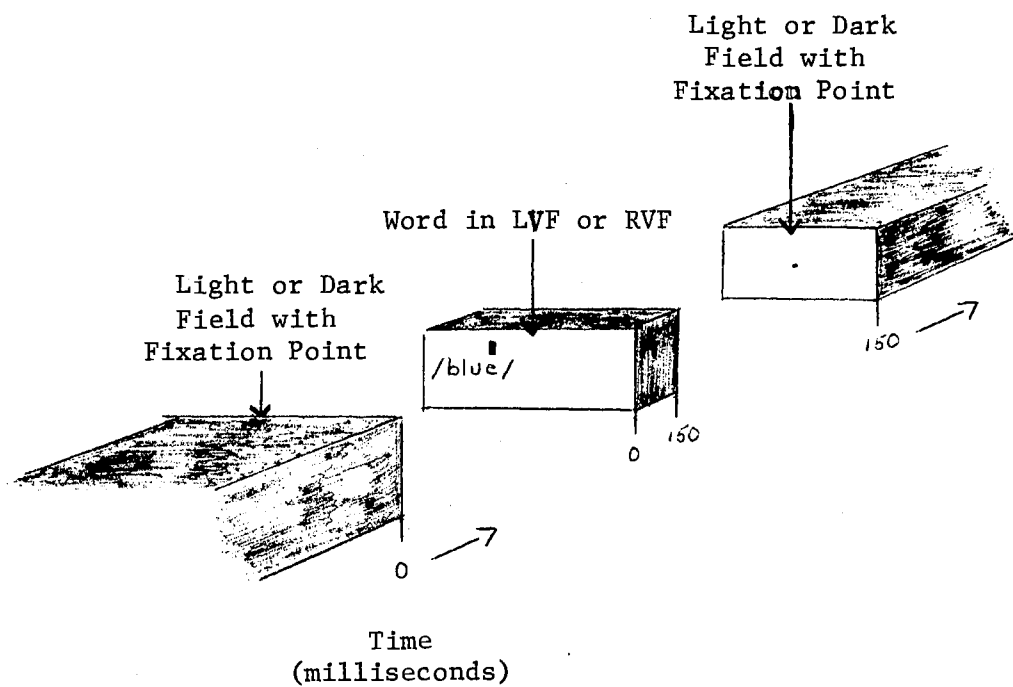


Figure 4. Outline of the Procedure

CHAPTER V

RESULTS

In order to reduce the effect of a few highly deviant response latencies on a subject's score, a logarithmic transformation was performed on the latency data. This transformation converted each subject's individual score for each word and each condition into its corresponding logarithmic value. The geometric mean for the S's score for each condition was then found and this value was converted again to milliseconds by taking the antilogarithm. In addition, all scores above 2500 milliseconds were deleted in calculating the mean. This involved 32 of the total 3072 individual latencies.

The results of the overall analysis of variance are summarized in Table II. A table of means and standard deviations for each condition is presented in Appendix C. The results show that for mode of processing, processing was faster for the percept condition than for the imagery condition ($F(1,22) = 4.01, p < .10$), for pre- and post-exposure fields, the dark condition interfered with processing ($F(1,22) = 184.23, p < .0005$), there was no difference between left and right visual fields ($F(1,22) = 2.22, p > .10$), and time to process the information was influenced by letter position ($F(3,66) = 14.29, p < .0005$).

The finding that no statistical significance existed between left and right visual field presentations could have been the result of a

TABLE II
 SUMMARY OF THE ANALYSIS OF VARIANCE FOR
 OVERALL MEAN RESPONSE LATENCIES

Source	Degrees of Freedom	MS	F
Between Subjects			
Mode of Processing (A)	1	2.0700	4.0138*
Subj. W. Groups	22	.5157	
Within Subjects			
Pre- and Post-Exposure (B)	1	1.7775	184.2359*****
A x B	1	.0296	3.0763*
B x Subj. W. Groups	22	.0096	
Visual Field (C)	1	.0106	2.2232
A x C	1	.0003	.0610
C x Subj. W. Groups	22	.0047	
Letter Position (D)	3	.1057	14.2977*****
A x D	3	.0181	2.4488
D x Subj. W. Groups	66	.0074	
B x C	1	.0001	.0187
A x B x C	1	.0099	1.9777
B x C x Subj. W. Groups	22	.0050	
B x D	3	.0088	1.7770
A x B x D	3	.0038	.7794
B x D x Subj. W. Groups	66	.0049	
C x D	3	.0189	4.9145***
A x C x D	3	.0031	.7946
C x D x Subj. W. Groups	66	.0038	
B x C x D	3	.0070	2.0692
A x B x C x D	3	.0041	1.7155
B x C x D x Subj. W. Groups	66		

* $p < .10$

** $p < .05$

*** $p < .005$

**** $p < .0005$

change in type of processing due to practice. For this reason, separate analyses of variance were performed on the data from the first and second halves of the subjects' trials. A table of means for each condition in the first and second halves of the trials is presented in Appendix D. The results of the analysis of variance on the first half of the trials (Appendix E) revealed no difference in left and right visual field presentation ($F(1,22) = .0318, p > .25$). The results of the analysis of variance on the second half of the trials (Appendix F), however, indicated a left visual field superiority ($F(1,22) = 3.958, p < .10$). These results are depicted in Figure 5.

In the overall analysis of the data significant interactions were found for mode of processing by pre- and post-exposure fields, ($F(1, 22) = 3.07, p < .10$), for mode of processing by letter position, ($F(3,66) = 2.44, p < .10$), and for visual field by letter position ($F(3,66) = 4.91, p < .01$).

Simple effects tests (Appendix G) revealed significant differences between mode of processing in the dark and light pre- and post-exposure fields. While the differences were not strong, Figure 6 indicates that the imagery condition produced significantly longer response latencies than the percept condition under dark ($p < .05$) pre- and post-exposure fields. There is also a trend toward the same longer latencies in the light ($p < .10$) pre- and post-exposure fields. Further, Figure 6 indicates that the dark pre- and post-exposure fields produced longer response latencies for both perception ($p < .01$) and imagery ($p < .01$).

Tests of simple main effects also revealed significant differences between mode of processing and three of the four letter

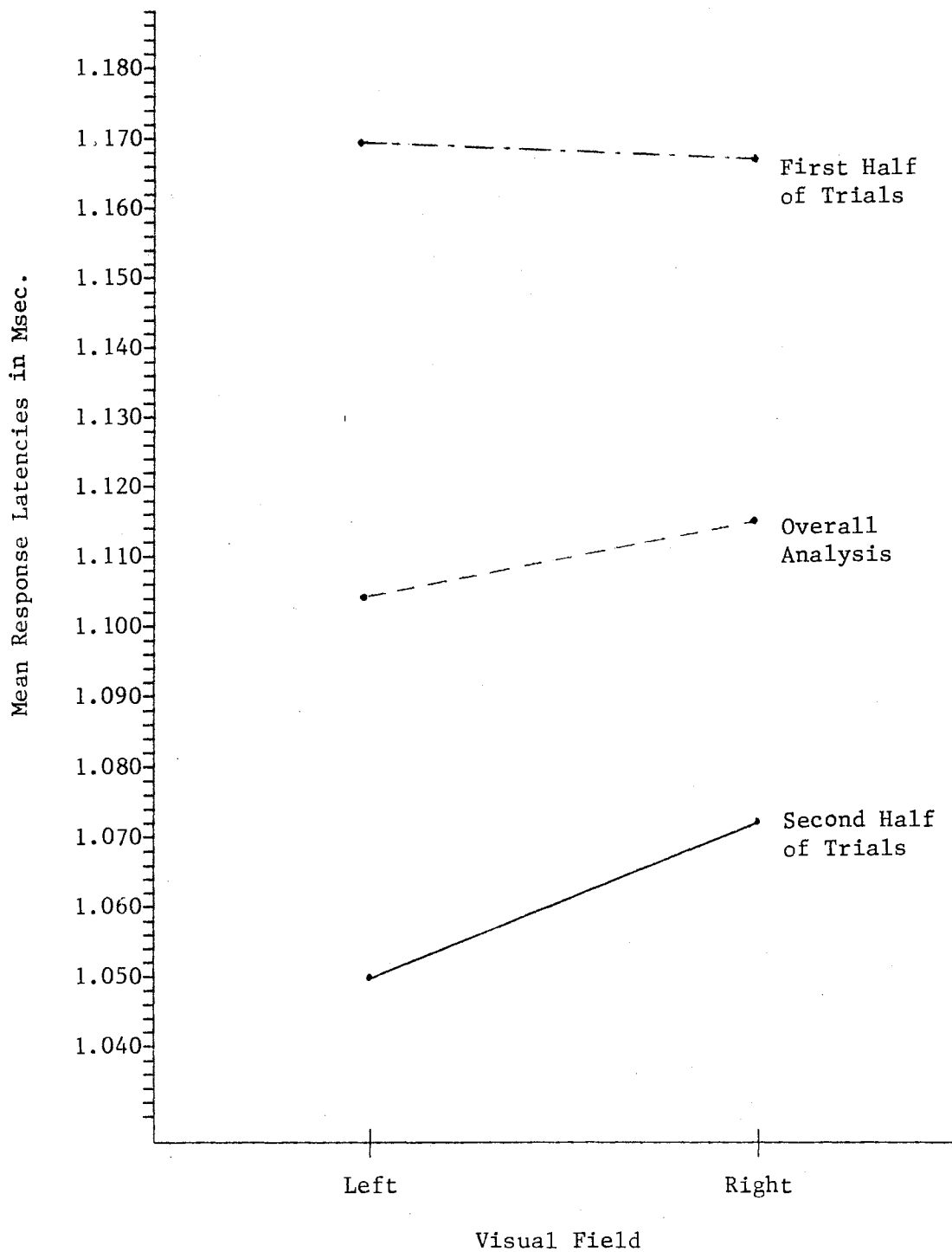


Figure 5. Left and Right Visual Field Comparisons in Overall Analysis, First Half of the Trials and Second Half of the Trials

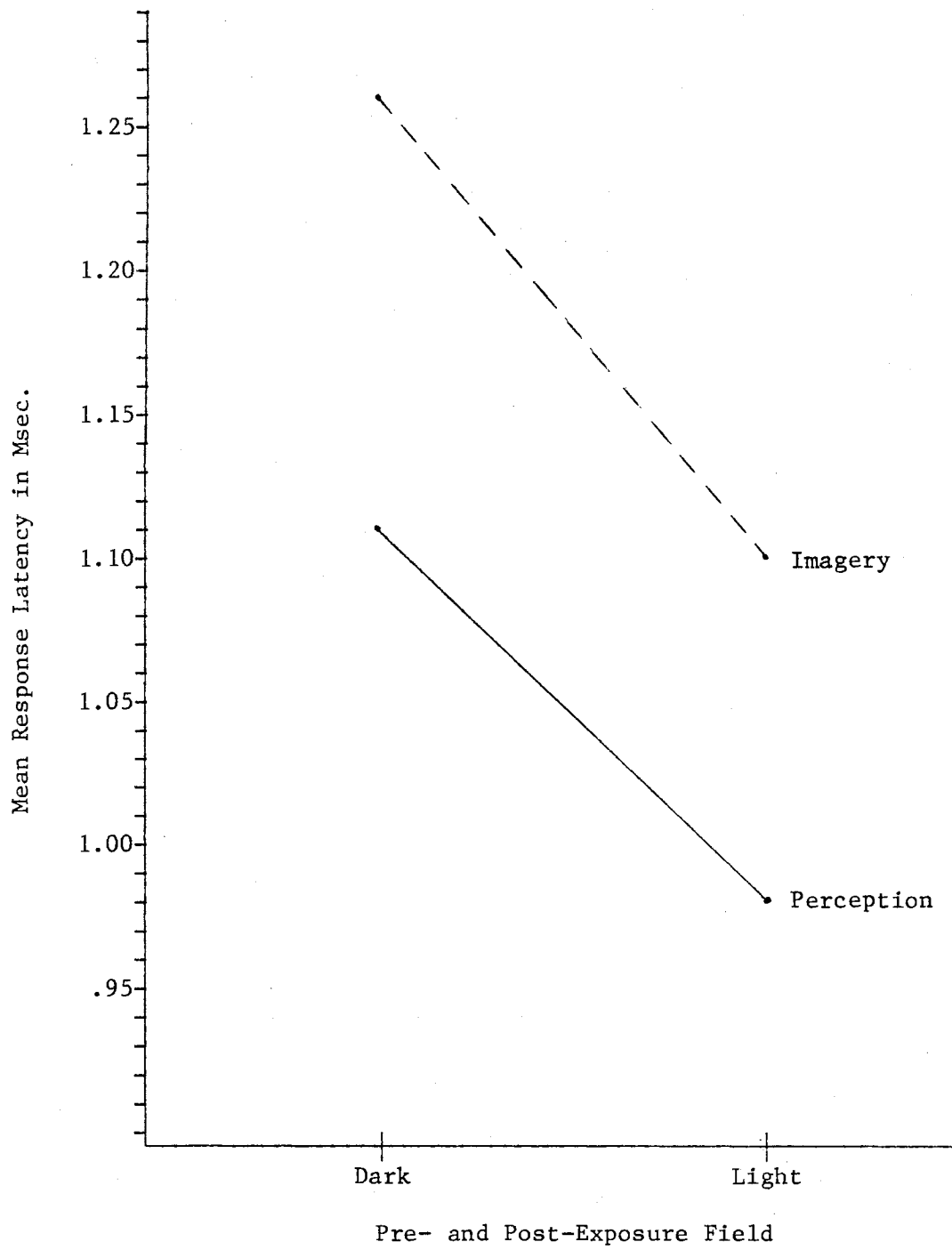


Figure 6. Imagery and Perception Conditions and Dark and Light Pre- and Post-Exposure Fields

positions. Thus, as Figure 7 depicts, perception produced significantly faster response latencies for the first, third, and fourth letter positions (each at the .05 level). As also depicted in Figure 7, the letter positions were significantly different from each other in both the perception ($p < .001$) and the imagery ($p < .001$) conditions.

To examine this position effect more closely Newman-Keuls tests were performed. The results are indicated by the letters adjacent to each plotted position in Figure 7. Within the range of each function, the letter positions having the same letter do not differ significantly; however, the letter positions having different letters do differ significantly. The Newman-Keuls tests are presented in Appendix H.

Thus, under the perception condition the response latencies for the third letter position are significantly higher than those for the first and fourth letter positions (each at $p < .05$), but not for those of the second letter position. Further, the second, first, and fourth letter positions do not differ significantly from one another. In the imagery condition the latencies for the third letter positions are significantly higher than the second ($p < .01$) and the first and fourth letter positions (each at $p < .05$). Further analysis (Appendix G) revealed that in the first half of the trials the third letter position was significantly higher than the fourth in the percept condition ($p < .05$). In the imagery condition it was significantly higher than all other letter positions ($p < .01$ for the first and fourth positions, $p < .05$ for the second). In the second half of the trials, however, there were no significant differences for latencies for the four letter positions in either perception or imagery conditions. Thus, the letter position was contained in the first half of the

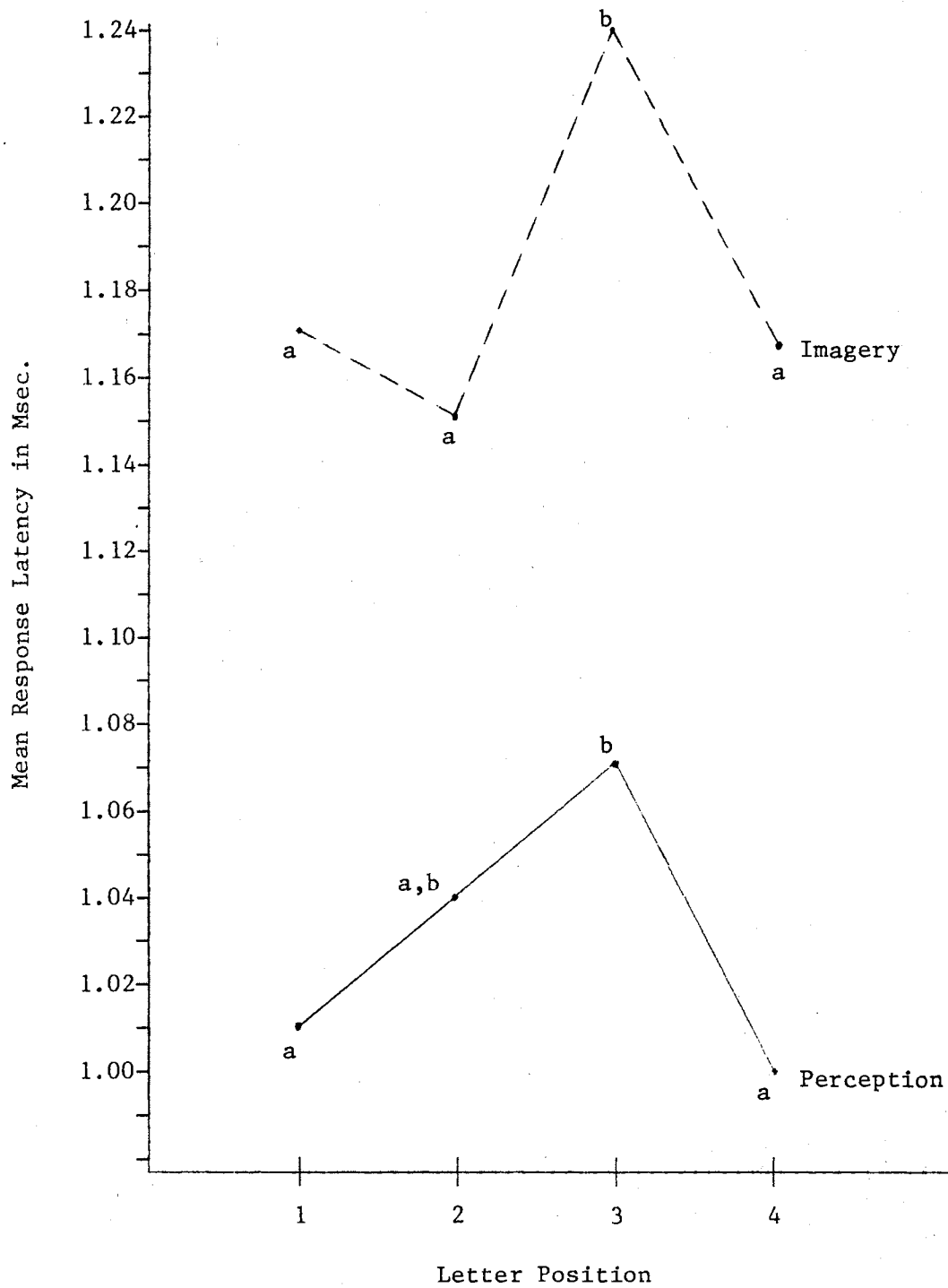


Figure 7. Perception and Imagery at the Four Letter Positions in Overall Analysis

trials and was produced by significantly higher response latencies in the third letter position. This effect was most pronounced in the imagery condition. These relationships are depicted in Figure 8.

The simple main effects tests performed on the visual field by letter position interaction also revealed significant differences. Figure 9 indicates significantly longer response latencies for right visual field at the second ($p < .01$) and the fourth ($p < .05$) letter positions. Figure 9 also depicts a significant difference between letter positions with left visual field presentation ($p < .01$), and a slightly less significant difference with right visual field presentation ($p < .05$).

In order to more clearly specify the relationships between letter positions and left and right visual field presentations, Newman-Keuls tests were performed (Appendix G). The results indicate that in the overall data analysis left visual field presentation results in the third letter position producing significantly longer response latencies than each of the other letter positions ($p < .01$ at each comparison), while the remaining three letter positions do not significantly differ from one another. The results also indicate no differences in letter positions for right visual field presentation. Further analysis of the data (Appendix G) revealed that this result is produced by significantly higher response latencies for the third letter position in the left visual field presentation for the first half of the trials only. In the second half of the trials there are no significant differences between any of the letter positions in either the left or the right visual fields. These results are depicted in Figure 10.

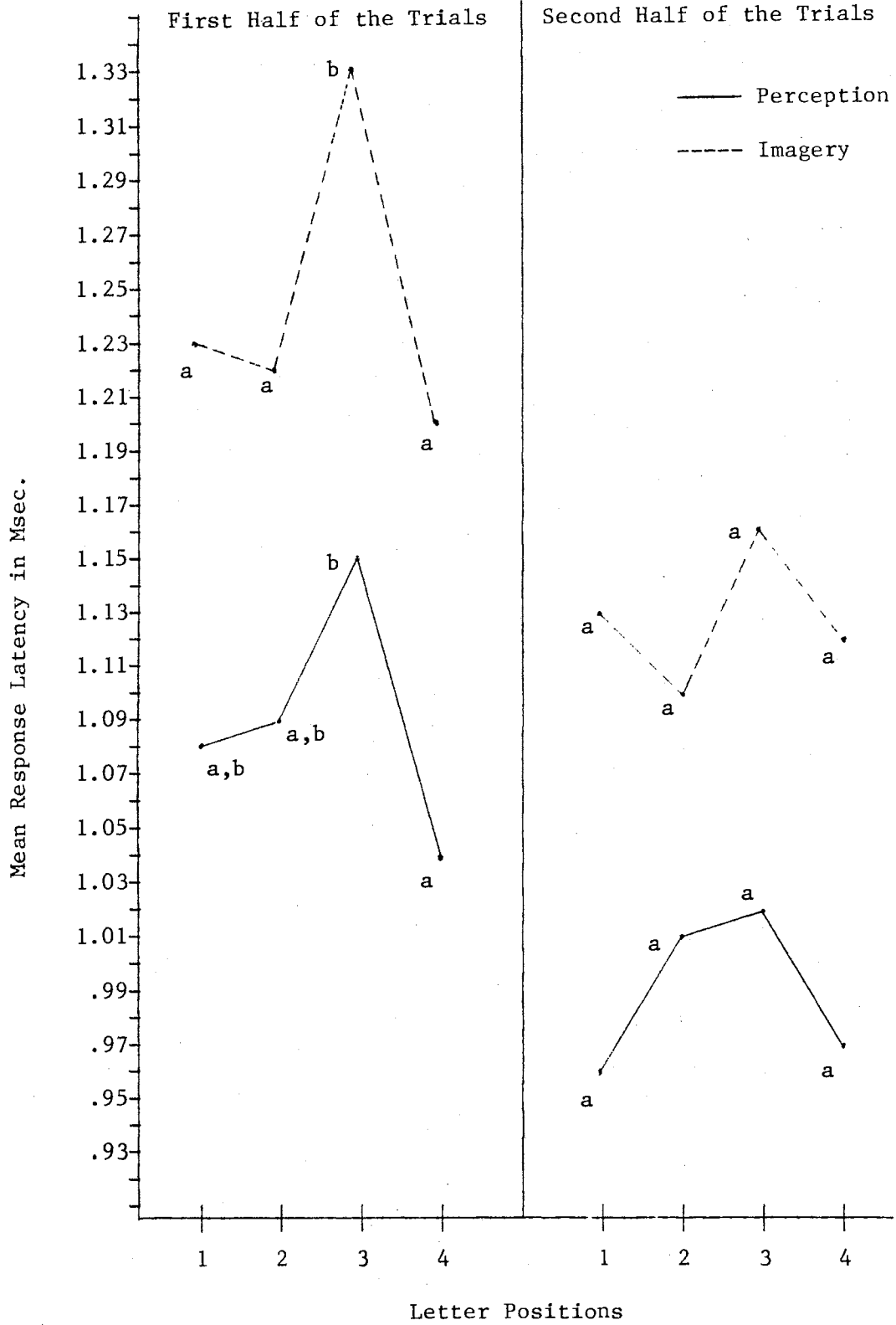


Figure 8. Perception and Imagery and the Four Letter Positions in the First and Second Halves of the Trials

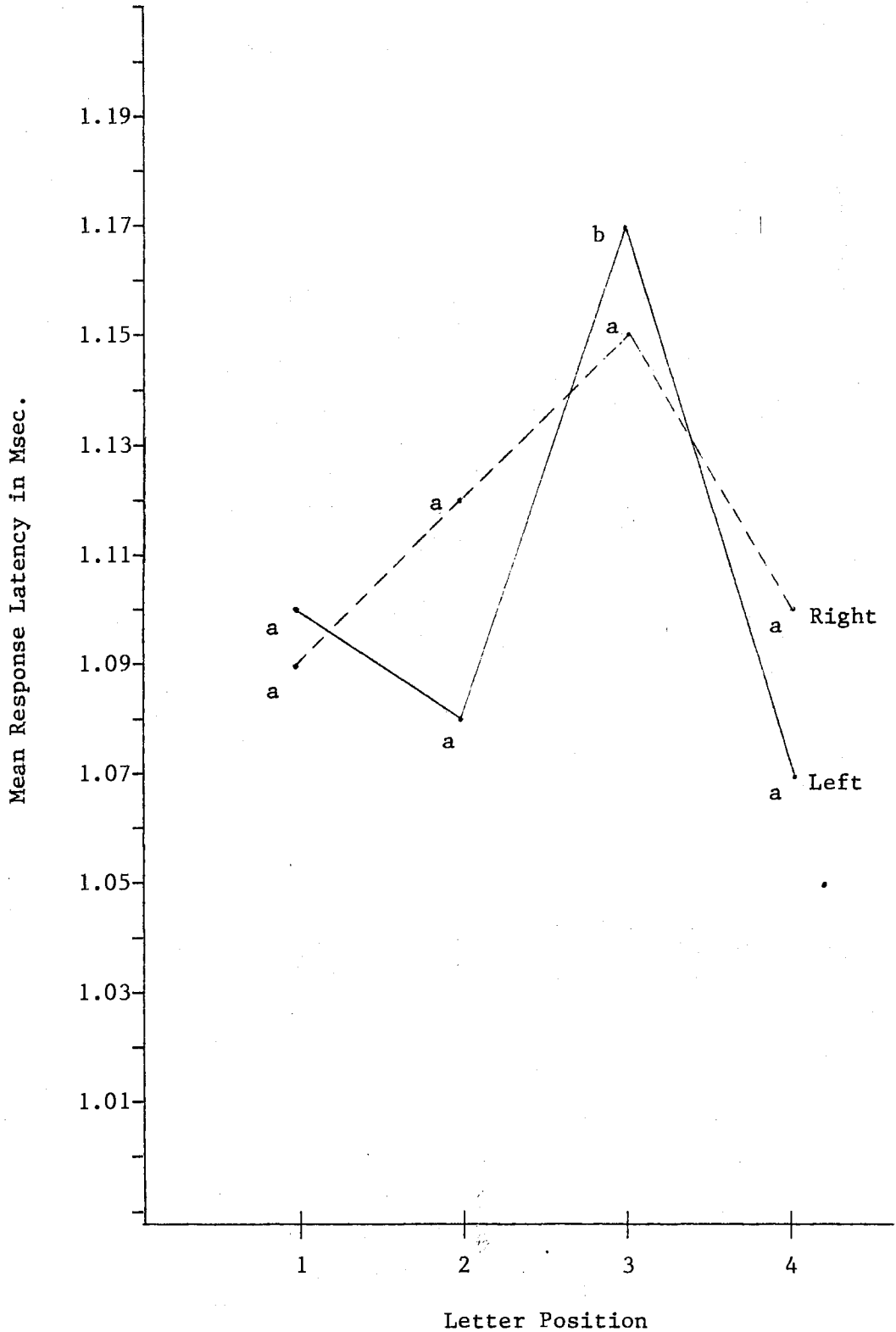


Figure 9. Left and Right Visual Fields at the Four Letter Positions in Overall Analysis

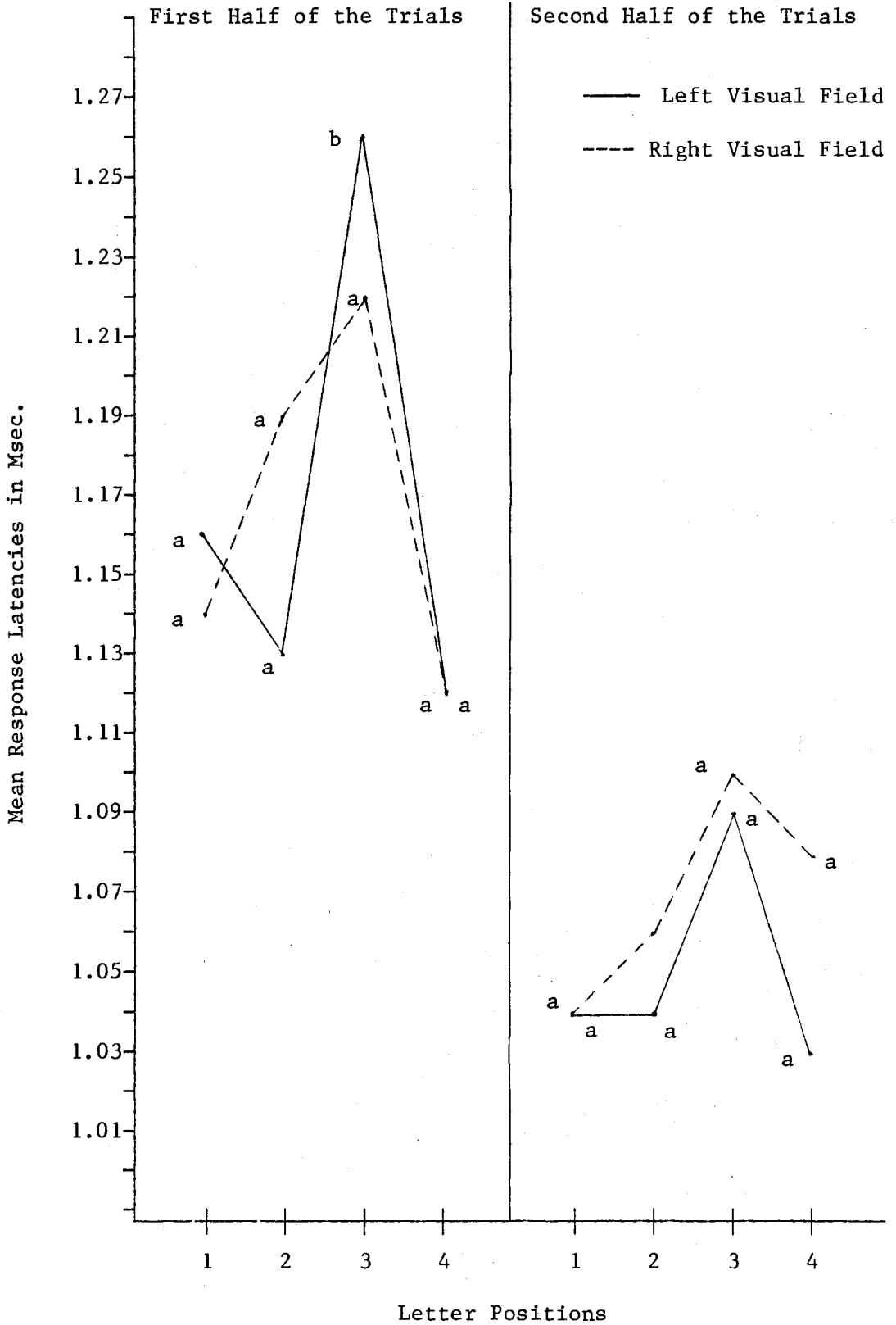


Figure 10. Left and Right Visual Fields at the Four Letter Positions in the First and Second Halves of the Trials

In summary, the results suggest that for the present study, the subjects were able to perform the perception task in less time than the imagery task. The dark pre- and post-exposure field effectively disrupted both perception and imagery, although its effect on imagery was more pronounced. A letter position effect was produced by significantly longer response latencies for the third letter position in the first half of the trials only. Finally, a difference in left and right hemispheric response latencies, while not occurring in the first half of the trials, did reveal a left visual field superiority for the second half of the trials. No S's in the imagery condition expressed any questions concerning the imagery task itself.

CHAPTER VI

DISCUSSION AND SUMMARY

Discussion

The overall finding that imagery processing produced longer response latencies than did perceptual processing was, of course, not surprising. The imagery processing required more complex processing (the formation of the image) than the perceptual processing task (although, as discussed below, other aspects of the two tasks may also have differed). Due probably to increased time needed for word recognition/identification, the mean response latency for the imagery condition was considerably longer (1.18 sec. for the overall analysis, 1.24 sec. for the first half of the trials and 1.13 sec. for the second half of the trials) than the processing times suggested by Weber and Castleman's (1970) study. These researchers found that nearly 2 letters could be processed per second. Weber and Bach (1969) similarly found that nearly 2.5 letters could be processed per second. In the earlier studies, however, the subjects' task was to process the entire alphabet one letter at a time and in sequence. Mean time to process each letter was then calculated by dividing the total time by 26. Weber, Kelly, and Little (1972) found that such sequencing between each letter is under verbal control. That is, in processing the sequential string of letters, S's name the individual next letter

before visualizing it and responding to its spatial characteristics. In the same study another experiment found that such an implicit verbal control is not involved in the processing of visual representations of words. The study used four letter words (like the stimuli used in the present study) and found that it was evidently possible to have all four letters in the visual image equally available for processing the spatial characteristics. Weber and Harnish (1974) have also found this same equal availability of individual letters in words using a probe technique (requiring individual decisions on single letters per trial) rather than sequential processing as the task. Indeed, in very short words (3 letters), they found no differences in processing for imagery and perception. This suggests why the differences in the perceptual and imagery processing were not very great in the present study. Weber and Harnish's (1974) technique, however, probed for the single letter in the percept condition while the subject had the actual stimuli before him. In the imagery condition the probe called for information about a single letter taken from an imagined visual representation of the word which had not been presented as a percept. In the present study, on the other hand, S's in the percept condition made their decisions based on visual iconic memory images of the stimuli rather than the actual continuously present stimuli. Subjects in the imagery condition had the stimuli presented to them perceptually and had then to build the image of the missing letter. As will be discussed below, these two differences, as well as the very brief (tachistoscopic) presentation of stimuli used in the present experiment, are important influences producing differences in the re-

results of the two studies in terms of processing times for imagining letters and making a decision concerning their spatial characteristics.

In the present experiment the dark pre- and post-exposure fields interrupted both the imagery and the perception tasks. Viewed in terms of the attempt to use the light and dark pre- and post-exposure fields as a mask for the imagery, this result is difficult to explain. Closer inspection of the results suggests possible processing patterns which do explain the finding, however. In masking with light the standard design uses a brief flash of light (TS) which is masked by a more intense flash of light of a larger area (MS) (Kahneman, 1968). Within this paradigm black figures on a white background have also been used, and it is well known that bright post-exposure fields lead to better masking (poorer visibility of the test stimulus) than dark post-exposure fields (Neisser, 1967). In the usual procedure, however, the intensity of the bright post-exposure field (MS) is more intense than that of the test stimulus (TS). In the present study black letters on a white ground were used and in the light condition the pre- and post-exposure fields were the same intensity as the test stimulus field. Direct comparisons to the masking literature are thus difficult to make. This limitation in the present study was necessary because only a two-channel tachistoscope-scope was available.

Sperling (1960), in studying the information available in brief visual presentations did one experiment which combined dark and light post-exposure fields (pre-exposure field was always dark) and tachistoscopic presentation of printed alphabetic stimuli. In this experiment the light post-exposure field was the same intensity as the stimulus field. His results showed that the light post-exposure field

greatly reduced the accuracy of both whole and partial reports of letters within an array. Sperling concluded, "The ability of a homogeneous visual stimulus to affect the available information is evidence that the process depends on a persisting visual image of the stimulus (Sperling, 1960, p. 27). Thus, the light post-exposure field masked the visual image (iconic memory) of the array, while the dark post-exposure field, in contrast, aided in its persistence. The icon can last up to 5 sec. in a dark post-exposure field, while it lasts less than half a second in a bright post-exposure field (Neisser, 1967).

Future work might include replications of Sperling's work using imagery. Visually presenting letters and giving an auditory command (at different intervals after the visual presentations) to imagine another letter and report its height would show if the letters are interfering with the image formation. Presentation of just the auditory command would help show that the disruption is or is not caused by the post-exposure fields themselves.

Thus, the results of the present study suggest that it is these persisting visual images of the stimulus (enhanced by the dark post-exposure field) which are interrupting the formation of the image of the missing letter in the imagery condition. A light post-exposure field might actually aid in the formation of the image by masking the disruptive images in the iconic memory. In both the perception and imagery conditions the persisting images seem to be interfering with spatial decision processes of the right hemisphere, much like the interference between vision and imagery found by Brooks (1968) and Segal and Fusella (1970, 1971). Thus, in the imagery condition the longer response latencies may be due to a combination of masking effects and

interference. If this is the case, one would expect an interaction between mode of processing and pre- and post-exposure fields in which imagery would be more strongly disrupted (or delayed) than perception in the dark pre- and post-exposure fields. While the interaction is present in the overall analysis, it appears even more strongly in the second half of the trials in which the subjects gave clearer evidence of successfully performing the imagery task without verbal interference. In future work the analysis of error data would also lend evidence to this point if more errors were made under conditions of dark pre- and post-exposure fields than under light in the imagery condition.

The suggestion is that in the percept condition it could be that both peripheral and central masking are occurring. Turvey (1973) produced a peripheral masking situation by directing both test stimulus and masking stimulus to the same hemiretina, and he produced central masking by directing the TS and the MS through different hemiretina to the same hemisphere. Both situations could have occurred in the present study. While it is difficult to make exact comparisons between the present experiment and Turvey's (1973) work (he used patterned masks in all of his experiments and, as mentioned above, he controlled for peripheral and central masking conditions with monoptic and dichoptic presentation of the TS and MS), some possible correlates and implications of his work for the present study can be drawn. He suggests, for example, that

when two stimuli compete for the services of peripheral systems, the greater energy event wins; on the other hand, when two stimuli compete for the services of the central decision process, the victor is likely to be the one that arrives second (Turvey, 1973, p. 39).

In Experiment XIX, Turvey (1973) tested the hypotheses that the situation in which target energy (stimulus field in the present study) was greater than the mask energy (black post-exposure field in the present study). He suggested that a very brief stimulus onset asynchrony (0 sec. in the present study) mask would fail to mask the target. In the case where the target intensity was less than the mask (possibly the light post-exposure field in the present experiment) the mask would mask the target. At this point any masking would be of a peripheral nature. With delayed stimulus onset asynchrony, however, masking switches to a central process in which both situations produce masking as the second stimulus (the MS or the post-exposure field in the present experiment) arrives later at the central processor. Thus, at one point the two functions cross as masking switches from being peripheral to central. In the case of the target energy being stronger than mask energy the central masking would not take place until stimulus onset asynchrony became so great that no masking occurred (the result would be a nonmonotonic U-shaped function usually found only in metacontrast situations in which TS and MS do not spatially overlap). In the case where the target energy is weaker than the mask energy, the masking effect would be great at short stimulus onset asynchrony, and would become less so with greater stimulus onset asynchrony time periods. At one point both cases ($TS < MS$ and $TS > MS$) would have the same masking effects. Then as the stimulus onset asynchrony became longer and longer, masking would become weaker and weaker in both cases until it no longer occurred. Turvey's experiment confirmed both hypotheses and the specific predictions. For Turvey's (1973) data (with 10 msec. exposures for both TS and MS) the two

functions approached each other in the stimulus onset asynchrony range of 48 to 72 msec. These figures are suggestive in conjunction with Gough's (1972) work on the events that transpire in one second of reading. According to his estimates, it takes at least 50 msec. and more likely nearly 100 msec. for an icon to develop, with a 150 msec. presentation the post-exposure field masking stimulus arrives within the next 50 msec. From the icon, letters are identified and read out starting from the time the icon is formed and at the rate of 10 to 20 msec. per letter. Using these approximations it is suggested that in the present study the perception condition leads to central masking in both the light and dark pre- and post-exposure field conditions. Masking is not complete, however, because readout of the letters has already begun. Longer response latencies in the dark condition were caused by visual interference from the persisting visual images which were not masked.

The letter position effect was caused entirely by the very long response latency of the third letter position. Furthermore, this finding of longer latencies as a significant effect was confined to the first half of the trials. Since this finding was unexpected, the stimuli presentation blocks were checked for possible bias toward early placement of the third letter position within the blocks. Four blocks of eight stimulus words were presented twice for the first and second halves of the trials. The order of the words was randomly selected for each of the eight blocks. Inspection showed, however, that in one half of the trials (first or second depending upon the subject) the third letter position is the test letter in the first word in three of the eight blocks (and it is the test letter in the

second word in the block in a fourth block). In the other half of the trials, however, the bias is even stronger as the third letter position is the test letter in the first word in five of the eight blocks (and it is the test letter in the second word in the block in two other blocks, as well as being the test letter in the second word in one block in which it also appears as the test letter in the first word). It would seem that the third letter position effect is created mainly by the early placement of the letter position within the stimuli blocks (and thus within the change to dark or light pre- and post-exposure fields). The effect was reduced with practice, however. There was no significant letter position effect in the second half of the trials.

Interactions between letter position and mode of processing and between letter position and visual presentation field, while they did appear in the overall analysis, were shown to be confined to the first half of the trials. Further, they were shown to be due mainly to a three way interaction which produced significantly higher response latencies in the third letter position in the imagery condition with left visual field presentation.

The interaction between letter position and mode of processing in which the imagery condition resulted in the highest response latency for the third letter position may have been contributed to by a phenomenon reported by Horowitz, White and Atwood (1968b). These researchers looked at the differences caused by different letter positions of the missing letters of the words. Their technique, however, was to use different word fragments to elicit the whole word. They presented fragments from the beginning, middle and end of words

to which the subjects had been previously exposed and asked them to recall the words. The middle fragment elicited the correct response least readily and with the longest latency. The beginning fragment gave the best cue for the word and the end fragment was better than the middle. Furthermore, the advantage of the beginning fragment over the end fragment was larger than that of the end fragment over the middle fragment. Thus, in the perception and imagery conditions, the third letter of the word may have produced longer response times due to there being less information in the fragment.

A letter position and visual field of presentation interaction may have been caused by a left visual field disadvantage. Fudin (1969, 1970) found there is a right visual field advantage for horizontal nonsense arrays tachistoscopically presented from the right and left visual fields successively (i.e., to one field at a time). In monoptic presentation of pattern arrays Fudin (1970) found that the nasal hemiretina has sharper acuity. Thus, when a word is presented in the right hemisphere, its most important section (i.e., its most informative fragment) is perceived more accurately. In left visual field presentation the effect of the nasal hemiretina is similar to that of the right visual field presentation. In this case, however, the most accurately perceived section of the word is not the most informative one. In the imagery condition when the third letter is missing there is very little information about the word available. Harcum and Dyer (1962) using a ten dot pattern presented simultaneously to left and right visual fields found that the ends of the pattern were perceived more accurately than the center sections of the pattern. Thus, since the left visual field presentation of stimuli in

the imagery condition with the third letter position letter missing contains little information as to the word and is perceived better than the more informative section of the word, there is the possibility for extremely high response latency scores for the third letter position.

The overall analysis of the data did not reveal the hemispheric differences expected if the subjects had been engaging in an imagery (spatial) task. The results were found in the second half of the trials, however. Even in this case the difference between the hemispheric processing times (taken to indicate the corpus callosum transfer time) was only 20 msec. as compared with the normal finding of 30 to 40 msec. Several problems with methodology in the present experiment may have contributed to this lack of hemispheric specificity. First, in the present experiment the subjects were shown the stimuli word with the missing letter in the imagery condition. According to Horowitz, Day, Light, and White (1968a) the word may have been verbally processed; then the missing letter would have been developed as an image and its spatial characteristic examined. These researchers presented S's with cards containing words with a missing letter. The S's had either to say the words or to say the missing letter. The S's were faster when they said the words.

Apparently the stimuli card elicited whole words rather than single letters. A single letter can certainly be said faster and there are fewer alternatives to choose from, but still the whole word seems to come to mind first. When the subject has to supply a letter he apparently thinks of the word first and then selects the appropriate letter out of it (Horowitz et al., 1968a, p. 72).

Horowitz et al. (1968a) conducted a related experiment in the same study. In this experiment one group of subjects learned nonsense

words in a paired associates task to a criterion of one perfect trial. A second group learned the same words in the PA task to a criterion of three perfect trials. When asked to say the nonsense words or to say the missing letter when presented cards as in the first experiment, the second group was much faster at saying the words than at saying the missing letter. The first group was about equal on both tasks. Horowitz et al. (1968a) concluded that as a word grows more familiar it becomes more available. As a word becomes more available, it develops the properties of a good gestalt. Thus, a fragment comes to elicit the whole word rather than the missing part.

This sequence of events would lead to a right visual field advantage, but such an advantage was not found. The 150 msec. presentation period was used in the present study to ensure recognition of the word, but eye movements can occur at this rate and if they did occur could have confounded any visual field superiority. Another problem is limited to the dark presentation field. In this condition, a white pinpoint of light was used for the fixation point in the pre- and post-exposure fields. Due to the time necessary to change the stimuli cards in the tachistoscope there is sufficient time for the autokinetic effect to emerge. After the ninth subject spontaneously reported the effect, all subjects were questioned as to whether they had experienced the effect. All but two of the subjects so questioned reported the effect. Although there is some controversy as to whether the effect is caused by eye movement (Spigel, 1965), the effect may have confounded the results in this condition. Finally, the use of the bar marker to indicate the letter to be processed in the percept condition may have acted as a mask for that letter. In future

research the use of shorter presentation times, a three channel tachistoscope in which the fixation point can be presented for a short period before the stimulus presentation and the use of tonal markers after the presentation might produce cleaner results.

Further research in this area is obviously warranted. Certainly Turvey's (1973) work in central and peripheral masking suggests replication studies using imagery rather than perceptual stimuli. The greater the understanding of the areas of central and peripheral masking and hemispheric specialization, the more tools there will be available to study the nature of imagery.

Finally, while the imagery was effectively disrupted in the present study, more research is needed to more clearly define the effect. Erdalyi (1974) suggests that we do not know exactly where perception takes place in the central processing mechanism. Perception is encoded into long-term memory, however. If as Seamon and Gazzaniga (1972) suggest, the encoding can be either of a verbal or a visual nature, the key to the controversy may lie here. Thus, when encoding is done in a visual (spatial) manner, imagery may be very much like "perception." When encoding is done in a verbal manner, however, imagery may be very little like "perception."

Summary

The purpose of the present study was to study the nature of imagery. Specifically, it was hoped that the experiment would contribute to the investigation of the question regarding imagery's similarity to perception. It was reasoned that if imagery and perception are similar in nature, then variables which affect perception ought to

affect imagery similarly. One such variable is the eyeblink. In perception the eyeblink can shut off incoming information, facilitate changes in focus and fixation, and provide added processing time for information (as blinks of technique in reading). Aspects of blinking also suggest correlates with the masking literature. It was suggested that in imagery, the blink might serve to mask or erase imagery. Work by Holland and Tarlow (1972) indicates that mental load affects blink rate. Indeed, they suggest that blinks might disrupt certain cognitive processes. It is suggested that visual imagery processing is one such cognitive process. In order to get a cleaner measure of imagery processing, the split-brain paradigm with normal subjects was used in the present experiment.

Tachistoscopic presentation of four letter words in conditions of dark and light pre- and post-exposure fields was used. Presentation was from the left or right visual presentation field. Subjects in the percept condition were presented the entire word with a bar marker over one of the letters. They were instructed to respond to the vertical height of the marked letter. Subjects in the imagery condition received the same words with one of the letters missing, and with a bar marker over the space where the letter would normally have appeared. They were instructed to imagine and respond to the vertical height of the missing letter. A bimanual response was used in order not to bias either hemisphere.

The results showed that the dark and light pre- and post-exposure fields did disrupt processing in the imagery and the perception conditions. It is suggested, however, that for perception the disruption was caused by masking in the light condition and by a combination of

masking and visual interference with the spatial decision process in the dark condition. For imagery, the masking of the percept in the light condition may have aided image formation, while persistence of the percepts in the dark condition may have hindered image formation as well as caused visual interference with the spatial decision once the image was formed. Hemispheric specialization effects while present were not strong and emerged only with practice. Methodological problems were suggested as reasons for this finding and suggestions were made for improvement in future research.

As a beginning step in the study of the possible masking effects on imagery, the present experiment is most valuable in pointing out areas for further research. Methodological problems make definitive conclusions on the basis of the present work impossible. Suggested future research in the areas outlined are expected to contribute to the knowledge of the nature of imagery.

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APPENDIXES

APPENDIX A

HANDEDNESS QUESTIONNAIRE

Handedness Questionnaire

Name _____ Phone _____

- I. Which hand do you use to perform each of the following activities? (Check the appropriate answer.)

	Right Hand	Left Hand	Either Hand
1. Write			
2. Throw a ball			
3. Hammer			
4. Pull back a bow string and arrow			
5. Use a racket (e.g., tennis, ping pong, etc.)			
6. Hold a match while striking it			
7. Use a toothbrush			
8. Hold the thread when threading a needle			
9. Use a table knife			
10. Use a spoon			
11. Hold a glass when drinking from it			

- II. Were any of the following relatives left-handed? (Check the appropriate answer.)

	Yes	No	Don't know or Not applicable
1. Mother			
2. Father			
3. Sisters			
4. Brothers			
5. Grandmothers			
6. Grandfathers			

III. Do you wear glasses? _____ Contact lenses? _____

APPENDIX B

INSTRUCTIONS

The following instructions were read to each S after he was seated in front of the viewing hood of the tachistoscope. The instructions given here are for the perception condition. When different from the perception condition, the instructions for the imagery condition are given within brackets immediately following those for the perception condition.

I am interested in finding out how fast people can process information. In particular I want to find out how fast you can make a decision about letters of the alphabet.

When we look at lowercase typed letters like these (E₁ presents S with a card containing the alphabet typed in lowercase letters), we see that they can be divided into two classes according to height. Thus, the letters are either large or not large. If a letter is large, let's label it "yes" and if it is not large, let's label it "no." For example . . . (E points to appropriate example letters in the list and labels them. Included are "problem" letters "i," "j" and "t.") Now I'm going to point to each letter and I want you to say "yes" or "no" according to whether the letter is large or not large. A large letter is "yes" and a letter which is not large is "no." (E₁ points to successive letters in the list and S labels them "yes" or "no." If S makes mistakes, E₁ corrects him.)

After you familiarize yourself with a list of eight words, I am going to show you one word at a time in this apparatus. Each word will have four letters and will appear very briefly. In each of the words there will be a bar marker over one of the letters. It will look like this. [In each of the words there will be a letter missing. The space where the letter should be will have a bar marker over it like this.] (E₁ shows S an example printed on a card.) Your task will be to decide as quickly as you can whether the letter which is indicated by the bar marker is large (that is, a "yes" letter) or not large (that is, a "no" letter) as we discussed already. Do you have any questions so far? [Your task will be to decide as quickly as you can whether the missing letter is large (that is, a "yes" letter) or not large (that is, a "no" letter) as we discussed already. Since the actual letter will be missing, you will have to visually imagine the missing letter in order to make your decision concerning its height. Imagining something visually is like picturing it in your mind. Do you have any questions so far? (E₁ makes a note if any S's express questions about the imagery task.)]

If you look through this viewer with both eyes, you will sometimes see a black dot on a white ground, like this. (S looks through viewer. E₂ adjusts the tachistoscope settings.) At other times you will see blackness with a white dot of light like this. (S looks through viewer.) Try to fixate on this dot before each word is shown. The dot marks the midpoint in the viewing field. The words will appear on either side of the midpoint (sometimes on the left, sometimes on the right), so that fixating on the dot will help you to get the most letters consistently correct.

If you decide that the marked [missing] letter is large, I want you to press these two outer (inner) switches with your two middle (index) fingers, like this. (E demonstrates.) If the marked [missing] letter is not large, then press these two inner (outer) switches with your two index (middle) fingers, like this. (E₁ demonstrates.) Now you try it. Press the switches to indicate a "yes" letter. (S presses the switches.) Press the switches to indicate a "no" letter. (S presses the switches.)

Let's practice with these two words. (E₁ shows S two practice words typed in lowercase letters on a card. The words appear within brackets.) Familiarize yourself with these words while we set up the apparatus. (E₂ adjusts the tachistoscope settings.) Now let's try a few practice trials. When you look through the viewer, fixate on the midpoint. I will say "set" and the word will be presented to you. You must then visually imagine the missing letter and decide whether it is large or not large. Try to respond as quickly as possible while striving for 100% accuracy. Remember to use your two middle (index) fingers to indicate a large letter and your two index (middle) fingers to indicate a letter which is not large. Press with the corresponding fingers from both hands each time you make a response. Any questions? Now put your fingers in position, look into the viewer and we will begin. (S is given 4 practice trials. The practice trials give the S experience with left and right visual fields, "yes" and "no" responses, and dark and light masks. S is not told whether or not his responses are correct or incorrect.)

Now I'd like you to familiarize yourself with these eight words. In a minute I'm going to give you a spelling test on them. (E₁ gives S a card with the eight stimulus words typed in lowercase letters within brackets. S studies the list while E₂ adjusts the tachistoscope settings and readies the stimulus cards.) Now I'd like you to take a short spelling test on the words. (E₁ takes the card with the 8 words from the S and gives S a small piece of paper with 8 numbered lines on it and a pencil.) As I say the word, just write it out on this paper. Please print. (E₁ says each word in order from the card. S writes out each word. E₁ watches and knows S's score by the time he is done.) That's perfect.

Remember, when you look through the viewer, try to fixate on the midpoint. I will say "set" and the word will be presented to you. You must then decide as quickly as you can whether the letter which is indicated by the bar marker is large or not large. [You must then visually imagine the missing letter and decide whether it is large or not large.] Try to respond as quickly as possible while striving for 100% accuracy. Remember to use your two index (middle) fingers to indicate a large letter and your two middle (index) fingers to indicate a letter which is not large. Press with the corresponding fingers from both hands each time you make a response. Any questions? O.K. If you'll get ready, then we'll get started. I know there is no room for your knees, so if you get cramped just let us know and we'll

rest for a short while. (S is given 64 trials.) O.K. We're half-way done. You may stretch for a minute if you'd like, while we get ready for the second half. Are you all ready? (S is given 64 trials.)

APPENDIX C

TABLE OF MEANS AND STANDARD DEVIATIONS FOR
EACH CONDITION OF OVERALL ANALYSIS

Mode of Processing	Pre- and Post- Exposure Field	Visual Field	Letter Position	Mean	Standard Deviation
Percept	Dark	Left	1	1.0601	.2262
			2	1.0945	.1952
			3	1.1283	.2293
			4	1.0614	.1952
		Right	1	1.0678	.2430
			2	1.1281	.2229
			3	1.1265	.2638
			4	1.0938	.1894
	Light	Left	1	.9678	.2119
			2	.9732	.2465
			3	1.0415	.2327
			4	.9246	.1892
		Right	1	.9617	.2251
			2	.9884	.2133
			3	1.0171	.2505
			4	.9382	.1993
Imagery	Dark	Left	1	1.2812	.1820
			2	1.1906	.1343
			3	1.3231	.1770
			4	1.2408	.1762
		Right	1	1.1987	.1570
			2	1.2492	.1418
			3	1.3194	.1809
			4	1.2728	.1692
	Light	Left	1	1.0837	.1372
			2	1.0569	.1402
			3	1.1754	.1585
			4	1.0605	.1533
		Right	1	1.1282	.1103
			2	1.1104	.1674
			3	1.1357	.1900
			4	1.0958	.1438

APPENDIX D

TABLE OF MEANS FOR FIRST AND SECOND
HALVES OF THE TRIALS

FIRST HALF OF THE TRIALS

Mode of Processing	Pre- and Post- Exposure Field	Visual Field	Letter Position	Mean
Percept	Dark	Left	1	1.1262
			2	1.1144
			3	1.2106
			4	1.1289
	Right	1	1.1397	
		2	1.1858	
		3	1.2226	
		4	1.1250	
Imagery	Dark	Left	1	1.0071
			2	1.0428
			3	1.0931
			4	.9688
	Right	1	1.0402	
		2	1.0172	
		3	1.0607	
		4	.9515	
Imagery	Dark	Left	1	1.3445
			2	1.2497
			3	1.4628
			4	1.2490
	Right	1	1.2133	
		2	1.3562	
		3	1.3896	
		4	1.2892	
Imagery	Light	Left	1	1.1759
			2	1.1006
			3	1.2772
			4	1.1486
	Right	1	1.1742	
		2	1.1904	
		3	1.1899	
		4	1.1227	

SECOND HALF OF THE TRIALS

Mode of Processing	Pre- and Post- Exposure Field	Visual Field	Letter Position	Mean
Percept	Dark	Left	1	1.0058
			2	1.0799
			3	1.0557
			4	1.0030
		Right	1	1.0084
			2	1.0784
			3	1.0543
			4	1.0664
	Light	Left	1	.9298
			2	.9288
			3	.9999
			4	.8846
Right		1	.8971	
		2	.9620	
		3	.9832	
		4	.9230	
Imagery	Dark	Left	1	1.2244
			2	1.1408
			3	1.2122
			4	1.2352
		Right	1	1.1937
			2	1.1776
			3	1.2591
			4	1.2511
	Light	Left	1	1.0087
			2	1.0213
			3	1.0921
			4	.9825
Right		1	1.0885	
		2	1.0435	
		3	1.0931	
		4	1.0761	

APPENDIX E

SUMMARY OF ANALYSIS OF VARIANCE FOR MEAN
RESPONSE LATENCIES IN FIRST HALF
OF THE TRIALS

SUMMARY OF THE ANALYSIS OF VARIANCE FOR MEAN
RESPONSE TIMES IN FIRST HALF OF THE TRIALS

Source	Degrees of Freedom	MS	F
Between Subjects			
Mode of Processing (A)	1	2.3425	3.5054*
Subj. W. Groups	22	.6682	
Within Subjects			
Pre- and Post-Exposure (B)	1	1.8925	99.5588****
A x B	1	.0040	.2086
B x Subj. W. Groups	22	.0190	
Visual Field (C)	1	.0004	.0318
A x C	1	.0067	.5674
C x Subj. W. Groups	22	.0118	
Letter Position (D)	3	.2344	13.9608****
A x D	3	.0102	.6072
D x Subj. W. Groups	66	.0168	
B x C	1	.0039	.4026
A x B x C	1	.0105	1.0750
B x C x Subj. W. Groups	22	.0098	
B x D	3	.0152	1.1034
A x B x D	3	.0093	.6758
B x D x Subj. W. Groups	66	.0138	
C x D	3	.0493	4.3782***
A x C x D	3	.0356	3.1626**
C x D x Subj. W. Groups	66	.0113	
B x C x D	3	.0211	1.4096
A x B x C x D	3	.0076	.5058
B x C x D x Subj. W. Groups	66	.0150	

* $p < .10$

** $p < .05$

*** $p < .01$

**** $p < .0005$

APPENDIX F

SUMMARY OF ANALYSIS OF VARIANCE FOR MEAN
RESPONSE LATENCIES IN SECOND HALF
OF THE TRIALS

SUMMARY OF THE ANALYSIS OF VARIANCE FOR MEAN
RESPONSE TIMES IN SECOND HALF
OF THE TRIALS

Source	Degrees of Freedom	MS	F
Between Subjects			
Mode of Processing (A)	1	1.8805	4.1552*
Subj. W. Groups	22	.4526	
Within Groups			
Pre- and Post-Exposure (B)	1	1.7043	111.7106*****
A x B	1	.0741	4.8602**
B x Subj. W. Groups	22	.0152	
Visual Field (C)	1	.0461	3.9581*
A x C	1	.0122	1.0448
C x Subj. W. Groups	22	.0116	
Letter Position (D)	3	.0466	5.2966****
A x D	3	.0379	4.3073***
D x Subj. W. Groups	66	.0088	
B x C	1	.0028	.2546
A x B x C	1	.0107	.9664
B x C x Subj. W. Groups	22	.0111	
B x D	3	.0198	2.2929*
A x B x D	3	.0107	1.2408
B x D x Subj. W. Groups	66	.0086	
C x D	3	.0117	1.5975
A x C x D	3	.0017	.2275
C x D x Subj. W. Groups	66	.0073	
B x C x D	3	.0054	.6135
A x B x C x D	3	.0140	1.6060
B x C x D x Subj. W. Groups	66	.0087	

* $p < .10$

** $p < .05$

*** $p < .01$

**** $p < .005$

***** $p < .00005$

APPENDIX G

SIMPLE EFFECTS SUMMARY TABLE

Source	SS	df	MS	F
Bet. Subjects				
Bet. A at b_1	1.298	1	1.298	4.9412*
Bet. A at b_2	.802	1	.802	3.0530
Error A at b_j	11.5583	44	.26269	
Bet. A at d_1	.604	1	.604	4.4914*
Bet. A at d_2	.269	1	.269	2.0003
Bet. A at d_3	.614	1	.614	4.5657*
Bet. A at d_4	.638	1	.638	4.7442*
Error A at d_1	11.8342	88	.13448	
Within Subjects				
Bet. B at a_1	.675	1	.675	69.9622*****
Bet. B at a_2	1.134	1	1.134	117.5365*****
Error B at a_i	.02122	22	.009648	
Bet. D at a_1	.162	3	.054	7.3011*****
Bet. D at a_2	.212	3	.071	9.5455*****
Error D at a_i	.48815	66	.007396	
Bet. C at d_1	.002	1	.002	.4902
Bet. C at d_2	.039	1	.039	9.5588***
Bet. C at d_3	.007	1	.007	1.7157
Bet. C at d_4	.020	1	.020	4.9020*
Error C at d_1	.35904	88	.00408	
Bet. D at c_1	.273	3	.091	16.1792*****
Bet. D at c_2	.102	3	.034	6.0450**
Error D at c_k	.589434	132	.0056245	

* $p < .05$

** $p < .001$

*** $p < .005$

**** $p < .0005$

APPENDIX H
NEWMAN-KEULS TESTS

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN OVERALL DATA
ANALYSIS (PERCEPTION CONDITION)

Letter Position	4	1	2	3			
Means	1.0045	1.0143	1.0460	1.0784	r	$q_{.95}(r,66)$	$s_{\bar{d}}q_{.95}(r,66)^a$
4		.0098	.0415	.0739*	3	3.74	.0656
1			.0317	.0641*	2	3.40	.0597
2				.0324	1	2.83	.0497

$$^a s_{\bar{d}} = .01755$$

$$* p < .05$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN OVERALL DATA
ANALYSIS (IMAGERY CONDITION)

Letter Position	2	4	1	3			
Means	1.1518	1.1675	1.1729	1.2384	r	$q_{.95}(r,66)$	$s_{\bar{d}}q_{.95}(r,66)^a$
2		.0157	.0211	.0866**	4	3.74	.0656
4			.0054	.0709*	3	3.40	.0597
3				.0655*	2	2.83	.0497

$$^a s_{\bar{d}} = .01755$$

$$**q_{.99}(2,66) = 4.59; s_{\bar{d}}q_{.99}(2,66) = .0806; p < .01$$

$$* p < .05$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN FIRST HALF OF
TRIALS (PERCEPTION CONDITION)

Letter Position	4	1	2	3			
Means	1.0435	1.0783	1.0900	1.1467	r	$q_{.95}(r,66)$	$s_{\bar{d}}q_{.95}(r,66)^a$
1		.0348	.0465	.1032*	4	3.74	.0989
2			.0117	.0684	3	3.40	.0899
3				.0567	2	2.83	.0748

$$^a s_{\bar{d}} = .02645$$

$$* p < .05$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN FIRST HALF OF
TRIALS (IMAGERY CONDITION)

Letter Position	4	2	1	3			
Means	1.2024	1.2242	1.2270	1.3299	r	$q_{.99}(r,66)$	$s_{\bar{d}}q_{.99}(r,66)^a$
4		.0218	.0246	.1275**	4	4.59	.1214
2			.0028	.1057*	3	4.28	.1132
1				.1029**	2	3.76	.0994

$$^a s_{\bar{d}} = .02645$$

$$* q_{.95}(2,66) = 3.40; s_{\bar{d}}q_{.95}(2,66) = .0899; p < .05$$

$$** p < .01$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN SECOND HALF OF
TRIALS (PERCEPTION CONDITION)

Letter Position	1	4	2	3			
Means	.9602	.9692	1.0123	1.0233	r	$q_{.95}(r,66)$	$s_d q_{.95}(r,66)^a$
1		.0090	.0521	.0631	4	3.74	.0716
4			.0431	.0541	3	3.40	.0651
2				.0110	2	2.83	.0542

$$^a s_d = .01914$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN SECOND HALF OF
TRIALS (IMAGERY CONDITION)

Letter Position	2	1	4	3			
Means	1.0958	1.1288	1.1362	1.1641	r	$q_{.95}(r,66)$	$s_d q_{.95}(r,66)^a$
2		.0330	.0404	.0683	4	3.74	.0716
1			.0074	.0353	3	3.40	.0651
4				.0279	2	2.83	.0542

$$^a s_d = .01914$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN OVERALL DATA
ANALYSIS (LEFT VISUAL FIELD
PRESENTATION)

Letter Position	4	2	1	3			
Means	1.0718	1.0788	1.0982	1.1671	r	$q_{.99}(r,66)$	$s_{\bar{d}}q_{.99}(r,66)^a$
4		.0070	.0264	.0953**	4	4.59	.0806
2			.0194	.0883**	3	4.28	.0751
1				.0689**	2	3.76	.0660

$$^a s_{\bar{d}} = .01755$$

** $p < .01$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN OVERALL DATA
ANALYSIS (RIGHT VISUAL FIELD
PRESENTATION)

Letter Position	4	1	2	3			
Means	1.0891	1.1002	1.1190	1.1497	r	$q_{.99}(r,66)$	$s_{\bar{d}}q_{.99}(r,66)^a$
1		.0111	.0299	.0606	4	4.59	.0806
			.0188	.0495	3	4.28	.0751
				.0307	2	3.76	.0660

$$^a s_{\bar{d}} = .01755$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN FIRST HALF OF
TRIALS (LEFT VISUAL FIELD
PRESENTATION)

Letter Position	4	2	1	3			
Means	1.1238	1.1268	1.1634	1.2609	r	$q_{.99}(r,66)$	$s_{\bar{d}}q_{.99}(r,66)^a$
4		.0030	.0396	.1371**	4	4.59	.1214
2			.0366	.1341**	3	4.28	.1132
1				.0975*	2	3.76	.0994

$$^a s_{\bar{d}} = .02645$$

$$* q_{.95}(2,66) = 2,83; s_{\bar{d}}q_{.95}(2,66) = .0748; p < .05$$

$$**p < .01$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN FIRST HALF OF
TRIALS (RIGHT VISUAL FIELD
PRESENTATION)

Letter Position	4	1	2	3			
Means	1.1221	1.1419	1.1874	1.2156	r	$q_{.95}(r,66)$	$s_{\bar{d}}q_{.95}(r,66)^a$
4		.0198	.0653	.0935	4	3.74	.0989
1			.0455	.0737	3	3.40	.0899
2				.0282	2	2.83	.0748

$$^a s_{\bar{d}} = .02645$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN SECOND HALF OF
TRIALS (LEFT VISUAL FIELD
PRESENTATION)

Letter Position	4	1	2	3			
Means	1.0263	1.0422	1.0427	1.0900	r	$q_{.95}(r,66)$	$s_{\bar{d}} q_{.95}(r,66)^a$
4		.0159	.0164	.0637	4	3.74	.0716
1			.0005	.0478	3	3.40	.0651
2				.0473	2	2.83	.0542

$$^a s_{\bar{d}} = .01914$$

NEWMAN-KEULS TEST ON RESPONSE LATENCIES FOR
LETTER POSITIONS IN SECOND HALF OF
TRIALS (RIGHT VISUAL FIELD
PRESENTATION)

Letter Position	1	2	4	3			
Means	1.0469	1.0654	1.0791	1.0974	r	$q_{.95}(r,66)$	$s_{\bar{d}} q_{.95}(r,66)^a$
1		.0185	.0322	.0505	4	3.74	.0716
2			.0137	.0320	3	3.40	.0651
4				.0183	2	2.83	.0542

$$^a s_{\bar{d}} = .01914$$

2
VITA

Marilyn McNabb Mallue

Candidate for the Degree of

Master of Science

Thesis: HEMISPHERIC SPECIALIZATION AND VISUAL MASKING OF PERCEPTION
AND IMAGERY

Major Field: Psychology

Biographical:

Personal Data: Born in Harvey, Illinois, March 10, 1946, the daughter of William L. and Ruth A. McNabb, married Henry E. Mallue, Jr., August 2, 1970.

Education: Graduated from Dixie M. Hollins High School, St. Petersburg, Florida, in June, 1964; received the Associate of Arts degree in May, 1966, from St. Petersburg Junior College, St. Petersburg, Florida; received the Bachelor of Arts degree with honors (with a major in English literature) in June, 1968, from the University of Florida, Gainesville, Florida; received the Bachelor of Arts degree (with a major in psychology) in June, 1972, from Florida Technological University, Orlando, Florida; completed requirements for the Master of Science degree at Oklahoma State University, Stillwater, Oklahoma, in December, 1974.

Professional Experience: Graduate Research Assistant, Department of Psychology, Oklahoma State University, 1972-73; Graduate Teaching Assistant, Department of Psychology, Oklahoma State University, 1973-74.

Professional Memberships: Midwestern Psychological Association, Phi Beta Kappa, Phi Kappa Phi.