Recognition of Verbal and Non-Verbal Stimuli in the
Lateral Visual Fields in Normal Children and
Those Manifesting Learning Disabilities

A Dissertation Presented to

the Faculty of the Department of Psychology
University of Houston

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

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by

James Felix Koetting

December, 1977

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ABSTRACT

In 1970, Koetting reported on an investigation concerning the ability to recognize words in each of the four lateral visual fields, noting that there is a significant superiority with respect to this ability in both components of the right field--especially the nasal field of the left eye. There is also evidence that such differences in recognition are a product of learning to read, and that they do not occur with non-verbal targets. To explore these latter contentions, this study was introduced in an attempt to demonstrate differences between groups of normal children and those designated as having learning-disabilities through use of verbal targets; and, the absence or other differences in the phenomenon in both groups using non-verbal targets. It involved the discrete tachistoscopic presentation of verbal and non-verbal stimuli in the four lateral parafoveal fields at a fixed lateral displacement from a point of fixation. Subjects were forty ten-year-old children--32 in the normal group and 8 in the learning-disabilities group.

A superiority of performance was found in the total right visual field for both verbal and non-verbal treatments in normal children at the .05 and .01 level of confidence, respectively; it was absent in children manifesting learning-disabilities. This evidence suggests that in normal children the phenomenon in which language skills are observed to be better established in the left cerebral hemisphere is only one manifestation of an overall propensity for the left cerebral hemisphere to process gestalts, and that this propensity is not as well established in ten-year-old children having learning-disabilities as in ten-year-old normal children. There are indications that in learning-disabilities children the decrement in the ability to more efficiently process verbal material is in the left-nasal component of the

right field, and non-verbal material in both the left-nasal and right-temporal components. There are also indications of a superiority for processing verbal gestalts via inputs from the left-nasal field and from the right-temporal field for non-verbal gestalts, favoring the normal group; and, an increased capacity in the left-temporal field with respect to both verbal and non-verbal gestalts favoring the learning-disabilities group.

Supported are positions that the portion of the brain used for processing a given type of input is determined by the nature of the input, and that this triggering mechanism is at least partially learned during a child's development.

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CHAPTER I

INTRODUCTION

Koetting (1970) reported on an investigation concerning the ability to recognize words in each of the four lateral visual fields. Using forty-six fifth grade elementary school children as subjects, he presented 3-letter English words tachistoscopically, and discretely, in a stereoscopic viewing device at positions laterally displaced from a central point of fixation, and at a typical reading distance from the subject's eyes.

In comparing total correct identifications of words in both of the right visual fields (i.e., the total of scores for the right field of the right eye and the right field of the left eye) to those of the left visual fields, he found a significant difference favoring total performance in the right field. Further, in comparing total scores mediated by the right eye (i.e., the total scores for the right field of the right eye and the left field of the right eye) and those mediated by the left eye, he found a significant difference favoring the left eye. In comparing scores in the temporal field of the left eye and the nasal field of the left eye, he found a significant difference favoring the nasal field of the left eye (I_2--See below).

Koetting referred to these systematic differences in word recognition between and among the four lateral visual fields as the "Iota Phenomenon." He later suggested that the Iota Phenomenon be described in terms of its four components, Iota 1 (I_1), Iota 2 (I_2), Iota 3 (I_3), and Iota 4 (I_4)--indicating for a given subject the scores for word recognition in the left-eye temporal field, left-eye nasal field, right-eye nasal field, and right-eye temporal field, respectively.

Reviewing his own observations and the studies and thoughts of other investigators, Koetting concluded that there is a dominancy of the left cerebral hemisphere with respect to the recognition of words, and that there is a learned post-exposural processing which accounts for the systematic differences which are encountered in experiments involving words but not in experiments involving non-alphabetical targets.

It has been suggested by many investigators that such a phenomenon arises through the process of learning to read. If this should be the case, then it might be anticipated that inasmuch as there are known differences in the ability to read, the Iota Phenomenon (in particular, the component I_2) might vary across individuals either because the ability to read is dependent upon its level of development, or conversely; or, because of some underlying factor upon which both measurements are dependent.

This leads to the postulation that neither the Iota Phenomenon _per se_, nor gradient of performance associated with the component I_2, should be manifested to the same degree if such an ability were not adequately developed, or if non-verbal targets rather than verbal targets were used in testing. Indeed, if there is a relationship between the phenomenon and the ability to read, it would be anticipated that it would be decreased, or even absent, in children having some sort of learning disorder, which generally involves poor reading.

The present study was introduced in an attempt to demonstrate such differences between groups of normal children and those designated as having learning disabilities through the use of verbal targets; and, the absence or other differences in the Iota Phenomenon in both groups using non-verbal targets.

REVIEW OF LITERATURE

Cerebral Dominancy -- Lewis (1961-62) and others (See below) have described cerebral dominancy as a tendency of one cerebral hemisphere to be better developed than the other for certain functions in processing information and motor performance. There is a considerable history leading to this concept of asymmetry of brain function in both animals and man--the older explorations in man having been primarily concerned with observations of brain-injured individuals and direct stimulation of the brain during surgery. This type of investigation continues and is exemplified by the work of Penfield and Roberts (1959), who report that left temporoparietal lesions result in disruption of language and associated thought processes, and that right temporoparietal lesions result in disturbances of spatial perception, awareness of body scheme, and spatial relations. Another example is found in the work of Milner (1962), who reports visual memory and perceptual deficiencies resulting from left hemispheric lobectomies.

However, as indicated by Kimura (1973), such investigations are now being supplemented through the study of brain function in normal people by the discrete presentation of perceptual stimuli. Based on a knowledge of neuroanatomy, such stimulation can be used to provide input to a given portion of the brain. She notes that it is characteristic of the human nervous system that each cerebral hemisphere receives input primarily from the opposite side of the body. This is especially true of the visual system (with the possible exception of the macular area--See below), in which the arrangement of neural fibers is such that vision to the right of a point of fixation is mediated by the left half of the brain, and vision to the left of a point of fixation is mediated by the right half of the brain.

Such discrete presentation of perceptual stimuli has also been used in studies involving perception and motor activities of brain-injured individuals, or subjects to whom certain sedatives (e.g., sodium amytal--See Kimura, 1973) have been administered to selectively influence one side of the brain or the other. These studies incorporating use of discrete presentation of perceptual stimuli with normal subjects or brain-damaged subjects in which the location of the lesion is known, with or without selective sedation, as well as the earlier observation of impairment of certain functions in brain-damaged individuals and the effects of stimulation of the exposed brain have all indicated that the left cerebral hemisphere is normally associated with speech and other aspects of the language arts.

Kimura (1966), however, reporting on a study involving tachistoscopic presentation of verbal and non-verbal stimuli to normal subjects in either the left or right visual field, further observed that not only the left posterior part of the brain is significantly involved in the identification of verbal conceptual forms but that the right posterior portion of the brain has functions for processing non-verbal stimuli. This is in accord with the observations of Penfield and Roberts (1959) presented above. Kimura's 1966 findings, at least with respect to the left cerebral hemisphere, are also supported by the studies of Lagrone (1943), Forgays (1953), Mishkin and Forgays (1952), Leavell and Beck (1959), Schrock (1965), Koetting (1970) and many others (See below).

With further exploration into cerebral asymmetry, Kimura (1973) even more clearly established that the left hemisphere play a dominant role in speech, and that the right plays a dominant role in man's perception of his environment. Through a series of perceptual tests involving (a) simultaneous presentation of dichotomous stimuli (e.g., dichotic stimuli to the two ears, respectively); (b) comparison of visual awareness and performance resulting from discrete presentation of stimuli serving as inputs to the left or right cerebral hemispheres, respectively; and, (c) through observation of certain skilled and free movements; she observed in normal, right-handed people:

1. A dominancy of the left cerebral hemisphere in auditory performance with respect to words, nonsense syllables, and backward speech; visual performance with respect to letters and words; and, manual performance with respect to skilled movements and free movements during speech.
2. A dominancy of the right cerebral hemisphere in auditory performance with respect to melodic patterns and nonspeech sounds (human); and, visual performance with respect to two-dimensional point location, dot and form enumeration, matching of slanted lines, and stereoscopic depth perception.

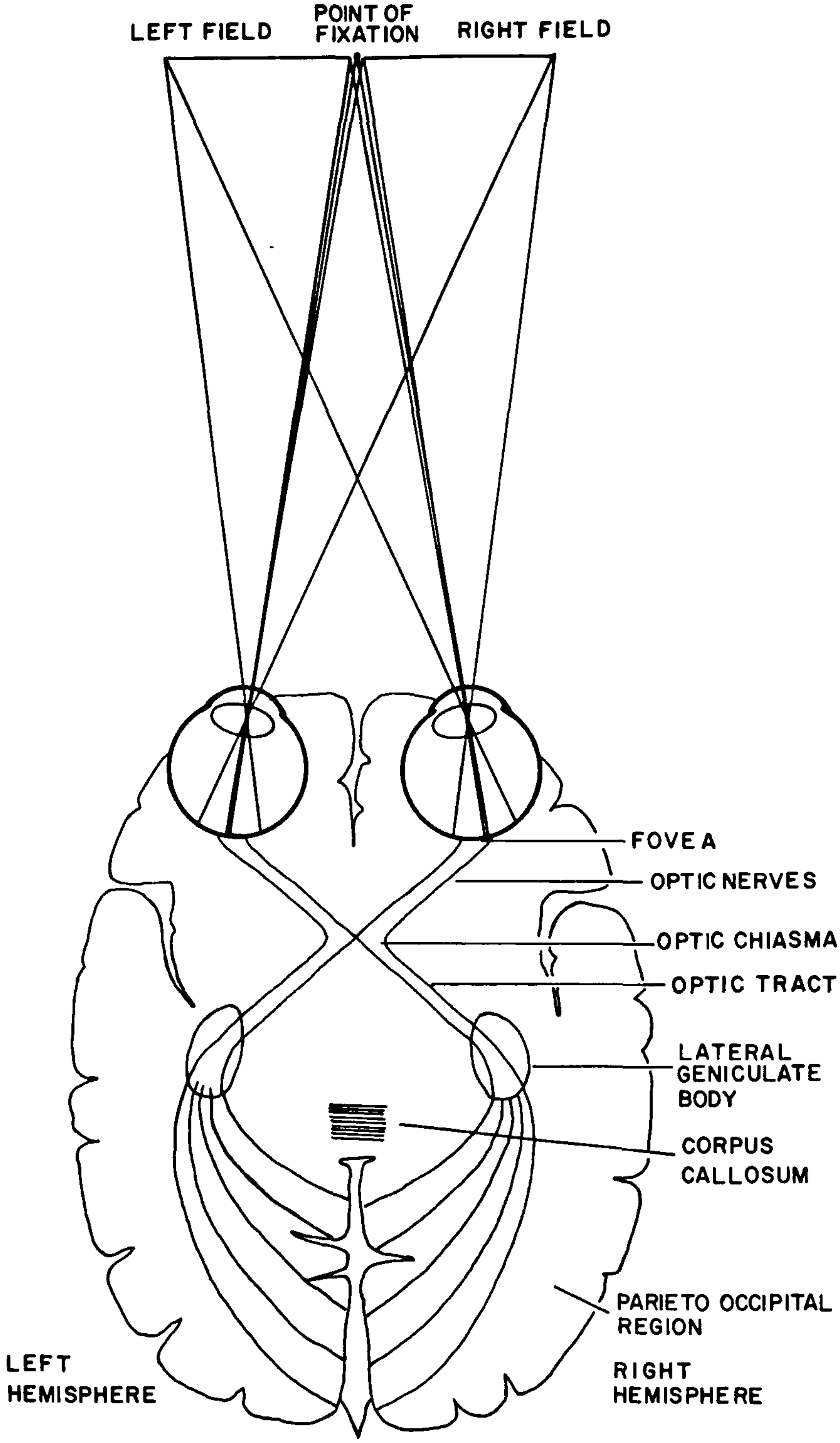
It should be noted that these various perceptual abilities and performances are observed with respect to both hemispheres; however, such perceptual abilities and performances are superior with respect to one or the other hemisphere. Further, it should also be noted that information concerning dominancy with respect to the right cerebral hemisphere appears to be for the most part indicative of tendencies rather than of true statistical significance.

Visual Field Dominancy - According to Spooner (1957, p. 59), Adler (1959, pp. 738-751), Wolff (1961, pp. 353-357), and Netter (1962, pp. 63-75), the axons of the ganglion cells leaving the nasal portion of each retina cross in a semi-decussation at the optic chiasma, and discharge into pathways leading to the cerebral hemisphere opposite to the eye supplied (See Fig. I). The axons of the ganglion cells and subsequent pathways from the temporal portion of each retina pass directly back to the cerebral hemisphere on the same side as the eye in question. According to Adler (1959, pp. 585-

FIGURE 1

THE VISUAL PATHWAYS

(AFTER DOREEN KIMURA, 1973)



605), this lateral division of the retina occurs in the sagittal plane of the central fovea, so that sensory inputs from the right visual field are carried over pathways from the nasal retina of the right eye and the temporal retina of the left eye, and terminate in area #17 of the left occipital cortex. Sensory inputs from the left visual field of the individual are carried over pathways from the nasal retina of the left eye and the temporal retina of the right eye, and terminate in area #17 of the right occipital cortex.

Although the evidence is less certain, there is an apparent recapitulation of this division even in the foveal area. Both Adler (1959, pp. 585-605), and Wolff (1961, pp. 353-357), however, indicate that there may be bilateral representation of the macular area in each of the cerebral hemispheres. Chief evidence for this concept is found in the sparing of the macular field in cases in which the peripheral fields have been unilaterally destroyed (e.g., posterior cortical lesions). There are strong arguments against this reasoning which will be discussed below. Physiologically, the division of the right and left visual fields has been known for years, and such knowledge has been utilized by neurologists, optometrists, and ophthalmologists in determining the location of lesions in the visual pathways and in the diagnosing of ocular diseases such as glaucoma.

In reviewing the literature relevant to visual field dominancy, Koetting (1970) noted that for the most part, investigation had been concerned with tachistoscopic stimulation in the total right and the total left visual fields (i.e., the simultaneous stimulation in the right field of the right eye and the right field of the left eye, or simultaneous stimulation in the left field of the right eye and the left field of the left eye). Stimulation of both eyes rather than stimulation in the right or left field of a respective eye had been given primary consideration. The work of Mishkin and Forgays

(1952), Forgays (1953), Orbach (1952), Heron (1957), and Terrace (1959) were representative of this type of investigation.

With the exception of Koetting's own work, only that of Carter (1953) and Crovitz and Lipscomb (1963) had been directly related to the investigation of dominancy in the right and left fields of the right and left eye respectively, and this had been accomplished using phi movement and color rather than alphabetical material. Despite her extensive study, even Kimura (1973) did not include specific stimulation in the right and left visual fields for the right and left eye, respectively.

Mishkin and Forgays (1952) performed four experiments to investigate the accuracy of tachistoscopic recognition of words exposed in the right and left peripheral fields of vision in an attempt to provide evidence for Hebb's (1949) explanation for equivalence of response and recognition through learning. Man demonstrates a form of equivalence through recognizing an object in any visual field of sufficient acuity; this phenomenon could be explained through learning, or in terms of "field theory" (Kohler, 1947) or "equipotentiality" (Lashley, 1942).

Mishkin and Forgays postulated that inasmuch as retinal areas corresponding to fields of equal visual acuity receive the same amount of training, man's ability to recognize objects in any visual field might be due to individual training with respect to separate parts of the receptor surface. In reading English text, the reader would be presented persistently with the next word for recognition in the right field while he was engaged with a word in central vision. This situation could constitute a selective training condition resulting in a non-equivalence between projections of the same word on different retinal loci. In presenting English words to adult subjects by means of a rotating tachistoscope, they demonstrated that subjects recognize significantly more words placed in certain parts of the right visual field than in corresponding parts of the left, and in the inferior field as compared to the superior field. Further, recognition differences are restricted to certain parts of the visual field depending on experimental conditions.

Explanations that subjects might have been attending respectively to the right perceptual field, that an anisotropia of visual space (Koffka, 1935, pp. 275-280) resulted in greater clarity or distinctiveness for patterns in the right field than in the left, or that the left occipital cortex was dominant for vision were discredited through an investigation comparing left and right field recognition of English words with that of Yiddish words (in which the letters run in the reverse order). Recognition was found to be forty percent greater for English words presented to the right than to the left of fixation, and 25 percent greater for Yiddish words presented to the left than to the right of fixation. The English difference was highly significant; the Yiddish difference was not. Mishkin and Forgays concluded that whatever facilitates recognition of English in the right visual field does not significantly affect the recognition of Yiddish, and that unidirectional factors (i.e., attention, anisotropy of visual space, dominant left occipital cortex) are not responsible for the differential recognition.

To investigate whether the beginning of a word is more important than its ending as a cue in word perception, Mishkin and Forgays (1952) also presented 8-letter words to 14 subjects--the initial four letters and final four letters being partly blurred by penciling, respectively for half of the words. Their findings indicate that differences between recognition scores of the left and right fields are not due to a disproportionate significance of the first half as compared to the second half of a word.

Forgays (1953) concluded that if learning to read English text constitutes a selective training condition, a developmental study should provide evidence regarding its effects. Specifically, he postulated that in the earlier educational grades there should be no gross differences in differential recognition of words presented to the right and left of central fixation. Further, there should be a gradual dispersion of curves of recognition when recognition of words respectively presented to the right and left of central fixation were plotted against educational grade level.

Using a rotating tachistoscope similar to that used by Mishkin and Forgays (1952), he presented twenty 3-letter and 4-letter English words to 12 subjects from each of the school grades two to ten and the first three college years. Total recognition scores were found to increase gradually through the educational levels. Recognition scores for words to the right or left of fixation displayed considerable overlapping for grade levels two to seven, and diverged through the remaining groups. The absolute number of words recognized when exposed to the left field decreased at educational grade-levels five through eight--a finding interpreted by Forgays as indicating a selective attention process operating during those years, and later becoming inoperative as indicated by the experiments of Mishkin and Forgays.

Orbach (1952), in reviewing Mishkin and Forgay's experiment (1952) in which it was found that more Yiddish words were recognized in the left visual field than in the right (as opposed to more English words being recognized in the right visual field than in the left), suggested that the superiority of recognition for Yiddish words, which was small, might be more conclusively explored if the experiment were performed with more fluent readers of the Jewish language. He employed a method not essentially different from that of Mishkin and Forgays, although a projector-type of tachistoscope with variable exposure-time (20 to 100 msec.) was used. Thirty-two readers of English and Jewish served as subjects. Sixteen were either Jewish teachers or members of a Jewish teachers' seminary in Montreal. Eight of the 32 were European newcomers who had been living in Canada for from one to three years. The remainder were high school or college students.

Subjects recognized English words to the right of fixation ninety percent better than to the left, and Jewish words equally well to the right and left of fixation. Subjects were then asked in which of the two languages they had first attained reading facility. For those subjects who had learned English first, recognition of Jewish words to the right of fixation was 35 percent better than to the left; for those subjects who had learned Jewish first, recognition of Jewish words to the left of fixation was 38 percent better than to the right.

Orbach (1952) also explored the phenomenon reported by Anderson and Crosland (1933) regarding the action of lateral eye-dominancy in the recognition of tachistoscopically exposed combinations of letters. Right-eyed subjects were reported to excel in the left visual field and left-eyed subjects to greatly excel in the right visual field. Orbach studied eye-dominancy as determined through use of the Manoptoscope (involving a phi test for lateral eye dominance) and word recognition, and was unable to discover a significant relationship. He notes, however, that Anderson and Crosland used meaningless combinations of consonants and vowels rather than meaningful English and Jewish words.

Heron (1957), in justifying his own experiments, reviewed evidence suggesting that English words are not always recognized more easily in the right visual field as opposed to the left. Glanville and Dallenbach (1929) found that letters to the left of the upper row of the two rows of letters across the visual field were more accurately perceived. Crosland (1931) found that when nonsense-words were exposed in the center of a field, more letters were reported accurately to the left of fixation than to the right. His results were in agreement with those of similar experiments carried out in German laboratories, and which have been summarized by Woodworth (1938). Anderson's investigations (1946) indicated that bi-lingual subjects recognize more English letters to the left of fixation than Hebrew letters to the right when English and Hebrew nonsense-words are presented at random.

Heron believed that even though the experimental procedures followed in these studies differed slightly from those of Mishkin and Forgays (1952), the most significant point of difference was that letters were used instead of words. The question had not been answered as to whether or not the difference between the right and left visual fields existed for non-alphabetical forms as well as words. He designed a series of experiments (1957) to investigate the effect of form and set on the recognition of tachistoscopically presented words in the respective right and left visual fields, and to explore the conflicting results reported by Crosland (1931) and Anderson (1946).

Subjects were college students who could read English fluently but who had proficiency in Jewish. A projection tachistoscope was used; exposure-time was approximately 100 msec. Subjects sat seven feet from a white screen on which stimulus-materials were projected, and a chin-rest was used to control distance and reduce head movements. Following presentation of targets, when letters were used as stimulus-objects, subjects were required to write what was seen; when non-alphabetical material was used, subjects were tested by a multiple-choice recognition-method.

Two experiments were conducted to discover whether the superiority of the right-field scores was apparent when non-alphabetical material was employed. In one experiment, 44 nonsense forms were exposed in each field to 15 subjects; in the other experiment, 12 familiar forms were exposed to 14 subjects in each field. In neither case was a significant difference found between the scores for forms exposed in the right field and those exposed in the left.

Using twenty subjects, Heron also exposed groups of upper-case letters arranged in a square at five different positions in either the right or left visual field. These positions were so situated that the mid-point of the square of letters was at angular distance of 1° 15', 2° 45', 4° 15', 5° 55', and 7° 7' from the point of fixation. Each letter square subtended an angle of 1° 27'. Sixteen groups of letters were exposed in each field at each angular distance; and for half of the exposures, subjects were told on which side of fixation the letters would appear, for the other half they were not. In a related experiment, using 12 subjects, he exposed single upper-case letters in four different positions in each visual field at angular distances of 4°, 5°, 6° and 7° from the point of fixation. Again, half of the stimulus-objects were exposed under the informed condition, and half under the uninformed condition.

In both of these experiments, more letters were perceived in the right visual field than in the left--the difference being most marked at 2° 45' and 4° 15' in the case of the four squares, and 5° and 6° in the case of single letters. Scores for the left field were significantly greater under the informed than under the uninformed condition; those for the right field remained the same.

Heron observed that even though these experiments demonstrated that alphabetical material is more easily recognized in the right field when the stimulus appears in one field or the other, subjects apparently recognize letters at the beginning of a series more accurately than those at the end regardless of field. He therefore designed an experiment to study which condition was more important in determining the response.

Using the same apparatus as in his other experiments, he tested 15 subjects with six different types of stimulus patterns: groups of four letters exposed in either the right or left visual field, groups of four letters exposed in either the right or left visual field with a thick horizontal line being exposed in the opposite field, two 4-letter groups exposed simultaneously in the right and left visual fields, two 4-letter groups exposed simultaneously in the right and left visual fields--the letters being spaced twice as far apart as in the previous condition, single letters exposed in either the right or left visual field, and single letters exposed simultaneously in both fields.

Heron interpreted his data as indicating that conditions of stimulation determine whether letters are seen more clearly in the right or left visual field. If exposure is simultaneous in both fields, more letters are recognized in the left field; if exposure is in one field only, more letters are recognized in the right field. Under conditions of simultaneous exposure, double-spacing of the letters results in a greater superiority in the left field; when letters are exposed in one field with a horizontal line being exposed in the other, more letters are seen in the right field. The latter observation would indicate that simultaneous stimulation must be of a specific type to enhance scores in the left field.

Terrace (1959), conscious that the studies of Mishkin, Forgays, Orbach, and Heron were leading to a postulation of a post-exposural attentional process, argued that if differences in right-left recognition scores for alphabetical and geometrical material were to be attributed to a post-exposural attentional process, pre-exposural set should be controlled. Simply randomizing the side on which the target was exposed would not control the possibility that the subject might be set for that particular type of target. He designed an experiment wherein both the type of stimulus (alphabetical or geometrical) and the side on which it appeared were randomly varied.

Using a projection tachistoscope (exposure-time approximately 100 msec.), he presented targets on a screen 9 ft. 10 in. from the eyes of subjects, thirty college students who could read English fluently but who had no experience with a language which was read from right to left. Both the type of stimulus and the side on which it was presented were randomly varied. When the stimulus was a word, the subject was required to write what was seen; when the stimulus was a nonsense form, he indicated what was recognized through a 3-choice recognition method.

The difference between scores for word-recognition on the right and left was significant; the difference for forms was not. Twenty-nine of the thirty subjects showed higher recognition scores for words on the right side; 17 showed higher recognition scores for forms on the left side, 7 for the right side, and 6 showed ties. Thus, the use of nonsense geometric forms to control for pre-exposural set did not appear to affect the superiority of tachistoscopic recognition of words in the right visual field.

In discussing the possibility of a post-exposural process, Terrace also called attention to the work of Hogg (1957) which demonstrated that college students recognize more words presented tachistoscopically than soldiers whose formal schooling did not extend beyond the elementary school levels; and of Solomon and Howes (1951), who demonstrated that the threshold for recognition of a word is a function of the frequency of its prior use.

Further, Gibson and Gibson (1955) had found that the accuracy of discrimination is a function of experience with similar stimuli.

In a somewhat different type of experiment, Carter (1953) repeated and modified a study reported by Jasper (1932) involving phi movement as an indicator of either cerebral or ocular dominancy as they related to problems in the language arts (i.e., stuttering). Jasper's experiment had consisted of alternately presenting two luminous targets situated at different distances from a subject and being so aligned that the target not fixated was seen diplopically and equidistant to the right and left of the one on which fixation was maintained. The near and far targets were flashed alternately at an optimal rate for an illusion of movement; and subjects were required to report whether the perceived movement was from the fixated central target to the right or left, or whether the fixated target was seen as splitting and moving in both directions.

Movement of the target in one direction only (the diplopic image being either suppressed or simply appearing to blink on and off) was considered as resulting from a mechanism of either visual dominance or laterality--a mechanism, through necessity, being of either an ocular or cerebral nature. When binocular fixation was maintained on the far target, perception of movement from the fixation target to the right diplopic image was attributed to either a dominancy of the left eye or left half of the cerebral cortex; and when binocular fixation was maintained on the near target, perception of movement from the fixation target to the right diplopic image was attributed to a dominance of either the right eye or the left cerebral hemisphere. Corresponding inferences were made regarding the converse situations; and through analyzing the near and far fixation results, a given subject could be classified as left cerebral dominant, right cerebral dominant, left ocular dominant, or right ocular dominant.

Carter reported that Jasper found a high incidence of left cerebral dominance in right-handed non-stutterers, a high incidence of right cerebral dominance in left-handed non-stutterers, equality of occurence of cerebral dominance in ambidexterous non-stutterers, and a virtual absence of cerebral dominance in stutterers. These findings suggested a relationship between the absence of cerebral dominance and stuttering.

Carter modified Jasper's apparatus through introducing two additional targets of the same size and color and the same distance from the observer as the more distant target. Thus, he provided a mechanism for determining monocular as well as binocular cerebral dominance, and five situations were available for presentation to subjects: a two-target situation with near fixation, a two-target situation with far fixation, a three-target situation with binocular fixation, a three-target situation with left eye only, and a three-target situation with right eye only. The near target was removed when the three-target situation was introduced, and multiple runs were made on each subject.

In most cases, subjects (college students--primarily from the University of California School of Optometry) reported at first that the central target appeared to split and move in both directions to the two side targets--the side targets then appearing to move back together again to fuse. After a variable period, nearly all subjects reported that the central target was moving in only one direction, left or right, and that the other target was simply blinking.

Because of the observation that several subjects were unable to maintain binocular fixation at the location of the fixation target when it went off and the other came on, and because several other subjects could maintain fixation only with great difficulty; Carter introduced a continuous fixation point just above each of the flashing targets. As a result of this modification, three or four subjects who had reported a pattern of movement indicating ocular dominance no longer reported such patterns. Instead, they reported patterns indicating cerebral dominance in accordance with their handedness. Carter concluded, therefore, that phi movement ocular dominance does not exist in persons having single binocular vision and approximately equal acuity in both eyes. His evidence also supports the position that there is some relationship between cerebral visual dominance and handedness.

Using the Gebrand mirror tachistoscope, Crovitz and Daves (1962) found that when exposing three numerals at 100 msec. to the left and right of fixation, respectively, when viewing is binocular, accuracy is just as great in the left field as when viewing is accomplished with the left eye only, and accuracy in the right field is just as great as when viewing is accomplished with the right eye only. As Crovitz and Lipscomb (1963) have indicated, such data would appear to be in accord with a suggestion made by Edridge-Green (1914) that when both eyes are open, the left eye predominates for the left visual field and the right eye predominates for the right visual field.

As Crovitz and Daves have noted, if this theory were correct, a simple observation could confirm it; that is, if a red card were presented to the left eye and a green card were presented to a corresponding area of the right eye, a bipartite color field, red on the left and green on the right, should be observed. It is well know that such conditions result in either binocular color rivalry or color fusion. Yet, at an exposure limit of 100 msec., they observed results which are consistent with the hypothesis.

Stimuli were presented in either a binocular fixation field, or in fields limiting stimuli to the left eye or right eye, respectively. Each field was 26 in. from the eye, and the apparatus permitted alternate presentation of fixation-points to both eyes to control accommodation, convergence and line of regard. Independent stimuli could be presented simultaneously to the left and right eye. Two main stimulus-conditions were introduced: a full field of green presented to the left eye and a full field of red presented to the right eye, and conversely; and a bipartite situation wherein the left eye was presented with a field with the left half green and the right half red, and the right eye was presented with a field with the left half red and the right half green, and conversely. Sixteen college students, predominantly women, served as subjects.

Under conditions of both the full-field and split-field presentations, the most frequently reported perceived colors corresponded to colors presented in the temporal fields. Under the full-field condition, the most commonly reported observation was that of a single field consisting of two colors --the colors stimulating the left eye being observed to the left of the color stimulating the right; under the split-field condition, the most commonly reported observation was that of a field consisting of but one color, the one stimulating the nasal portion of the two eyes.

Working with retarded readers, Leavell and Beck (1959) studied visual efficiency in the lateral halves of the visual field in subjects having "established" lateral dominance (right-handed and right-eyed or left-handed and left-eyed) as opposed to that of having "mixed" dominance (right-handed and left-eyed or vice versa). The hypothesis tested was: by virtue of neurological dominance and the necessity of a left-to-right progression in reading, children retarded in reading manifest different abilities in the peripheral perception of symbols exposed at different speeds and in different lateral fields of exposure.

Thirty-eight white male elementary school children were categorized with respect to hand-eye dominance (right-handed, right-eyed; left-handed, left-eyed; and mixed), and the subjects in these groups were equated for C.A., I.Q., and reading quotient. Targets were presented to subjects tachistoscopically at a distance of twenty feet at 1/10 sec., 1/25 sec., and 1/50 sec. Each target consisted of a series of a number, upper-case letter, and number, with the upper-case letter always appearing at the point of fixation and the numbers appearing on either side at progressively greater distances from the point of fixation. The most widely separated positioning of the numbers was 11°--$5\frac{1}{2}^{\circ}$ to the right and left of the point of fixation, respectively.

The three groups were compared by means of analysis of variance to determine significance of the differences in correct left and right responses. In no case was significance discovered. In comparing the groups on their left visual field responses, however, the left-eyed, left-handed group and the right-eyed, right-handed group responded significantly better than the mixed group at 1/50 sec.; yet only the left-eyed, left-handed group responded significantly better at 1/25 sec. Each group scored significantly higher in the left visual field at all speeds.

In studying the response to targets having numbers presented at the two outermost positions from the point of fixation, the responses for the right and left field, respectively, showed no significant difference between the three groups. However, in computing t tests for correlated means, it was found that in each group the correct number of left responses exceeded the right at the .01 level of confidence. Subjects with an estimated dominance were found to see significantly better in the right visual field than subjects with "mixed" dominance at 1/25 sec. exposure.

From this analysis of data, Leavell and Beck concluded that lateral dominance appears to favor efficiency in peripheral vision in both lateral halves of the visual field.

Harcum (1969), in a continuing series of experiments, tested the hypothesis that the usual hemifield differences in perceptual accuracy for binary tachistoscopic patterns bisected by the point of fixation (i.e., superiority of recognition to the left of fixation) are produced by a perceptual scanning of the pattern from end-to-end, causing one end to be favored by a primacy effect. Targets were binary patterns of typewritten horizontal rows of zeros which extended so far into peripheral vision that the patterns had no perceivable ends. Stimulus cards were white, with various zeros colored with black ink. He presented binary patterns tachistoscopically to twenty-four college students who were instructed to fixate a cross in the center of locus of presentation of these "continuous" patterns. Under such condition, elements in neither hemifield were favored by a perceptual primacy effect, and elements nearest fixation were most accurately reproduced. No lateral differences were found for binocular viewing or for monocular viewing with either eye.

Nice (1973) tested the hypothesis that increased stimulation to a given side facilitates perception for stimuli in that hemifield when binary patterns are exposed tachistoscopically across fixation because a subject's attention is drawn to that side. This could account for more accurate perception on the left of fixation if for some reason the nature of the task drew the subject's attention to the left. Inasmuch as extraneous lateral stimulation affects lateral differences in other perceptual tasks (Werner and Wapner, 1952), he postulated that the pre-exposural sounding of a buzzer randomly on the left or right side of a subject should reduce the number of errors on the side of increased stimulation.

Using eight circles in a horizontal row, with four being blackened to form different patterns, subjects (college students) fixated a cross at the center of locus of presentation of the stimulus array. The typical left superiority was attenuated as predicted when the buzzer was presented on the right, even though the left superiority occurred under all conditions.

To study the covert scanning of inputs, and to eliminate artifacts, Harcum and Nice (1975) developed a technique called mutual masking in which two equivalent strings of letters, identical in spatial location but different in content, are presented successively so that each is potentially either a stimulus or a mask. This masking technique was used in the presentation of compound 8-letter English words having different beginning or ending four letters which could be flashed to the right or left of fixation or with the point of fixation bisecting the word.

Compound word pairs used permitted meaningful blends (e.g., "headache" and "backrest" could yield "headrest" or "backache"). Inasmuch as subjects (college students) frequently identified the components at the left within the first word and the right within the second word when fixation was at the center of the array, a left-to-right serial processing was indicated. Subjects, however, tended to identify the component away from fixation of the first word and the fixated part of the second when fixation was on either the beginning or the end component--thus, indicating a scanning from periphery toward fixation.

Also using the mutual masking technique, Nice and Harcum (1976) attempted to demonstrate that serial processing of tachistoscopic patterns that occurs when all potential artifacts such as familiarity with certain words, and certain sets based on anticipated difficulty of the task, are eliminated. Working with ten subjects (graduate and undergraduate students), they presented two nonsense arrays of six letters successively at the same position--fixation point bisecting the arrays. More letters from the temporally first string on the left of fixation and more from the second string on the right of fixation were identified. This was interpreted to demonstrate that tachistoscopic performance at various positions reflects a sequential left-to-right processing of information, possibly at different rates.

Nice and Harcum point out that their results do not prove that all tachistoscopic perception of multiple-element targets involves serial processing. They apparantly concur with Haber (1973) who distinguished four levels of information processing: iconic storage, feature analysis and codification, short-term memory, and long-term memory; and, Turvey (1973) who suggested that the difference in such levels parallels the locus of relevant processing. Accepting Dick's (1971) argument that the sensory register operates in parallel as opposed to the short-term storage process which operates serially, they conclude that the levels of processing which are involved in a particular task might determine which mechanisms are operative.

Koetting (1970) reported on an investigation concerning the ability to recognize words in each of the four lateral visual fields. Using forty-six fifth-grade elementary school children as subjects, he presented 3-letter English words tachistoscopically, and discretely, in a stereoscopic viewing device at positions laterally displaced from a central point of fixation, and at a typical reading distance from the subject's eyes.

He reported significant results as follows:

1. In comparing performances in the respective nasal visual fields of the right and left eyes, there is a difference favoring the left nasal field which is significant at the 0.005 level of competence.

2. In comparing total performance in both of the right visual fields and both of the left visual fields, there is a difference favoring the total performance in the right visual fields which is significant at the 0.01 level of competence.
3. In comparing total performance mediated by the right eye and that mediated by the left eye, there is a difference favoring the left eye which is significant at the 0.05 level of competence.
4. In comparing performances in the temporal field of the right eye and the nasal field of the right eye, there is a difference favoring the temporal field of the right eye which is significant at the 0.05 level of competence.
5. In comparing performances in the temporal field of the left eye and the nasal field of the left eye, there is a difference favoring the nasal field of the left eye which is significant at the 0.05 level of competence.

On the basis of these results, Koetting concluded that:

1. With respect to the recognition of words exposed for brief periods of time, differences in performances in the four lateral visual fields can be measured, and are significant, in fifth-grade elementary school children.
2. A superiority of performance in the nasal field of the left eye is chiefly responsible for the superiority of performance in the total right binocular visual field as compared to the total left binocular visual field--a phenomenon which has been observed by other investigators.
3. A superiority of performance in the left nasal field is also responsible for superiority of performance in the left eye as compared to the right eye when total scores for both fields of one eye are compared with those of the other.
4. The numerical superiority of nerve fibers servicing a given peripheral field is not the responsible factor for the superior ability to recognize words presented in that field.
5. Learned post-exposural processing accounts for the systematic arrangement of differences encountered in experiments which utilize words as compared to the absence of such differences encountered in experiments involving non-alphabetical targets.
6. There is a dominancy of the left cerebral hemisphere with respect to the recognition of words.

In general, the results of this study were not in conflict with either the work or theorizing of Mishkin and Forgays (1952), Orbach (1952), Heron (1957), Terrace (1959), Leavell and Beck (1959), Crovitz and Lipscomb (1963), and Carter (1953); or to the speculations of Heron (1957) regarding pre-exposural set and post-exposural processing. However, they varied considerably from those of Forgays (1953) who conclude that differential accuracy between the two fields is not present during a period corresponding to educational grade-levels two through seven, and that some superiority of the left field is found in grades four and five.

Much of Kimura's (1973) work in the visual modality although supporting the position that the recognition of visual verbal material is more accurately perceived when it initially stimulates the left hemisphere, has dealt with uncovering some of the specialized functions of the right hemisphere. Noting that injury to the right posterior part of the brain (the parieto-occipital region) results in impairment of complex abilities such as drawing, finding one's way from place-to-place, and building models from a plan or picture; she introduced tachistoscopic experiments with normal subjects that indicated that the right hemisphere is also primary for some fundamental visual processes.

She reports that in the simplest kind of spatial task--the location of a single point in a two-dimensional area--the right hemisphere is dominant. She presented dots tachistosopcially one at a time in either the left visual field or in the right visual field for 1/100 sec. (10 msec.) at various locations within a circle drawn on a plain white card. Subjects identified the location of the dot on a similar card outside the tachistoscope. Scores for correctly located dots were higher for the left field than for the right. Similarly, ascertaining the number of dots or geometric forms was more accurate for the left field. Inasmuch as simple detection of dots was no more accurate in one field than in the other, Kimura postulates that the right hemisphere includes important components of a system of spatial coordinates that facilitates the location of a point in space.

In conjunction with Margaret Durnford she also initiated some studies in depth perception with respect to the right and left visual fields. Initially a classical depth-perception box was used which contained a fixed vertical central rod in line with a central point of fixation. On each side of this central rod was a track on which another vertical rod could be moved. The variable rod was presented tachistoscopically to both eyes, and the subject asked whether it was nearer than the central rod or further away. When the variable rod was presented in the left visual field, the reports were more accurate.

Using a three-field tachistoscope, Kimura also presented visual stimuli in which the only cue to depth was binocular disparity (stereopsis). In the three-field tachistoscope, the subject sees a reflection of the fixation field in an appropriately-angled, partially-silvered mirror. Exposure fields are similarly observed. The subject is asked to fixate on a point in the center of the field, and the fixation-field light is turned off and either the right or left exposure-field light is simultaneously turned on for a few milliseconds. Thus, exposure of images in either field can be accomplished. Random-dot stereograms can be used with appropriate Polariod filters for achieving binocular disparity with respect to the two eyes to permit stereopsis in either the right or the left field. Kimura found identification of such stereoscopic stimuli to be clearly better when presentations were made in the left visual field.

Kimura also determined a small but consistent superiority for slope identification in the left visual field. Using a two-field tachistoscope which permitted exposure of targets to either the right or left of the point of fixation, she presented lines varying in slope from 15° to 165° in fifteen-degree steps. Subjects were required to pick from a multiple-choice array of slanted lines on a sheet of paper for identification.

On the basis of these results, Kimura concludes that the right hemisphere clearly works better than the left hemisphere in analysizing information about visual location of objects in space.

THEORY

In reviewing the data and the postulations of the investigators listed above, it is apparent that various theoretical positions are emerging with respect to visual field dominance and its relation to verbal, spatial, and other perceptual abilities; cognition; and, memory. These emerging theoretical positions regarding visual field dominancy and related observed phenomena might be summarized as follows:

1. There is a dominancy of the left cerebral hemisphere with respect to the recognition of words (Koetting, 1970; many others).
2. Subjects recognize significantly more words in the right visual field than in the left, and more words in the inferior visual field than in the superior (Hebb, 1949, pp. 49-50; Mishkin and Forgays, 1952; Forgays, 1953; Orbach, 1952; Heron, 1957; Terrace 1959; Koetting, 1970, Kimura, 1973).
3. An observed superiority of word recognition in the left nasal field is chiefly responsible for the superiority of performance in the total right binocular visual field as compared to the total left binocular visual field (Koetting, 1970).
4. The superiority of word recognition in the left nasal field is also responsible for superiority of performance in the left eye as compared to the right eye when total scores for both fields of one eye are compared with those of the other (Koetting, 1970).
5. Superiority of either the right or left field is restricted to certain parts of the fields, and is therefore dependent upon experimental conditions (Mishkin and Forgays, 1952; Heron, 1957).
6. With respect to the recognition of words exposed for brief periods of time, differences in performances in the four lateral visual fields can be measured, and are significant in fifth-grade elementary school children (Koetting, 1970).
7. Selective "retinal" training arises through the process of learning to read (Mishkin and Forgays, 1952; Forgays, 1953; Orbach, 1952; Heron, 1957; Terrace, 1959; Leavell and Beck, 1959).
8. In reading Latin script, inputs mediated by the left hemi-retinas are used more extensively than those mediated by the right, and the intensive training mediated by the left hemi-retinas modifies neural organization leading to the formation of particular reading habits (Orbach, 1952).

9. Two types of mechanisms are involved in the processing of information presented in the visual fields: pre-exposural set, which results in the subject's attending to one part of the field anticipating the appearance of a stimulus-target; and post-exposural processing, which operates after exposure and is affected by the properties of the stimulus (Heron, 1957; Terrace, 1959).
10. Pre-exposural set does not change the observed superiority of the right visual field with respect to the recognition of words (Terrace, 1959).
11. The English reader establishes two tendencies to move his eyes: (a) to fixate near the beginning of a line of print, and (b) to move his eyes along a line of print from left to right. When alphabetical material is exposed in the right field only, there is no conflict between these tendencies; when alphabetical material is exposed in the left field only, the tendency to move the eyes to the beginning of the line is in conflict with the tendency to move the eyes from left to right. As a consequence, under conditions of successive presentation, more letters are recognized in the right field; under conditions of exposure occurring simultaneously in both fields, the dominant tendency to move the eyes to the beginning of the line resulting in more letters being recognized in the left field. Inasmuch as nonsense figures and geometrical forms are not read, they are recognized equally well in both fields (Heron, 1957).
12. Post-exposural processing of information develops during the course of learning to read, and eye movements play a vital role in its development and subsequent use (Heron, 1957; Crovitz and Lipscomb, 1963).
13. With respect to phi movement, there is a dominancy of the right visual field in right-handed individuals (whether that dominancy be measured for the right eye or the left eye), and of the left visual field in left-handed individuals (Carter, 1953).
14. With respect to exposures of short duration, dominancy in certain types of perception is related to anatomic distinctions (numerical superiority of nerve fibers). Color rivalry is absent and temporal field dominance for color is observed at exposures of 100 msec. (Crovitz and Lipscomb, 1963).
15. The numerical superiority of nerve fibers servicing a given peripheral field is not the responsible factor for the superior ability to recognize words presented in that field (Koetting, 1970).
16. The right cerebral hemisphere plays a dominant role in man's perception of his environment with respect to two-dimensional point location, dot and form enumeration, matching of slanted lines, and stereoscopic depth-perception (Penfield and Roberts, 1959; Milner, 1962; Kimura, 1973).
17. There are several levels of information extraction or transduction such as iconic storage, feature analysis and codification, short-term memory, and long-term memory which are responsible for the nature of scanning of targets which is triggered by the nature of the target itself and level of information extraction or transduction required. This is controlled by feedback which does not change the icon, but dictates the features of the icon

which are processed first or more frequently (Harcum, 1976; Haber, 1973; Turvey, 1973; Dick, 1971).

STATEMENT OF THE PROBLEM

The present study was introduced in an attempt to demonstrate differences in the Iota Phenomenon between groups of normal children and those designated as having learning disabilities through the use of verbal targets; and, the absence or other differences in the Iota Phenomenon in both groups using non-verbal targets. It was hoped that through detection of differences and appropriate comparison of paradigms that:

1. Supporting evidence might be obtained for the position that the Iota Phenomenon is dependent on post-exposural processing which is triggered by the nature of the task (i.e., verbal or non-verbal), and primarily accomplished in one hemisphere of the brain as opposed to the other.
2. Supporting evidence might be obtained with respect to a relationship of I_2 (performance in the nasal field of the left eye) and the ability to read, which might be studied to eventually be utilized in the development of clinical instruments to evaluate reading readiness and to introduce training procedures to enhance I_2 and the ability to read.
3. The existence of a gradient in I_2 across individuals might be found, thereby contributing to the basic knowledge of brain activity, and providing a parameter which might be used in investigations relating to cerebral asymmetry.

The study was accomplished through the use of a modification of the Iotascope* and Koetting's original procedure for measuring performance in the four lateral visual fields. However, in addition to the verbal targets used in the original study, non-verbal targets (patterns) comparable in size and contour to the verbal targets were introduced. A display of patterns was provided for subjects' identifying these non-verbal targets.

Thus, experimentation involved two conditions for each subject--one devoted to testing with verbal targets, the other non-verbal. With respect

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*Name assigned by Koetting to his original apparatus.

to verbal testing, each subject in both the normal and learning-disabilities groups was required to identify 3-letter English words exposed discretely in each of the four lateral visual fields according to an undisclosed, non-systematic order. With respect to non-verbal testing, each subject was required to identify discretely-exposed 3-character patterns instead of words.

This led to a basic experimental model of four autonomous distributions of scores based on type of treatment: normal verbal, normal non-verbal, learning-disabilities verbal, and learning-disabilities non-verbal. Two other autonomous distributions were also developed for difference scores between paired normal and learning-disabilities subjects for the verbal and non-verbal conditions, respectively.

These six autonomous distributions could be studied indivdiually through a random-effects two-way analysis of variance to detect the presence or absence of a significant difference between the four lateral visual fields. If a significant difference between fields were indicated, further study of a given distribution through post-hoc comparisons using the Scheffe' Method could be accomplished to establish a paradigm of maximal and minimal performance with respect to the four fields.

Further, the scores for the nasal field of the left eye and the temporal field of the right eye, and for the temporal field of the left eye and the nasal field of the right eye, respectively, could be combined to indicate performance in the total right field and the total left field for subsequent analysis. However, if a significant difference between the right and left fields were indicated by the random-effects two-way analysis of variance, superiority in either the right or left field could be immediately determined through inspection of the means of these distributions. The Scheffe' Method for post-hoc comparisons would not be necessary.

CHAPTER II

METHOD AND PROCEDURE

This experiment involved the discrete presentation of verbal and non-verbal stimuli in the four lateral visual fields at a fixed lateral displacement from a point of fixation, and the subsequent obtaining of scores for the comparison of performance in the various fields. Tachistoscopic presentation of targets was utilized to eliminate searching movements of the eyes, and a display of patterns was incorporated to enable subjects to identify non-verbal targets.

Experimental apparatus for presenting targets was similar to that described by Koetting in 1970. However, certain parameters with respect to size of targets and locus of presentation relative to the point of fixation which were determined through that original study permitted a modification of apparatus to simplify construction and facilitate use.

As with the original apparatus, a system for permitting projection of targets discretely in any one of the four lateral visual fields, and a mechanism for tachistoscopically flashing targets constituted essential parts. However, instead of using a stereoscopic viewing device for presentation of targets discretely in any one of the fields, projections were polarized and these polarized targets were viewed through Polaroid filters (analyzers) so that only the intended part of a respective retina was stimulated. Projection was accomplished by means of a Keystone Overhead Tachistoscope onto a smooth silvered screen which did not influence the polarity of the reflected light.

Subjects viewed the smooth silvered screen at a distance of approximately 100 cm from their face through a viewing device which housed the appropriate filters to polarize light in meridians at right angles to each other before the respective eyes. Targets polarized in one or the other of these meridians were flashed on the screen using the Keystone Overhead Tachistoscope.

Thus, even though subjects would view the entire display area with both eyes, they would receive stimulation from exposed targets to only one eye or the other. Whether stimulation occured in the right or left field of that eye was dependent upon whether the target was exposed to the right or left of the point of fixation. Thus, discrete stimulation could be accomplished in each of the four lateral visual fields: left field of the left eye (left-temporal), right field of the left eye (left-nasal), left field of the right eye (right-nasal), and right field of the right eye (right-temporal).

Subjects were required to visually fixate a small cross at the center of a fixation target centrally located in their binocular field. They were informed that a target would be flashed to either the right or left of this fixation point (a demonstration being given in each field), and were required to orally report what words were seen, or to indicate what patterns were seen through use of an array. Performance was judged on the accuracy of such reports.

Projection slides for use with the Keystone Overhead Tachistoscope were specially constructed to include all of the words and patterns necessary for verbal and non-verbal demonstration and testing. Words and patterns in these slides were of appropriate size and placement so that they were projected at the desired distance lateral to the central point of fixation and were of the correct size. Polarizing of projections was accomplished through use of a Polaroid filter, which could be rotated, placed over the optics of the projector in the pathway of projected light.

The distance from the screen to the plane of the viewing device, size of words, and lateral displacement from the point of fixation were maintained through construction of the apparatus. As in Koetting's original study, room illumination, luminance of targets, and other characteristics of experimental space were controlled.

Mathematical transformation of the size of test targets and the disparity between fixation point and the loci of presentation were made from data of Koetting's original experiment to take into account the difference in viewing distance. However, the only other difference in the basic testing procedure was that of introducing a different proximal awareness due to the subject's observing a somewhat increased viewing distance, and not being misled in this observation through the artificial confines of an enclosed instrument incorporating a stereoscope.

It was assumed that such an awareness would not give rise to significantly different findings with respect to word recognition or pattern recognition in the lateral visual fields. That is, it was assumed that the Iota Phenomenon would be manifested similarly whether a subject thought of a target as being situated in a plane approximately 40 cm. from their eyes, or approximately 100 cm. from their eyes--both distances being situated in near visual space.

Size of targets and lateral displacement were based on Koetting's original determinations and varied only slightly with final adjustment of the apparatus from the calculated equivalent measurements for an approximate 100 cm. viewing distance. Inasmuch as differences in accuracy of reports might most likely be detected when the physical characteristics of the stimulus were close to the threshold of discrimination, a preliminary phase of the study involved the determining of an appropriate luminance of targets for the size of targets and lateral displacement indicated through these calculations. The purpose was to select a luminance which would decrease the probability of subjects recognizing all targets--yet, not decreasing such probability to a degree wherein the recognizing of some targets might become unlikely. Luminance, the size and displacement of targets, and the physical characteristics of stimuli and experimental space were subsequently held constant.

Scores were obtained for each of the four lateral fields for each subject using a series of verbal and non-verbal targets, respectively. Analysis of variance was introduced to determine significance regarding differences between the four lateral fields in each of the appropriate distributions through the testing of null hypotheses. If significance were found between the four lateral fields, that distribution was subsequently explored through the Scheffe' Method to determine which field(s) might be responsible for the differences. As indicated above, this was not necessary in distributions involving the total right and total left fields.

The study included three basic aspects: (a) consideration of a group of normal subjects with respect to differences between the four lateral fields under circumstances of verbal and non-verbal treatments, respectively; (b) consideration of a group of individuals having a history of learning disabilities with respect to differences between the four lateral fields under circumstances of verbal and non-verbal treatments, respectively; and, (c) consideration of paired differences between matched normal and learning-disabilities subjects with respect to differences in the four lateral fields under circumstances of verbal and non-verbal treatments, respectively.

Inasmuch as the nature of presentation of verbal and non-verbal targets differed to a degree (i.e., twenty different 3-letter words were utilized in the verbal presentation; but only five patterns, presented four times each, constituted the non-verbal treatments), a direct statistical analysis between verbal and non-verbal distributions was not considered appropriate. However, a general, non-statistical comparison of the results of the verbal and the non-verbal situations was accomplished for the normal group and the learning-disabilities group, respectively.

In the aspect involving comparison of normal and learning-disabilities subjects, distributions of paired differences based on the performance of matched subjects were generated for each of the four lateral fields. This permitted detection of differences between the four fields which might be indicative of a gradient in one or more of the fields which could possibly be related to learning disorders. These paired difference scores were also appropriately combined to develop distributions reflecting performance in the total right and total left visual fields, respectively, for comparison.

Thus, in all, there were twelve distributions that might be tested for differences, all of which were relevant to the goals of the study. The rationale leading to predictions, and null hypotheses related to such predictions were as follows:

1. If the Iota Phenomenon is dependent upon post-exposural processing which is triggered by the nature of the task (i.e., verbal or non-verbal), and is better accomplished in one hemisphere of the brain than the other; it should be anticipated that it might be observed in normal subjects when verbal targets are presented, and either be absent or manifested in some other way when non-verbal targets are utilized.

H: Difference in variance between the four lateral visual fields for normal subjects receiving verbal treatments is 0.

2. Hypothesis #2 is based on the same reasoning as Hypothesis #1.
   H: Difference in variance between the four lateral visual fields for normal subjects receiving non-verbal treatments is 0.
3. Hypothesis #3 is based on the same reasoning as Hypothesis #1.
   H: Difference in variance between the total right field for both eyes and the total left field for both eyes for normal subjects receiving verbal treatments is 0.
4. Hypothesis #4 is based on the same reasoning as Hypothesis #1.
   H: Difference in variance between the total right visual field and the total left visual field for normal subjects receiving non-verbal treatments is 0.
5. If a relationship between the Iota Phenomenon and the ability to read exists, it should be anticipated that the phenomenon might not be manifested to the same degree in subjects having a learning disorder, which generally involves poor reading, and might either be absent or manifested in some other way when non-verbal targets are utilized.
   H: Difference in variance between the four lateral visual fields for learning-disabilities subjects receiving verbal treatments is 0.
6. Hypothesis #6 is based on the same reasoning as Hypothesis #5.
   H: Difference in variance between the four lateral visual fields for learning-disabilities subjects receiving non-verbal treatments is 0.
7. Hypothesis #7 is based on the same reasoning as Hypothesis #5.
   H: Difference in variance between the total right visual field and total left visual field for learning-disabilities subjects receiving verbal treatments is 0.
8. Hypothesis #8 is based on the same reasoning as Hypothesis #5.
   H: Difference in variance between the total right visual field and the total left visual field for learning-disabilities subjects receiving non-verbal treatment is 0.
9. If a gradient related to the ability to read exists with respect to performance in one or more of the four lateral visual fields, either with verbal or non-verbal targets, it should be anticipated that differences might be observed between normal and learning-disabilities subjects. Paired difference scores between matched normal and learning-disabilities subjects for each of the four lateral visual fields should be studied for significant differences.
   H: Difference in variance between the four lateral visual fields for paired-differences for matched normal and learning-disabilities subjects receiving verbal treatments is 0.
10. Hypothesis #10 is based on the same reasoning as Hypothesis #9.
    H: Difference in variance between the total right visual field and the total left visual field for paired-differences for matched normal and learning-disabilities subjects receiving verbal treatments is 0.
11. Hypothesis #11 is based on the same reasoning as Hypothesis #9.
    H: Difference in variance between the total right visual field and the total left visual field for paired-differences for matched normal and learning-disabilities subjects receiving verbal treatments is 0.

12. Hypothesis #12 is based on the same reasoning as Hypothesis #9. H: Difference in variance between the total right visual field and the total left visual field for paired-differences for matched normal and learning-disabilities subjects receiving non-verbal treatments is 0.

CONSIDERATIONS

In reporting his original study, Koetting (1970) presented certain considerations which were taken into account in establishing a method and for designing apparatus. These considerations are equally relevant to the method and design of apparatus in the present study.

1) Although there is an apparent recapitulation in the foveal area of the lateral division observed in the overall retina with respect to neurons associated with a given cerebral hemisphere, it has been suggested that total bilateral representation from the macular area might exist in each of the hemispheres (Adler, 1959, pp. 585-605; Geldard, 1953, pp. 83-93). This position has been disputed by Harrington (1971, pp. 127-131), who points out that this theory has been postulated by several authors to account for macular sparing in homonymous hemianopsia in instances of damage to the occipital cortex, but that the notion that macular vision is diffusely represented throughout the entire visual cortex has no anatomic basis. Such sparing of the fixation area varies from less than one-half degree to a major portion of the affected half-field, and generally is decreased with more anterior lesions.

Clinical observations of macular sparing might be due to incomplete destruction of the occipital lobe, or could be an artifact due to a shift of fixation toward the blind field during testing. Surgical or traumatic anteroposterior splitting of the chiasm produces a total bitemporal hemianopsia without macular sparing, which indicates that decussation of macular fibers would need to be prechiasmal in the brain stem or callosal commissures, and that these areas would be productive clinically of visual field defects; yet, they are not. Further, if the maculas were bilaterally represented, lesions of one occipital pole would result in bilateral scotomas involving both halves of both fields. This is not observed.

Anatomic evidence strongly supports the theory of unilateral representation of the macula. Nevertheless, in searching for a superiority of performance in the lateral fields for the ultimate purpose of making inferences about cerebral dominancy, and to avoid controversy, it is thought advisable to avoid stimulating the central macular (foveal) area which is stated by Rodieck (1973, p. 366) as being approximately 5.2 degrees in diameter.

2) Targets should be presented sufficiently far out in the peripheral field to avoid encroachment on the macular area, or on the opposite field, as a result of physiological nystagmus. Ratliff and Riggs (1950, pp. 687-701) as indicated by Geldard (1953, pp. 83-93) found that the movements of the eyes during physiological nystagmus may be as great as 10' of arc--the movements being composed of slow drifts of 5' excursions on which more rapid movements of 1' to 5' are superimposed. Therefore, in his orignial experiment, Koetting presented test targets at least 10' beyond the circumference of the projected foveal field so that even during the more extreme movements of the eyes, the stimulus would not be placed accidentally on part of the foveal area or on that portion of the retina servicing the opposite field.

Considering the entire foveal (macular) area to be 3^{o} to 5^{o} in diameter (Miles, 1949), a position at least 2^{o} 40' on either side of the central fovea was indicated. A position 3^{o} to 4^{o} from the central fovea appeared most advisable if problems associated with physiological nystagmus, slight errors in the apparatus, technique and anatomical differences of subject were to be eliminated. At a distance of 36.6 cm. (the distance from the subject to the point of fixation in Koetting's original experiment), the lateral displacements from the point of fixation corresponding to 3^{o} and 4^{o} were 19.2 mm. and 25.6 mm., respectively (i.e., lateral displacement 3^{o} = tan 3^{o} x 366 mm. = 19.2 mm.; lateral displacement 4^{o} = tan 4^{o} x 366 mm. = 25.6 mm.).

3) The regions stimulated were therefore situated in the parafoveal area of the retina (Adler, 1959, pp. 585-605, after Polyak). The absolute threshold for visual acuity with respect to size is considerably higher in the parafoveal area than in the central foveal area (an area only 250 microns in diameter) wherein maximal visual acuity is found. Consequently, the size of the test letters needed to be somewhat larger than if testing were accomplished in the central field (Adler, 1959, pp. 585-605; Adler and Meyer, 1935; Jones and Higgins, 1947; Ludvigh, 1941).

4) Use of the right and left parafoveal fields for presentation of targets also appeared to be most desirable because such a situation conforms to that actually encountered in reading. If visual field dominancy exists, it would appear reasonable that in the reading situation it would involve an area larger than the entire foveal (macular) field, which at a distance of 36.6 cm. (that utilized by Koetting in his original experiment) encompasses a lateral line of print of only about 32.0 mm.* Ophthalmographic studies, in which the number of fixations per line of print are recorded photographically, indicate that the average lateral span of recognition during reading is considerably greater than 32.0 mm. (Taylor, Frackenpohl, and Pettee, 1960).

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*This figure is calculated on the basis of data presented by Miles (1949) giving the overall diameter of the entire foveal (macular) field as 3^{o} to 5^{o}. At a typical reading distance of 36.6 cm., the projected lateral span of maximal visual acuity would be at most 32.0 mm. (i.e., span = tan 5^{o} x 366 mm = 32.0 mm).

5) Inasmuch as it appeared probable that the presentation of targets in the more peripheral portions of the retina, and the introduction of such targets tachistoscopically, would increase the threshold of recognition, the first phase of Koetting's original study constituted a search for some sort of threshold of recognition with respect to size for adequate interpretation in the symbolic dimension at an appropriate lateral displacement from the point of fixation (i.e., 3° to 4°).

Such thresholds of recognition might differ regarding the right and left field of each eye respectively. However, inasmuch as neither Koetting's original experiment nor the present study were intended to measure threshold, but rather, that threshold was important only in that stimuli be sufficiently above it to permit recognition, and not too far above it to result in lack of sensitivity; it was assumed that some latitude existed regarding the size of targets. In the present study, the size of targets and locus of presentation were based on those measurements determined in Koetting's original study which had provided a sufficiently sensitive test (See below).

6) According to Borish (1954, pp. 138-169), Geldard (1953, pp. 83-93), and Adler (1959, p. 695), environmental and psychological factors influencing visual acuity include age, sex, refractive status, individual anatomical differences, pupillary size, intensity of illumination, duration of exposure, color, contrast, field, length of line (if print is used as the stimulus), and set (e.g., awareness, motivation, etc.). Most of these factors were held constant through the design of the apparatus.

However, both in Koetting's original experiment and the present study random sampling was thought necessary to reconcile minor individual anatomical differences, such as interpupillary distance, and motivation. Subjects were selected at random from a heterogeneous population with respect to sex.

All subjects were "screened" to guard against uncorrected problems regarding refractive status and binocularity, and subject-experimenter interactions were controlled through the reading of instructions and, hopefully, through the utilization of a sufficient number of subjects.

7) As indicated above, Terrace (1959) found that the use of nonsense geometric forms to control for pre-exposural set did not appear to affect the superiority of tachistoscopic recognition of words in the right visual field. His experimentation, however, was not introduced to indicate whether or not a superiority exists in one or the other visual fields, but rather to determine whether or not such differences are a function of pre-exposural set or post-exposural processing.

In the case of Koetting's original experiment, pre-exposural set for word recognition was held constant; in the present study pre-exposural set for both word recognition and pattern recognition was held constant--the objective being the determination of performance differences in the four lateral visual fields, not the nature of such superiority or differences as a function of pre-exposural set or post-exposural processing. However, some future study should include such an investigation under the conditions of the present experiment.

8) As indicated above, Mishkin and Forgays (1952) have reported that the recognition differences for tachistoscopically presented 4-letter English words is restricted to parts of the visual field falling within a visual angle subtended by points at 1^{o} 11' and 4^{o} 46' from the point of fixation. Heron (1957) found that the position in which differences between the two fields is most marked is 5^{o} to 6^{o} in the case of single letters, and 2^{o} 45' and 4^{o} 15' in the case of letter groups. The position of presentation 3^{o} to 4^{o} form the point of fixation, as indicated above as optimal for avoiding

stimulating the foveal area or opposite visual field as a result of physiological nystagmus, falls within the 1° 11' to 4° 46' region recommended by Mishkin and Forgays.

Inasmuch as the data of Mishkin and Forgays was obtained through exposure of 4-letter English words, the situation was considered analogous to that of Koetting's original experiment and the present study, except that in these latter cases words were of three letters rather than four. Koetting had reasoned when designing his original apparatus that if the vertical dimension of the targets were held the same as that of Mishkin and Forgays, comparable results might be anticipated.

The height of the test letters (expressed in degrees) indicated by Mishkin and Forgays (0° 36')* was used as the vertical dimension for letters; the width of the targets (expressed in degrees) was somewhat shorter (2° 2') than that of Mishkin and Forgays (2° 23')** because 3-letter words rather than 4-letter words were used. The work of Heron which also indicated a position of exposure eliciting maximal performance differences was not directly applicable because of the design of targets.

It should be noted that in Mishkin and Forgays' study, in Koetting's original experiment, and in the present study, measurement regarding displacement from the point of fixation was made to the center of words or patterns. Most other investigators have also used the center of the words or center of other targets in determining this distance.

9) Forgays (1953), using 3-letter and 4-letter English words, stimulated approximately the same retinal areas as those which were stimulated in

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*determined through solving for angle θ; tan θ = height of target/distance of target from eye of observer, tan θ = 6.3 mm./ 609.6 mm. = 0103; $\theta = 0^{\circ}$ 23'.

**determined through solving for angle θ; tan θ = width of target/distance of target from eye of observer; tan θ = 25.4 mm./609.6 mm. = 0416; $\theta = 2^{\circ}$ 23'.

Koetting's original experiment. His findings indicated that differential accuracy between the two visual fields (right and left) is not present during the earlier years of life--those corresponding roughly to educational grade-levels two through seven. Indeed, he found some superiority of the left field in grades four and five, and superiority of the right field at all other levels, even when the difference was not significant.

Because of certain procedural factors (i.e., relatively slow time of exposure--.15 sec. (150 msec.), the substituting of a new target when the subject's eyes were observed to move during exposure, and the limited number of subjects--12 at each grade level), the sensitivity of his testing procedure is questionable. It is conceivable that a difference between the right and left visual field might have existed but might not have been measured through his approach. Therefore, despite the fact that his findings suggested that further experimentation using subjects younger than those in grade eight should result in negative findings, Koetting's orignial experiment employed exclusively subjects from the fifth grade level.

The reason for this was twofold: the inference that a difference in performance did not exist between the two fields in this age group was equivocal; and, if the results of his own study were to be applied to future consideration of children manifesting learning disabilities, the age group in which evaluative and remedial measures were typically introduced should be the one considered.

As previously noted, on the basis of the results of his original experiment, Koetting (1970) concluded that differences in performances in the four lateral visual fields can be measured, and are significant, in fifth-grade elementary school children.

EXPERIMENTAL APPARATUS

The apparatus designed for this experiment, and the position of subject and experimenter relative to the apparatus, are presented in Plate I. A polarizing viewing device and display area, and tachistoscopic projector mechanism and targets, constituted essential parts.

Polarizing Viewing Device and Display Area - As shown in Plate I, subjects observed a display area through a typical optical viewing device composed of a one-piece headrest and two apertures, one for each eye, in which were mounted appropriate filters for polarizing light. These polarizing filters permitted maximal transmission to the left eye in the 45° meridian, and to the right in the 135° meridian--a horizontal line from left to right as viewed by the subject being considered the $0\text{-}180^{\circ}$ meridian. This viewing device was supported by a shield confronting the subject (See Plate II).

The display area was a smooth silvered screen permanently situated at a 105 cm. distance from the shield and viewing device through which it was observed, and large enough so that its edges could not be seen when viewed through the apertures. The shield and the smooth silvered screen, appropriately separated, were fastened to a base which in turn was attached to an instrument table for verticle support and adjustment.

A thin cardboard target (an "I") was affixed flush with the smooth silvered screen with its center at eye level when viewed through the polarizing viewing device and situated in the horizontal meridian at a point corresponding to the midline between the two eyes (See Plate III). Thus, the center of this target constituted a central point of visual fixation, and appropriately polarized tests targets could be flashed in loci to right or left of the point of fixation at eye level onto the smooth silvered screen by means of the

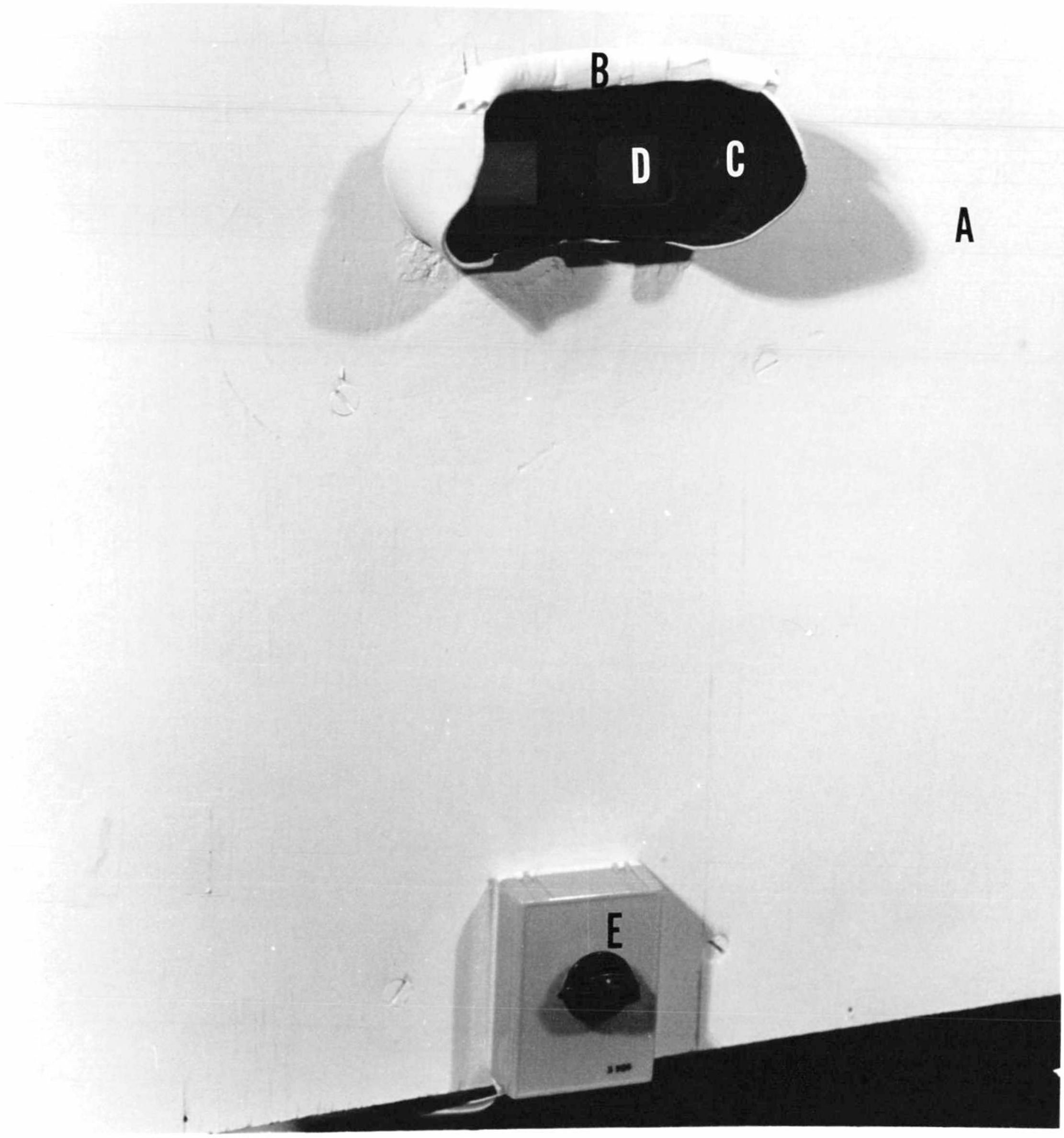
PLATE I

OVERVIEW OF APPARATUS AND EXPERIMENTAL SPACE

A. SMOOTH SILVERED SCREEN
B. FIXATION TARGET
C. POSITION OF INCANDESCENT LIGHT SOURCE BEHIND SCREEN
D. PATTERN DISPLAY
E. BASE
F. FRONT SHIELD
G. INSTRUMENT TABLE
H. SUBJECT
I. EXPERIMENTER
J. KEYSTONE OVERHEAD TACHISTOSCOPE

PLATE II

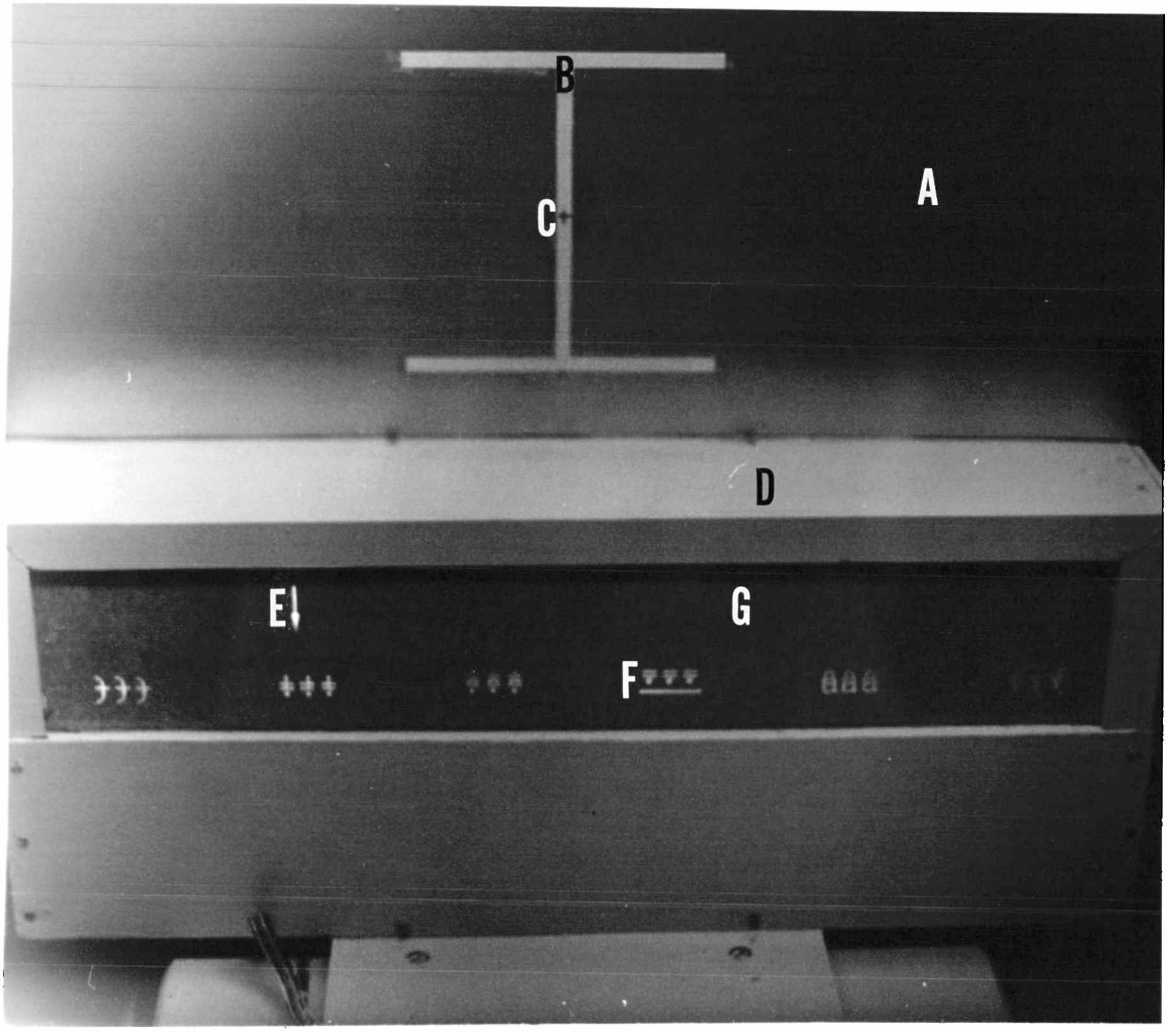
FRONT SHIELD OF APPARATUS



A. FRONT SHIELD
B. HEADREST
C. OPTICAL VIEWING DEVICE
D. APERTURE WITH POLAROID FILTER
E. SELECTOR SWITCH FOR USING ARRAY

PLATE III

DISPLAY AREA



A. SMOOTH SILVERED SCREEN
B. CENTRAL FIXATION TARGET
C. CENTRAL POINT OF FIXATION
D. RECTANGULAR BOX
E. ARROW
F. PATTERN
G. GLASS MOUNTING FOR TRANSPARENCIES

Keystone Overhead Tachistoscope. The center of the projection system of the latter (See Plate IV) was situated approximately one meter (93 cm.) behind the shield and thus behind the subject (i.e., 198 cm. from the display screen)--this distance having been determined for the required size of projected targets.

Other dimensions were based on those of Koetting's original experiment, but required adjustment for the proposed viewing distance of approximately 100 cm. as opposed to 36.6 cm. of the original experiment. These mathematical transformations, which are presented in Table I, were accomplished through multiplying the various dimensions reported by Koetting (1970) with respect to his original study by 2.73. This constant was determined through dividing the proposed distance of the display from the subjects' eyes (100 cm.) by the comparable distance used in the original study (36.6 cm.). As would be expected, the ultimate measurements of various parameters in the completed apparatus, after final adjustment, varied to a slight degree from those indicated by these mathematical transformations.

Based on the transformed dimensions, the fixation "I" was constructed to approximate 174.7 mm. (175 mm.) in height with horizontal arms also approximately 174.7 mm. (175 mm.) (See Fig. 2). The overall horizontal and vertical dimensions of the "I" encompassed a visual angle of 9° 28', respectively.* The width of the arms and bar of this "I" were approximately 8.2 mm. (8.0 mm.) in width subtending a visual angle of 0° 26'.** The true point of fixation was the center of a black cross (arms 7 mm. in length rather than the 5.5 mm. as indicated in Table I) marked with pen and India ink at the center of the vertical bar of the "I", and subtending a visual angle of 0° 18'.***

*9° 28' of arc: $\tan \theta = 175.0$ mm./1050 mm.; $\theta = 9^{\circ}$ 28'.
**0° 26' of arc: $\tan \theta = 8.0$ mm./1050 mm.; $\theta = 0^{\circ}$ 26'.
***0° 18' of arc: $\tan \theta = 5.5$ mm./1050 mm.; $\theta = 0^{\circ}$ 18'.

PLATE IV

KEYSTONE OVERHEAD TACHISTOSCOPE WITH ADJUSTABLE POLAROID FILTER

A. ADJUSTABLE FRONT-SURFACED MIRROR
B. CENTER OF PROJECTION SYSTEM
C. ADJUSTABLE POLAROID FILTER
D. HOUSING FOR POLAROID FILTER
E. SHUTTER RELEASE
F. TIME ADJUSTMENT
G. CAMERA SHUTTER
H. SWITCH FOR FIXED OPENING OF SHUTTER
I. DIAPHRAGM ADJUSTMENT
J. OPTICAL SYSTEMS (NOT VISIBLE) WITHIN HOUSINGS
K. SHIELDED FLASHLIGHT BULB TO ILLUMINATE SLIDE FOR ADJUSTMENT
L. HINGED LIGHT STOP
M. APERTURE
N. TARGET SLIDE
O. SLIDE PLATFORM INCLUDING LIGHT STOP AND APERTURE (NOT VISIBLE)
P. PROJECTOR LIGHT SOURCE (NOT VISIBLE) WITHIN HOUSING

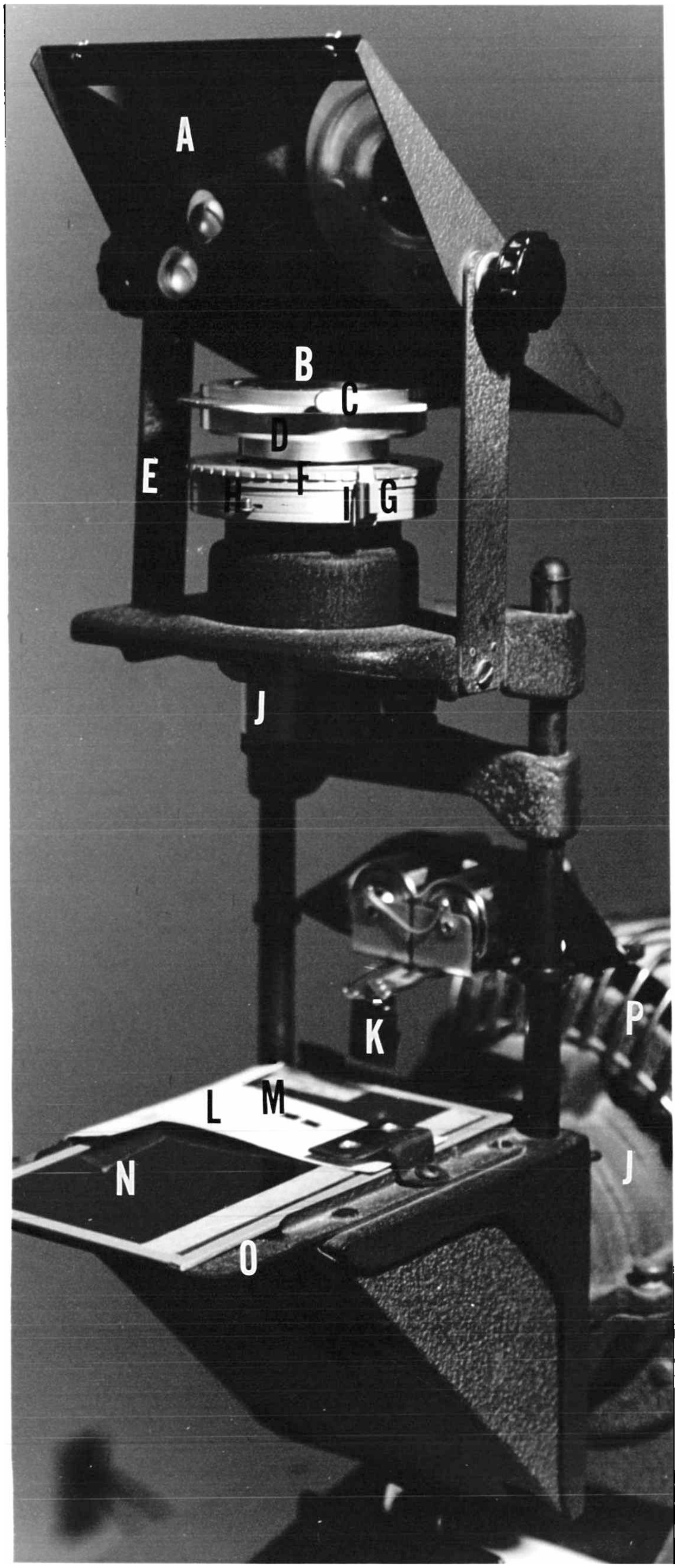


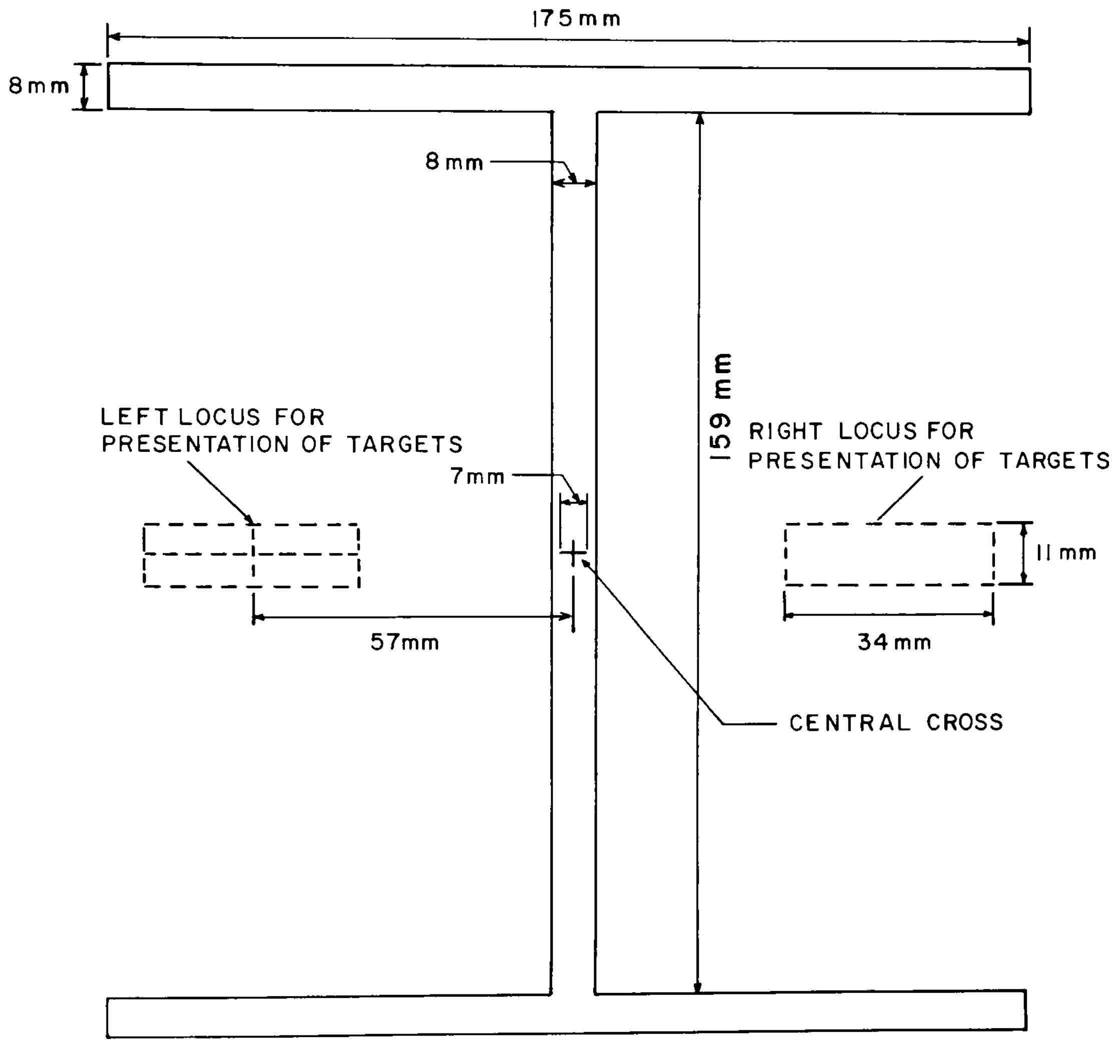
TABLE I

Mathematical transformations of dimensions from those used with a viewing distance of 36.6 cm. to those to be used at a viewing distance of 100 cm. through multiplying by the constant 2.73.

Parameter	Visual Angle Subtended	Linear Dimension At 36.6 CM Viewing Distance	Linear Dimension At 100 CM Viewing Distance
Height of Fixation "I"	9° 55'	64.0 mm.	174.7 mm.
Horizontal Arms of Fixation "I" (Length)	9° 55'	64.0 mm.	174.7 mm.
Width of Arms and Bar of Fixation "I"	0° 28'	3.0 mm.	8.2 mm
Length of Arms of Fixation Cross	0° 19'	2.0 mm.	5.5 mm.
Vertical Projected Size of Words	0° 36'	3.8 mm.	10.2 mm.
Horizontal Projected Size of Words	2° 2'	13.0 mm.	35.5 mm.
Lateral Displacement of Center of Projected Words from Point of Vixation	3° 17'	21.0 mm.	57.3 mm.

FIGURE II

CENTRAL DISPLAY AREA SHOWING DIMENSIONS OF FIXATION "I", SMALL CENTRAL CROSS, LOCI OF PRESENTION, AND TARGETS.



Considerably below the fixation target and the line of sight when the subject's eyes were in the proscribed position for testing, but nevertheless easily viewed when the subject's eyes were turned in a downward direction, was mounted an array of patterns which could be used by the subject for identifying non-verbal targets (See Plate III). This array was constructed through photographing each of the patterns used in the experiment, and enlarging them on black and white negative film to form transparencies having a clear figure and an opaque (black) background. These transparencies were then appropriately mounted between two pieces of glass together with a translucent yellow filter having the same transmission as that used in the construction of projection slides (See below). Included in this glass mounting were also transparencies of an arrow pointing to each of the patterns, respectively.

The completed array was incorporated as one wall of a rectangular box which contained lights for rear-illumination--a light being placed in each of six compartments corresponding to each of the six arrows of the array. A selector switch (See Plate II) on the front shield of the apparatus, centrally located at the bottom of the shield and thus readily available to the subject, permitted the illumination of each compartment discretely, so that adjustment of this switch gave the illusion of an arrow passing from one pattern to the next. Thus, the subject might use the switch for identifying non-verbal targets. Rear-illumination of patterns in the array emanated from a single compartment for all patterns and remained constant.

Experimental space was a room in which illumination could be controlled. The display area was constantly illuminated by a 100 watt incandescent bulb mounted behind the display area in a special holder which permitted directional illumination and adjustment of intensity by means of a diaphragm

(See Plate I). This light source was aimed at the ceiling to provide low indirect illumination of the display area. Luminance of that portion of the display area onto which targets were projected was 0.02 candelas/m^2 as measured by the Prichtchard Photometer. This luminance was established empirically on the basis of being sufficient to permit veiwing of the central fixation target, yet low enough to provide adequate contrast with the projected target to permit recognition.

The luminance of the projected targets was 0.99 candelas/m^2, and as indicated above, was determined in a preliminary phase of the study. Because of its influence on visual acuity, luminance could be modified (reduced) for increasing the sensitivity of the testing situation (i.e., creating a situation in which approximately 50% of the targets would be recognized and fifty percent of the targets missed).

Differences in luminance with respect to both the display area and targets, with the array on and the array off, could not be measured with accuracy, but were minimal. The array was not illuminated during verbal testing.

Tachistoscopic Projector Mechanism and Targets - The Keystone Overhead Tachistoscope* as shown in Plate IV is an instrument used by various professionals for perceptual testing and training. Essentially, it consists of an appropriate light source, an optical system for projecting slides placed on a horizontal platform, and changeable light stops and apertures which permit the projecting of targets upward and then at an approximate right angle toward a projection screen via an adjustable front-surface mirror. Interposed in this line of projection is a camera shutter which can be adjusted

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*A commercial instrument available through the Keystone/Mast Corporation, Davenport, Iowa.

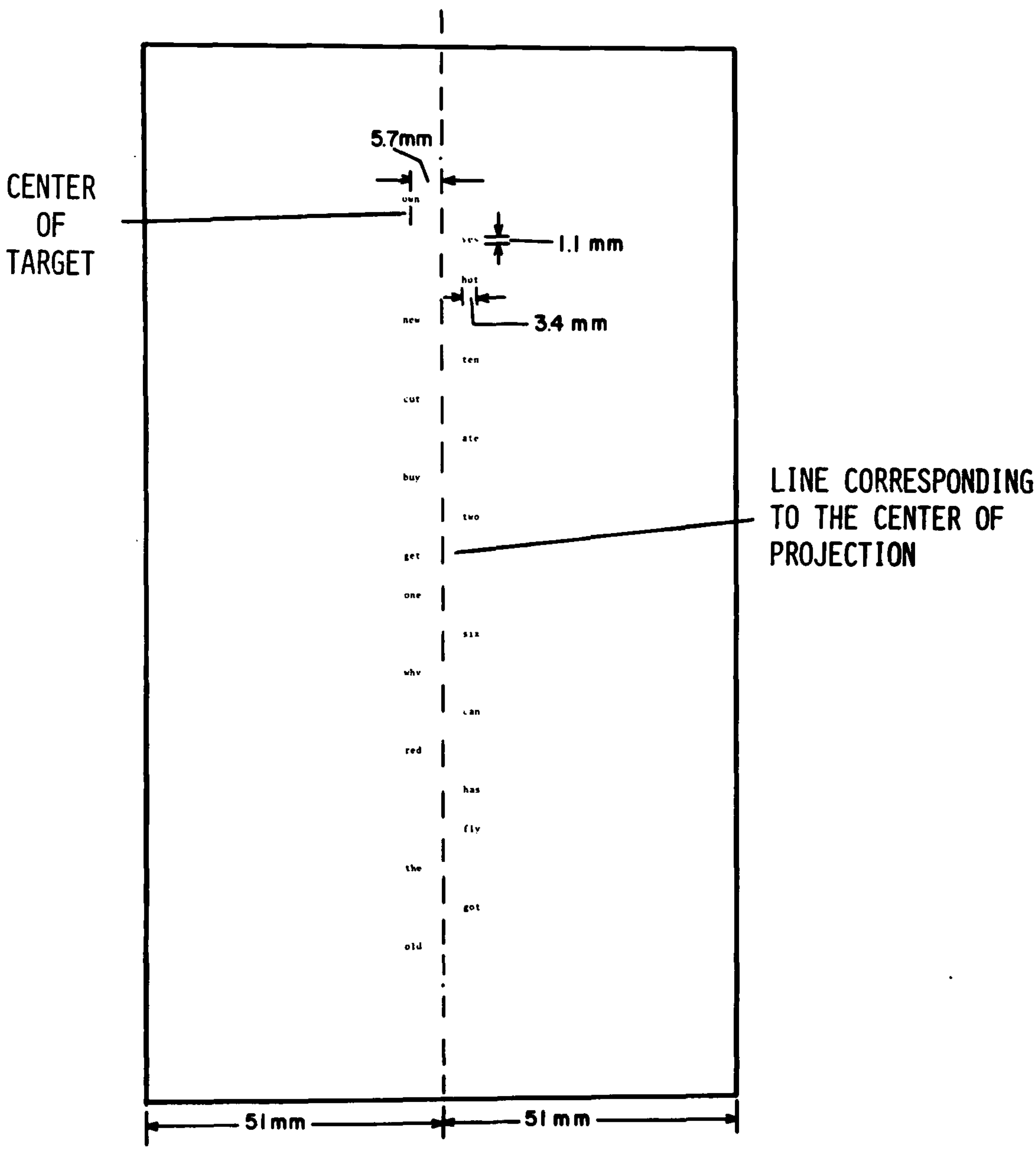
for various speeds and intensity of flash. As indicated above, an attempt was made to adjust the diaphragm of this camera shutter to a setting wherein the luminance of targets would result in approximately a fifty percent probability of correct response. This resulted in a luminance of 0.09 candelas/m^2.

The camera shutter was set for 1/100 sec. (10 msec.) flash. Projection slides were photographic transparencies on which words or patterns appeared a bright yellow in an opaque (black) field. All targets to be projected for a given sequence (i.e., for one of the verbal, or one of the non-verbal treatments, respectively) were included on a single projection slide typical of those used with the Keystone Overhead Tachistoscope (See Figure III). These slides, nevertheless, were specially-constructed to provide the proper size and lateral displacement of projected targets. During introduction of the various targets, the appropriate slide was simply moved forwards or backwards across an aperture in the line of projection which permitted the discrete presentation of each "line" on the slide (one word or pattern per "line").

Although the slide was the same size as those used in the Keystone Tachistoslide Series for presentation of Dolch Words, the size of the targets were considerably reduced in order to achieve the appropriate size of projection. The vertical height of a lower case "o" in the plane of the slide was approximately 1.1 mm.; separation of the center of each target from the midline of the slide was approximately 5.7 mm. (See Fig. III). These dimensions were orignially based on the magnification of the projector (10X) at approximately 2m. distance from the screen and the required projected vertical height of a lower case "o" of 10.2 mm. and a lateral displacement of the center of projected word from the point of fixation of 57.3 mm. in the plane of the screen (as indicated in Table I). After construction and final adjustment

FIGURE III

SPECIALLY-CONSTRUCTED PROJECTION SLIDE SHOWING DIMENSIONS OF TARGETS AND THEIR DISPLACEMENT FROM THE CENTRAL POINT OF PROJECTION.



of apparatus, the projected vertical height of a lower case "o" was 11 mm. (0° 36')* and the horizontal projected size of words was approximately 34 mm. (1° 51')** (rather than the 10.2 mm and 35.5 mm., respectively, indicated in Table I). The lateral displacement of center of projected words from point of fixation was 57.0 mm. (3° 6')*** rather than 57.3 (See Fig. II).

An IBM typewriter having Delegate type was used to prepare both words and patterns (See Box I). Patterns other than letters were constructed of various characters on the typewriter keyboard and were photographed and mounted in the same manner in which the array was constructed except that instead of enlarging the words or patterns, a reduction in size was necessary.

Through consulting the mathematical transformations in Table I, a relationship between the lateral displacement from the point of fixation to the center of projected targets and the horizontal projected size of words was determined and expressed in terms of typewriter character spaces. First, it was determined that lateral displacement of the center of targets from the point of fixation was to be 57.3 mm. and the horizontal dimension of the projected size of words was to be 35.5 mm. This indicated through appropriate calculation that the displacement of the center of words should be 1.6 times greater than that of the width of targets (57.3 mm./35.5 mm.= 1.6). Inasmuch as each target was three character spaces wide, this meant that in preparing typed copy to be photographed for slides that the lateral displacement of the center of targets from the center of projection should be 3 x 1.6, or 4.8, character spaces.

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*0° 36' of arc: $\tan \theta = 11.0$ mm./1050 mm.; $\theta = 0^\circ$ 36'.
**1° 51' of arc: $\tan \theta = 34.0$ mm./1050 mm.; $\theta = 1^\circ$ 51'.
***3° 6' of arc: $\tan \theta = 57.0$ mm./1050 mm.; $\theta = 3^\circ$ 6'.

BOX I

Twenty 3-letter words used for verbal targets and demonstration word.

ate	get	one	ten
buy	got	old	the
can	has	own	two
cut	hot	red	why
fly	new	six	yes

Demonstration word = how

A.

Five 3-character spaces patterns constructed from characters other than letters from typewritter keyboard and demonstration pattern.

Pattern A = }}}
Pattern B = ÷÷÷
Pattern C = ***
Pattern D = 888
Pattern E = √√√

Demonstration pattern = ÷÷÷

B.

Consequently, the typed copy used for preparation of slides had a separation between the two columns of targets (corresponding to stimuli to be presented in the right field and the left field, respectively) of ten character spaces to achieve an approximate relationship of 4.8, (i.e., 5) on each side of the midpoint which would conform to the central point of fixation. Thus, the relationship between target size and lateral displacement would be approximately that which was indicated by the mathematical transformations in Table I. Obviously, if typewritter spacing were used, the exact number of 4.8 character spaces could only be approximated in terms of a complete character space (i.e., 5).

Now, it was known that Delegate character spaces are 0.1" (2.54 mm.) in width; the separation between center of columns of the typed copy therefore was 25.4 mm. (2.54 mm. x 10). Inasmuch as magnification of projected targets at 2m. distance was determined to be approximately 10, this separation in the plane of the slide needed to be reduced to 11.5 mm. to achieve a projected separation in the plane of the screen of 114.6 mm. which was indicated in Table I (i.e., twice the lateral displacement of center of projected words from the point of fixation). Thus, a reduction of all dimensions in the plane of the slide to 0.45 that of typed copy was required. That is, inasmuch as the distance between center of columns in the plane of the slide needed to be 11.5 mm., and this same distance in typed copy was 25.4 mm., a reduction in size to 0.45 (11.5 mm./25.4 mm.) of the typed copy was necessary. From a practical point of view, the total length of one column in the plane of the typed copy was measured, and in photographing the corresponding column was simply reduced to 0.45 of that measurement. This process was facilitated through a knowledge that there are six lines of Delegate type to the inch. Preparation of slides in this manner permitted a reasonably close approximation to the desired relationship of horizontal size of projected targets to lateral displacement from the point of fixation.

A hinged light stop having apertures corresponding to the appropriate positions for projecting the right and left columns, respectively, was affixed over the standard light stop and aperture of the instrument (See Plate IV). Hairline markings on this special stop were utilized for the precise placement of targets in these apertures, and only one target could appear in one or the other of these apertures with any given position of the slide. Therefore, each position of the slide could be used for discrete presentation of targets to either the right or left of the center of projection. The latter could not be projected because of the nature of the background of the slide which was black, and because the position was blocked by the hinged light stop, which contained apertures only appropriate for projecting from either the right or left columns of targets.

Three-letter words composed of lower case letters from the Dolch Basic Sight Vocabulary of 220 Words (Dolch, 1960, pp. 256-257) were used in preparation of the verbal slides; 3 character-space patterns created from the same IBM Delegate keyboard were used in the preparation of non-verbal slides. Thus, non-verbal targets were comparable in size and contour to verbal targets.

According to Table I, at the viewing distance of 100 cm., the required projected size of targets was calculated to be 10.2 mm. in the vertical dimension, and approximately 35.5 mm. in the horizontal dimension, subtending visual angles of 0^{o} 36' and approximately 2^{o} 2', respectively. Lateral displacement of the center of projected targets from the point of fixation was calculated to be 57.3 mm., subtending a visual angle of 3^{o} 17'. An attempt was made to achieve these calculated dimensions as closely as possible. As indicated above, however, the viewing distance used was 105 cm. rather than 100; and as indicated in Fig. II, the projected size of targets after final adjustment of the apparatus was approximately 11 mm. in the vertical dimension, and approximately 34 mm. in the horizontal, subtending visual angles of 0° 36' and approximately $1^{\circ}51'$, respectively. Lateral displacement of center of projected targets from the point of fixation was 57 mm., subtending a visual angle of 3° 6'.

Final adjustment of the size of projected targets was accomplished through minor changes in the distance of the projector from the screen which ultimately was established as 198 cm. The vertical dimension of projected targets was based on the vertical dimension of lower case "o"'s; the overall horizontal dimension of both words and patterns varied to a degree because of minor differences in width of typewritter characters. The assumption, however, was made that the influences of such differences would be canceled out through random selection of words and the balancing of treatments across subject (See below).

A Polaroid filter was mounted in a holder in the line of projection, and affixed over the lenses of the projector by means of a machined housing which permitted rotating the filter in the horizontal plane precisely through an arc of 90° (See Plate IV). The housing of the Polaroid filter was initially adjusted to polarize light in one position to result in a projected target that was polarized for maximal transmission through the analyzing Polaroid filter in the right-eye side of the Polaroid viewing device, and minimal transmission through the left. When the Polaroid filter was rotated through a 90° arc, a converse condition pertained.

Thus, a target which was projected into the right visual field could be polarized for maximal transmission in the 45° meridian to be visible only to the left eye of the subject through the left polarizing filter of the viewing device which was similarly polarized, but not to the right eye, so that only the nasal field of the left eye would be stimulated. Stimulation of the three other fields (i.e., left-temporal, right-nasal, right-temporal) could be introduced through appropriate manipulation of the filter and projection of target to the right or left of fixation.

SUBJECTS

Two clinical samples of male and female children, ages ten years to eleven years one month, were selected at random from populations of children visiting the University of Houston College of Optometry Clinic. One group (normal) visited the Clinic for routine vision evaluation and manifested no indications of learning disorders. The other group (learning-disabilities) were children who visited the Clinic because of some form of learning disability and the indication of possible problems in perceptual development. Potential subjects in both groups were not included if they manifested certain relevant conventional visual defects (See below).

With respect to the learning-disabilities population, the following criteria were applied for acceptance as subjects:

1. Clearly experiencing difficulty in school.
2. Average, or above average intelligence (i.e., I.Q. greater than 90).
3. No "hard" neurological signs (i.e., positive electroencephalogram or other manifestations of neurological involvement).
4. No primary emotional disturbance.
5. No primary sensory impairment.
6. Receiving no medication which might influence the central nervous system.

Two hundred six subjects were selected at random for possible participation in the study. Of these 206 children only 32 who were available were found to satisfy the criteria established for the normal group; only 8 who were available were found to satisfy the criteria for the learning-disability group. Some of the potential 206 were not available for testing either because of conflict of schedules or disinterest on the part of parents; others displayed one or more problems in visual acuity, binocularity, or visual fields, or questionable characteristics with respect to satisfying the criteria of the learning-disabilities population. Of the qualifying 32 subjects in the normal group, 14 were male and 18 were female; of the qualifying 8 subjects in the learning-disabilities group, 3 were male and 5 were female.

EXPERIMENTAL PROCEDURE

Preliminary Screening - Because of the nature of the population from which potential subjects were selected (i.e., a clinical population having received a vision evaluation in the University of Houston College of Optometry Clinic), an immediate determination of visual defects with respect to visual acuity, binocularity, integrity of visual fields, and possible ocular health problems was possible. Criteria for participation with respect to visual adequacy included a minimum of 20/20 distance visual acuity for each eye (with spectacles if necessary), the ability to maintain fusion of inputs from each of the two eyes without cortical suppression or suspension of perception of these inputs, and full visual field recognition with no depression due to ocular disease or other disorders. If spectacle lenses were worn for distance seeing, the screening test was accomplished, and experimental procedures introduced, with lenses in place.

Further, before testing with the Iotasocpe, each subject was presented with a list of words to be used as verbal targets, and asked to read orally the column of words from top to bottom. This was necessary to ascertain whether or not the subject was capable of reading the words correctly, and to facilitate understanding on the part of the experimenter with respect to pronunciation when the words were later reported verbally. These words were typed in alphabetical order with the same IBM Delegate characters used in the construction of targets. No potential subject failed to pass this portion of preliminary screening.

Testing with the Iotascope - The first step in the experimental procedure using the Iotascope was to position the projector so that projected targets were not only of the appropriate size, but that the locus of presentation of targets with respect to vertical positioning (i.e., at the level of the fixation target) and horizontal position (i.e., lateral displacement from the point of fixation) were correct. Such adjustments were accomplished just prior to the subject's being seated comfortably in the chair of the apparatus and the latter being adjusted for their height.

The experimenter would then read instructions to the subject (See Boxes II and III) according to a plan of presentation (verbal or nonverbal presentation first) for that particular subject appropriate to the balanced design of sequences utilized for control (See below). While reading instructions, he would demonstrate how and where targets were to be presented. This was accomplished through the flashing of the same demonstration word or pattern (not one of those used in the study proper) discretely in each of the temporal fields--the left-temporal first, then the right. Thus, the subject came to appreciate how a word might appear to the left of the point of fixation or to the right.

Based on the balanced design for presentation as indicated below, twenty 3-letter words from the Dolch Basic Sight Vocabulary of 220 Words (See Box I) were exposed individually in random order--five being presented in each of the four lateral visual fields--through utilization of one of four randomly-selected sequences of randomly-paired words and fields (See

BOX II

General instructions which were read to subjects--verbal presentation first.

"Now <u>(name)</u> I'll read these instructions to you so I won't forget anything.
"First of all, you shouldn't take your head away from the apparatus until we're through. Keep your head touching the headrest all the time--like it is now. (head gently pushed into position)
"Do you see the big letter 'I'?
"Look right at the black cross in the middle of the big letter 'I'. Do you see the black cross in the middle of the big letter 'I'?

VERBAL TESTING

"Whenever I say, 'Ready', look at the black cross. Then I'll say 'Set', and then <u>'Now'</u>, and then I'll flash a <u>3-letter word</u> to one side of the black cross when I say 'Now': like this, READY, SET, <u>NOW!</u>
"I want you to tell me what the word is. Did you see it?
"Now I might also flash the word on the other side: like this, READY, SET, <u>NOW!</u> Did you see it? Say it.
"You will probably miss some of the words. Don't let that bother you. You can guess. You'll have 10 seconds to tell me what the word is.
"Here's the first word. There'll be twenty words altogether. Be sure to look right at the black cross whenever I say 'Ready'.
"READY, SET, <u>NOW!</u>, etc. (verbal targets are presented)

NON-VERBAL TESTING

"Now <u>(name)</u> let's try something different.
"This time, when I say 'Ready', look at the black cross just like you have been. Then I'll say 'Set', and then <u>'NOW'</u>, but this time I'll flash a <u>picture</u> to one side of the black cross: like this, READY, SET, <u>NOW!</u>
"Then I want you to turn this switch (subject's hand is placed on switch and guided in adjusting it to move arrow across display patterns) so that the arrow points to the picture you saw. Did you see the picture?
"Now I might also flash the picture on the other side: like this, READY, SET, <u>NOW!</u> Did you see it? Move your arrow.
"You'll probably miss some of the pictuers. Don't let that bother you. You can guess. You'll have 10 seconds to show me what the picture is.
"Here is the first picture. There'll be twenty pictures altogether. Be sure to look right at the black cross whenever I say 'Ready'.
"READY, SET, <u>NOW!</u>, etc." (non-verbal targets are presented)

BOX III

General instructions which were read to subjects--non-verbal presentation first.

"Now (name) I'll read these instructions to you so I won't forget anything.
"First of all, you shouldn't take your head away from the apparatus until we're through. Keep your head touching the headrest all the time--like it is now. (head gently pushed into position)
"Do you see the big letter 'I'?
"Look right at the black cross in the middle of the big letter 'I'. Do you see the black cross in the middle of the big letter 'I'?

NON-VERBAL TESTING

"Whenever I say 'Ready', look at the black cross. Then I'll say 'Set', and then 'Now', and then I'll flash a picture to one side of the black cross when I say 'Now': like this, READY, SET, NOW!
"Then I want you to turn this switch (subject's hand is placed on switch and guided in adjusting it to move arrow across display pattern) so that the arrow points to the picture you saw. Did you see the picture? Now I might also flash the picture on the other side: like this, READY, SET, NOW! Did you see it? Move your arrow.
"You'll probably miss some of the pictures. Don't let that bother you. You can guess. You'll have 10 seconds to show me what the picture is.
"Here's the first picture. There'll be twenty pictures altogether. Be sure to look right at the black cross whenever I say 'Ready'.
"READY, SET, NOW!, etc. (non-verbal targets are presented)

VERBAL TESTING

"Now (name) let's try something different.
"This time when I say 'Ready', look at the black cross just like you have been. Then I'll say 'Set', and then 'Now', but this time I'll flash a 3-letter word to one side of the black cross: like this, READY, SET, NOW!
"I want you to tell me what the word is. Did you see it?
"Now I might also flash the word on the other side: like this, READY, SET, NOW! Did you see it? Say it.
"You'll probably miss some of the words. Don't let that bother you. You can guess. You'll have 10 seconds to tell me what the word is.
"Here's the first word. There'll be twenty words altogether. Be sure to look right at the black cross whenever I say 'Ready'.
"READY, SET, NOW!, etc." (verbal targets are presented)

Box IV). Subjects verbally reported what they saw under a ten second time constraint. If the report for any word were correct, a score of one was recorded for the appropriate field; if the report were incorrect in any way, a score of zero was recorded.

Again, based on the balanced design, twenty 3-character patterns constructed using type from the same IBM typewriter keyboard (See Box I) were also presented individually in random order; however, only five patterns were utilized, and therefore each pattern was presented four times to each subject. Presentation was accomplished through utilization of one of four randomly-selected sequences of randomly-paired patterns and fields (See Box V). Subjects indicated patterns which they saw through use of the selector switch which permitted the indicating of the pattern on the array in the display area (See above). If the selection for any pattern were correct, a score of one was recorded for the appropriate field; if the selection were incorrect, a score of zero was recorded.

All subjects received both verbal and non-verbal treatments--the first sixteen in the normal group received verbal stimulation first, followed by non-verbal stimulation; the second sixteen in the normal group received non-verbal stimulation first, followed by verbal stimulation. This was in accord with the balanced design introduced as a control as described below. Unfortunately, all 8 subjects in the learning-disabilities group received verbal stimulation first, and only two of the four randomly-selected sequences of randomly-paired patterns and fields. Complete balancing was precluded through a difficulty encountered in obtaining an adequate number of subjects, which was not anticipated.

In all cases, targets were flashed at 1/100 sec. (10 msec.).

BOX IV

Four randomly-selected sequences of randomly-paired words and fields presented to subjects according to a balanced design.

TREATMENTS

I	II	III	IV
RN own	RN has	LT ate	LN ten
RT yes	LN why	RN hot	RT yes
LN hot	LT red	LN own	LT two
RN new	RN ten	RT new	RN can
LN ten	LN can	RN yes	LT six
LT cut	RT yes	RT red	LN one
RT ate	LT old	LT why	LT own
RN bye	LN the	LN ten	RT has
RT two	LT ate	RT one	RN get
RN get	RT bye	LN bye	LT got
LT one	RN new	RT has	LN new
LN six	RT six	LT six	RT the
LT why	LT got	RT get	RN hot
LN can	RN hot	RN cut	LN cut
RN red	LN get	LT the	RN ate
LN has	LT own	LN fly	RT red
RT fly	RT cut	RN can	RN fly
LT the	LN fly	LN two	LN bye
RT got	RT two	LT old	RT why
LT old	RN one	RN got	LT old

RT = right temporal field
RN = right nasal field
LT = left temporal field
LN = left nasal field

BOX V

Four randomly-selected sequences of randomly-paired patterns and fields presented to subjects according to a balanced design. (Capital letters denote non-verbal patterns as indicated in Box I.)

TREATMENTS

I	II	III	IV
RT C	LT A	LT E	RT A
RN A	RT C	RT A	LT E
RT E	LT A	LT C	LN C
LT D	LN D	RN E	RN D
LN B	LT A	LN A	RT A
RN A	RT E	RN D	LN E
LT C	LT A	LT B	RN C
LN D	LN C	LN D	LT E
RT B	RN D	RT B	LN B
LN D	LN B	RN C	RT D
RT A	RT E	LN B	RN B
RN C	RN C	RN A	LT C
LN D	LN D	LT D	RN D
RT A	RN B	LN E	LN B
RN E	RT D	RT B	RT A
LT B	LT B	LT D	RN D
RN C	RN E	LN A	RT E
LT E	LN C	RT C	LT C
LN B	RN B	RN E	LN A
LT E	RT E	RT C	LT B

RT = right temporal field
RN = right nasal field
LT = left temporal field
LN = left nasal field

CONTROLS

An attempt was made to control variables influencing visual acuity through the maintaining of consistent physical conditions with respect to presentation of targets, and psychological factors (e.g., set, subject-experimenter interactions) through the reading of instructions. Random selection of subjects was utilized from both normal and learning-disabilities populations to control differences in scholastic ability. Such selection also resulted in subjects being fairly evenly distributed with respect to sex (in the normal group, 14 male, 18 female; in the learning-disability group, 3 male, 5 female).

To minimize sequencing effects, the possibility that some words were more easily recognized than others, the influence of order of presentation, and associated interactions, an attempt was made to balance verbal treatments and non-verbal treatments across subjects so that each verbal treatment was presented to the same number of subjects and each non-verbal treatment was presented to the same number of subjects. Further balancing was to be accomplished through presenting verbal treatments first and non-verbal treatments first to an equal number of subjects, respectively. Such a design using four verbal and four non-verbal sequences required 32 subjects, and was accomplished with respect to the normal group. As indicated above, it was precluded in the case of the learning-disabilities group because of the difficulty in obtaining a sufficient number of subjects.

Determining Verbal Treatments - Four verbal treatments (sequences) utilizing the same twenty 3-letter English words from the Dolch Basic Sight Vocabulary of 220 Words (Dolch, 1960, pp. 256-257), differing in order and locus of presentation, were selected at random from a population of such treatments which satisfied the criteria of the basic procedure. These criteria required that each visual field be stimulated an equal number of times (five) and that no field be stimulated successively. Random selection of a treatment from this population was accomplished in two steps.

The first step involved the writing of each of the 20 words used in Koetting's original experiment (which had been selected using a table of random numbers) on each of 20 cards, thoroughly mixing these cards, and using the resulting mixed stack for determining the order of presentation of words--the upper-most card (word) in the stack would be presented first, the next card (word) presented second, and so forth.

The second step involved the writing of the respective abbreviations for the four lateral visual fields (LT, LN, RN, and RT) on each of five cards for a total of twenty, mixing the cards thoroughly, and following somewhat the same system as that used for determining the order of words for determining the order of locus of presentation. However, in this latter operation, if two successive cards indicated stimulation of the same field, the second card was returned to the stack and mixed with the remaining cards. This operation in selection was continued until a field was indicated which was acceptable under the criteria for testing.

It should be noted, that when an unacceptable locus of presentation were indicated, if it were utilized in the developing sequence, the resulting sequence would be one that was not part of the population of acceptable sequences described by the above criteria from which random selection was to be made. Therefore, it was considered appropriate by the experimenter to return the unacceptable locus of presentation card to the batch of cards from which subsequent selections were to be made because that selection had not been from the correct population.

Four such verbal treatment sequences were thus determined that could be presented to an equal number of subjects in the normal group and learning-disabilities group, respectively (See Box IV).

Determining Non-Verbal Treatments - Determination of non-verbal sequences was accomplished in much the same manner as verbal sequences; however, inasmuch as only five non-verbal patterns were utilized in the development of sequences of twenty patterns, four cards for each pattern were prepared for the initial batch of cards to be mixed in the first step which was concerned with the order of presentation of patterns. In the second step in which patterns were randomly assigned to the respective fields, the criteria of the basic procedure again pertained; that is, that each visual field be stimulated an equal number of times (five) and that no field be stimulated successively.

No attempt was made to further limit the population from which this random selection was made through precluding the presentation of the same pattern successively or more than once in a given field. The logistics of accomplishing such a procedure appeared disproportionate to the control that might be achieved--especially taking into account that any successive presentation of the same target or multiple presentation in a given field would be controlled through the random selection of successive presentations or multiple presentations from a population of all such successive presentations or multiple presentations.

Similarly, the use of only five patterns rather than twenty might be challenged, but again justification is attempted through noting the logistic difficulties to be encountered in the development of twenty such patterns, and the probable insurmountable difficulty the subject would encounter in attempting to select a nameless pattern from an array of twenty such patterns. It was assumed that random sampling and the balancing of treatments across subjects would minimize any resulting bias.

Four non-verbal treatment patterns were developed for presentation (See Box V).

TREATMENT OF DATA

Preliminary Study of Data - Data were arranged in various distributions appropriate for testing the 12 basic hypotheses listed under METHODS AND PROCEDURES (pp. 36-38). Random-effects two-way analysis of variance tests as recommended by Hays (1963, pp. 430-437) for differences between treatments for each of the 12 situations were accomplished. According to Hays (1963, p. 358) this model is appropriate when an experiment involves only a random sample of the population of treatments about which inferences are to be made. The assumption is made that errors within treatments are normally and independently distributed and have the same variance irrespective of the particular treatment under which an observation is made. Further, it must be assumed that there is a distribution of possible values for effects that might appear in a given repetition of the experiment which has a mean of 0 and a variance of some finite value (Hays, 1963, p. 418).

As indicated above, in cases in which significance was found between treatments, the Scheffe' Method for post-hoc comparisons as described by Hays (1963, pp. 484-487) was to be applied to determine which of the four respective lateral peripheral visual fields were responsible. In cases of distribution of combined scores (i.e., total right field scores for the left and right eyes, and total left field scores for the right and left eyes), this type of analysis would not be necessary, because only two treatments representing the right and left fields, respectively, were included in the distribution. If significants were indicated by the F ratio, the combined field having the greater scores could be determined through inspection of descriptive statistics (i.e., the means of the combined fields).

As indicated under RESULTS (pp. 75-101) the Scheffe' Method was only required in the case of evaluating the distribution of scores for the normal subjects receiving verbal treatments.

CHAPTER III

RESULTS

Raw scores for each of the four lateral visual fields (right-temporal, RT; right-nasal, RN; left-temporal, LT; left-nasal, LN) for normal subjects receiving verbal treatments, normal subjects receiving non-verbal treatments, learning-disabilities subjects receiving verbal treatments, and learning-disabilities subjects receiving non-verbal treatments are presented in Tables II, III, IV, V, respectively. Difference scores for each of the four lateral fields between paired normal and learning-disabilities subjects receiving verbal treatments are presented in Table VI; difference scores for each of the four lateral fields between paired normal and learning-disabilities subjects receiving non-verbal treatments are presented in Table VII.

Tables VIII, IX, and X include descriptive statistics (number, mean, and standard deviation) for these distributions across subjects for each of the four lateral fields. Tables XI and XII include descriptive statistics for distributions of scores of eight normal subjects receiving the same treatments as those subjects in the learning-disabilities group with respect to both verbal and non-verbal stimulation across subjects for each of the four lateral fields and for total right field and total left field, respectively. The latter two distributions were needed for the purpose of evaluating sensitivity of the testing situation (See below).

Frequency distributions of total correctly reported recognitions out of the possible twenty per subject for normal subjects receiving verbal treatments, normal subjects receiving non-verbal treatments, learning-disabilities subjects receiving verbal treatments, and learning-disabilities subjects receiving non-verbal treatments are presented as Tables XIII, XIV, XV, and XVI, respectively. It should be noted that in no case is the median of these distributions 10--the number of correct responses considered optimal for eliciting a phenomenon. Indeed, with the exception of the learning-disabilities group receiving non-verbal treatments, the median is greater than ten, ranging from 15.5 for the normal group receiving verbal treatments, through 13.5 for the learning-disabilities group receiving verbal treatments, to 12.5 for the normal group receiving non-verbal treatments. The increased number of correct recognitions, especially with respect to the normal group receiving verbal treatments, would suggest a decreased sensitivity with respect to the testing situation (See below).

STATISTICAL TESTS

Results of random-effects two-way analyses of variance relative to the four lateral visual fields, treatments, and the interaction between these two variables for normal subjects receiving verbal and non-verbal treatments, respectively; learning-disabilities subjects receiving verbal and non-verbal treatments, respectively; and, for difference scores between paired normal and learning-disabilities subjects receiving verbal and non-verbal treatments, respectively, are presented in Tables XVII, XIX, XXI. Random-effects two-way analyses of variance relative to the total scores in the right visual field (left-nasal scores plus right-temporal scores) and the left visual field (left-temporal scores plus right-nasal scores) for each of these situations are presented in Tables XVIII, XX, XXII.

Only one Scheffe' post-hoc comparison of scores was required, because only one analysis of variance between the four lateral fields, wherein such delineation was necessary, showed significance (i.e., between the four lateral fields for normal subjects receiving verbal treatments). Such a comparison, of course, was not necessary in analyzing distributions involving total right field and total left field scores because a significant difference between the two distributions of right field scores and left field scores could be interpreted through simple comparison of the means of these distributions. The Scheffe' post-hoc comparison of scores in the four lateral visual fields of normal subjects receiving verbal treatments is presented in Table XXIII. No significant differences are indicated.

Because of the decreased sensitivity of the testing situation, as noted above, and the related possibility of a Type II error (i.e., that of not rejecting a null hypothesis when it is false), random-effects two-way analyses of variance between total respective right and left field scores of a group of normal subjects matched with the learning-disabilities group with respect to number and treatments received was introduced for both the verbal and non-verbal situation. This was accomplished in an attempt to demonstrate that the testing situation was sufficiently sensitive to elicit phenomena observed in normal children even if the number of subjects were limited to that of the learning-disabilities group (i.e., 8). These analyses of variance are presented in Table XXIV.

Significant findings may be summarized as follows:

1. With respect to differences between the four lateral visual fields in normal subjects receiving verbal treatments, the null hypothesis is rejected at the .01 level of confidence (See Table XVIIA). Differences, however, can not be further delineated through post-hoc Scheffe' comparison at this level of confidence (See Table XXIII).

2. With respect to differences between the total right visual field scores and total left visual field scores in normal subjects receiving verbal treatments, the null hypothesis is rejected at the 0.05 level of confidence (See Table XVIIIA). Descriptive statistics (See Table VIII) indicate superior performance in the right visual field.
3. With respect to differences between the total right visual field scores and total left visual field scores in normal subjects receiving non-verbal treatments, the null hypothesis is rejected at the 0.01 level of confidence (See Table XVIIIB). Descriptive statistics (Table VIIIB) indicate a superior performance in the right visual field.
4. With respect to differences between the total right visual field scores and the total left visual field scores in a group of normal subjects matched with the learning-disabilities group with respect to number and non-verbal treatments, the null hypothesis is rejected at the 0.05 level of confidence (See Table XXIVB). Descriptive statistics (Table XIIB) indicate superior performance in the right visual field.

As recommended by Hays (1963, pp. 435-437), differences between both columns and rows is most appropriately tested by MS interaction rather than by MS error in the random-effects two-way analysis of variance. Interaction is tested by MS error. The F ratios, therefore, are placed in parentheses to indicate that this system of testing has been followed and that the F values have not been obtained in the usual manner.

In no case is interaction found to be significant. However, as indicated in Tables XVIIIB, XIXB, XXB, and XXIA, a significant difference is found between treatment sequences which ranges between the .01 and .05 levels of confidence. Such differences might have been anticipated, and are not considered important inasmuch as the orthogonal design of the experiment resulted in an equal number of subjects receiving each treatment sequence, and interaction between treatments and respective lateral fields is not significant.

TABLE II

Raw scores for each of the four lateral visual fields for normal subjects receiving verbal treatments.

TREATMENT	SUBJECT	RT	RN	LT	LN	TOTAL SCORE
	1	3	2	4	4	13
	2	5	4	3	5	17
	3	5	4	3	5	17
I	4	2	4	1	2	9
	17	2	1	0	0	3
	21	3	4	5	5	17
	25	5	3	5	5	18
	29	4	5	4	3	16
	5	5	4	3	5	17
	6	3	1	2	2	8
	7	4	1	2	4	11
II	8	3	1	0	3	7
	18	4	0	3	5	12
	22	5	3	4	5	17
	26	5	3	4	5	17
	30	4	5	4	5	18
	9	4	3	4	4	15
	10	3	2	2	4	11
	11	4	4	4	4	16
III	12	3	2	1	3	9
	19	4	3	4	5	16
	23	4	3	4	5	16
	27	5	5	4	5	19
	31	5	5	4	5	19
	13	3	1	0	0	4
	14	3	1	1	3	8
	15	4	2	1	3	10
IV	16	4	3	2	2	11
	20	3	3	3	4	13
	24	4	2	3	3	12
	28	5	4	4	4	17
	32	3	5	5	5	18

TABLE III

Raw scores for each of the four lateral visual fields for normal subjects receiving non-verbal treatments.

TREATMENT	SUBJECT	RT	RN	LT	LN	TOTAL SCORE
	1	2	1	3	2	8
	5	4	2	1	3	10
	9	4	2	4	2	12
I	13	1	2	1	2	6
	17	3	3	2	1	9
	18	2	3	3	5	13
	19	5	2	2	5	14
	20	4	4	5	2	15
	2	4	2	3	4	13
	6	2	3	1	3	9
	10	4	3	4	4	15
II	14	2	2	3	1	8
	21	3	3	5	2	13
	22	5	2	4	2	13
	23	5	3	4	4	16
	24	4	1	3	4	12
	3	4	3	2	3	12
	7	1	3	1	2	7
	11	4	1	1	2	8
III	15	1	2	1	2	6
	25	3	4	4	4	15
	26	4	4	4	4	16
	27	1	5	2	3	11
	28	2	1	3	5	11
	4	5	4	2	3	14
	8	5	4	1	1	11
	12	4	2	2	3	11
IV	16	5	4	4	4	17
	29	5	3	4	4	16
	30	5	5	2	5	17
	31	5	4	3	1	13
	32	5	5	5	3	18

TABLE IV

Raw scores for each of the four lateral visual fields for learning-diabilities subjects receiving verbal treatments.

TREATMENT	SUBJECT	RT	RN	LT	LN	TOTAL SCORES
	1	2	3	1	2	8
I	2	1	2	2	3	8
	3	5	4	3	4	16
	4	4	3	3	3	13
	5	5	4	5	3	17
II	6	5	4	3	2	14
	7	5	2	3	4	14
	8	4	2	2	3	11

TABLE V

Raw scores for each of the four lateral visual fields for learning-disabilities subjects receiving non-verbal treatments.

TREATMENT	SUBJECT	RT	RN	LT	LN	TOTAL SCORES
I	1	0	0	2	1	3
	5	3	3	4	5	15
II	2	3	2	1	1	7
	6	1	1	4	1	7
III	3	2	2	2	1	7
	7	4	3	3	3	13
IV	4	3	3	2	3	11
	8	5	4	4	4	17

TABLE VI

Difference scores for each of the four lateral visual fields between paired normal and learning-disabilities subjects receiving verbal treatments.
(normal scores less learning-disabilities scores)

TREATMENT	SUBJECT PAIRS	RT	RN	LT	LN	TOTAL SCORES
	1	1	-1	3	2	5
I	2	4	2	1	2	9
	3	0	0	0	1	1
	4	-2	1	-2	-1	-4
	5	0	0	-2	2	0
II	6	-2	-3	-1	0	-5
	7	-1	-1	-1	0	-3
	8	-1	-1	-2	0	-4

TABLE VII

Difference scores for each of the four lateral visual fields between paired normal and learning-disabilities subjects receiving non-verbal treatments. (normal scores less learning-disabilities scores)

TREATMENT	SUBJECT PAIRS	RT	RN	LT	LN	TOTAL SCORES
I	1	2	1	1	1	5
	5	1	-1	-3	-2	-5
II	2	1	0	2	3	6
	6	1	2	-3	2	2
III	3	2	1	0	2	5
	7	-3	0	-2	-1	-6
IV	4	2	1	0	0	3
	8	0	0	-3	-3	-6

TABLE VIII

Descriptive statistics for the distribution across normal subjects receiving verbal treatments for each of the four lateral visual fields.

LEFT-TEMPORAL FIELD (LT) Number = 32 Mean = 2.9 Standard Deviation = 1.5	LEFT-NASAL FIELD (LN) Number = 32 Mean = 3.8 Standard Deviation = 1.5
RIGHT-NASAL FIELD (RN) Number = 32 Mean = 2.9 Standard Deviation = 1.5	RIGHT-TEMPORAL FIELD (RT) Number = 32 Mean = 3.8 Standard Deviation = 1.1

A.

Descriptive statistics for the distribution across normal subjects receiving non-verbal treatments for each of the four lateral visual fields.

LEFT-TEMPORAL FIELD (LT) Number = 32 Mean = 2.8 Standard Deviation = 1.3	LEFT-NASAL FIELD (LN) Number = 32 Mean = 3.0 Standard Deviation = 1.1
RIGHT-NASAL FIELD (RN) Number = 32 Mean = 2.9 Standard Deviation = 1.1	RIGHT-TEMPORAL FIELD (RT) Number = 32 Mean = 3.5 Standard Deviation = 1.5

B.

TABLE IX

Descriptive statistics for the distribution across learning-disabilities subjects receiving verbal treatments for each of the four lateral visual fields.

LEFT-TEMPORAL FIELD (LT) Number = 8 Mean = 2.8 Standard Deviation = 1.0	LEFT-NASAL FIELD (LN) Number = 8 Mean = 3.0 Standard Deviation = 0.7
RIGHT-NASAL FIELD (RN) Number = 8 Mean = 3.0 Standard Deviation = 0.9	RIGHT-TEMPORAL FIELD (RT) Number = 8 Mean = 3.9 Standard Deviation = 1.4

A.

Descriptive statistics for the distribution across learning-disabilities subjects receiving non-verbal treatments for each of the four lateral visual fields.

LEFT-TEMPORAL FIELD (LT) Number = 8 Mean = 2.8 Standard Deviation = 1.0	LEFT-NASAL FIELD (LN) Number = 8 Mean = 2.4 Standard Deviation = 1.5
RIGHT-NASAL FIELD (RN) Number = 8 Mean = 2.3 Standard Deviation = 1.1	RIGHT-TEMPORAL FIELD (RT) Number = 8 Mean = 2.6 Standard Deviation = 1.5

B.

TABLE X

Descriptive statistics for the distribution of difference scores between paired normal and learning-disabilities subjects receiving verbal treatments for each of the four lateral visual fields.
(normal scores less learning-disabilities scores)

LEFT-TEMPORAL FIELD (LT)	LEFT-NASAL FIELD (LN)
Number = 8 Mean = -0.5 Standard Deviation = 1.6	Number = 8 Mean = 0.8 Standard Deviation = 1.1
RIGHT-NASAL FIELD (LN)	RIGHT-TEMPORAL FIELD (RT)
Number = 8 Mean = 0.4 Standard Deviation = 1.4	Number = 8 Mean = 0.1 Standard Deviation = 1.8

A.

Descriptive statistics for the distribution of difference scores between paired normal and learning-disabilities subjects receiving non-verbal treatments for each of the four lateral visual fields.
(normal scores less learning-disabilities scores)

LEFT-TEMPORAL FIELD (LT)	LEFT-NASAL FIELD (LN)
Number = 8 Mean = -1.0 Standard Deviation = 1.9	Number = 8 Mean = 0.3 Standard Deviation = 2.0
RIGHT-NASAL FIELD (RN)	RIGHT-TEMPORAL FIELD (RT)
Number = 8 Mean = 0.5 Standard Deviation = 0.8	Number = 8 Mean = 0.8 Standard Deviation = 1.6

B.

TABLE XI

Descriptive statistics for the distribution across normal subjects receiving the same verbal treatments as learning-disabilities subjects for each of the four lateral visual fields.

LEFT-TEMPORAL FIELD (LT) Number = 8 Mean = 2.3 Standard Deviation = 1.1	LEFT-NASAL FIELD (LN) Number = 8 Mean = 3.8 Standard Deviation = 1.1
RIGHT-NASAL FIELD (RN) Number= 8 Mean = 2.6 Standard Deviation = 1.5	RIGHT-TEMPORAL FIELD (RT) Number = 8 Mean = 3.8 Standard Deviation = 1.0

A.

Descriptive statistics for the distribution across normal subjects receiving the same non-verbal treatments as learning-disabilities subjects for each of the four lateral visual fields.

LEFT-TEMPORAL FIELD (LT) Number = 8 Mean = 1.8 Standard Deviation = 0.8	LEFT-NASAL FIELD (LN) Number = 8 Mean = 2.6 Standard Deviation = 0.9
RIGHT-NASAL FIELD (RN) Number = 8 Mean = 2.8 Standard Deviation = 0.8	RIGHT-TEMPORAL FIELD (RT) Number = 8 Mean = 3.4 Standard Deviation = 1.3

B.

TABLE XII

Descriptive statistics for the distribution across normal subjects receiving the same verbal treatments as learning-disabilities subjects for the total left visual field and total right visual field, respectively.

LEFT VISUAL FIELD (LT + RN)	RIGHT VISUAL FIELD (LN + RT)
Number = 8	Number = 8
Mean = 4.9	Mean = 7.5
Standard Deviation = 2.1	Standard Deviation = 2.2

A.

Descriptive statistics for the distribution across normal subjects receiving the same non-verbal treatments as learning-disabilities subjects for the total left visual field and total right visual field, respectively.

LEFT VISUAL FIELD (LT + RN)	RIGHT VISUAL FIELD (LN + RT)
Number = 8	Number = 8
Mean = 4.5	Mean = 6.0
Standard Deviation = 0.8	Standard Deviation = 1.7

B.

TABLE XIII

Frequency distribution of total correctly reported verbal recognitions out of a possible twenty per subject in the normal group.

SCORE	f
20	0
19	2
18	3
17	7
16	4
15	1
14	0
13	2
13	2
12	2
11	3
10	1
9	2
8	2
7	1
6	0
5	0
4	1
3	1
2	0
1	0
0	0
	32

median = 15.5

TABLE XIV

Frequency distribution of total correctly reported non-verbal recognitions out of a possible twenty per subject in the normal group.

SCORE	f
20	0
19	0
18	1
17	2
16	3
15	3
14	2
13	5
12	3
11	4
10	1
9	2
8	3
7	1
6	2
5	0
4	0
3	0
2	0
1	0
0	0
	32

median = 12.5

TABLE XV

Frequency distribution of total correctly reported verbal recognitions out of a possible twenty per subject in the learning-disabilities group.

SCORE	f
20	0
19	0
18	0
17	1
16	1
15	0
14	2
13	1
12	0
11	1
10	0
9	0
8	2
7	0
6	0
5	0
4	0
3	0
2	0
1	0
0	0
	8

median = 13.5

TABLE XVI

Frequency distribution of total correctly reported non-verbal recognitions out of a possible twenty per subject in the learning-disabilities group.

SCORE	f
20	0
19	0
18	0
17	1
16	0
15	1
14	0
13	1
12	0
11	1
10	0
9	0
8	0
7	3
6	0
5	0
4	0
3	1
2	0
1	0
0	0
	8

median = 9

TABLE XVII

Random-effects two-way analysis of variance relative to performance in the four lateral visual fields for normal subjects receiving verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	12.4	3	4.1	$\left(\frac{4.1}{1.2} = 3.4\right)$	no	
Columns (fields)	27.2	3	9.1	$\left(\frac{9.1}{1.2} = 7.6\right)$	yes	0.01
Interaction	11.0	9	1.2	$\frac{1.2}{1.8} = 0.7$	no	
Error	201.1	112	1.8			
Totals	251.7	127				

A.

Random-effects two-way analysis of variance relative to performance in the four lateral visual fields for normal subjects receiving non-verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	19.5	3	6.5	$\left(\frac{6.5}{2.5} = 2.6\right)$	no	
Columns (fields)	10.9	3	3.6	$\left(\frac{3.6}{2.5} = 1.4\right)$	no	
Interaction	22.8	9	2.5	$\frac{2.5}{1.5} = 1.7$		
Error	165.6	112	1.5			
Totals	218.8	127				

B.

TABLE XVIII

Random-effects two-way analysis of variance relative to performance in the total respective right and left visual fields for normal subjects receiving verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	24.9	3	8.3	$\left(\frac{8.3}{4.9} = 1.7\right)$	no	
Columns (fields)	54.4	1	54.4	$\left(\frac{54.4}{4.9} = 11.1\right)$	yes	0.05
Interaction	14.6	3	4.9	$\frac{4.9}{5.8} = 0.8$	no	
Error	324.6	56	5.8			
Totals	418.5	63				

A.

Random-effects two-way ayalysis of variance relative to performance in the total respective right and left fields for normal subjects receiving non-verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	39.0	3	13.0	$\left(\frac{13.0}{0.3} = 43.3\right)$	yes	0.01
Columns (fields)	11.4	1	11.4	$\left(\frac{11.4}{0.3} = 38\right)$	yes	0.01
Interaction	0.8	3	0.3	$\frac{0.3}{3.8} = 0.1$	no	
Error	211.4	56	3.8			
Totals	262.6	63				

B.

TABLE XIX

Random-effects two-way analysis of variance relative to performance in the four lateral visual fields for learning-disabilities subjects receiving verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	3.8	1	3.8	$\left(\frac{3.8}{1.5} = 2.5\right)$	no	
Columns (fields)	5.8	3	1.9	$\left(\frac{1.9}{1.5} = 1.3\right)$	no	
Interaction	4.4	3	1.5	$\frac{1.5}{1.2} = 1.3$	no	
Error	28.2	24	1.2			
Totals	42.2	31				

A.

Random-effects two-way analysis of variance relative to performance in the four lateral visual fields for learning-disabilities subjects receiving non-verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	13.0	3	4.3	$\left(\frac{4.3}{0.9} = 4.8\right)$	yes	0.05
Columns (fields)	1.3	3	0.4	$\left(\frac{0.4}{0.9} = 0.4\right)$	no	
Interaction	7.7	9	0.9	$\frac{0.9}{2.3} = 0.4$	no	
Error	36.0	16	2.3			
Totals	58.0	31				

B.

TABLE XX

Random-effects two-way analysis of variance relative to performance in the total respective right and left visual fields for learning-disabilities subjects receiving verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	7.5	1	7.5	$\left(\frac{7.5}{0.7} = 10.7\right)$	no	
Columns (fields)	5.0	1	5.0	$\left(\frac{5.0}{0.7} = 7.1\right)$	no	
Interaction	0.7	1	0.7	$\frac{0.7}{3.5} = 0.2$	no	
Error	42.2	12	3.5			
Totals	55.4	15				

A.

Random-effects two-way analysis of variance relative to performance in the total respective right and left visual fields for learning-disabilities subjects receiving non-verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	26.0	3	8.7	$\left(\frac{8.7}{0.7} = 12.4\right)$	yes	0.05
Columns (fields)	0.0	1	0.0	$\left(\frac{0.0}{0.7} = 0.0\right)$	no	
Interaction	2.0	3	0.7	$\frac{0.7}{7.5} = 0.1$	no	
Error	60.0	8	7.5			
Totals	88.0	15				

B.

TABLE XXI

Random-effects two-way analysis of variance relative to differences in performance in the four lateral visual fields between paired normal and learning-disabilities subjects receiving verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	18.0	1	18.0	$\left(\frac{18.0}{0.9} = 20\right)$	yes	0.025
Columns (fields)	7.7	3	2.6	$\left(\frac{2.6}{0.9} = 2.9\right)$	no	
Interaction	2.7	3	0.9	$\frac{0.9}{2.2} = 0.4$	no	
Error	53.5	24	2.2	$\underline{0.9} = 0.4$	no	
Totals	81.9	31				

A.

Random-effects two-way analysis of variance relative to differences in performance in the four lateral visual fields between paired normal and learning-disabilities subjects receiving non-verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	9.2	3	3.1	$\left(\frac{3.1}{1.6} = 1.9\right)$	no	
Columns (fields)	14.9	3	5.0	$\left(\frac{5.0}{1.6} = 3.1\right)$	no	
Interaction	14.8	9	1.6	$\frac{1.6}{3.8} = 0.4$	no	
Error	61	16	3.8			
Totals	99.9	31				

B.

TABLE XXII

Random-effects two-way analysis of variance relative to differences in performance in the total respective right and left visual fields between paired normal and learning-disabilities subjects receiving verbal treatment.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	36.0	1	36.0	$\left(\frac{36.0}{9.2} = 3.9\right)$	no	
Columns (fields)	2.0	1	2.0	$\left(\frac{2.0}{9.2} = 0.2\right)$	no	
Interaction	9.2	1	9.2	$\frac{9.2}{5.4} = 1.7$	no	
Error	64.5	12	5.4			
Totals	111.7	15				

A.

Random-effects two-way analysis of variance relative to differences in performance in the total respective right and left visual fields between paired normal and learning-disabilities subjects receiving non-verbal treatments.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	17.5	3	5.8	(3.9)	no	
Columns (fields)	9.0	1	9.0	$\left(\frac{9.0}{1.5} = 6.0\right)$	no	
Interaction	4.5	3	1.5	$\frac{1.5}{11.0} = 0.1$	no	
Error	8.0	8	11.0			
Totals	119.0	15				

B.

TABLE XXIII

Scheffe' post-hoc comparison of scores in the four lateral visual fields of normal subjects receiving verbal treatments.

	MEAN	VISUAL FIELD LN	RN	RT
Mean		3.81	2.91	3.84
VISUAL FIELD				
LT	2.91	-0.90	0.00	-0.93
LN	3.81		0.00	0.03
RN	2.91			-0.93

F ratio for 3 and 9 df at 0.01 level of confidence = 6.99

confidence interval (CI) for each comparison difference:

$$(CI - 1.24) \leq CI \leq (CI + 1.24)$$

no significant differences.

TABLE XXIV

Random-effects two-way analysis of variance relative to performance in the total respective right and left visual fields for a group of normal subjects matched with the learning-disabilities group with respect to number and verbal treatments received.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	10.5	1	10.5	$\left(\frac{10.5}{5.2} = 2.0\right)$	no	
Columns (fields)	27.5	1	27.5	$\left(\frac{27.5}{5.2} = 5.3\right)$	no	
Interaction	5.2	1	5.2	$\frac{5.2}{5.1} = 1.0$	no	
Error	61.2	12	5.1			
Totals	104.4	15				

A.

Random-effects two-way analysis of variance relative to performance in the total respective right and left visual fields for a group of normal subjects matched with the learning-disabilities group with respect to number and non-verbal treatments received.

SOURCE	SS	df	MS	F	HYPOTHESIS REJECTED	LEVEL OF CONFIDENCE
Rows (treatments)	7.5	3	2.5	$\left(\frac{2.5}{0.5} = 5.0\right)$	no	
Columns (fields)	9.0	1	9.0	$\left(\frac{9.0}{0.5} = 18.0\right)$	yes	
Interaction	1.5	3	0.5	$\frac{0.5}{2.6} = 0.2$	no	
Error	21.0	8	2.6			
Totals	39.0	15				

B.

CHAPTER IV

DISCUSSION

The most interesting aspect of this study is that despite a decreased sensitivity in the testing situation, a significant difference favoring the right visual field was found in normal children for both verbal and non-verbal targets. The superiority of recognition in the right field with respect to words was anticipated; the superiority in the right visual field with respect to the non-verbal patterns was not. On first encounter, this latter finding appears to be completely contradictory to those of others—especially Heron (1957) and Terrace (1959) who reported no significant difference between the fields with respect to geometric forms, and Kimura (1973) whose work would indicate, if anything, that geometric forms would be processed in the right cerebral hemisphere. Reflecting on the nature of verbal and non-verbal targets, however, a commonality can be appreciated between the two types which was not given consideration in designing the experiment. Both were gestalts, composed of many parts (i.e., lines, curves, dots), which needed to be perceived in terms of their total configuration for identification.

The principal difference between the two types of targets was that the word gestalts served as symbols for verbal meaning, the pattern gestalts did not. Yet, each required being perceived as a whole. The findings of this experiment, therefore, suggest that the phenomenon wherein language skills (whether spoken, heard, or read) are observed to be associated with the left cerebral hemisphere is but one manifestation of an overall propensity for the left cerebral hemisphere to process gestalts.

If Kimura's work (1973) is re-examined, it can be seen that this propensity for processing gestalts in the left cerebral hemisphere might be inferred not only in vision, but in audition and manual performances. In audition, a left hemisphere dominance is found with respect to words, nonsense syllables, and backward speech; with respect to manual activities, left hemisphere dominance is found with respect to skilled movements and free movements during speech--both of which are total meaningful patterns of performance (gestalts?).

On the other hand, the right hemisphere, as suggested by Kimura, would appear to play a dominant role in man's perception of his environment. In audition, there is observed a right hemisphere dominance for melodic patterns and non-speech sounds; in manual performance, there is a right hemisphere dominance for non-visual location. In vision, the right cerebral hemisphere is observed to be dominant for two-dimensional point location, dot and form enumeration, matching of slanted lines, and stereoscopic depth-perception.

These findings, considered with the observations of the present study, would suggest that there is a propensity of the left cerebral hemisphere for processing gestalts as opposed to the right cerebral hemisphere being primarily concerned with discrete measurements and appreciations of dimensions of time and space. Language involves the use of total patterns as symbols, and therefore its function would be primarily associated with the left cerebral hemisphere.

The results of this experiment, therefore, would tend to support and complement the contentions of Kimura. Unfortunately, they are in direct conflict with those of Heron (1957) who found no significant difference in recognition between either nonsense forms or familiar forms exposed in the right field and those exposed in the left; and, Terrace (1959) who reported no significant difference with respect to recognition of nonsense geometric forms between the right and left fields. Nevertheless, in reviewing these latter studies, differences from the present experiment are apparent which might account for this disagreement.

Both Heron and Terrace used college students as subjects rather than 10-year-old children, and differences in findings might be due to differences in the phenomenon across populations of different ages.

Both used a relatively slow exposure time (about 100 msec.) which is questionable with respect to precluding eye movements. This might have changed the nature of the testing situation from one of measuring recognition in a given field to one of simply measuring reaction time. In particular, this would have been the case if the nonsense geometric forms were of an increased size, or had other characteristics, which permitted easier recognition than letters or words. Indeed, Terrace reports that the nonsense geometric stimuli used were two to three times as tall as the words used in his experiment--the words subtending a visual angle 1° 54' vertically, which is over three times as great as the vertical height of targets in the present study (0° 36'). The width of the forms used by Heron apparently subtended visual angles in both the horizontal and vertical meridians of 1° 30', which is comparable in the horizontal meridian of the present study (1° 51'), but almost three times as great in the vertical meridian. Both relatively slow exposure time and increased size of targets would promote recognition to the right and left of a point of presumed fixation, but would not necessarily even be a measurement in a given field if the eyes moved. This could account for no differences being observed between the respective fields.

Finally, nonsense geometric forms, if sufficiently simple in construction, which apparently they were, might trigger their being processed by the right hemisphere in terms of their spatial components rather than as gestalts, to be processed by the left. Even the familiar forms used by Heron (e.g., heart, star, triangle, square) were simple in construction, and might have been processed in terms of shape rather than as total complex patterns, and therefore processed by the right hemisphere.

Both Heron and Terrace, of course, reported no difference in the ability to recognize these geometrical forms in either the right or the left visual fields. However, it is possible that their testing situations were not sufficiently sensitive to show a significant superiority to the left of fixation, which would be in the field corresponding to the right hemisphere. It should be noted that although Kimura found a right hemisphere dominance for two-dimensional point location, dot and form enumeration, and matching of slanted lines; the differential between right hemisphere performance and left hemisphere performance was not as great as that for words or letters.

The findings of Harcum (1969), Harcum and Nice (1975), and Nice and Harcum (1976) are somewhat more difficult to reconcile with the present observations, although not insurmountably.

In his 1969 experiment in which Harcum exposed across fixation horizontal tachistoscopic patterns extending so far into peripheral vision that they had no perceivable end, precluding end-to-end scanning, he found that there is no scanning effect, but that elements nearest the central point of fixation are more accurately reproduced. Further, he found no lateral differences in this latter effect.

The absence of scanning in this particular testing situation, and the presence of a left-to-right scanning which Harcum and Nice (1975) and Nice and Harcum (1976) have shown in situations in which scanning is possible can be integrated without serious conflict with the present observations and those of others. The left-to-right scanning would simply support the contention of other investigators such as Heron (1957) who concludes that readers establish two tendencies to move their eyes: (a) to fixate near the beginning of a line of print, and (b) to move their eyes along a line of print from left to right. Although it is true that Heron and others are apparently postulating overt changes in fixation as opposed to Harcum's postulating covert scanning or other processing of icons; the ultimate outcome of these processes, whether overt or covert is the same.

When alphabetical material is exposed in the right field only, there is no conflict between these tendencies; when alphabetical material is exposed in the left field only, the tendency to move the eyes or attending to the icon to the beginning of the line is in conflict with the tendency to move the eyes or scan from left-to-right. Heron's observation that under conditions of successive presentation, more letters are recognized in both fields, but to a greater degree in the left, under conditions of exposure occurring simultaneously in both fields, can be accounted for through the dominant tendency to move either the eyes or the attending to the icon to the beginning of the line resulting in more letters being recognized in the left field. Thus, many of the basic observations are not in conflict, albeit the explanations differ.

The lack of lateral differences in Harcum's 1969 experiment which precluded scanning and Harcum and Nice's 1975 experiment with fixation on beginning or end components of words which indicated a scanning from periphery toward fixation is more difficult to reconcile.

In the absence of scanning, it would be anticipated that elements nearest fixation would be more accurately reproduced than those further removed, which was the case. Harcum used a horizontal row of zeros with certain of the elements blackened as test targets. It certainly might be suggested that these types of targets would require discrete evaluation of spatial characteristics rather than processing as gestalts. Thus, processing would be thought to occur in the right cerebral hemisphere, and that a superiority of performance in the left visual field would be indicated, but it was not. The absence of lateral differences in the ability to recognize targets under circumstances of this experiment, however, might be attributed to a lesser differential in the capacity for the required processing between the two hemispheres, as the work of Kimura would indicate, and a lack of sensitivity with respect to Harcum's testing procedure.

Exposure time was exceptionally slow, approximately 1/7 sec. (150 msec.), which would have permitted considerable movement of the eyes about the point of fixation so that both right and left fields might be stimulated by targets on either side of the point of fixation. Further, the size of each element subtended a visual angle of only 0° 13.2' of arc--approximately one third the size of letters used in the current experiment (0° 37')*, which could have accounted for the decreasing performance away from the point of fixation because of lowered visual acuity in the periphery. In addition, subjects were college students rather than 10-year-olds.

Thus, Harcum's 1969 study, which was not primarily designed to investigate

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$$\frac{\text{*width of 3-character targets in present study}}{3} = \frac{1^{\circ}51'}{3} = 0^{\circ}37'$$

performance in one visual field as opposed to the other, but rather to determine the presence or absence of sequential scanning under circumstances of a continuous pattern wherein the ends could not be seen, should not be used to support a position of lack of superior performance in either the right or left visual fields.

The work of Harcum and Nice in 1975 involved mutual masking in which two compound words of eight letters were flashed in rapid succession to determine whether serial or parallel processing were involved under various situations. A left-to-right processing was indicated when fixation was in the center of the projected targets, and processing from periphery to point of fixation was indicated when targets were projected to either the right or left of fixation. Again, there was apparently no significant difference between performance in the right or left fields under circumstances of this experiment.

Harcum and Nice attributed peripheral to central scanning in this study to the selection of different methods for processing icons based on the nature of the stimulus such as locus of presentation. Thus, a centrally-presented target would be scanned from left-to-right, eccentrically presented targets would be processed in such a way as to first identify the weaker items in the icon store. If the present investigator has correctly interpreted the writings of Harcum and Nice, the icon is an input pattern which is very temporarily held in memory and which is scanned covertly rather than through overt changes in fixation. Again, there is no basic conflict with the notion that under circumstances of eccentrically presented targets that there is a covert peripheral-to-center scanning; however, the absence of a difference in the ability to recognize words between the right and left visual fields under circumstances of such scanning is in conflict with the postulation of a superior capacity for processing verbal gestalts in the left cerebral hemisphere.

Thus, the postulation of a covert left-to-right scanning of words is not in conflict with previous notions accounting for superiority of recognition of words presented in the right visual field because this left-to-right scanning would pertain to words presented in the right visual field and be supported by a tendency to fixate near the beginning of a line of print. As indicated by Heron (1957) when alphabetical material is exposed in the left field only, the tendency to move the eyes to the beginning of the line is in conflict with the tendency to move the eyes from left to right. This concept could be equally true of covert scanning of icons rather than eye movements. However, Harcum and Nice's finding that words projected eccentrically to the point of fixation are processed from periphery to the point of fixation is contradictive to the idea of a tendency to either point the eyes or covertly attend to the first part of a line of print in the icon.

As in the case of Harcum's 1969 study, there are certain aspects of the 1975 Harcum and Nice study which appear to preclude use of observations to either support or challenge the notion of superiority of recognition in either the right or left visual fields. Again, the size of letters was quite small (subtending only 0° 25' of arc in width) and exposure times was relatively slow. In the 1975 experiment, these exposure times were 40 msec. and 30 msec.

The total word lengths used subtended visual angles of 4.3°, or 2° 9' on either side of the point of fixation when the targets were projected centrally. This distance was increased by sixteen minutes when targets were projected eccentrically. It is this investigator's experience that letters of the size used would be too small to be seen in more peripheral portions of the field stimulated. Therefore, there is a good probability that because of the relatively slow exposure time, subjects were simply moving their eyes, at least to a degree, in overt scanning. This supposition would be supported by the idea that some parts of the targets could not be seen without such movement because of their decreased size. Again, this study was also conducted using college students as subjects, which is a complicating issue when observations are to be compared with those made in ten-year-olds.

Consideration of other results of the present experiment is somewhat confounded by a lack of sensitivity in the testing situation and a small sample size in the learning-disabilities group.

As noted in Tables XIII, XIV, XV, and XVI, the median of the frequency distribution for the normal group receiving verbal treatments was 15.5, for the normal group receiving non-verbal treatments 12.5, for the learning-disabilities group receiving verbal treatments 13.5, and for the learning-disabilities group receiving non-verbal treatments 9.0. Inasmuch as a median of 10 correct responses was considered optimal for eliciting a response, only the learning-disabilities group receiving non-verbal treatment approximated the desired index of sensitivity.

The size of the learning-disabilities group was limited to eight subjects because of difficulties in obtaining subjects as noted above. Sixteen potential learning-disabilities subjects were found who satisfied the criteria for that group; however, in five cases, a misalignment or other mechanical defect relative to the apparatus was discovered precluding the use of obtained data. The number was further reduced to eight in order to maintain the orthogonal design.

With respect to the consideration of the scores of normal subjects, differences between performance in the individual four lateral visual fields could not be demonstrated, even though differences for both verbal and non-verbal treatments could be demonstrated when the scores for the total right visual field were compared to the scores for the total left. This was especially disconcerting because Koetting in 1970 had found a superiority of performance in the nasal field of the left eye (I_2) which he concluded to be responsible for the superiority of performance in the total right field as compared to the total left in normal subjects receiving verbal treatments.

Inspection of the descriptive statistics in Table VIII for the distribution across normal subjects receiving verbal treatments for each of the four lateral visual fields reveals identical means for performance in both the left-nasal (I_2) and right-temporal (I_4) fields (i.e., the components of the total right visual field); and, identical means for performance in both the left-temporal (I_1) and right-nasal fields (I_3) (i.e., the components of the total left visual field). Thus, although comparisons of the total scores in the right and left visual fields, respectively, was significant; no significance could be demonstrated between performance in the left-nasal field and right-temporal fields which had led to Koetting's earlier conclusion that performance in the left-nasal field was superior to that in the right-temporal, and was primarily responsible for superiority of performance in the total right field.

Inasmuch as there is no reason to challenge the validity of Koetting's earlier work, the failure to detect a significant difference between performance in these two lateral fields (i.e., I_2 and I_4) is thought to be a lack of sensitivity in the present testing for subtle differences in these two fields as compared to the rather pronounced differences in the total right and total left visual fields. There is no reasonable alternative to the suspending of judgement at this time.

One of the goals of this study was to obtain evidence that might indicate a relationship between I_2 and the ability to read. In both the verbal and non-verbal testing in the learning-disabilities group, comparison of performance in both the four lateral visual fields and between the total right and total left visual fields indicated no significant differences.

Although the testing situation was not considered to be sufficiently sensitive to detect differences between the four lateral visual fields, the absence of a significant difference between the total right and total left visual fields in learning-disabilities subjects receiving verbal treatments might be indicative of inadequate development of the increased capacity for processing verbal information in the left cerebral hemisphere. In the normal group receiving verbal treatments, this difference is significant at the 0.05 level of confidence (See Table XVIIA).

However, because of the small sample size used in the learning-disabilities investigation, and because of the recognized decreased sensitivity of the testing situation, there is considerable danger with this inference of committing a type II error--that is, one in which the hypothesis is accepted when in reality it should be rejected. To determine possible insensitivity accounting for this lack of significant difference, the scores of a group of the normal subjects matched with the learning-disability group with respect to number and verbal treatments was analyzed for significance (See Table XXIVA). Significance could not be demonstrated between the right and left visual fields for this adjusted group of subjects. Again, therefore, judgement obviously must be suspended.

It should be noted, nevertheless, that inspection of the descriptive statistics relative to verbal treatments in each of the four lateral visual fields in the learning-disabilities group (See Table IXA) suggests the emergence of a pattern wherein scores in the left-temporal (I_1), left-nasal (I_2), and right-nasal (I_3) fields are equal, and that scores in the right-temporal (I_4) are greater. The mean of the scores for I_1 is 2.8; I_2, 3.0; I_3, 3.0; and, I_4, 3.9. Given a sufficient number of subjects, and a sufficiently sensitive testing situation, a significant difference indicating a superiority of I_4 over the performance in all the other lateral fields, including I_2, might be demonstrated. Or, put another way, a loss of superiority in the I_2 field might eventually be shown to be chiefly responsible for a lessening in total right field scores. This could be indicative of a lesser capability for the recognition of verbal gestalts via the I_2 component of the right visual field as opposed to a decreased ability in both the I_2 and I_4 components of the right visual field encountered with non-verbal gestalts (See below).

If the descriptive statistics in Table XIA relative to the special distribution of scores for normal subjects matched with the learning-disabilities group with respect to number and verbal treatments is consulted, it can be seen that no such decrement in the I_2 component of the right visual field is suggested in the normal group. (Indeed, the typical pattern of superiority of I_2 and I_4 would appear to be emerging, albeit the difference cannot be shown to be significant.) This would lead to the very serious consideration that in learning-disabilities children there is some lack of ability for processing verbal material via the I_2 component.

As will be seen below, this decrement in the I_2 component is also noted in the descriptive statistics regarding the scores of learning-disabilities children receiving treatments with non-verbal gestalts; however, in that group, a decrement is also found in the I_4 component, which is not observed in the group of normal subjects matched with the learning-disabilities group with respect to number and verbal treatments.

In analyzing the data of the learning-disabilities group receiving treatment with non-verbal gestalts, as indicated in Table XIXB, the null hypothesis is accepted. Again, the possibility of a type II error exists because of a possible lack of sensitivity and because of the small sample size. However, in this instance, analysis of data from a group of normal subjects matched with the learning-disabilities group with respect to number and non-verbal treatments indicates a significant difference favoring the total right visual field (See Table XXIVB). Further, the descriptive statistics associated with the distribution of scores for each of the four fields for this group (See Table XIA) would suggest the emergence of the same pattern of means for the four respective visual fields that was found for the total normal group of thirty-two (See Table XIIB). Inspection of the descriptive statistics relative to scores of the learning-disabilitiesgroup receiving non-verbal treatments (See Table IXB) reveals little difference in the means between the four lateral visual fields as opposed to a reasonable superiority indicated for the I_4 component in the group of normal subjects matched to the learning-disabilities group with respect to number and non-verbal treatments.

This would appear to indicate: (a) that in normal subjects, with respect to non-verbal gestalts, the testing situation was sufficiently sensitive to measure a significant difference favoring the right visual field even using a number of subjects limited to eight; and, (b) although not demonstrable statistically, through inspection, the lack of significant difference between the total right visual field and total left visual field found in the group of subjects having learning disabilities is due to a loss in the I_4 component of the right field.

The attempt to demonstrate the existence of a gradient in I_2 across individuals through developing difference scores for paired normal and learning-disabilities subjects for each of the four lateral fields (normal scores less learning-disabilities scores) proved to be futile. The lack of sensitivity of the testing situation and limited number of such paired observations (i.e., eight) are again thought to be responsible. Analyses of variance for differences for each of the four lateral fields for verbal treatment and non-verbal treatments, respectively, which are presented in Tables XXIA and XXIB, indicate no difference between the four lateral fields; analyses of variance of difference scores between the total right visual field and total left visual field for verbal and non-verbal treatments, respectively, presented in Tables XXIIA and XXIIB, also show no significant differences.

Inspection of descriptive statistics presented in Tables XA and XB would suggest a superiority of I_2, I_3, and I_4 (especially I_2 favoring the normal group, and I_1 favoring the learning-disabilities group) for verbal treatments; and, a superiority of I_2, I_3, and I_4 (especially I_4 favoring the normal group, and I_1 favoring the learning-disabilities group) for non-verbal targets. These findings would indicate the possibility of a gradient of ability to recognize targets in any one of the four lateral visual fields under circumstances of both verbal and non-verbal treatment which might be positively correlated with the ability to learn (especially I_2 in the verbal situation and I_4 in the non-verbal situation), and which might be negatively correlated with the ability to learn with respect to I_1 in both the verbal and non-verbal situations.

The results of this study, then, lead to some new concepts in the emerging theory of field dominance and cerebral asymmetry--some of which can be supported statistically, some of which are equivocal, and some of which are little more than speculation.

It would appear to be clearly indicated through statistical testing that there is a superior ability to recognize both verbal and non-verbal gestalts in the right visual field as opposed to the left in normal subjects. Inspection of the descriptive statisics for each of the four lateral visual fields would indicate an approximately equal ability with respect to the left-nasal field (I_2) and right-temporal field (I_4) using verbal treatments; however, inspection of the descriptive statistics for non-verbal treatments in normal subjects, would suggest some superiority in the right-temporal field (I_4) over the other component of the right field, the left-nasal field (I_2).

If it is assumed that lack of sensitivity in testing precluded detecting differences between I_2 and I_4, and that Koetting's original findings that verbal recognition in the nasal field of the left eye (I_2) is somewhat superior to the right-temporal field in normal subjects, this might lead to the conjecture that there is not only a propensity for processing gestalts in the left cerebral hemisphere, but that inputs from the left-nasal field are more important in the processing of verbal gestalts, and inputs from the right-temporal field are more important for processing non-verbal gestalts.

With respect to the learning-disabilities group, the null hypothesis could not be rejected at the 0.05 level of confidence for either differences between the four lateral visual fields or the right and left fields with respect to either verbal or non-verbal treatments. Although not statistically significant, descriptive statistics would indicate a decrement in the left-nasal field (I_2) for verbal targets and a decrement in the right-temporal field (I_4) for non-verbal targets when compared to the descriptive statistics of the normal group. Interestingly enough, there is apparantly no decrement in the right-temporal field (I_4) for verbal targets.

If the idea expressed above, that although there is a propensity for processing gestalts in general in the left cerebral hemisphere; and if the processing of verbal gestalts is more efficiently accomplished when mediated by the left eye, and the processing of non-verbal gestalts is more efficiently accomplished, when mediated by the right eye; then it might be argued that in children with learning disabilities, there is a lessening of the ability for processing verbal gestalts in the left-nasal field (I_2), and non-verbal gestalts in the right-temporal field--that is, in those portions of the left cerebral hemisphere in which some organization for processing inputs from those respective fields normally develops.

It must be remembered, however, that sensitivity of the verbal testing with respect to the learning-disabilities group could not be demonstrated through a consideration of a group of normal-subjects, matched to subjects in the learning-disabilities group with respect to treatment and number, even for the total right and left visual fields. Thus, the matter of decrement in the right visual field in learning-disabilities children must remain a matter of speculation, especially with respect to which of the components, or both of the components, are responsible for this decrement if it should exist.

Sensitivity of non-verbal testing with respect to the learning-disabilities group could be demonstrated through consideration of a group of normal subjects matched to subjects in the learning-disabilities group with respect to treatment and number in comparing the total right and left fields. The position, then, that there is a decrement in the right field associated with learning-disabilities for processing non-verbal gestalts in the right visual field is somewhat more than a matter of speculation. Again, however, differences between the four individual fields could not be demonstrated statistically, and the matter must remain one in which judgement is suspended.

With respect to differences between the performance of normal subjects and learning-disabilities subjects in each of the four lateral fields for both verbal treatments and non-verbal treatments, although no statistical difference could be shown between fields, inspection of descriptive statistics would indicate a superiority for processing verbal gestalts via input from the left-nasal field (I_2) and from the right-temporal field (I_4) for non-verbal gestalts favoring the normal group. There would also appear to be an increased capacity in the left-temporal field (I_1) with respect to both verbal and non-verbal gestalts favoring the learning-disabilities group. This could be indicative of deviant performance (i.e., development of some superiority for recognition of targets in the left-temporal field) established by learning-disabilities subjects when normal development of cerebral processes is precluded through minimal brain damage or other causes.

For the most part, these concepts represent an expansion of the emerging theoretical position regarding visual dominance as outlined in the section THEORY (See p. 27), and do not include conflicting thoughts. Some modification regarding the localization of language skills in the left cerebral hemisphere is needed to include the idea that normally the left cerebral hemisphere is responsible for the processing of gestalts, taking into account non-verbal patterns as well as verbal patterns (words), and that the verbal patterns are more efficiently processed when mediated by the left-nasal field (I_2) and the non-verbal patterns are more efficiently processed when mediated by the right-temporal field (I_4).

These ideas complement those of Kiumra (1973) with respect to cerebral asymmetry; namely, that not only does the left hemisphere play a dominant role in speech but that the right hemisphere plays a dominant role in man's perception of his environment. It is suggested that this notion be expressed as man's understanding total, intricate, patterns either as symbols or at least as organized, meaningful entities, is accomplished through more efficient processing of information in the left cerebral hemisphere; and that discrete measurements of time and space (e.g., rhythm, measurements, size) are more efficiently processed in the right cerebral hemisphere.

As noted above, in the experiments of both Heron (1957) and Terrace (1959) in which no superiority of either right or left field was demonstrated using geometrical forms, both familiar and otherwise, targets might not have been intricate enough to trigger processing in the left cerebral hemisphere, or might have been considered dimensions of space and relegated to the right cerebral hemisphere for more efficient processing.

There is no basic conflict with the concepts of Harcum (1969), Harcum and Nice (1975), and Nice and Harcum (1976) with respect to an apparent scanning from left-to-right when verbal material is presented tachistoscopically in the central field, or from periphery to point of fixation when targets are presented eccentrically, whether this be an overt movement of the eyes, covert scanning of an icon, or combination of both. Failure to find differences between the right and left fields with respect to verbal targets is in conflict with most other investigators, and as indicated above, could very likely be due to an increased time of exposure which permitted eye movements for overt scanning. If this should be the case, their observations would be useless in making inferences about the peripheral fields because changes in fixation would result in central stimulation of the macular area, and input to a respective cerebral hemisphere would be uncertain. This criticism could also be applied to the work of both Heron and Terrace.

The suggestion of Nice and Harcum (1976) that the nature of the requirements of a given situation, with respect to targets triggers what type of scanning will be introduced can certainly be reconciled with the present contention that gestalts are processed more efficiently when presented in the right visual fields, and that dimensions of time and space are more efficiently processed in the left, corresponding to left and right cerebral hemispheres, respectively.

The present study supports the position that subjects recognize significantly more words in the right visual field than in the left as reported by Hebb (1949, pp. 49-50), Mishkin and Forgays (1952), Forgays (1953), Orbach (1952), Heron (1957) Terrace (1959), Koetting (1970), and Kimura (1973). That this occurs through selective "retinal" training resulting from the process of learning to read as advocated by Mishkin and Forgays (1952), Forgays (1953), Orbach (1952), Heron (1957), Terrace (1959) and Leavell and Beck (1959) is supported by the present study through observed lesser manifestation of the phenomenon in children having learning-disabilities, which are considered to stem in part from problems in perceptual development.

This concept might be expanded to include the idea that superiority of non-verbal gestalt recognition in the right visual field could be at least patially dependent upon the development of that capacity to recognize verbal gestalts in the left cerebral hemisphere, simultaneous development of both the capacity for processing verbal and non-verbal gestalts in the left cerebral hemisphere, or represent a basic capacity for recognition of gestalts which might be further modified through learning to read.

The results certainly confirm Koetting's (1970) findings that at least differences between the right and left fields exist with respect to recognition of words, and in the present case also with non-verbal patterns, exposed for brief periods of time. These differences can be measured and are significant in normal ten-year-old children.

If Terrace's (1959) conclusion that pre-exposural set does not change the observed superiority of the right visual field with respect to the recognition of words, and if this finding is assumed to apply equally well to non-verbal patterns, the observed phenomena might be considered a manifestation of post-exposural type of processing, which is determined by the properties of the stimulus (Heron, 1957; Terrace, 1959; Heron, 1957; Crovitz and Lipscomb, 1963; Koetting, 1970; Nice and Harcum, 1976).

Further, observations in the present study would support Koetting's (1970) conclusion that the numerical superiority of nerve fibers servicing a given peripheral field is not the responsible factor for superior ability to recognize words presented in that field inasmuch as the number of nerve fibers servicing the total right visual field would be approximately the same as those servicing the total left field. This concept can now be extended to include the numerical superiority of nerve fibers servicing a given peripheral field not being the responsible factor for a superior ability to recognize non-verbal gestalts.

The two principal negative criticism which might be directed at the present study would appear to be that of lack of sensitivity of the testing situation and the lack of control for pre-exposural set.

The sensitivity of future testing in experiments of this type could be readily increased through decreasing either the luminance or size of the targets.

Terrace (1959) found through a pilot study of eye muscle potentials that in a series in which only letters were presented, subjects tended to shift their fixation to the right of a central fixation point. In an experiment to determine the influence of such pre-exposural set, he presented words randomly alternated with nonsense geometrical forms. He concluded that pre-exposural set does not significantly influence the greater recognition of words in the right visual field. However, pre-exposural set could have been controlled in the present study through the random interspersing of non-verbal patterns and words, and should be introduced in future studies of this type.

Such future investigation should include studies to further delineate differences between the four lateral visual fields rather than simply between the right and left visual fields. Further, if a superiority of I_2 should again be found in normal subjects with respect to recognition of verbal gestalts (as in Koetting's original study), and a superiority of I_4 should be found in normal subjects with respect to non-verbal gestalts; then investigation into whether or not such phenomena are absent in learning-disabilities children would be indicated. If gradients in these phenomena should exist in learning-disabilities children, they might be related to IQ or measurements of scholastic achievements. It is conceivable that if these abilities are poorly established or absent with respect to one or more of the four lateral visual fields, that appropriate patching of one eye, or use of Polariod filters might be introduced in specifically training the ability to recognize either verbal gestalts or non-verbal gestalts through stimulation of the appropriate cerebral hemisphere.

As perceptual phenomena emerge, electrophysiological correlates should be sought for verification and further expansion of knowledge. Such parameters might eventually provide the basis for clinical monitoring.

CHAPTER V

SUMMARY AND CONCLUSIONS

In 1970, Koetting reported on an investigation concerning the ability to recognize words in each of the four lateral visual fields, noting that there is a significant superiority with respect to this ability in both components of the right field--especially the nasal field of the left eye. There is also evidence that such differences in recognition are a product of learning to read, and that they do not occur with non-verbal targets. To explore these latter contentions, this study was introduced in an attempt to demonstrate differences between groups of normal children and those designated as having learning-disabilities through use of verbal targets; and, the absence or other differences in the phenomenon in both groups using non-verbal targets. It involved the discrete tachistoscopic presentation of verbal and non-verbal stimuli in the four lateral parafoveal fields at a fixed lateral displacement from a point of fixation. Subjects were forty ten-year-old children--32 in the normal group and 8 in the learning-disabilities group.

Experimental apparatus for presenting targets was similiar to that described by Koetting in 1970. However, certain parameters with respect to size of targets and locus of presentation relative to the point of fixation which were determined through the original study permitted a modification of apparatus to simplify construction and facilitate use.

As with the original apparatus, a system for permitting projection of targets discretely in any one of the four lateral visual fields, and a mechanism for tachistoscopically flashing targets constituted essential parts. However, instead of using a stereoscopic viewing device for presentation of targets discretely in any one of the fields, projections were polarized and these polarized targets were viewed through Polariod filters (analyzers) so that only the intended part of a respective retina was stimulated. Projection was accomplished by means of a Keystone Overhead Tachistoscope onto a smooth silvered screen which did not influence the polarity of the reflected light.

Subjects viewed the smooth silvered screen at a distance of approximately 100 cm. from their face through a viewing device which housed the appropriate filters to polarize light in meridians at right angles before the respective eyes, and targets polarized in one or the other of these meridians were flashed using the Keystone Overhead Tachistoscope. Subjects were required to visually fixate a small cross at the center of a target centrally located in their binocular field. They were informed that a target would be flashed to either the right or left of this fixation point (a demonstration being given in each field). They were required to orally report what words were seen or to indicate what patterns were seen through use of a display. Performance was judged on the accuracy of such reports.

Two clinical samples of male and female children, ages ten years to eleven years one month, were selected at random from populations of children visiting the University of Houston College of Optometry Clinic. One group (normal) were children who visited the clinic for routine vision evaluation with no indications of learning disorders. The other group (learning-disabilities) were children who visited the Clinic because of some form of learning disability and the indication of possible problems in perceptual development.

Of the thrity-two subjects satisfying the criteria of the study for the normal group, fourteen were male and eighteen were female; of the eight subjects satisfying the criteria of the study for the learning-disabilities group, three were male and five were female.

Based on a balanced design for presentation, all subjects received both verbal and non-verbal treatments. Verbal treatments were twenty 3-letter words presented individually in random order--five being presented in each of the four lateral visual fields; non-verbal targets were twenty 3-character patterns presented individually in random order--five being presented in each of the four lateral visual fields.

With respect to words, subjects verbally recorded what they saw; with respect to non-verbal targets, subjects indicated patterns which they saw through use of an array. The number of words reported correctly in each of the four lateral fields, and the number of patterns indicated correctly in each of the four lateral fields were respectively tallied. Data were appropriately grouped and analyzed to test various hypotheses.

Significant findings were as follows:

1. With respect to differences between performance in the four lateral visual fields in normal subjects receiving verbal treatments, the null hypothesis is rejected at the 0.01 level of confidence. Differences, however, can not be further delineated through post-hoc comparison.
2. With respect to differences between performance in the total right visual field and total left visual field in normal subjects receiving verbal treatments, the null hypothesis is rejected at the 0.05 level of confidence. Descriptive statistics indicate superior performance in the right visual field.
3. With respect to differences between performance in the total right visual fields and total left visual field in normal subjects receiving non-verbal treatments, the null hypothesis is rejected at the 0.01 level of confidence. Descriptive statistics indicate a superior performance in the right visual field.

4. With respect to differences between performance in the total right visual field and the total left visual field in a group of normal subjects matched with the learning-disabilities group with respect to number and non-verbal treatments, the null hypothesis is rejected at the 0.05 level of confidence. Descriptive statistics indicate superior performance in the right visual field.

CONCLUSIONS

1. With respect to the recognition of words and patterns exposed for brief periods of time, differences in performance in the right and left visual fields can be measured, and are significant in the 10-year-old normal children.
2. Inasmuch as a significant difference favoring the right visual field is found for both verbal and non-verbal targets in normal subjects, the phenomenon wherein language skills are observed to be associated with the left cerebral hemisphere is only one manifestation of an overall propensity for the left cerebral hemisphere to process gestalts. Language involves the use of total patterns (gestalts) as symbols, and therefore its function is primarily associated with the left cerebral hemisphere. The right cerebral hemisphere would appear to be primarily concerned with processing discrete measurements and appreciations of dimensions of time and space.
3. The propensity for processing both verbal and non-verbal gestalts in the left cerebral hemisphere is not as well established in 10-year-old children having learning-disabilities as in 10-year-old normal children.
4. There is a probability that the decrement in the ability to more efficiently process verbal gestalts presented in the right visual field is in the left-nasal (I_2) component of that field in children having learning-disabilities.
5. There is a probability that the decrement in the ability to more efficiently process non-verbal gestalts in the right visual field is in both left-nasal (I_2) and right-temporal (I_4) components of the right visual field in children with learning disabilities.
6. In comparing the performance of normal subjects and learning-disabilities subjects, there are indications of a superiority for processing verbal gestalts via inputs from the left-nasal field (I_2) and from the right-temporal field (I_4) for non-verbal gestalts favoring the normal group; and, an increased capacity in the left-temporal field (I_1) with respect to both verbal and non-verbal gestalts favoring the learning-disabilities group. This could be indicative of deviant performance established by learning-disabilities subjects when normal development of cerebral processes is precluded through minimal brain damage or other causes.
7. The portion of the brain used for processing a given type of input is determined by the nature of the input, and both the mechanism of recognition and assignment to a given portion of the brain for processing, and the organization required for appropriate processing, are at least partially learned during a child's development.

Future investigation should include studies to further delineate differences between the four lateral visual fields rather than simply between the right and left visual fields. Further, if a superiority of I_2 should again be found in normal subjects with respect to recognition of verbal gestalts, (as in Koetting's original study) and a superiority of I_4 should be found in normal subjects with respect to non-verbal gestalts; then investigation into whether or not such phenomena are decreased or absent in learning-disabilities children would be indicated. If gradients in these phenomena should exist in learning-disabilities children, they might be related to IQ or measurements of scholastic achievements. It is conceivable that if these abilities are poorly established or absent with respect to one or more of the four lateral visual fields, that appropriate patching of one eye, or use of Polaroid filters, might be introduced for specifically training the ability to recognize either verbal gestalts or non-verbal gestalts by stimulation of the hemisphere.

As perceptual phenomena emerge, electrophysiological correlates should be sought for verification and further expansion of knowledge. Such parameters might eventually provide the basis for clinical monitoring.

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