Active and Passive Perceptual Learning in the Visually Impaired

Beverley E. Conrod

A Thesis

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements
for the Degree of Masters of Arts at
Concordia University
Montréal, Québec, Canada

February, 1984

© Beverley E. Conrod

ABSTRACT

Active and Passive Perceptual Learning in the Visually Impaired

Beverley E. Conrod

Active and passive perceptual training methods were tested with 30 macular degeneration patients to improve their residual vision. Six different measures were tested: visual acuity, a self-report questionnaire, a reading test, the Frostig Figure Ground test (FFG), the Bender-Gestalt Test, and the Farnsworth-Munsell 100-Hue Test (FM-100). Participants were grouped according to two levels of impairment (moderate or severe) and three training conditions (active, passive, and control) in a 2 x 3 multivariate design. It was expected that the training sessions would improve visual task performance, and that active participants would show more improvement than other groups. A multivariate ANOVA found an overall main effect for the learning factor, and univariate tests showed that the active group improved significantly more than the passive and control groups on the FFG test. No other differences were significant. The main conclusion was that perceptual training may contribute to successful visual adjustment and that the effect of training is not limited to a particular level of visual impairment.

Acknowledgements

Sincere appreciation is extended to my co-advisors, Dr. Michael Bross and Dr. Charles White, for their helpful advice and co-operative efforts during the various stages of this project. The patience and encouragement they have shown over the last two years has been invaluable. I am also indebted to Dr. Olga Overbury, both personally and professionally, for her unfailing support throughout this venture. As well, I wish to express my gratitude to Dr. Bruce Jackson who has provided the opportunity to work with the patients in the Royal Victoria Hospital Low Vision Clinic. In addition, I wish to thank Miss Cathie Hagenson who was cheerful and competant at all times in the Clinic, and Mr. Stanley Rog whose meticulous efforts reproduced the training stimuli for this study. Finally, none of this would have been possible without the enduring understanding of my husband, Scott.

Table of Contents

Statement of the Problem

Ongoing research in low vision indicates that some individuals are unable to cope with visual loss because they have not developed the necessary perceptual skills to maximize their residual sensory, perceptual or cognitive capacities. This thesis examines the question of the role played by perceptual learning in the adaptation processes of the visually impaired.

From a theoretical point of view, the problem is addressed through an investigation of the active-passive learning paradigms in perceptual performance. Past research in this area, with normally-sighted subjects, has concentrated on the adaptation process when artificially distorted visual input, such as produced by prisms and inverting mirrors, is introduced. In these experiments, it has been repeatedly demonstrated that, with practice, perceptual learning and adaptation do occur. More specifically, the process of learning and adaptation has been found to be most efficient when visual-motor activity is encouraged.

This was combined with certain conceptualizations from Gestalt psychology, particularly the importance of the figure-ground principle as a fundamental perceptual process. Furthermore, since the present study tested visual impairment, the training materials and figure-ground discrimination tasks utilized the Gestalt approach to perceptual learning.

This study presents an attempt to determine whether visually impaired individuals can also acquire or further develop perceptual strategies to accommodate physiological changes in the visual system. Because the majority of patients in this investigation were diagnosed as having macular degeneration, an ocular disease where foveal acuity is diminished, the experiment concentrated on teaching eccentric or peripheral viewing techniques. To this end, the participants were asked to work with figure-ground discrimination tasks which required them to use visual search strategies.

Participants were assigned randomly to an "active" or "passive" treatment condition, and blocked according to severity of visual impairment. This design evaluated the importance of visual-motor integration in perceptual learning. In clinical terms, it was hypothesized that the acquisition of new perceptual strategies would aid in the adjustment process when visual loss has occurred. Finally, it was the aim of this study to determine whether previous findings in perceptual learning generalize to an aging population.

The Perceptual Model

Active and Passive Learning

Clinical observations have suggested that the improvement of deficient perceptual skills may aid in the process of adjustment to visual loss. The theoretical rationale justifying further investigation of this claim derives from theories of visual perception that emphasize the perceiver's role in the information processing. The perceptual model proposed here thus includes the concepts of learning, thinking and memory where perception is viewed as active and constructive.

It was from theories of motion perception that the concept of an "active" process of perception emerged. Helmholtz was the first to suggest a motion-detector system which included the postulate that the position of the body with respect to the visual plane determines the perception of motion (Helmholtz, 1867/1925). In this conceptualization, light from a moving object, given a stationary eye, falls on successive retinal points, thereby providing the information that something in the environment is moving. A century later, Hubel and Wiesel (1962) demonstrated in their studies with cats that there are indeed cortical cells with large receptive fields primarily responsible for detecting movement on the retina. In experiments with human subjects, proponents of the motion-detector system also find support for this theory in the study of motion after-effects (Sekuler & Ganz, 1963).

Additionally, Gibson (1966) suggested that the nature of the flow of information on the retina accounts for the ability to differentiate between object and perceiver movement. Gibson was concerned that most theories of perception do not take into account the discrepancy between incoming sensory information and the final perceptual experience. In an attempt to explain this difference, he focused on the idea of retinal displacement and the interpretive or organizational process which follows from it. Rather than the image of the external world being displaced across the retina, Gibson (1968) suggests that the retina, which is constantly in motion, is scanning across the object.

Given this change in the source of information about the external stimulus, he states further that the perception of motion results from changes in the ambient array of reflected light on the retina (Gibson, 1968). These transformations, which occur as a result of both object and observer movement, are the relative retinal displacements which indicate whether a specific object, the entire visual world, or the perceiver has moved. In this pschophysical view, the ultimate determining factor is the correlation between visual information and perceived change in the visual world.

A more complex theory of motion perception was proposed by von Holst (1954). Gibson's model had stated that only self-produced and externally-produced visual information are differentiated by the brain; a retinal motion, for example, will be distinguished from any externally produced stimulation as a saccadic eye movement because the brain is so programmed to make this differentiation (Gibson, 1966). Von Holst's theory, on the other hand, presupposes a system where comparisons of afferent and efferent neural activities are made. In effect, there is an integration of motor and perceptual information in a system which produces copies, matches information, and deduces the origin of stimulation.

The studies which supported this view investigated the process of adaptation to distorted visual input, and they were based on the reafference model proposed initially by von Holst, which suggested that when visually distorted information was presented, the individual would have to readjust the internal correlation between motor-kinesthetic and perceptual-motor acts (von Holst, 1954). In order to regain proper visual-motor coordination in response to changing patterns of stimulation, the perceiver would consider the visual consequences of his self-initiated movement, which was termed reafferent stimulation by von Holst. Exafference, on the other hand, refers to stimulation of the sensory organs, as produced by the external world.

Von Holst then used the concept of the efferent impulse to account for the initiation of the efferent movement, and introduced the idea of an efferent copy to describe the process which stores the image of the efferent movement in the central nervous system. As described by von Holst (1954), all movements of the eye (efference) are recorded and stored for comparison with reafferent information. Basically, the organism can distinguish between movement produced by the eye and externally produced motion by the presence or absence of an efferent copy. If the input matches the stored copy, then the information is assumed to be reafferent or the result of self-initiated movement. If not, there is a perception of motion in the external world.

The extent to which efferent information contributes to the perceptual process is still unclear, although there has been considerable interest in this area. Adaptation to distorted visual input has been the major method employed in many investigations and as the following review of the literature shows, the collective evidence strongly suggests an important role for the reafference model.

Adaptation Studies

In the Innsbruck studies, by I. Kohler and his associates, prisms and inverting mirrors were worn by subjects for periods of time extending from 5 to 124 days. Visual input was systematically altered and controlled so that the investigators could monitor the adaptation process. Kohler (1954) concluded from his investigations that for adaptation to take place it was necessary to study the total perceptual situation as well as the individual points of stimulation. For example, there was a general prism effect, where lines appeared distorted because of differences in the angle of deviation of light rays reaching the face of the prism. There were also changes in the curvature, angle, and distance of perceived objects due to the relative motion of the eye as opposed to head-spectacle movement, thus making the distortion effect even more severe. He emphasized that the apparently varying retinal sensory reactions were not random occurrences, but that they were governed by very specific environmental factors. Thus the presence or absence of an after-image or retinal sensitivity to colours, for instance, is dependent on optical stimuli, but is also affected by non-optical input, such as muscular movement.

Furthermore, it was suggested that this relationship is correlational, that it is not necessary to imply a causal effect when explaining these situational events. Kohler (1954) insisted that only by studying these relationships can the peculiar sensory fluctuations which accompany situational factors be understood, for example, the perceived location of an object cannot be determined by retinal factors alone. The perceptual response, which evolves gradually, is influenced by body position and other non-optical variables such as kinesthetic sensations. On this basis, Kohler concluded that successful adaptation to visual distortion is based on the dynamic, as opposed to static, relationship between two sets of sensory data. Finally, Kohler emphasized the importance of freedom of movement on the part of the perceiver in his relationshhip to the environment.

Further work on the reafferent-exafferent conceptualization of von Holst has come from Held and Hein's developmental studies with kittens (Held & Hein, 1963). They studied the differential effects of active and passive movement in yoked pairs of animals and it was observed that for adaptive visuomotor integration to take place, active movement rather than just sensory experience, was necessary. They found, in a test of spatial discrimination using the visual cliff model, that all of their "active" kittens chose to descend at the shallow side of the cliff and concluded that active movement was responsible for promoting spatial perception and locomotion as well as perceptual-motor coordination.

Held and Hein (1958) had earlier demonstrated, in experiments with humans, that active movement produces a greater degree of visual adaptation. In that study, subjects wearing prisms were asked to point to intersecting lines; pretest and posttest comparisons indicated that the critical factor in adapting to the displacement was reafferent stimulation. Those perceivers who were allowed free hand movement showed substantial improvement whereas those whose hands were mechanically, or passively, moved showed no change.

Festinger and Canon (1965) further elaborated on this view by suggesting that active movement was not essential, as long as a record of efferent impulses was available. What was needed was a central readiness to activate the efferent signal; that is, visual information has to be supplemented by non-optical information, in order for accurate perceptual-motor behavior to occur.

Festinger contended that explaining the distinction between active and passive perceptual adaptation through reafference alone is too simple as an explanation: rather, what is required is more specificity about the role of efference. Festinger, Burnham, Ono, and Bamber (1967) attempted to clarify this issue by altering pre-programmed sets of efferent instructions without changing the pattern of retinal stimulation. It was reasoned that if a change in visual perception could be so produced, one could assume evidence for efferent readiness. In these experiments, subjects wore prism spectacles, which produced the appearance of a curvature in the straight lines which were being examined. Arm movements, however, corresponded to the objective contours of the lines. Basically, two sets of conditions were employed, where one set of "active" conditions facilitated learning of a new efferent-afferent association, while the other "active" set hindered such learning. In operational terms, one condition required subjects to move their arms along the lines; the arms of the second group, however, were mechanically, that is, passively guided thus assuring that no new efferent commands were issued. In all experiments it was found that when learning of a new efferent-afferent association was encouraged, the perception of a straight line was increased. The data, therefore, supported the view that visual input activates a set of learned efferent references. The authors commented that while their evidence for efferent readiness was not conclusive, the data were nevertheless supportive for their theory.

While persuasive to some reseachers, the introduction of reafference as sensory feedback responsible for adaptation has been criticized by others. Held and Hein (1958) suggested that perceivers were unable to adapt because there was no reafferent memory trace available for comparison with current visual feedback. Other researchers have produced conflicting evidence in studies where passive movement and no-movement conditions did produce adaptation in the subjects (Wallach, Kravitz & Lindauer, 1963; Howard, Kraske & Templeton, 1965; Melamed, Halay & Gildew, 1973). Nevertheless, the active-passive hypothesis appears thus far to be the most complete attempt to explain the adaptation process.

The Gestalt Approach

The term Gestalt, which is sometimes mistranslated as meaning "form" is more accurately defined as "organized structure", suggesting a "whole" that is orderly and rule-governed (Kanizsa, 1979). With regard to visual impairment, a situation which requires perceptual learning, Gestalt psychology offers a source for training materials in rehabilitation. A primary principle of Gestalt psychology is that of

Figure and Ground, a concept basic to all perceptual processes: "A form tends to be a figure set upon a ground, and the figure-ground dichotomy is fundamental to all perception. The simplest form is a figure of undifferentiated quality set upon a ground" (Boring, 1942, p.253). Also, the application of figure-ground discrimination tasks, traditionally used in clinical assessments with children, is now being extended to low vision evaluations, and there are indications that this primary skill may be lacking in some patients.

The basic observational data for Gestalt psychologists are the phenomenological experiences derived from our perceptions of whole objects, which may occur with or without awareness of the contributing elements. The important distinction is that we may have "knowledge of" without "knowledge about" objects in the field (Boring, 1957). Additionally, Wertheimer (1923) was the first to recognize that "spontaneous grouping in sensory fields" is a primary process. Gestalt theory argues that for primary concepts it is not necessary to learn what comprises the aggregate of sensations, rather elementary visual organization makes this information immediately available to us. The total perceptual experience, according to Gestalt theory, consists of the stimulation pattern, the organization, and the response to the products of organization.

<u>Some Traditional Uses of Visual Perception Tests</u>

According to Frostig (1972), figure-ground discrimination problems, an important concept in Gestalt psychology, are so common in children with learning disabilities that one could probably equate them with visual perception disturbances in general. Fortunately, however, these difficulties may be improved with practice, using exercises similar to the tasks required in the Frostig Figure Ground test, where the subject has to identify and outline overlapping geometric figures. Intersecting letters, words and numbers have also been used successfully to help draw a child's attention to the figures to be discriminated.

Another test which has been used for a variety of purposes, from personality assessment to the measurement of organic damage, is the Bender-Gestalt Visual-Motor Test. This procedure consists of presenting nine simple designs which participants must copy. The test is interpreted in terms of factors relating to organization, size, changes in the Gestalt, and distortion (Hutt, 1977). Studies which have compared the five sub-tests of the Frostig Developmental Test of Visual Perception with the Bender Gestalt have found significant but moderate correlations between the two sets of test scores. (Bryan & Bryan, 1978). In consideration of the similarities inherent in the two tests, the present study will utilize both measures in assessing improvement of perceptual skills.

In summary, the theoretical framework presented here suggests that there are a number of factors at work which will determine whether or not an individual will be successful in problem-solving situations involving visual perception skills. Specifically, an active or passive contribution in the adaptation process, and the use of perceptual strategies as described by Gestalt theory will affect the adjustment process when visual loss has occurred. The FFG and Bender Gestalt suggest themselves as the most reliable measures of adequate perceptual functioning. In those cases where this adaptation process is lacking, it could be that training may enhance these skills, a proposition this thesis will examine by comparing active and passive learning conditions in visually impaired patients.

Rationale for Thesis Research

Evaluation of remaining visual capacities in visually impaired patients has generally consisted of assessing visual acuity and the degree of field defect. Although there are a variety of testing materials available, typical assessment devices include the Snellen projected chart and the Goldmann Perimeter. It is well known, however, that the number of letters correctly identified by the individual and the size of scotoma revealed by a field test do not necessarily correspond to the degree of success experienced by the patient in coping with visual loss (Barraga, 1976; Overbury, Grieg & West, 1982; Wild & Wolffe, 1982). Fortunately, the traditional view of low vision, defined as acuity worse than 20/70 in the better eye or a visual field of less than 20 degrees, has recently been replaced with a more subjective appraisal. Today, low vision applies to individuals whose lifestyles or work habits are limited by some degree of visual impairment (Faye, 1976a).

Some low vision patients adapt very well; when visual aids are introduced they adjust readily and go on to lead active and productive lives. On the other hand, some persons who have equivalent field and acuity losses do not adjust well to their visual deficits. Also, they express greater dissatisfaction with their visual abilities, the aids which are prescribed, and in many cases, life in general. The importance of psychological factors thus is apparent, as many patients are found to have negative psychological attitudes with respect to their visual loss (De l'Aune & Needham, 1977; Overbury et al., 1982). The challenge for the low-vision specialist is to differentiate between these patients on the basis of some objective measurement. Until recently, there have been few investigations into areas other than acuity and field losses, although it is known that these two tests simply do not yield an accurate low vision profile (Bailey, 1978a, 1978b; Genensky, 1981). What is called for is a comprehensive assessment, tests that will discriminate between "adjusters" and "nonadjusters" on the basis of one or more critical parameters. In addition to the more accurate diagnosis obtained on these individuals, these tests will also indicate to the low vision investigator the specific areas in which the visually impaired person requires help.

Alternative Uses of Visual Perception Tests.

In a recently completed study at the Royal Victoria Hospital (Overbury & Conrod, 1982), seven tests measuring different aspects of remaining visual capacity were administered to a group of visually-impaired patients. The examination included both distance and near acuity measures, a reading test (continuous text), and a functional interview developed by Murphy and Donderi (1980) for use with aphakic patients. A field test, using the Goldmann Perimeter, was routinely administered, as well as the Frostig Figure Ground Test of Visual Perception and the Farnsworth-Munsell 100-Hue Test.

Using the above measures, the investigators identified those patients whose performance on visual perception tasks compared unfavourably to other results in the test battery. In figure-ground discrimination tasks, these patients also had difficulties unscrambling and tracing overlapping and embedded designs, which was evident in FFG test scores. Interestingly, while acuity, reading and field test results did not reveal any deficencies, a self-report questionnaire did suggest that these patients were feeling dissatisfied with their remaining visual abilities. The data suggested that some patients were unable to master those visual-motor tasks which play an important role in the adjustment process of a visually impaired individual.

The reasons for these discrepancies in test scores are not immediately clear. It is possible that the dissatisfied patient, who performs at an inferior level on perceptual tasks, has not developed eccentric viewing strategies. All participants in this study were previously diagnosed as having macular degeneration, where object identification and fine discrimination had become increasingly difficult as the size of the central scotoma increased. Whereas some of these patients had learned to use peripheral vision to compensate for the decrease in central viewing abilities, others had not.

A second possibility is that these individuals were not efficient in using perceptual strategies such as closure and figure-ground discrimination. They were unable to generalize previously integrated perceptual experiences to other similar sets of stimuli. In the Frostig test, they were unable to follow the lines to figure completion. They could not fill in gaps where reduced central vision obliterated sections of lines and disguised form, even where the objects were familiar items such as stars or diamonds.

The third possibility concerns the inevitable presence of dynamic factors. Since recent studies have shown that dynamic factors may be implicated in the ensuing adjustment process when visual capacity has been reduced (Murphy & Donderi, 1980; Overbury et al., 1982), perhaps these patients were lacking in motivation, persistence, or interest.

It is clear, whatever the reasons for these differences, that the clinician today has to understand more than the optical implications of visual loss. Prescribing the appropriate high-power aid is not sufficient. As suggested by Bailey (1978b), the fears and frustrations, restrictions and life-style changes will often affect the psychological well-being of the patient. To the extent that some patients in the above-mentioned study expressed a general dissatisfaction when interviewed, the objective evidence provided by the FFG suggests that perceptual tests may be valuable indicators of successful adjustment to visual impairment.

While it is expected that the FFG, when used in conjunction with more traditional low vision tests, will be an important predictor in the assessment process, there is another advantage to be gained by including a section on perceptual skills in the test battery. Since it has been shown that a deficit in visual perception abilities can often be improved, there is reason to believe that any improvement due to repeated performance on the FFG may be carried over into useful visual activities in everyday life.

It has long been accepted that perceptual skills can be enhanced by exercise, practice and repetition (Barraga, 1964; Frostig, 1972; Gibson, 1950; Goodrich & Quillman, 1977; Overbury & Bross, 1978; Sells & Fixott, 1956). Previous investigations have seldom addressed the importance of the total synthesis of the visual experience, and concentrated instead on refractive problems and disease etiology, whereas contemporary researchers are beginning to realize the importance of teaching perceptual strategies to low vision patients.

Unfortunately, there is not much that can be done to make up for a destroyed field or acuity loss, and this inability to provide direct help represents a constant source of frustration for both clinician and patient. In fact, it is not uncommon for an individual, confronted with the reality of failing vision, to ask for suggestions in the way of exercises or therapy to improve the situation. The role of perceptual tasks, therefore, goes beyond that of a simple assessment test; the training of perceptual skills may prove to be a useful therapeutic device to aid in the adjustment stages to visual impairment.

Low Vision Research

Whereas the active-passive research on adaptation to novel perceptual fields was concerned with an artificial distortion of visual input, low vision research is concerned with visual disruptions due to degeneration, generally macular, or disease within the visual system. Here, the level of visual distortion is not under the control of the researcher. Thus the problem is not a matter of looking at adaptation in terms of specific amounts of distortion, which constitutes a major difference between the two types of studies. Since it is very difficult to judge just how much capacity is left in a visually-impaired individual, and because a patient's residual vision often fluctuates, it is difficult to predict which patients may improve.

Faye (1976a) believes that there is no simple value defining the "sharpness of vision"; it varies, rather, as much as individuals themselves. Training and practice have produced improvement in visual function and efficiency in children even in cases where total blindness was originally assumed. Some observers have noted the use of residual vision in children with distance acuities as low as 5/200 and 3/200. Faye (1976b) is in agreement with this view and argues that acuity has been exaggerated in importance; she reiterates that there is no single precise measure of functional vision and emphasized that this is a crucial point in dealing with low vision. Even the most visually-impaired patients can potentially benefit from instructions and practice. According to Goodrich (1982), the only patients who may be assumed to be inadmissable for low-vision training should be those in whom bilateral enucleation has occurred. The problem thus becomes one of determining, through acuity and field testing, the optimal retinal area for developing perceptual skills.

<u>Eccentric Viewing</u>

It has been hypothesized that there are two visual systems in operation (Schneider, 1969; Weiskrantz, 1980). The primary, cortical system is connected with foveal or central vision, and is often termed the "what" system, as it is associated with recognition of objects and fine feature discrimination. The second, sub-cortical visual system is responsible for detecting where objects are located in the peripheral field. When central scotomas develop as a result of macular degeneration, a variety of problems may arise, as the complementary nature of these two roles is disrupted. The peripheral locating system has to compensate for the loss of the foveal ability to define and identify objects. In addition to this acuity loss, there may also be an increase in nystagmus, causing fixation difficulties. The individual may learn, however, on his or her own, or with the help of low vision instructors, to use the peripheral "where" system to greater advantage. With practice the patient may begin to perceive, in a more discriminating fashion, the objects and events which have been picked up by the "where" system in the peripheral visual field. Also, the natural tendency to fixate centrally in the newly blind area, when searching for an object, may be overcome, as a visual search relocates the object peripherally.

Goodrich and Quillman (1977) discuss several eccentric viewing techniques along with suggestions of how to use devices such as a mounted target, wallclock, commercial rotater, or slide projector in the instructional training sessions. The authors emphasize that in order to select the appropriate target size, one must be precise in describing the exact location of the central scotoma and the degree of residual acuity. Careful scrutiny of field test results before training begins is, therefore, an important consideration. The importance of generalization also must be stressed: what is learned in the clinic can be considered successful only if the newly acquired visual abilities are adapted to daily life.

Goodrich, Mehr, Quillman, Shaw and Wiley (1977) found that with 10 days of training and practice, reading speed and duration increased significantly for patients using optical aids. Interestingly, visual acuity was not correlated with the dependent measures; rather, the findings suggested that motivational factors were more important as indicators of eventual success with low vision aids. In another study, Holcomb and Goodrich (1976) utilized two different eccentric viewing techniques to improve visual functioning in patients with central scotomas. Both methods involved selecting the field area which would offer maximum acuity and this was determined through an examination of visual field results. Letters were then moved vertically and horizontally until the image appeared sharpest to the patient. In the first condition a strobe was flashed projecting a threshold size letter into the parafoveal field, as subjects practiced to improve speed of recognition and length of fixation.

In the second condition, patients were similarly assessed to determine the optimal viewing area on the retina; however, a strobe was not used for training. Instead these individuals, when searching for targets, were instructed to direct their eyes to a calculated distance from the target. In this technique, eye-hand coordination was involved as the patients progressed to tasks where they had to track and then catch a moving ball. Improvement in eccentric viewing occurred for both groups, although not as consistently with the second technique. The small sample size prevented the authors from making any definitive statements about preferred eccentric viewing training techniques; however, they did suggest that alternative methods for eccentric training should be considered, and that individual differences, such as age and degree of scotoma are important factors in the decision-making process.

Visual-Motor Tests

In an attempt to find appropriate training methods, some researchers have utilized pencil-and-paper perceptual tasks as an alternative way to assess visual problems. Quillman, Mehr and Goodrich (1981) found the FFG Test to be a useful assessment device in evaluating sensory-perceptual capacities in low vision paients. Not only was the Frostig Test easily administered and scored, but it also provided predictive information in terms of the patient's reading performance. Using their prescribed lens, subjects were asked first to point to and then identify the geometric forms. They were requested to trace each figure, using a different coloured marker for each shape. The number of figures correctly traced gave each subject a total score which was then correlated with reading speed measures. It was found that FFG results were more accurate than acuity measures as reading speed predictors.

Another advantage of the test was that the participants could be observed as they worked, and qualitative information about the presence of perceptual strategies such as closure and persistence could be obtained. Also, where there is an inconsistency with the results of other aspects of the low vision evaluation, the authors believe the FFG test to be helpful in predicting what they termed "visual performance capacities." For example, FFG performance from one patient was much better than would be expected if the visual field results were taken into account. The authors investigated further and found that the scotomata were not nearly as extensive as the plot had originally shown; they concluded that "psychological overlay" was interfering. The patient subsequently received psychological intervention and with time his visual performance increased to match his capacity. It seems that the presence or absence of motivational factors in completing the test often affects performance, and eye-hand coordination.

Turning to the investigation of visual impairment as presented in this thesis, traditional visual-motor tests were used for the purposes of both training and assessment. Two groups, representing active and passive conditions, learned to apply visual search strategies to figures which were constructed on the principles of Gestalt theory in an the attempt to unscramble and identify overlapping and embedded figures. Also, two dependent measures, the FFG and Bender Gestalt, were used to assess visual perception skills. Because these pencil-and-paper tasks evaluate eye-hand coordination, they served as pretest and posttest measures of perceptual function.

Additionally, the FM-100, a diagnostic colour vision test, was administered to determine whether the proposed training procedures generalize to other types of perceptual problems. The FM-100 requires the participant to arrange a series of graduated coloured discs in order of hue, in between two fixed colours at each end of a continuum. The test was thus presumed to be a good measure of visual-motor integration as well as an indicator of training generalization. Whether or not the techniques alone or the total training environment was responsible for changes in performance must be considered an important issue; it was expected that the FM-100 performance might help to address this problem especially since research has generally shown that colour discrimination does not improve as as function of practice (Sells & Fixott, 1956). To complement these measures, continuous text reading and acuity measures were taken to determine further whether perceptual adaptation to visual loss had occurred. Finally, a self-report of satisfaction with visual abilities was used as an indicator of psychological adjustment.

Research Hypotheses

The project adopted the rationale underlying many current low vision studies, by postulating that the practice of visual search strategies increases the use and efficiency of eccentric viewing techniques. The method of training, however, differed to accommodate the active-passive question in perceptual learning.

The expectation was that eccentric viewing would improve as a result of practice, instruction, and repetition of visual perception tasks. Sessions consisted of two one-hour training periods, in which sequential presentations of black-on-white overlapping and embedded figures served as stimuli to encourage the development or further use of these perceptual skills. By locating and identifying various hidden targets, the individual was expected to learn to make optimal use of whatever parafoveal or peripheral vision was left.

There were three specific questions addressed in this study. First, the evidence drawn from studies with low vision patients, as well as the investigations of adaptation to distorted visual input, suggested that training and practice have a positive effect on the adjustment process when vision has been reduced. It was, therefore, expected that all participants who received any type of training would show improvement on the measured perceptual skills.

Second, in view of the issues surrounding the active-passive dichotomy, it was hypothesized that there are alternative ways of dealing with visual problems. Therefore, two training techniques were employed in an attempt to determine the optimal strategy for increasing perceptual adaptation. For the "passive" model, eccentric viewing without freedom of movement was utilized, where participants visually scanned the drawings, but otherwise remained immobile. A chinrest and forehead rest ensured that head movements did not occur.

"Active" learning was employed in the second training group. In this pencil-and-paper visual-motor task condition, participants not only had freedom of movement, for example, to lift or rotate the paper, but in addition they were also required to trace the overlapping and embedded figures. It was expected that this "active" group would show more improvement than the "passive" group.

A final question of interest concerned the age of the sample to be tested. The patients in the present study were upwards of 60 years in age, but previous research has involved younger subjects. Thus it was important to determine whether the findings in these studies, which indicate that perceptual adaptation and learning occur with training, would generalize to an elderly population.

Method

Participants

Thirty patients attending the Low Vision Clinic at the Royal Victoria Hospital participated in this study. They were asked to sign a voluntary consent form (Appendix A), and were reimbursed after each session for travel expenses. The participants were selected on the basis of age (over 60 years) and acuity level, 6/21 (20/70) or lower in the better eye. They were divided into two categories: moderately impaired 6/21 - 6/60 (20/70 - 20/200) and severely impaired, lower than 6/60 (20/200). They were randomly assigned to one of three groups: passive learning, active learning and control.

Materials

For all individuals the initial assessment or pretest consisted of a test of visual acuity using the Snellen projected chart. Participants also underwent a field test with the Goldmann Perimeter (Haag-Streit), a Feinbloom distance acuity test, a three-paragraph reading test in one of two print sizes, a self-report questionnaire expressing degree of satisfaction with visual abilities, a Bender-Gestalt Test of Visual Perception, a Frostig Figure Ground Test, and a Farnsworth Munsell 100-Hue Test. (See Appendix B for samples of these tests). All 7 tests, 6 of which served as dependent measures, were readministered at the end of the training period. The field test was not included as a dependent measure but served as an indicator of the optimal retinal viewing area for a given patient.

Training stimuli for the active and passive groups consisted of a series of black on white overlapping and embedded figures (numbers, letters, geometric forms) presented on 22 x 28 cm sheets of paper (Appendix C). A chinrest and a forehead bar were used by the passive learning participants to restrict head movements. The active participants used coloured markers to trace the figures.

Procedure

After permission of the patient to participate in the study had been obtained, a brief explanation of its rationale was given to these subjects. Specifically, they were told that the investigators were looking for new methods to improve visual functioning in low vision patients. Because these patients tend to worry about their physical condition, it was stressed that there was nothing unusual about their visual problem that demanded this extra attention.

The first and second meetings with all participants consisted of completing a pretest battery of seven measures as described above (acuities, field test, reading, self-report, FFG, Bender-Gestalt, and FM-100). Other than the initial assessment, the control subjects remained untreated. They were simply asked to return in one month for further testing. Members of two experimental groups then each attended two individually-administered one-hour training sessions.

The passive participants were seated at a table and were instructed to remain still, while the stimuli were individually presented for examination. The individual was then asked to locate and identify the hidden figures in each stimulus according to the instructions indicated on each page. After each series of tasks was completed, the experimenter reviewed the sequence, pointed out corrections, and made suggestions as to how visual search strategies could be enhanced. For example, the participant was instructed to follow lines to figure completion, to direct eye movements avoiding central fixation, and to use the edge of the page as a guide to location. On the fourth visit, the initial test battery was readministered to complete the set of dependent measures.

The procedure was similar for active participants, the critical difference being that the active subjects were encouraged to engage in voluntary body movement, including the lifting and rotating of pages. They were also required to trace the hidden figures with coloured markers, rather than to simply identify them. Instructions, feedback, and explanations were also offered to this group.

Results

The data collected for each of the tests were compiled in raw form where possible, and transformed when necessary for statistical analysis. Pretest and posttest scores for the 30 participants on 6 measures are presented in Appendix D. The 4-point satisfaction scale was left in its raw data form; likewise the FFG test with a maximum score of 28, and the Bender which was scored out of 10 points were left in the original form. The data for reading were transformed, using a formula which takes into account a speed-accuracy trade-off, according to the following equation:

$$\text{Rate} = \frac{210 - 5(E)}{T},$$

where 210 is the total number of words in the text, E is the total number of errors and T is the time in minutes required to read the text.

Acuity scores were calcuted by converting the distance acuity fraction into minutes of visual angle by the following formula:

$$\text{Acuity} = \frac{1}{DA_f},$$

where DA_f is the distance acuity fraction. For example, a score of 20/20 (6/6) = 1 min of visual angle and would represent an average performance by a normally sighted individual; 1/(20/200) (6/60) = 10 min of visual angle, and this level of impairment would be classified as "legally blind". Better FM-100 performance is also represented by a lower score, ranging between 0 and 30 in a non-visually impaired person.

A 2 x 3 (impairment levels x learning conditions) multivariate

ANOVA was performed to determine the effects of different learning and impairment levels on the performance of six vision-related tests. The analysis was conducted on the differences between pretest and posttest scores for the six tests: distance acuity, a self-report questionnaire, reading, FFG, Bender Gestalt, and the FM-100.

A Hotelling's T^2 test, which is an extension of the F test for multivariate cases, yielded a significant main effect for the learning factor, $F(2,38)=2.78$, $p<.01$. The other multivariate tests indicated that there was neither a significant effect of the impairment factor, nor was there an overall interaction between the learning and impairment factors.

The univariate F tests for the six dependent variables further specified the differences indicated by the Hotelling's T^2 test. These analyses are presented in Appendix D. As expected, a significant main effect for learning was found in the FFG results, $F(2,24)=7.81$, $p<.01$. Tukey post hoc tests at the .05 level of significance indicated that the mean score on the FFG for the active learning group (7.8) was significantly higher than that recorded in the passive learning condition (3.8) or the control group (1.7). Graphic presentations of the FFG scores are given in Figure 1. The remaining five univariate F tests did not reveal any other significant changes in posttest performance.

There were, however, some interesting trends. There was an apparent, but not significant, effect for the training condition on acuity, reading, and the Bender Gestalt Test (Appendix D).

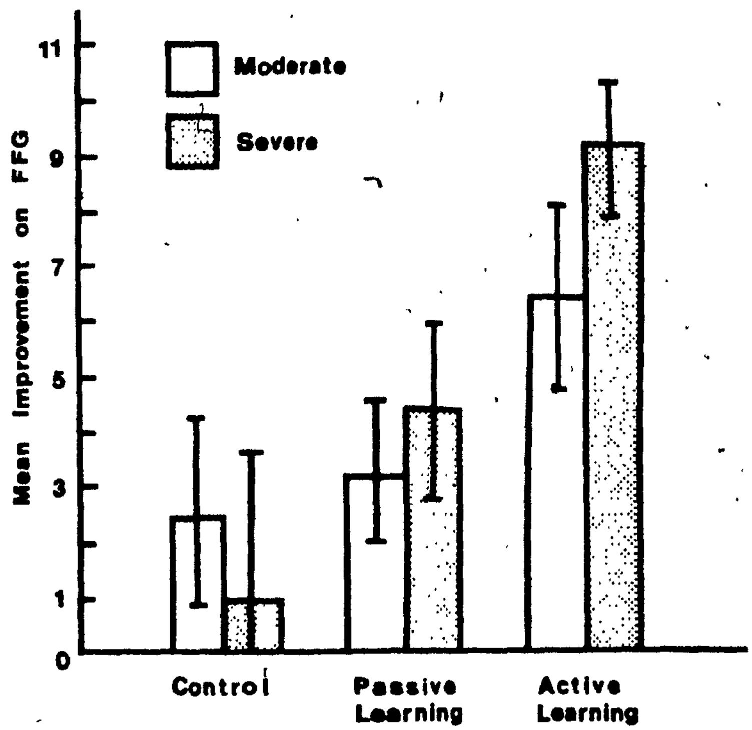


Figure 1. Mean improvement on Frostig Figure Ground Test scores in three training conditions.

Satisfaction ratings also suggested some differences as a function of impairment level, and finally there was a trend towards an interaction between learning and impairment for reading scores. These results too are presented in Appendix D.

Table 1 presents the mean difference scores and standard errors for the three learning conditions. An inspection of the data shows that it was the active learning condition that tended to have higher acuity scores. Also, on the reading test, the passive condition performed at a higher level than the active one. The other test which seems to have been affected as a function of learning was the Bender Gestalt, where scores were higher in the active condition than in the passive condition.

Table 2 features a comparison of difference scores in terms of the two impairment levels. Satisfaction ratings were somewhat lower for severely impaired individuals in both active and passive conditions. Finally, it can be seen that the change in reading scores may suggest an interaction, which fell short of statistical significance, between the passive learning condition and a moderate level of impairment.

The significant changes in FFG performance as a result of the active training condition are presented in Table 1. A further examination of the FFG scores, in Table 2, shows a tendency for severely impaired subjects to improve more than the moderate groups in both the active and passive conditions.

An analysis of covariance using the pretest acuity scores as a covariate determined that the initial differences among subjects on acuity level were not a critical factor. Once again, there was a main

Table 1

Mean Difference Scores and Standard Errors for Learning Models.

Group[a]	Acuity[b]	Satisfaction	Reading	FFG	Bender	FM-100[b]
Active	−3.05	−0.10	3.40	7.80	1.10	14.80
(S.E.)	(1.50)	(0.29)	(2.78)	(1.53)	(0.48)	(33.18)
Passive	−1.30	−0.10	12.42	3.80	0.30	−31.50
(S.E.)	(1.36)	(0.33)	(8.36)	(0.89)	(0.36)	(58.07)
Control	−0.15	−0.30	−1.34	1.70	0.20	−72.70
(S.E.)	(0.36)	(0.16)	(5.37)	(0.96)	(0.21)	(43.17)

[a]n = 10 per group.

[b]Negative scores for acuity and FM-100 represent improvement.

Table 2

Mean Difference Scores for Learning Models with Moderate and Severe Impairment

Group[a]	Acuity[b]	Satisfaction	Reading	FFG	Bender	FM-100[b]
			Moderate Impairment			
Active	-2.90	0.40	3.99	6.40	1.10	2.60
Passive	-0.80	0.20	21.34	3.20	0.30	-76.00
Control	0.30	-0.20	-9.40	2.40	0.50	-73.80
			Severe Impairment			
Active	-3.20	-0.60	2.80	9.20	1.10	27.00
Passive	-1.80	-0.39	3.50	4.40	0.30	13.00
Control	0.00	-0.40	6.73	1.00	-0.10	-71.60

[a]n = 5 per group.

[b]Negative scores for acuity and FM-100 represent improvement.

effect for learning as demonstrated by the Hotelling's T^2 test, $\underline{F}(12,36)=2.71$, $\underline{p}<.01$. The univariate F tests also showed a significant effect of learning on FFG scores $\underline{F}(2,23)=7.50$, $\underline{p}<.01$. Impairment did not have an effect and there was no interaction. No other significant changes were found in this analysis.

Discussion

A major challenge in the field of low vision is to demonstrate empirically that the residual capacity in visual impairment can be functionally improved. The efficacy of perceptual training was the primary topic of this project; specifically, the goal was to assess whether the use of different learning paradigms plays a determining role in the adaptation process when visual loss has occurred. In addition, the viability of applying selected training procedures to an older (60 years plus) population was an issue addressed in this investigation.

An analysis of the differences between pretest and postest scores suggests that with practice and training the visually impaired can improve use of their residual vision. These results are in agreement with other low vision investigations (Barraga, 1964; Goodrich et al, 1977; Holcomb & Goodrich, 1976; Goodrich & Quillman, 1977).

It was also hypothesized that active participants would show a greater improvement than their passive counterparts. This hypothesis was supported in that the active learning group improved significantly in comparison to the two other groups on figure-ground discrimination tasks. This question of active-passive learning has received its greatest impetus from the theory of von Holst (1954), who had proposed that the visual consequences of self-initiated movement, termed reafference, are a necessary component in the adaptation process when visual distortion occurs. In this model, reafferent information is compared to the stored copy of efferent impulses to determine the source of movement in the observer's visual world. Kohler's experiments (1954) of spatial inversion extended this theory to explain the adaptation process in a prism-distorted situation, where active or self-initiated movement produced more rapid perceptual changes than the passive conditions. Held and his associates have produced similar results in their prism studies which equated experimental conditions on all factors except the source of bodily movement (Held & Hein, 1958; Held & Schlank, 1959; Held & Rikosh, 1963). Until now, the active-passive hypothesis has not been applied to visual impairment studies; however, the significant improvement demonstrated by active participants suggests that a consideration of different learning paradigms may be an important factor in the rehabilitative process.

Held (1961) elaborated on the theoretical aspects of von Holst's reafference work by suggesting that there is a memory component or correlation storage which takes into account changes over time. Thus, previous combinations of efferent and afferent information are available for comparison with current stimulation. The comparisons take place in the comparator, and the resulting selected efferent signals determine the perceptual response. The series of experiments by Held and his colleagues show that reafference is necessary for the establishment of new correlations. Presumably, the training and practice concept in visual impairment corresponds to the idea of memory correlation, as new afferent-efferent associations are learned and stored for future considerations.

Festinger (1971) proposed another modification of von Holst's theory by suggesting that reafference is not necessary in the adaptation process as long as a variety of efferent programmes are readily available for comparison to the afferent visual input. This argument may help to explain why some investigators have found that passive movement may produce adaptation. Also, in the current project, there was no significant change in the passive learning condition, yet there were indications that these participants improved in some areas, particularly reading.

Investigations of the active-passive question by Harris (1965) provided evidence that active movement is only a pre-condition to adaptation; the end result is a change in position sense. More specifically, he distinguished between bodily movement and head movement in the learning process. In his experiments, Harris found that learning did not transfer to the opposite hand when head movements were constricted. He suggested that the perceptual change was a change in the felt position of a body part and not a sensori-motor change. When head movements were permitted, head-body adaptation occurred, which affected both arms equally, thus producing intermanual transfer (Harris, 1965). These results also provide a possible explanation for the data obtained in the present study which demonstrated a significant improvement of active subjects relative to the passive group on the FFG. The felt position or proprioceptive change may have been a contributing factor in resolving this visual-motor figure-ground discrimination task, but not relevant for other tests, such as reading or distance acuity.

Concerning the problem of severity of visual loss, the results in the present study were also encouraging. There was no significant difference between the moderately and severely impaired groups, and this finding may provide some useful information for low vision assessment purposes. For example, it seems that training is beneficial to many types of people, regardless of degree of impairment. There were, in fact, some indications that severely impaired individuals improved more than those with moderate visual loss, at least on certain types of tasks. Although these results may be reflecting a statistical regression to the mean, there may be other implications of this finding, which are discussed below.

To return to the question of training, it appears from the present results that training methods relate to specific demands in visual problem-solving situations. The training stimuli used in this study were derived from the theoretical framework underlying Gestalt psychology. Thus the tasks employed used figure-ground relationships as well as embedded and overlapping geometric configurations. It is noteworthy that significant changes occurred on the FFG, the measure which most closely resembles the training stimuli, and demands visual-motor coordination of a similar nature. The six tests which comprised the dependent measures were specifically selected to cover a wide range of visual functions, and it was not expected that performance would improve in every area. The FM-100, for example, served as a control measure; it was thought that if training procedures alone were responsible for improvement, FM-100 scores would not change because the test only requires colour discrimination and is not a perceptual-motor task *per se*. However, if confounding variables such as experimenter bias, motivational differences, attitudes or feedback were operating, an improvement in FM-100 scores would imply a contamination by extraneous variables. In general, FM-100 scores remained stable, where the variability that was present was probably due to random error. Thus, the conclusion that the training technique was the primary factor at work during these sessions appears justifiable.

As the FFG scores provided the only statistically significant differences, it seems that the skills being attended to in the training sessions were not similar enough to the strategies required for the other tests. The acuity test, for example, involved reading numbers on a distance chart, and the reading test involved continuous text which is held at a distance of 10-40 cm (4-16 in.) Evidence from results on the Bender Gestalt Test also suggest that training may indeed be task specific. This test is similar to both the FFG and the training stimuli in that it involves a pencil-and-paper test of basic geometric forms, and although statistically non-significant, the active groups showed improvement on the Bender Gestalt Test. An additional interesting trend, related to the notion of training specificity, emerges from the contrast between the mean improvement scores on reading for the moderately impaired passive participants who scored 21.3 words per min versus 4.0 words per min for active participants. This finding suggests that here, too, the training had differential effects for these conditions.

It appears that the strategies inherent in passive training are transferable to reading, which in itself may be construed as a passive task. Visual search strategies, closure, and steady fixation are skills that involve eye movements; however, they do not necessarily involve hand-eye or head-eye coordination, or in a more general sense, reafferent information. In the light of these findings, it is reasonable to suggest that low vision training sessions concentrate on specific goals, with a focus on the specific needs of the patient. Distance viewing, close reading and figure-ground discrimination tasks likely require the practice of different perceptual strategies; for example, the individual who is concerned about mobility and particularly the ability to read signs outdoors might well concentrate on identifying appropriate signals and shapes at a distance. Blash (1976) utilized street signs, stop signs, railroad crossings, and bus stops in his study with apparent success, although the number of subjects in his investigation was very limited.

It should also be noted that reading scores did not improve to the same extent for severely as for moderately impaired participants, a finding for which psychological factors may have been responsible. Considerable attention has been devoted to this aspect of visual loss, and the consensus is that motivational factors play a major role in the rehabilitative process (Barraga, 1976; De l'Aune & Needham, 1977; Emerson, 1971; Fonda, 1961; Overbury et al. 1982). It may well be that moderately impaired subjects were more highly motivated in certain respects. Fine print reading is often considered to be synonymous with normal vision, and many individuals in the early stages of visual loss deny or resist their visual disability. It has often been observed in clinical situations that many severely impaired patients have already concluded, even before the low vision assessment, that there is nothing to be done to ameliorate the condition, and reading is certainly out of the question. This type of attitude may conceivably contribute to the poorer performance of some severely impaired subjects on the reading task. Satisfaction ratings were also generally lower for the severely impaired after training. This may well reflect the suggestion by Friedman, Kayne, Tallman, and Asarkof (1975) and Bailey (1978b), that feelings of hopelessness are common in low vision patients. It is quite conceivable that these feelings surfaced, at least temporarily in the present study, as the individual was forced to confront the reality of a visual impairment problem in the training sessions.

As suggested by Quillman et al. (1981), the FFG may be providing additional information in low vision assessment in that it is not perceived as a visual test by most individuals, and performance is, therefore, less contaminated by self-fulfilling expectations about what a visually impaired person can or cannot do. This may explain the improvement in the FFG scores in the present study. Whereas poor reading skills would be consistent with the self-image of a severely impaired individual, the FFG circumvents this negative attitude because the subject neither knows what to expect nor how to react to it.

There are, as well, some clinical implications to be drawn from these observations. Traditional vision tests are often contaminated by patient bias; the potential for improvement in visual function may be more accurately assessed using a comprehensive test battery that evaluates the problem of low vision from several perspectives. The results from this study are also in agreement with the suggestions of Overbury and Conrod (1982) and Quillman et al. (1981) that the FFG may serve as a useful predictor of successful adjustment in low vision functioning.

The two remaining measures in this study, acuity and satisfaction, also require some explanation. The results on these tests were non-significant on the pretest and posttest comparisons, but there were indications, especially where acuity is concerned, that the instrument itself may have been inadequate. Criticism regarding the relevance, accuracy and interpretation of distance acuity testing has been a topic of concern for some time (Barraga, 1964; Faye, 1976a; Jones, 1962; Quillman et al, 1981; Sloan & Brown, 1963). Difficulties with this type of acuity test may be the result of target type, size, illuminance, contrast, distance, and length of exposure.

In the present study, acuity changes were measured on the Feinbloom chart which was held at a distance of 3m (10 ft). Although most subjects in both active and passive conditions improved their performance by at least one line on the chart (4 out of 20 produced lower scores), it is likely that the instrument was not precise enough to measure the kinds of changes that may have been taking place. For example, in relating a distance vision test to a real life visual task, an appropriate comparison might be the ability to identify objects or faces on a television screen. The Feinbloom chart, however, bears little resemblance in terms of contrast, object size or subject matter to the visual problems encountered on a TV screen or in day-to-day personal interactions. Future investigations may extract more information about the various parameters of learned perceptual skills by utilizing finer instruments such as contrast sensitivity or vernier acuity, as well as more relevant and meaningful distance targets. This may allow a more accurate assessment of contrast sensitivity, on the one hand, and minimal separable acuity on the other.

The satisfaction rating presented its own particular difficulties. It was originally designed as a simple questionnaire for assessing the degree of attitude change resulting from the training condition; however, for the purposes of the present study, the measure was not discriminative enough. On several occasions suggestions were voiced that there were too few categories: many participants perceived themselves as falling somewhere between two points on the satisfaction scale.

In general, particularly after training was complete, subjects had more to say than the response categories permitted. For example, a typical comment in a posttest interview indicated that the individual was no more satisfied with his or her remaining visual ability than before training; on the other hand, the same person felt that the practice had been beneficial, and hopefully a training programme would continue to be available. This type of response resulted in an objective "no" in terms of the satisfaction rating, followed by a subjective "yes" in terms of attitude change, which was not reflected in the scale itself. An alternative suggestion, which might improve an attitude scale as described here, would be to have several questions dealing with various aspects of visual functioning resulting in a global attitude score.

Several other observations made during the course of this investigation raise some interesting points. Although there were no pretest differences in the moderately or severely impaired groups, some participants were surprisingly efficient at certain tasks. High acuity scores and FFG results provided some puzzling information which led to an examination on two levels.

All subjects in this study had been initially tested on the Snellen projected chart to assess their acuity. The Feinbloom pretest acuity measure, however, one of the six dependent variables, gave in some cases conflicting evidence about visual efficiency. Some subjects, originally labelled as severely impaired for purposes of this study, performed surprisingly well in certain situations, such as the FFG and Feinbloom, thus suggesting that the criteria used in low vision assessments may be misleading.

For example, the acuity of one patient in the control group was measured as "count fingers" vision (1/200 - 2/200). His performance on the FFG (24/28 and 25/28), in view of this information seemed astounding, even though he was also identified as one of the "persistent" workers. An attempt to explain his performance is bolstered by an hypothesis advanced by Sekuler (1982). In general terms, Sekuler suggests that human spatial vision is a function of a multi-channel neural system which embodies different sets of neurons to accommodate different kinds of targets. The subject in question had difficulty in discriminating large distant letters (medium spatial frequency), but was very efficient at close detailed work (high spatial frequency), such as the last three figures on the FFG. Other individuals demonstrated the opposite pattern. The multi-channel approach may assist in explaining these differences in situations where the medical diagnosis is less than definitive.

It has also been reported that medium spatial frequencies are very important in stimulating the accommodation reflex (Owens, 1980). Thus, in some patients, there may be a deficiency in the accomodative power of the lens, which creates difficulties in identifying large, low contrast objects at a normal distance. Additionally, Sekuler (1982) has shown that sensitivity to contrast decreases with advancing age, particularly in the middle and higher frequency ranges and to complicate matters even further, the correlation between sensitivity to low and high frequencies is weak. Thus, traditional acuity measures, such as Snellen and Feinbloom charts, which test high spatial frequencies under uncontrolled conditions of illumination, do not provide adequate information about the ability to discriminate low spatial frequencies or large objects.

A major conclusion that can be drawn from this project is the importance of individual differences in the low vison population. The nature of low vision research has task and subject specific problems that weaken strict experimental control. Factors that are unavoidable include unsuspecting clinic patients who may be too reticent or overzealous in their attempts to be helpful, elderly individuals who are unsophisticated in their understanding of research, and commitments and scheduling problems that would defy the rigours of any scientific endeavour. There were also differences with respect to length of impairment, attitudes concerning low vision and psychological changes that accompany the different stages of visual loss. Finally, visual abilities often change from day to day in macular degeneration patients, leaving the patient, and often the clinician, baffled about the probable course of events.

There is, however, a common thread that links all of the participants of this study, and indeed the general population that is being addressed, which creates a starting point for low vision training. All of these individuals exhibited macular degeneration, and so it can be assumed that training in eccentric viewing is a primary goal. To this end, the abundant evidence which demonstrates the success of eccentric viewing training using a variety of methods, in laboratory settings, augers well for the benefits of these methods (Goodrich et al, 1977; Goodrich & Quillman, 1977; Holcomb & Goodrich, 1976).

What has so far not been closely investigated is the generalizability of these results to other visual tasks and to real life situations. The current project suggests that training should be specific to the visual task, but prior investigations have not concentrated on this question. Considerable attention had been devoted to these problems in a major review article by Gibson (1953). Her findings can be summarized by stating that the evidence was inconclusive at that time, and there has been little attention paid to this issue in recent years. For example, in those situations where the recognition of tachistoscopically presented letters improved, it was unclear whether this ability transferred beyond the laboratory setting (Gibson, 1953). Also, tachistoscopic presentations offer precision and specificity in terms of experimental situations, but this approach to perceptual problem-solving is obviously not practical or desirable in most clinical settings (Groffman, 1969). Future work in the area of perceptual training will have to address these questions in greater detail to provide a more comprehensive understanding of these variables.

Low vision training also incorporates many objectives which are not limited to perfecting the use of the peripheral retina. Given that perceptual training for the visually impaired is a beneficial addition to clinical procedures, factors relating to time and cost efficiency must also be assesed. Observations over the last year in the Low Vision Clinic have suggested that the method chosen for the current project provided an acceptable environment which afforded individuals the opportunity to practice eccentric viewing, to experiment with a new visual aid, and at the same time to discuss problems unique to their visual impairment. Few clinicians or patients have unlimited hours to spend in training sessions. The approach used in this study, therefore, may well coincide with other necessary office visits, since this would increase the utilization of time and resources. Scheduling the training in 2 to 4 short sessions emphasizes to the paient that visual efficiency is a dynamic situation, where motivation and practice are essential contributors to successful visual adjustment.

In conclusion, the empirical evidence generated from this project, and some of the major implications for future investigations can be summarized under the following points: (a) Perceptual training in visual impairment does enhance the use of certain residual abilities. (b) In general, active participation (which involves a visual-motor interaction) is to be preferred over passive involvement. (c) In addition to learning eccentric viewing techniques, the training should be task specific, to meet individual needs. (d) Low vision assessments do require an interactive approach to relate individual differences to anatomical, physiological, and psychological changes in the aging individual. (e) Age and severity of impairment apparently do not limit the potential for successful intervention. (f) Traditional acuity measures can be misleading; a comprehensive low vision assessment should utilize testing devices from several perspectives. The findings from this project, in conjunction with current low vision investigations, suggest that perceptual training, which should incorporate pragmatic solutions to accommodate clinical settings, represents a valuable and viable addition to the rehabilitative process in the visually impaired.

References

Bailey, I.L. (1978a). A profile of the low-vision patient. Optometric Monthly, 137-145.

Bailey, I.L. (1978b). Taking case histories of low-vision patients: the key to success. Optometric Monthly, 92-95.

Barraga, N.C., Collins, & Hollis, J. (1977). Development of efficiency in visual functioning: a literature analysis. Journal of Visual Impairment and Blindness, 9, 387-391.

Barraga, N.C. (1964). Increased visual behavior in low vision children. New York: American Foundation for the Blind.

Bender, L. (1938). A visual motor Gestalt test and its clinical use. American Orthopsychiatry Association Res. Monographs, No. 3.

Blash, D. (1976). Visual Efficiency Training Based on Familiarity for the low vision client. Unpublished manuscript.

Boring, E.G. (1942). Sensation and perception in the history of experimental psychology. New York: Appleton-Century Crofts.

Boring, E.G. (1957). A history of experimental psychology. New York: Appleton-Century Crofts.

Bryan, T.H., & Bryan, J.H. (1978). Understanding learning disabilities. Sherman Oaks: Alfred Publishing Co.

Carroll, H.C., & Hibbert, F.C. (1973). The perceptual ability of a class of partially sighted children. The Visually Handicapped International Archives for Research, 3, 106-118.

De l'Aune, W., & Needham, W. (1977). Psychological factors having a bearing on successful utilization of prosthetics and sensory aids. Proceedings of the fifth New England bioengineering conference. Cannon, M., (Ed.), New York : Pergamon Press, 111-115.

Faye, E.E., (1976a). Clinical low vision. Boston: Little, Brown, & Company.

Faye, E.E. (1976b). The role of eye pathology in low vision evaluation. Journal of the American Optometric Association, 47, 1395-1401.

Festinger, L., Burnham, C.A., Ono, H., & Bamber, D. (1967). Efference and the conscious experience of perception. Journal of Experimental Psychology, 74, 1-36.

Festinger, L., & Canon, L.K. (1965). Information about spatial location based on knowledge about efference. Psychological Review, 72, 373-384.

Friedman, D.B., Kayne, H.L., Tallman, C.B. & Sarkof, J.E. (1975). Comprehensive low vision care: part two. The New Outlook, 5, 207-211.

Frostig, M. (1976). Administration and scoring manual for the Marianne Frostig developmental test of visual perception. Palo Alto, California: Consulting Psychologists Press.

Frostig, M. (1972). Visual perception, integrative functions and academic learning. Journal of Learning Disabilities, 5, 1-15.

Genensky, S.M. (1981). Aging and the partially sighted. Unpublished manuscript, Center for the Partially Sighted, Santa Monica.

Gibson, E.J. (1953). Improvement in perceptual judgements as a function of controlled practice or training. Psychological

Bulletin, 50, 401-429.

Gibson, J.J. (1950). The perception of the visual world. Boston: Houghton Mifflin.

Gibson, J.J. (1966). The senses considered as perceptual systems. Boston: Houghton Mifflin.

Gibson, J.J. (1968). What gives rise to the perception of motion? Psychological Review, 75, 335-346.

Goodrich, G.L. (1982, July). Personal communication, Orlando.

Goodrich, G.L. (1977). Mehr, E.B., Quillman, R.D., Shaw, H.K., & Wiley, J.K. Training and practice effects in performance with low-vision aids: a preliminary study. American Journal of Optometry and Physiological Optics, 54, 312-381.

Goodrich, G.L. & Quillman, R.D. (1977). Training eccentric viewing. Journal of Visual Impairment and Blindness, 71, 377-381.

Groffman, S. (1969). Operant conditioning and vision training. American Journal of Optometry and Archives of American Academy of Optometry, 8, 583-594.

Harris, C. (1965). Perceptual adaptation to inverted, reversed and displaced vision. Psychological Review, 72, 419-444.

Held, R. (1961). Exposure-history as a factor in maintaining stability of perception and coordination. Journal of Nervous and Mental Diseases, 132, 26-32.

Held, R., & Hein, A.V. (1958). Adaptation of disarranged hand-eye coordination contingent upon re-afferent stimulation. Perceptual and Motor Skills, 8, 87-90.

Held, R., & Hein, A.V. Movement-produced stimulation in the development of visually guided behavior. Journal of Comparative and Physiological Psychology, 56, 872-876.

Held, R., & Rekosh, J. (1963). Motor sensory feedback and geometry of visual space. Science, 141, 722-723.

Held. R., & Schlank, M. (1959). Adaptation to disarranged eye-hand coordination in the distance dimension. The American Journal of Psychology, 72, 603-605.

Helmholtz, H. von. (1867). Physiological Optics. Translated 1925. Edited by Southall, J.P.C. Optical Society of America.

Holcomb, J.G., & Goodrich, G.L. (1976). Eccentric viewing training. Journal of the American Optometric Association, 47, 1438-1443.

Holst, E. von. (1954). Relations between the central nervous system and the peripheral organs. British Journal of Animal Behavior, 2, 89-94.

Howard, I.P., Craske, B., & Templeton, W.B. (1965). Visuomotor adaptation to discordant exafferent stimulation. Journal of Experimental Psychology, 70, 189-191.

Hubel, D.H., & Weisel, T.N. (1962). Receptive fields, binocular interaction, and functional architecture in the cat's visual cortex. Journal of Physiology, 160, 160-154.

Hutt, M.L. (1977). The Hutt Adaptation of the Bender Gestalt Test (3rd ed.), New York: Grune & Stratton.

Jones, J.W. (1962). Problems in defining and classifying blindness. New Outlook for the Blind, 56, 115-121.

Kanizsa, G. (1979). Organization in vision: Essays on Gestalt perception. New York: Praeger Publishers.

Kohler, I. (1964). The formation and transformation of the visual world. Psychological Issues, 3, 28-46, 116-143.

Melamed, L.E., Haley, M., & Gildow, W. (1973). An examination of the role of task oriented attention in the use of active and passive movement in visual adaptation. Journal of Experimental Psychology, 98, 125-201.

Murphy, S.B., & Donderi, D.C. (1979). Predicting the success of cataract surgery. Journal of Behavioral Medecine, 3, 1-14.

Overbury, O., & Bross, M. (1978). Improvement of visual acuity in partially and fully sighted subjects as a function of practice, feedback, and instructional techniques. Perceptual and Motor Skills, 46, 815-822.

Overbury, O., & Conrod, B.E. (1982, July). Perceptual, psychophysical and functional correlates of success with low vision aids. Paper presented at the meeting of the American Association of Workers for the Blind, Orlando.

Overbury, O., Grieg, D., West, M. (1982). The psychodynamics of low vision: a preliminary study. Journal of Visual Impairment and Blindness, 101-105.

Owens, D.A. (1980). A comparison of contrast sensitivity and accomodative responsiveness for sinusoidal gratings. Vision Research, 20, 159-167.

Quillman, R.D., Mehr, E.B., & Goodrich, G.L. (1981). Use of the Frostig Figure Ground in evaluation of adults with low vision.

American Journal of Optometry and Physiological Optics, 58, 910-918.

Schneider, G.E. (1969). Two visual systems. Science, 163; 895-902.

Sekuler, R. (1982). Spatial vision in older humans. In R. Sekuler, D. Kline, & K. Dismukes, (Eds.), Aging and Human Visual Function. New York: Liss, A.R.

Sekuler, R.W., & Ganz, L. (1963). Aftereffect of seen motion with a stabilized retinal image. Science, 139, 419-420.

Sells, S.B., & Fixott, R.S. (1956). Evaluation of research on effects of visual training on visual functions. Paper presented at the Association for Research in Ophthalmology, Washington, D.C.

Sloan, L.L., & Brown, D.J. (1963). Reading cards for selection of optical aids for the partially sighted. American Journal of Ophthalmology, 55, 1187-1199.

Wallach, J., Kravitz, J.H., & Lindauer, J.A. (1963). A passive condition for rapid adaptation to displaced visual direction. American Journal of Psychology, 76, 568-578.

Weiskrantz, L. (1980). Varieties of residual experience. Quarterly Journal of Experimental Psychology, 32, 365-386.

Wertheimer, M. (1923). Untersuchungen zur Lehre von der Gestalt, II. Psychologische Forschung, 4.

Wild, J.M., & Wolffe, M. (1982). Residual vision in the low vision patient: some concepts. American Journal of Optometry and Physiological Optics, 59, 686-691.

Appendix A

Hôpital Royal Victoria

Royal Victoria Hospital

687, AVENUE DES PINS OUEST
MONTRÉAL, QUÉBEC
H3A 1A1
(514) 842-1231

Consent Form

The study in which you are being asked to participate is designed to investigate the visual abilities, attitudes, and feelings of patients with low vision. This study will provide important information about these patients for both the medical and educational professions. It is hoped that this knowledge will help to build a basis for better health care in this area.

It is understood that the information which you provide will be kept in strict confidence, and that you will have a right to the data, in summary form, following the completion of the study. It is also understood that you may withdraw from the study at any time.

Your signature below indicates that you have understood the above statements, and that you agree to participate in the study.

Signature: ______________________________

Name (print) : ______________________________

Date: ______________________________

File Number: ______________________________

Appendix B

Acuity Measures

Distance Acuity: Acuity Test Charts

The usual method of acuity testing requires the patient to occlude one eye while reading the letters on a projected Snellen chart. The vision in each eye is measured both without and with correction. The refraction expressing acuity is a combination of the distance at which the patient reads the chart (numerator) and the distance at which a normal person reads the same line (denominator). 20/20 indicates normal vision. The Feinbloom method uses a non-projected chart at a distance of 10 feet; 10/10 indicates normal vision.

Self Report of Satisfaction with Functional Vision

Are you satisfied that you are functioning to the best of your ability with your remaining vision?

0 = not at all satisfied

1 = somewhat satisfied

2 = satisfied

3 = very satisfied

If you were to begin to enumerate the various uses of paper, you would find the list almost without end. Yet, there was a time when this familiar item was a precious rarity, when the sheet of paper you now toss into the wastebasket without thinking would have been purchased at a great price and carefully preserved. Indeed, for long centuries in man's history, paper was unknown. People wrote on specially prepared sheepskins or goatskins called parchment.

About twenty-two hundred years ago, the Chinese People discovered how to manufacture paper from wood pulp. Later the secret reached Europe. But for many years, the whole operation was done by hand. Imagine making paper by hand, sheet by sheet. It was a reasonably simple process, but it is easy to see why paper was used only by the wealthy.

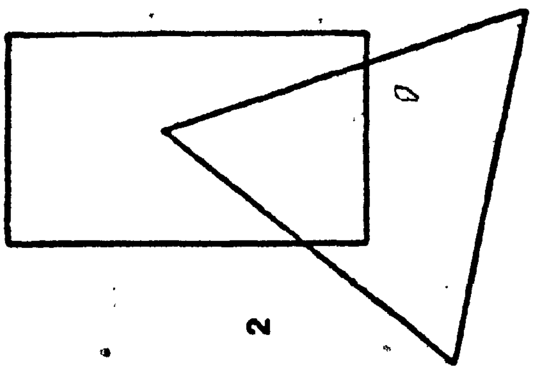
The first machine for making paper was invented by a Frenchman named Louis Robert. It was a crude machine by today's standards. Many European and American inventors have since contributed to the development of the more efficient papermaking machines now in use. In our time, paper is used throughout the world. It is most widely used in our country. The United States manufactures and uses more than half the world's paper products.

IF YOU WERE TO BEGIN TO ENUMERATE THE VARIOUS USES OF PAPER, YOU WOULD FIND THE LIST ALMOST WITHOUT END. YET, THERE WAS A TIME WHEN THIS FAMILIAR ITEM WAS A PRECIOUS RARITY, WHEN THE SHEET OF PAPER YOU NOW TOSS INTO THE WASTEBASKET WITHOUT THINKING WOULD HAVE BEEN PURCHASED AT A GREAT PRICE AND CAREFULLY PRESERVED. INDEED, FOR LONG CENTURIES IN MAN'S HISTORY, PAPER WAS UNKNOWN. PEOPLE WROTE ON SPECIALLY PREPARED SHEEPSKINS OR GOATSKINS CALLED PARCHMENT.

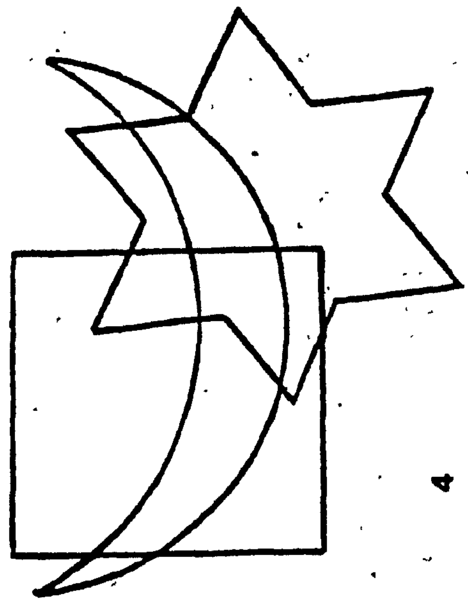
ABOUT TWENTY-TWO HUNDRED YEARS AGO, THE CHINESE PEOPLE DISCOVERED HOW TO MANUFACTURE PAPER FROM WOOD PULP. LATER THE SECRET REACHED EUROPE. BUT FOR MANY YEARS, THE WHOLE OPERATION WAS DONE BY HAND. IMAGINE MAKING PAPER BY HAND, SHEET BY SHEET. IT WAS A REASONABLY SIMPLE PROCESS, BUT IT IS EASY TO SEE WHY PAPER WAS USED ONLY BY THE WEALTHY.

THE FIRST MACHINE FOR MAKING PAPER WAS INVENTED BY A FRENCHMAN NAMED LOUIS ROBERT. IT WAS A CRUDE MACHINE BY TODAY'S STANDARDS. MANY EUROPEAN AND AMERICAN INVENTORS HAVE SINCE CONTRIBUTED TO THE DEVELOPMENT OF THE MORE EFFICIENT PAPERMAKING MACHINES NOW IN USE. IN OUR TIME, PAPER IS USED THROUGHOUT THE WORLD. IT IS MOST WIDELY USED IN OUR COUNTRY. THE UNITED STATES MANUFACTURES AND USES MORE THAN HALF THE WORLD'S PAPER PRODUCTS.

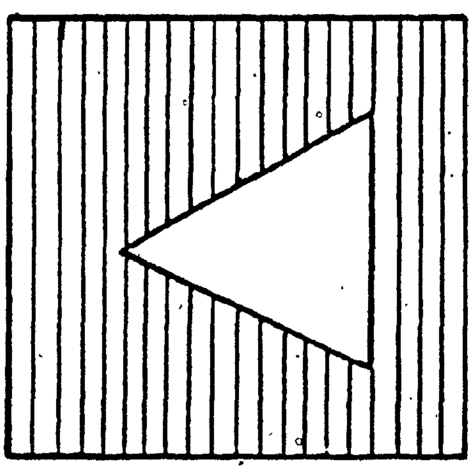
FFG



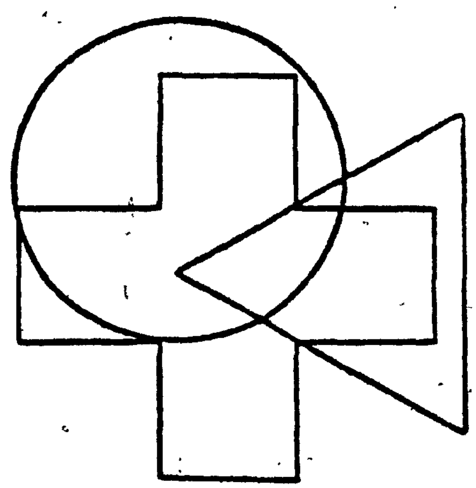
2



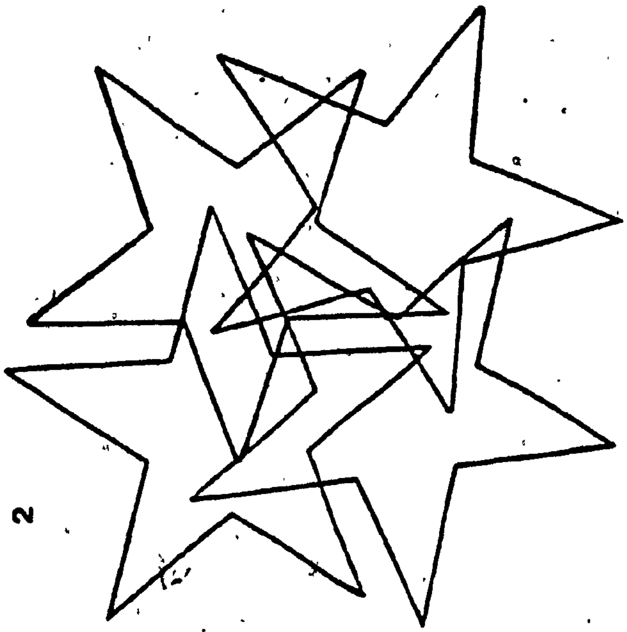
4



1

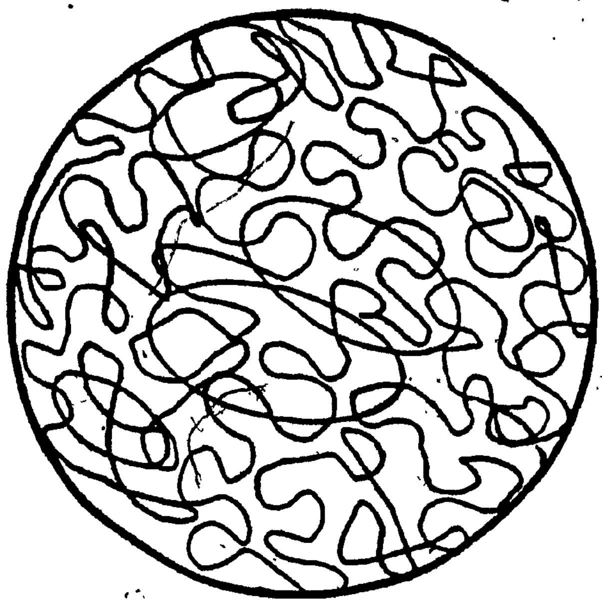


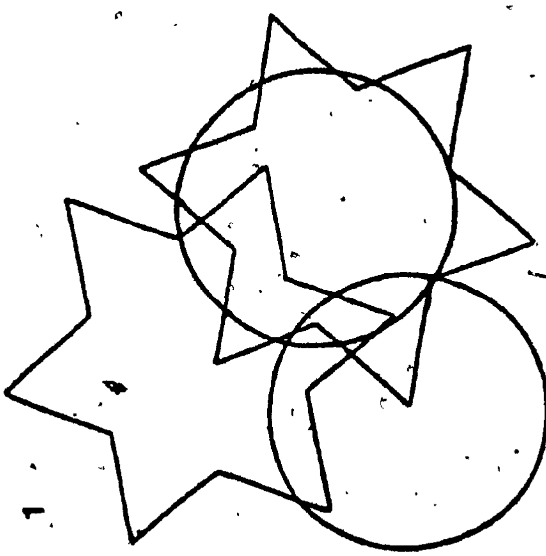
3



2

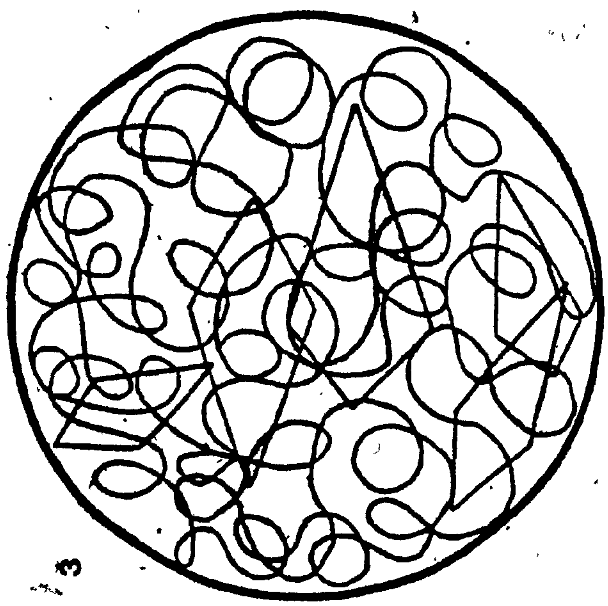
4

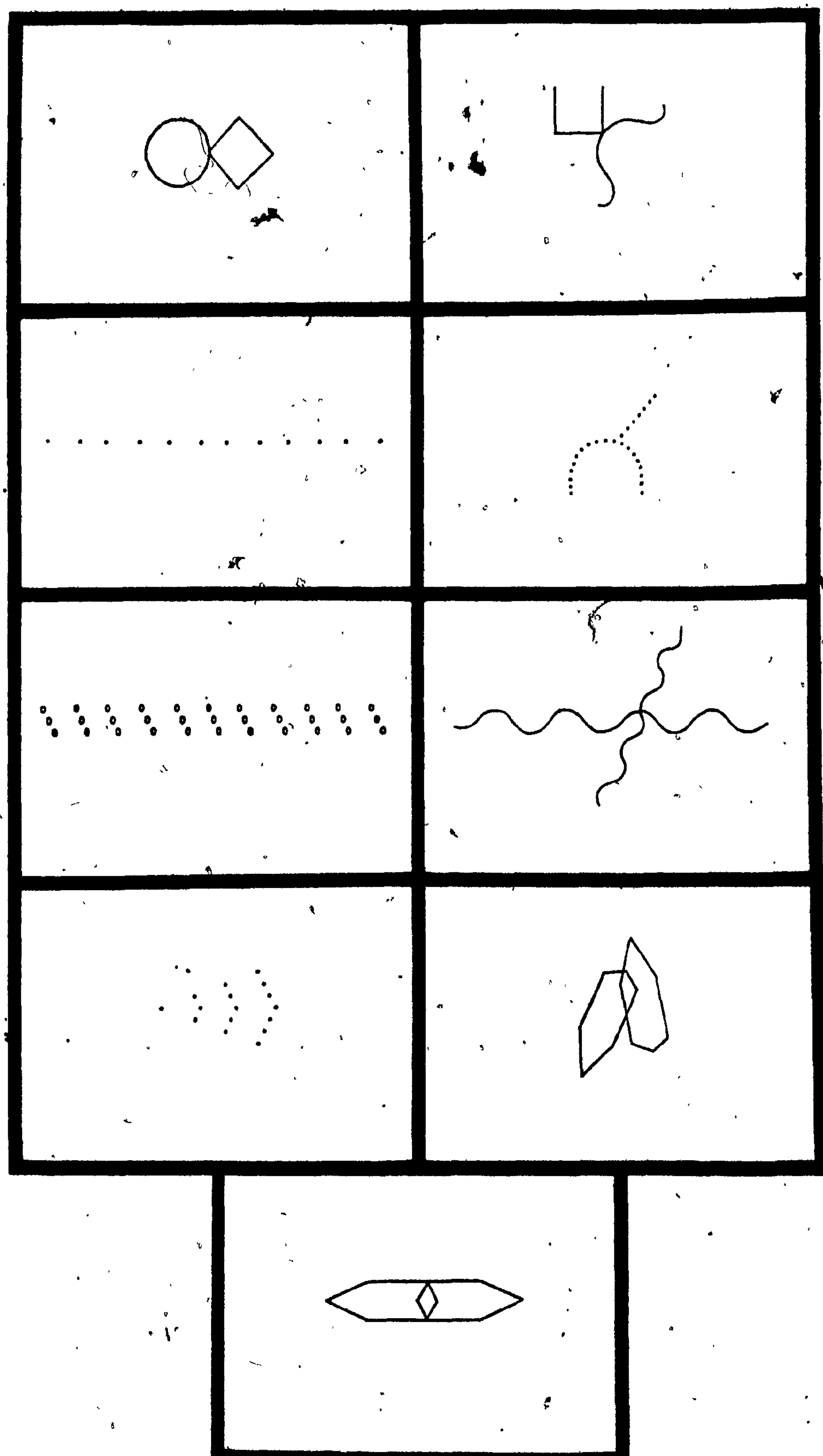




1

3





TEST DE FARNSWORTH 100 HUE

65

Nom .... **Age** .... **Date** ....

85	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	

TEMPS

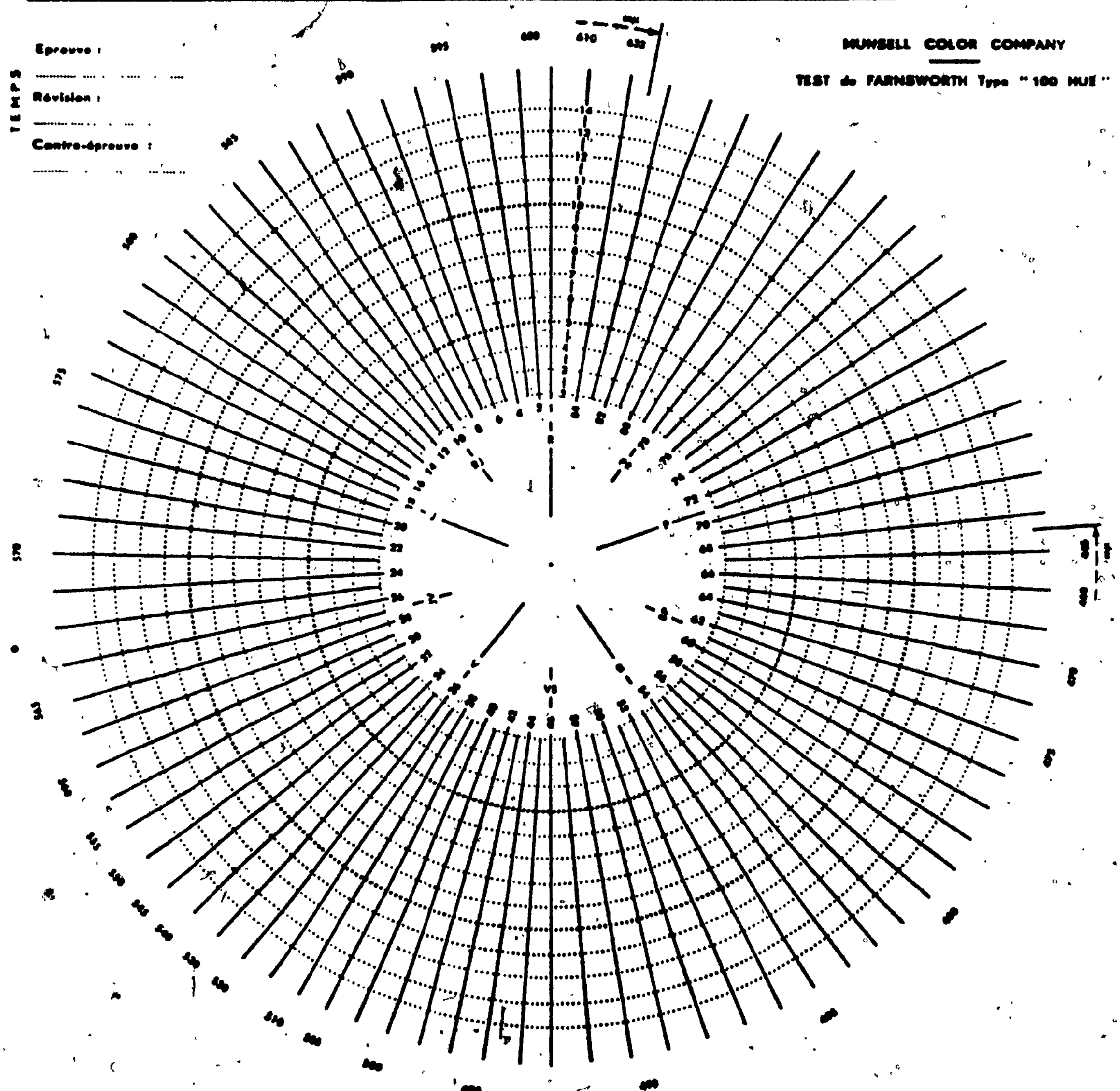
Epreuve : ....

Révision : ....

Contre-épreuve : ....

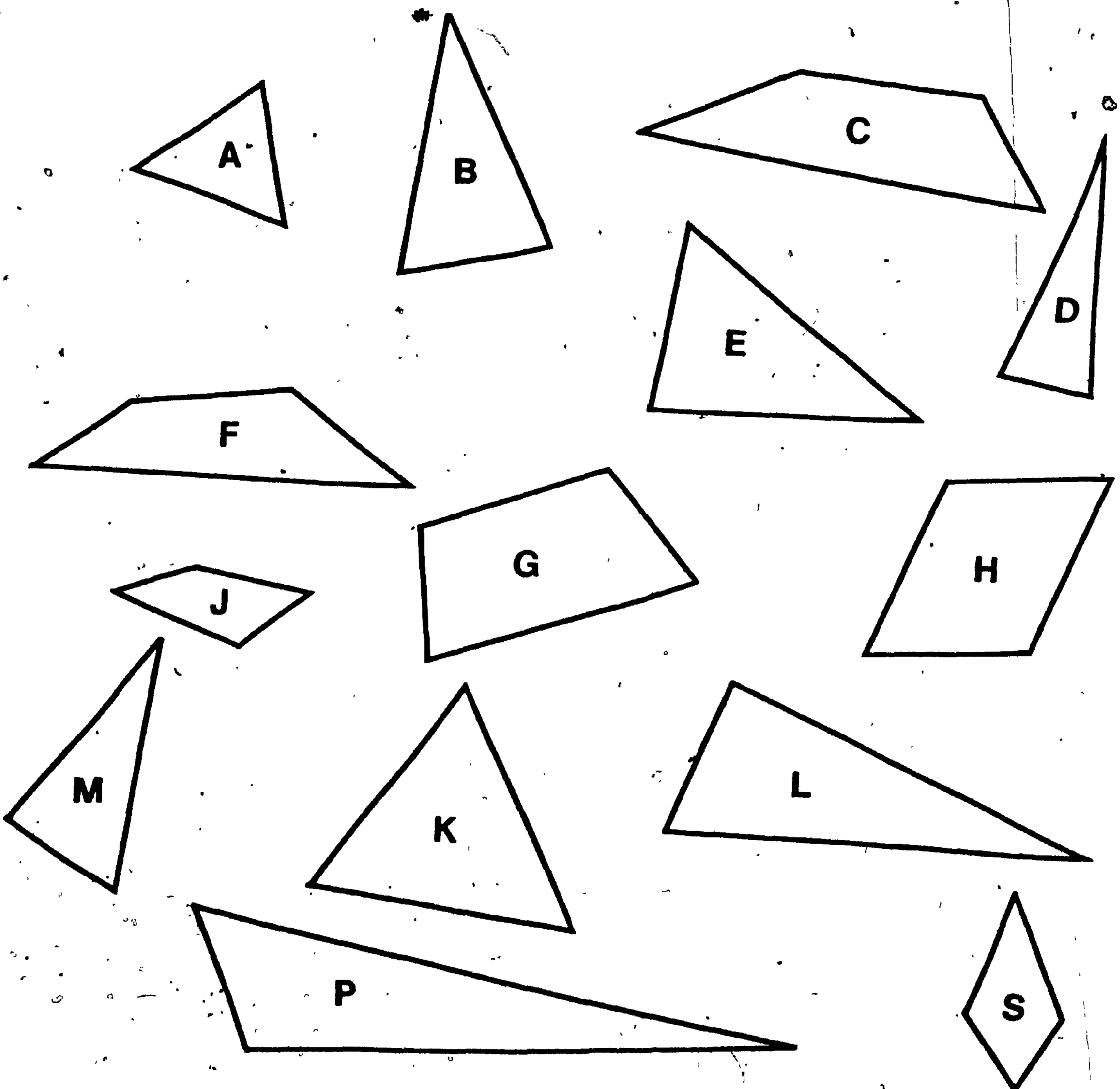
MUNSELL COLOR COMPANY

TEST de FARNSWORTH Type "100 HUE"

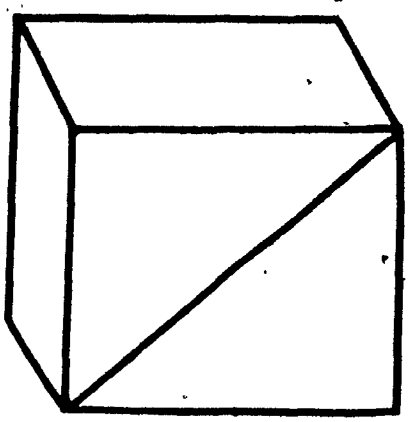


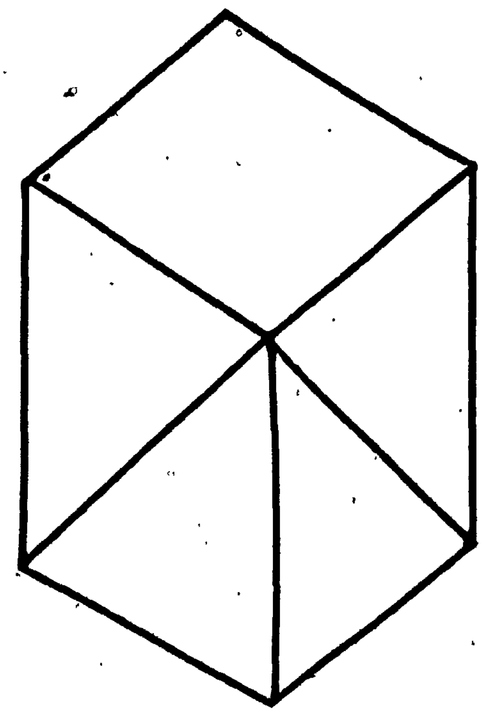
Appendix C

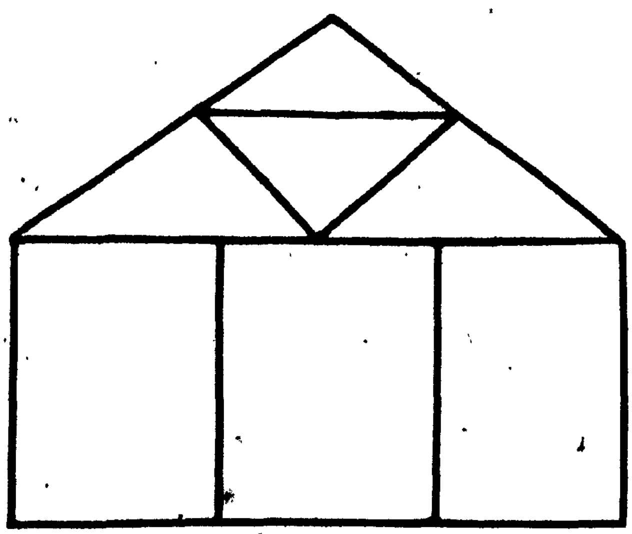
TRIANGLES: Locate or Trace



TRIANGLES: Locate or Trace

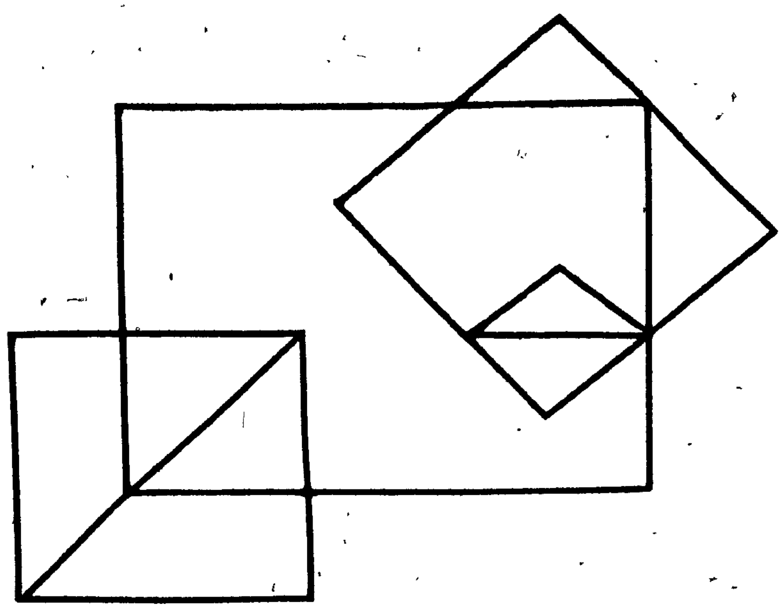


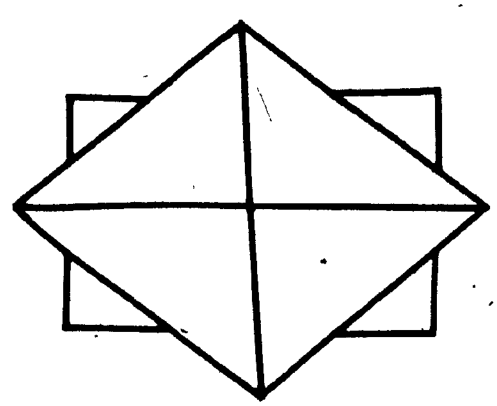


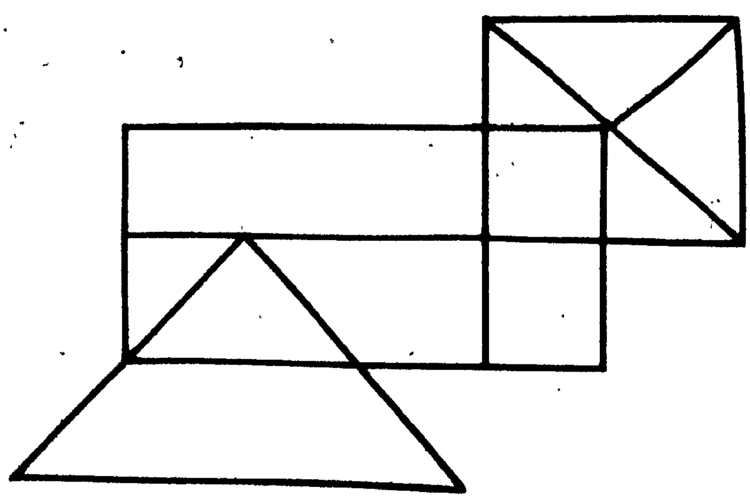


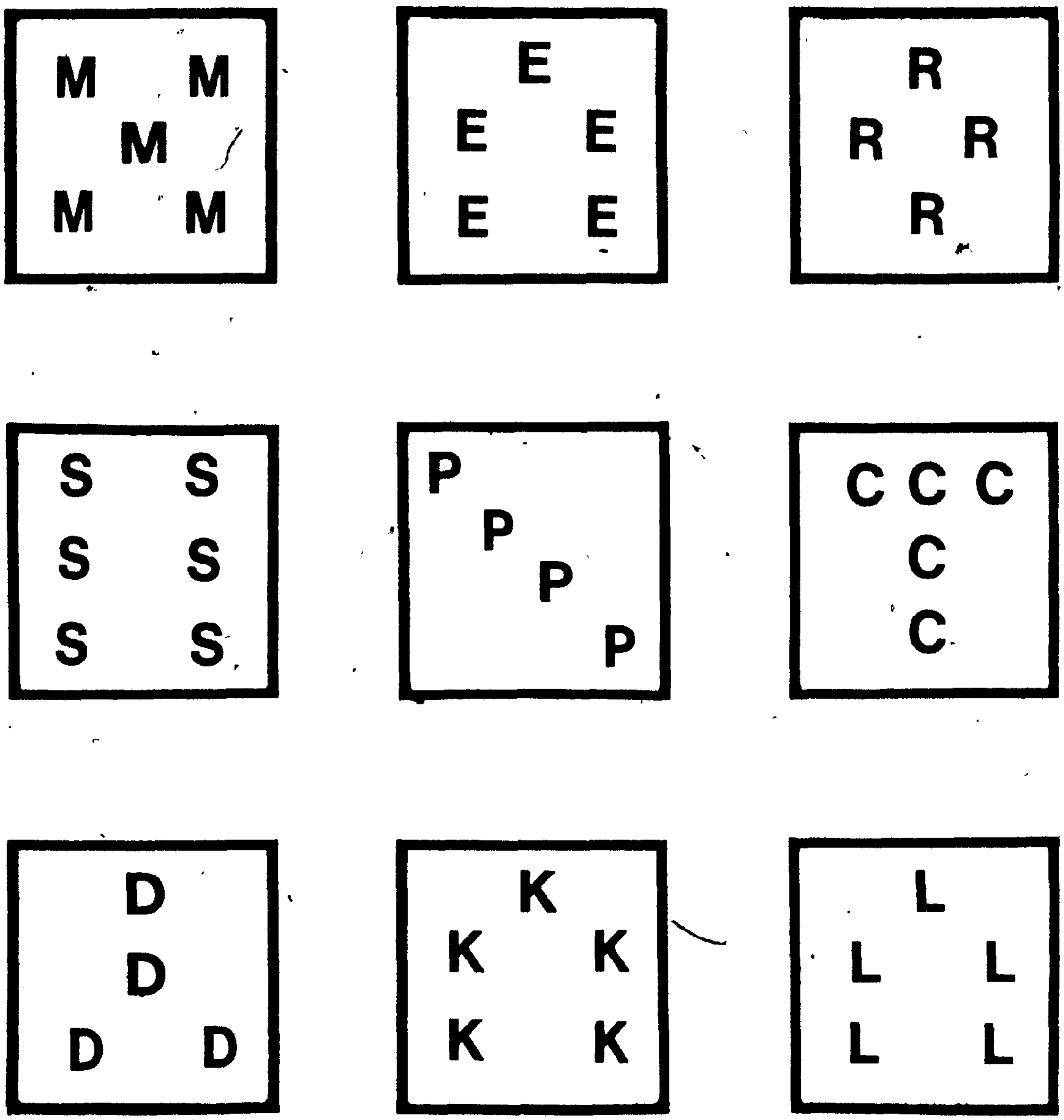
TRIANGLES:

Locate or Trace





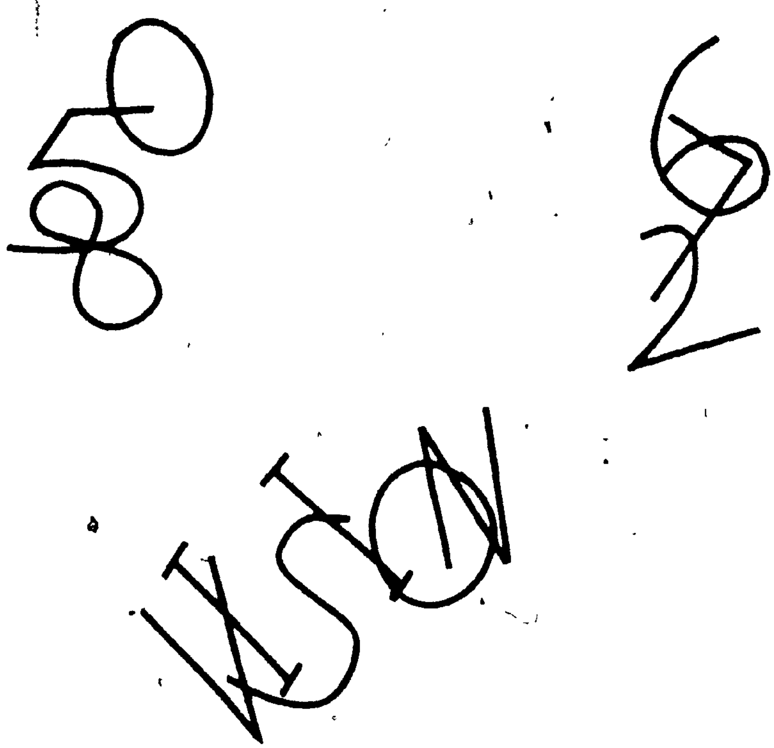




Locate all Sets Containing

$\boxed{5}$ Letters

Name or Trace



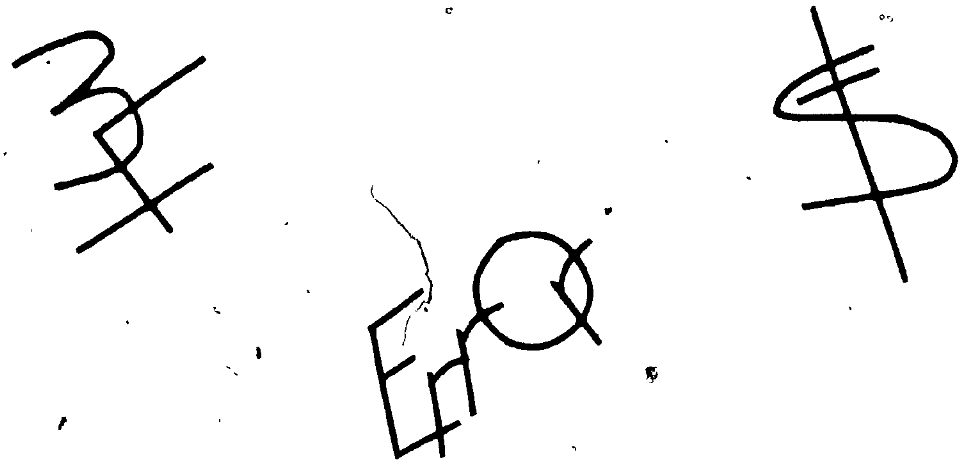
How many times does

"AT"

appear ? Trace.

MATT'S CAT ATTACKED A TABBY LATE ON SATURDAY.

Name or Trace



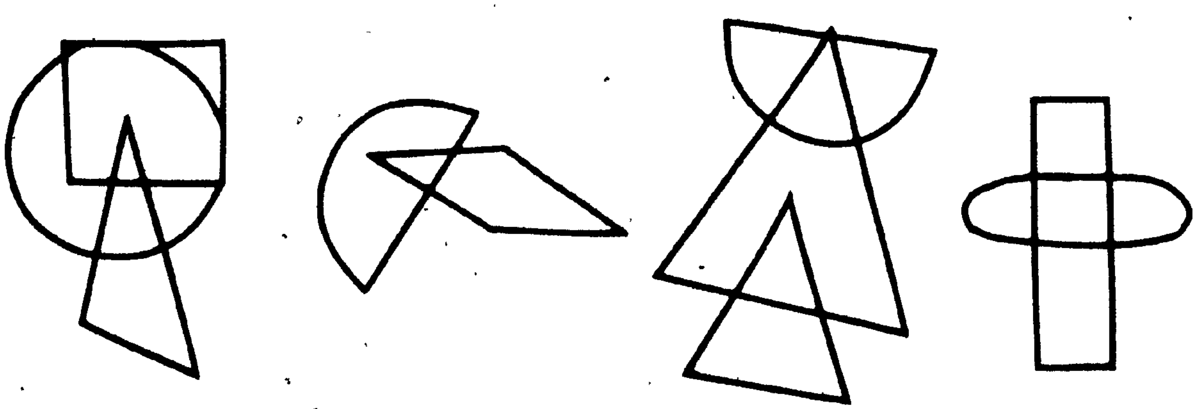
How many times does

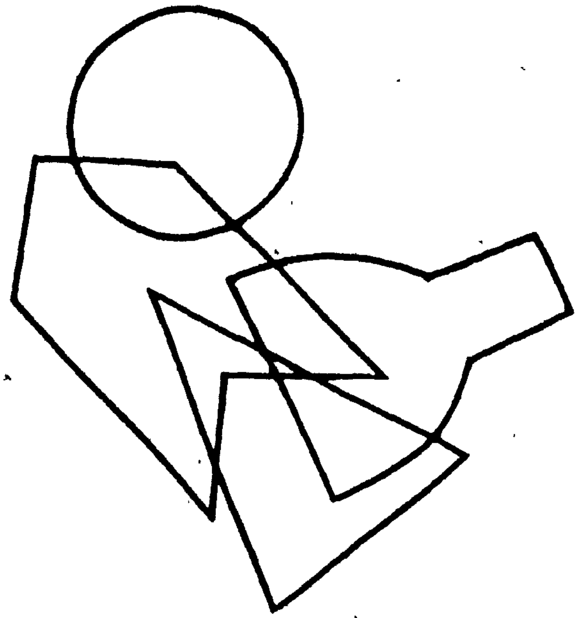
"OR"

appear? Trace.

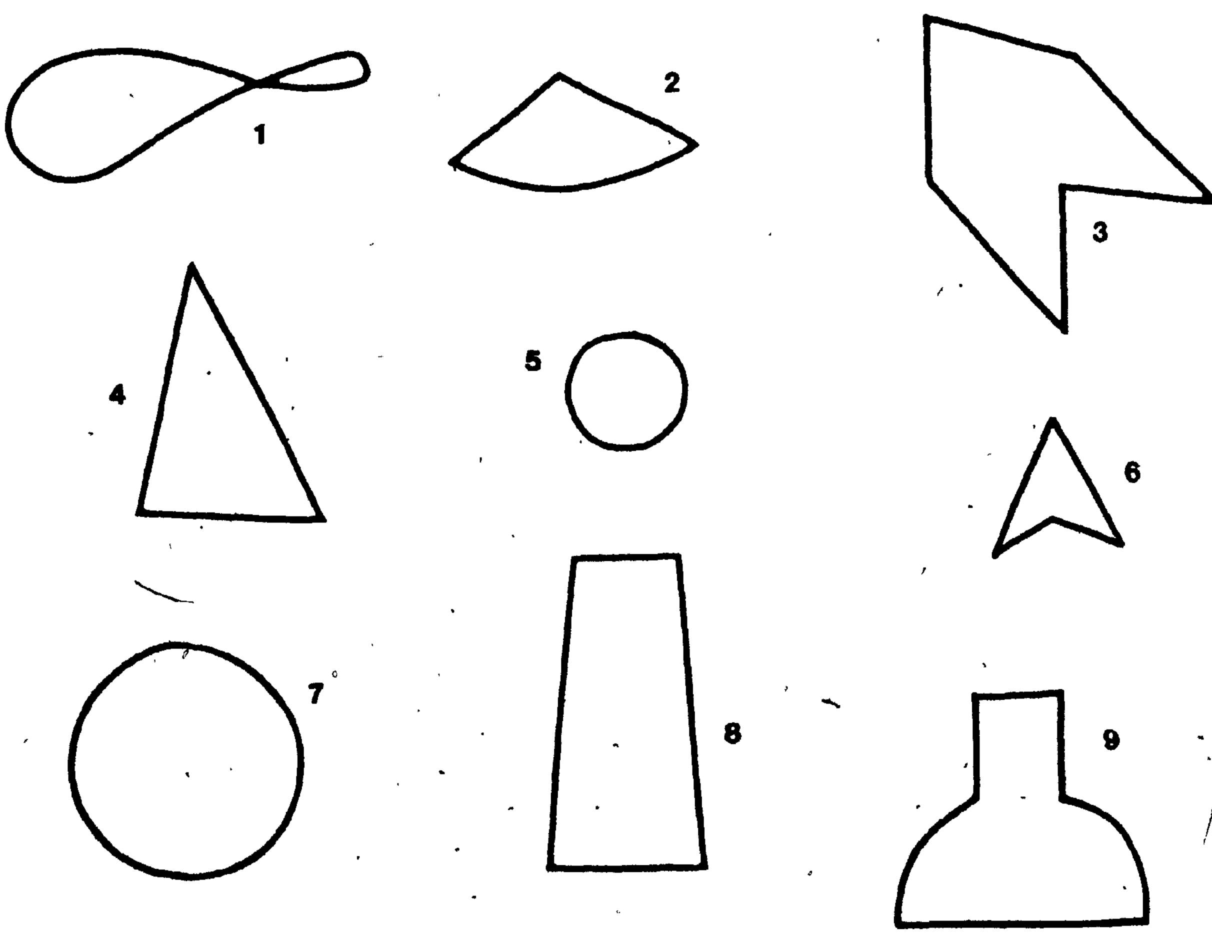
GORDON ORDERED A MOTOR FOR A FORD

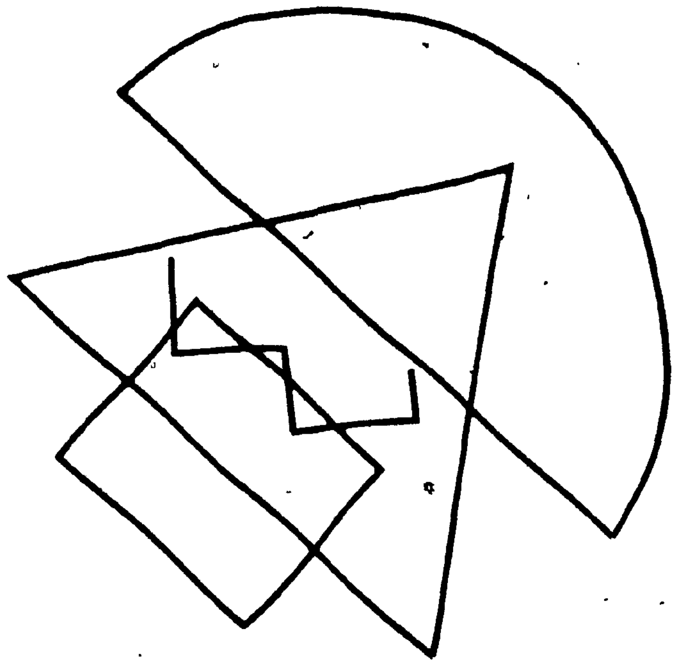
Identify the Shapes



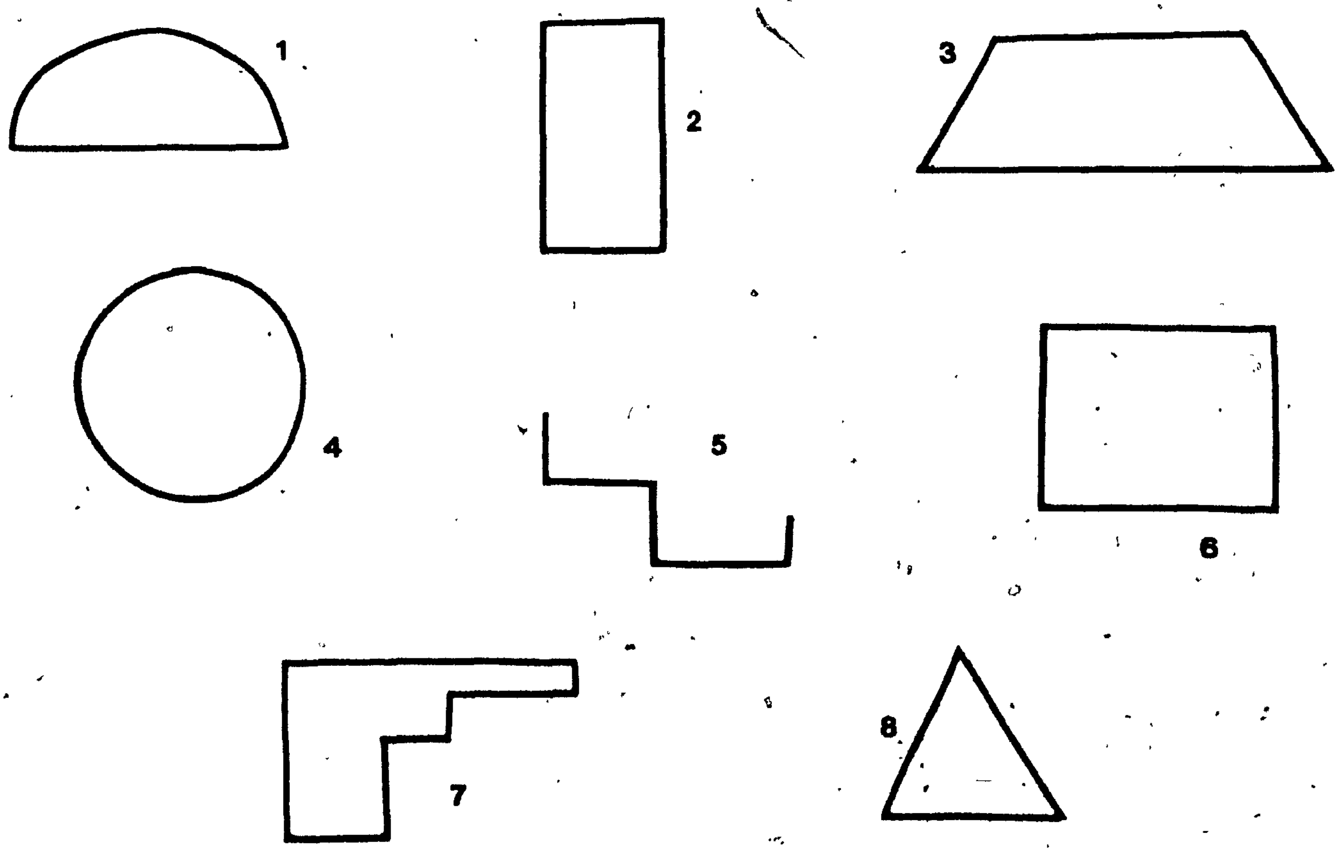


Which are found in the design above ?



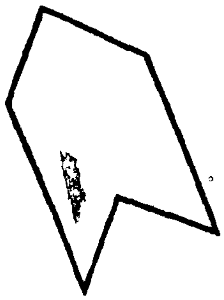


Which are found in the design above?

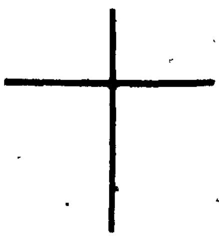


Match or Trace

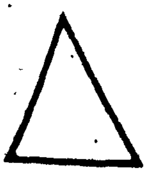
A



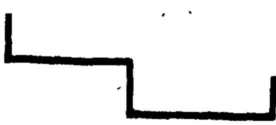
B



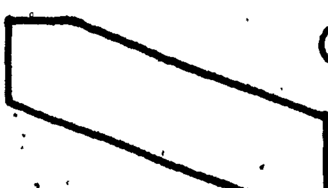
C



D

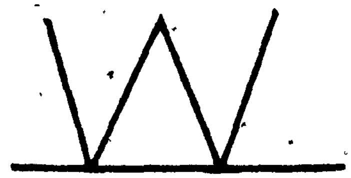


E

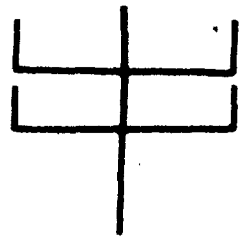


F

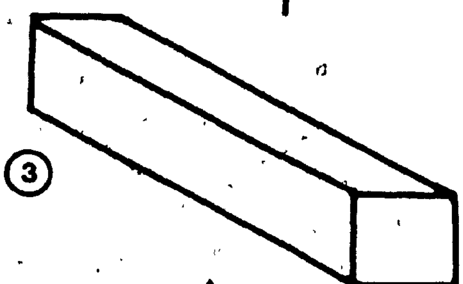
1



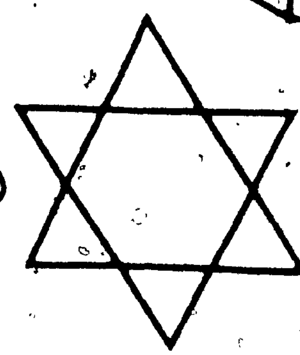
2



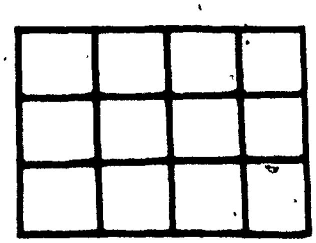
3



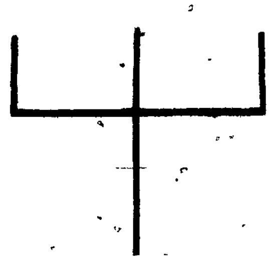
4



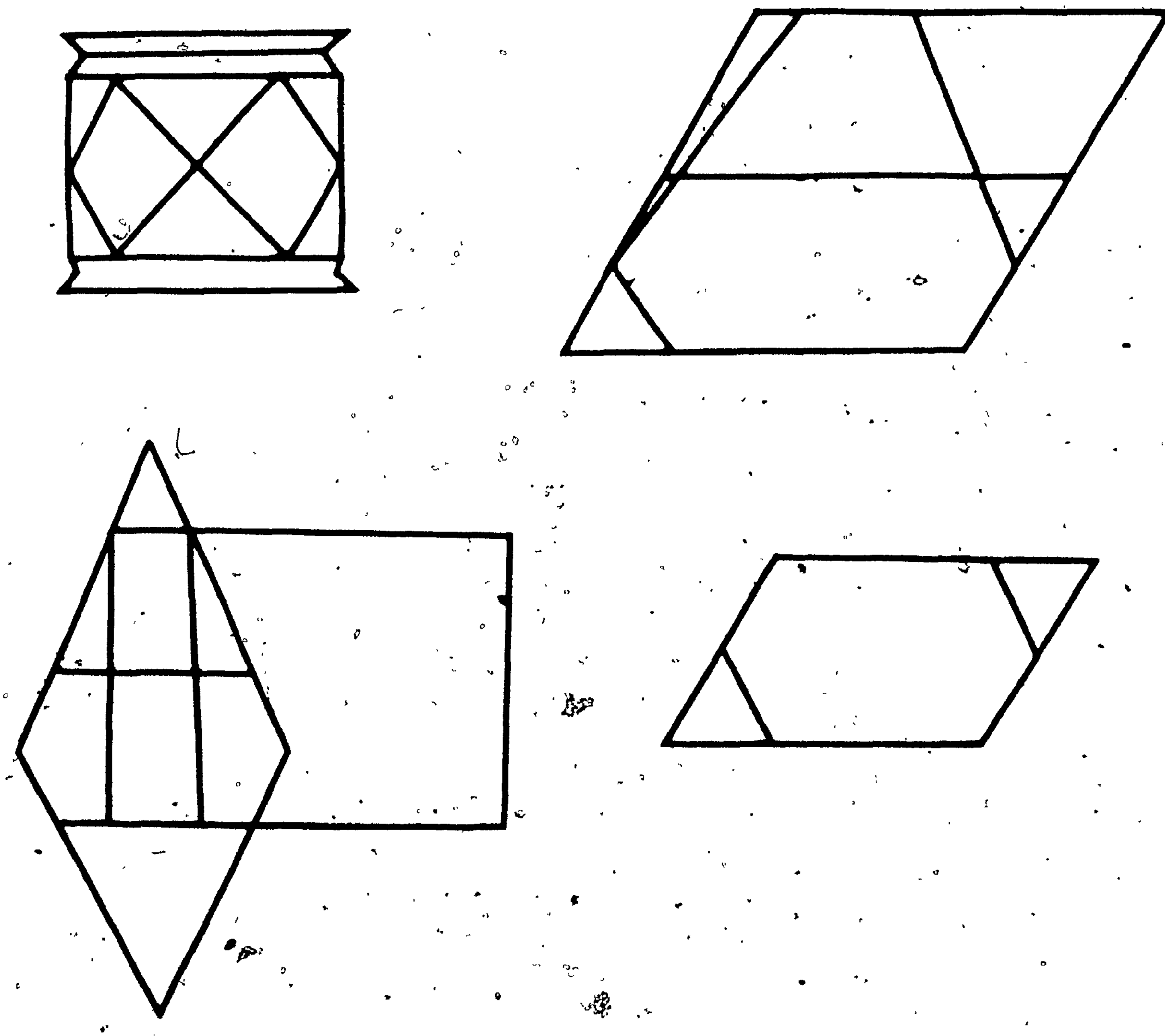
5

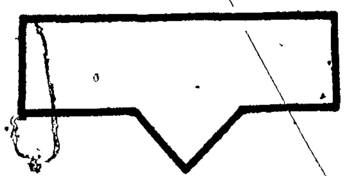


6

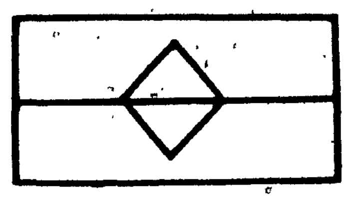


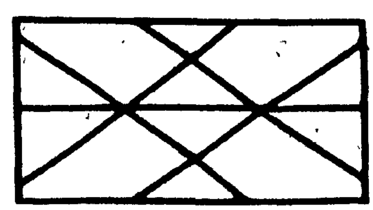
Is this figure found in any of the designs below?

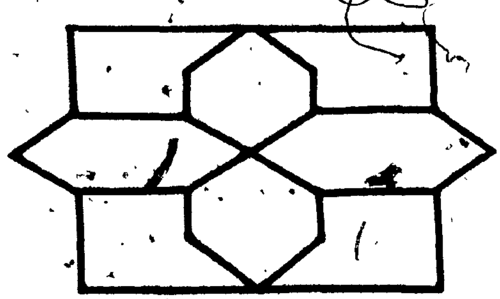




Is this figure found in any of the designs below ?







Appendix D

Table D.1

Univariate Analysis of Variance for Acuity Scores

Source	SS	df	MS	F	P
Model	51.35	2	25.67	1.81	0.1857
Impairment	2.13	1	2.13	0.15	0.7018
MI	0.82	2	0.41	0.03	0.9717
Error	340.90	24	14.20		

Table D.2

Univariate Analysis of Variance for Satisfaction Ratings.

Source	SS	df	MS	F	P
Model	0.80	2	0.40	0.63	0.5404
Impairment	1.63	1	1.63	2.58	0.1214
MI	1.07	2	0.53	0.84	0.4431
Error	15.20	24	0.63		

Table D.3

Univariate Analysis of Variance for Reading Scores

Source	SS	df	MS	F	P
Model	977.45	2	388.72	1.63	0.2160
Impairment	7.01	1	7.01	0.02	0.8796
MI	1442.81	2	721.41	2.41	0.1110
Error	7176.51	24	299.02		

Table D.4

Univariate Analysis of Variance for FFG Scores

Source	SS	df	MS	F	P
Model	192.07	2	96.03	7.81	0.0024
Impairment	5.63	1	5.63	0.46	0.5050
MI	22.00	2	11.23	0.91	0.4147
Error	295.00	24	12.30		

Table D.5

Univariate Analysis of Variance for Bender-Gestalt Scores

Source	SS	df	MS	F	P
Model	4.87	2	2.43	1.84	0.1802
Impairment	0.30	1	0.30	0.23	0.6280
MI	0.60	2	0.30	0.23	0.7985
Error	31.70	24	1.32		

Table D.6

Univariate Analysis of Variance for FM-100 Scores

Source	SS	df	MS	F	P
Model	38324.60	2	19162.30	0.93	0.4065
Impairment	11136.10	1	11136.10	0.54	0.4682
MI	10166.90	2	5083.43	0.25	0.7824
Error	491985.20	24	20499.38		

Table D.7

Pre-test and Post-test scores on Six Measures

Group			Acuity		Satisfaction		Reading		FFG		Bender		FM-100	
			Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
ACTIVE	(Mod.)	1)	18.0	12.0	2	2	26.3	42.8	16	24	6.5	9.0	608	534
		2)	6.0	2.0	1	2	96.7	83.7	24	27	6.5	7.0	156	300
		3)	3.0	2.5	2	3	23.3	26.5	18	28	6.0	9.0	364	430
		4)	12.0	10.0	2	2	19.4	33.0	16	25	8.0	8.0	582	420
		5)	6.0	4.0	3	3	106.0	105.0	17	19	7.5	7.0	455	494
	(Sev.)	6)	20.0	10.0	3	1	70.0	68.3	8	23	5.0	7.0	777	664
		7)	18.0	18.0	2	2	31.7	33.3	15	18	4.0	6.0	281	312
		8)	12.0	16.0	2	2	9.0	13.4	19	24	5.5	8.0	505	530
		9)	40.0	30.0	2	2	32.5	41.0	6	15	4.0	4.0	423	508
		10)	67.0	67.0	1	0	20.0	21.1	4	18	3.0	2.5	667	774
	means		20.2	17.2	2	1.9	43.1	46.5	14.3	22.1	5.6	6.75	481.8	496.6
PASSIVE	(Mod.)	11)	2.5	3.5	1	1	74.6	125.0	25	28	7.5	7.5	205	111
		12)	8.0	8.0	1	2	105.0	105.0	18	23	4.0	6.5	513	548
		13)	16.0	10.0	1	2	27.7	28.9	10	12	6.0	5.0	658	397
		14)	2.5	3.5	2	0	105.0	168.0	28	28	7.0	7.0	109	93
		15)	10.0	10.0	1	2	31.7	23.8	12	18	6.0	6.0	658	614
	(Sev.)	16)	20.0	18.0	2	1	15.0	22.5	14	16	4.0	5.5	709	805
		17)	20.0	15.0	2	2	9.0	9.0	3	12	4.0	4.0	577	365
		18)	20.0	12.0	1	1	29.0	40.2	10	13	5.0	5.0	738	528
		19)	4.0	10.0	0	0	74.0	58.5	6	12	3.5	4.5	727	1041
		20)	12.0	12.0	1	2	19.0	33.3	11	13	5.5	4.5	705	782
	means		11.5	10.2	1.2	1.3	48.8	61.1	13.7	17.5	5.3	5.6	559.9	528.4
CONTROL	(Mod.)	21)	5.0	6.0	1	1	102.5	95.0	20	28	6.0	6.0	453	345
		22)	5.0	6.0	2	2	50.0	50.0	27	28	7.5	7.5	390	261
		23)	3.5	4.0	1	1	185.8	149.6	26	26	7.5	9.0	486	275
		24)	3.5	3.0	2	2	159.1	140.0	27	27	8.0	8.0	218	211
		25)	3.0	2.5	3	2	13.2	29.0	4	7	2.5	3.5	885	971
	(Sev.)	26)	18.0	20.0	1	1	38.0	52.5	21	20	8.0	8.0	686	597
		27)	10.0	8.0	3	2	35.0	35.0	13	18	9.0	10.0	801	506
		28)	6.0	6.0	2	2	40.0	51.3	28	27	8.5	8.0	732	636
		29)	133.0	133.0	2	2	26.1	32.0	24	25	9.0	9.0	541	525
		30)	6.0	6.0	2	1	32.0	34.0	3	4	4.0	3.5	903	1041
	means		19.3	19.4	1.9	1.6	68.0	66.7	19.4	21.0	7.0	7.25	609.5	536.8