AN EXPLORATORY ANALYSIS OF SPACE PERCEPTION IN CONGENITALLY BLIND AND SIGHTED INDIVIDUALS

Thesis for the Degree of Ph. D.

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William F. Hunter

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This is to certify that the

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AN EXPLORATORY ANALYSIS OF SPACE PERCEPTION IN CONGENITALLY BLIND AND SIGHTED INDIVIDUALS

By

William F. Hunter

AN ABSTRACT

Submitted to the School for Advanced Graduate Studies
of Michigan State University of Agriculture and
Applied Science in partial fulfillment
of the requirements for
the degree of

DOCTOR OF PHILOSOPHY

College of Education

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Approved John E. Gordan

WILLIAM F. HUNTER ABSTRACT

The Problem

This exploratory study was concerned with ascertaining the characteristics of space perception in congenitally blind and sighted individuals. The primary emphasis was directed at the effects evolving in the human organism when visual imagery is presumed to be lacking.

Specifically, the study attempted to test three hypotheses:

1. The blind and sighted differ significantly in their ability to manipulate a curved surface to a flat surface.
2. The blind and sighted differ significantly in their ability to orient themselves to objects in space.
3. The blind and sighted differ significantly in their ability to orient themselves in space.

The Sample

The sample consisted of twelve congenitally blind children selected from the enrollment of the Michigan School for the Blind. This group was matched as to age, sex and IQ with sighted children enrolled in the East Lansing, Michigan, public schools. The age range of the subjects was 12 years, 1 month to 18 years, 2 months; IQ's ranged from 91 to 118.

Procedures and Methodology

Three separate spatial experiments were designed and administered individually to each subject in the two groups.

1. The first experiment involved tactually exploring the circumference of three different sized cylinders and then estimating this distance with the fingers on a meter stick.
2. The second experiment required exploring the placement of eight, fixed three-dimensional objects on a metal plate and then duplicating the same placement with an identical set of objects on another plate that had been reoriented.
3. The third experiment required the estimation, both subjectively and objectively, of the size of three different rooms.

The study used the psychophysical method of average error with sampling statistics in the analysis of the data. Statistical procedures involved computing error means and variances and using t tests to determine if significant differences existed between the performance of the two groups.

Results

The data supported the first and second hypotheses. However, the results of the third experiment were inconclusive which may have been due to the presence of some uncontrolled variables that influenced the findings.

To summarize the study, the overall results revealed behavior on the part of the blind group which seemed to indicate a lack of ability to utilize various types of stimuli to the degree accomplished by the sighted. Evidently, congenital blindness is associated with subtle, but significant, impairment. An inquiry was made into the nature of this impairment to consider if the etiology was a matter of sensory deprivation or some pathological process.

The final chapter deals with the implications of the study on educational and rehabilitation practices when dealing with the congenitally blind.

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A DISSERTATION

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CHAPTER I

THE NATURE OF THE PROBLEM

The present investigation was concerned with ascertaining the constituants of non-visual space or the "space" of the congenitally blind. Research in this area has tended to be scattered, sporadic and unrelated to a theoretical system. Facts contributed by these largely descriptive studies have been useful, but they have not resulted in a system of knowledge related to the problems of the blind. A theoretical system which can be subjected to experimental clarification is a necessity in order to draw generalized conclusions from research data.

The results of investigations on sighted persons indicate that space perception depends upon location, size, shape, and angulation of surface contours or their alteration through differences between the convergence and accomodation of the retinal illumination of the two eyes (47:447). Since the congenitally blind function successfully in a three-dimensional world, by what process are the other senses utilized to circumvent the loss of photic stimuli? How do these individuals actually perceive their environment? Evidently, blind individuals, in some manner, build their conception of the world

in which they live by relying almost exclusively upon tactual and auditory perceptions and kinesthetic experience.

The emphasis of this research was upon the individual as an organism which possesses sensory receptors for contacting his surrounds, and the differences that exist between this individual and another person who was born lacking one of these receptors, namely vision. Knowledge of these basic differences can then be related to applied areas such as instructional methods and vocational training.

GENERAL PROBLEM

Tactual space perception of the blind is different from the visual space perception of the sighted. For this reason, it is difficult for the blind to understand what visual experiences really mean, just as it is for the sighted to understand what it means to be completely blind. Sighted people cannot place themselves in the position of a blind person who possesses no visual imagery. The sighted may close their eyes and get some idea of the difficulties involved, but they do not give up the use of visual imagery and with all efforts, cannot do so.

If the sense of touch would serve people as well as the sense of sight, the congenitally blind individual would not be at any particular disadvantage. However, tactual experience has distinct limitation caused by the fact that tactual perception requires direct contact with the object to be observed. Certain objects are inaccessible for direct contact; others are too large, too small, or fragile. Objects in motion or undergoing a chemical change such as burning wood, do not lend themselves well to tactual observation.

Another very important difference between visual and tactual perception lies in the fact that photic stimuli permits much greater perceptual activity than tactual stimuli. In the sighted person, the eyes are almost constantly open, and he perceives most of what occurs in his surrounds. This is not true for the congenitally blind person. Hands used to produce tactual stimuli must be actively applied if perception is to evolve and, at best, the "tactual stimuli horizon" remains within the limited scope of the outstretched arms and hands.

As already explained, tactual perception requires direct contact with the stimulus object which must be observed as a whole if the congenitally blind person is to gain a complete and adequate concept of it. Very often total observation is not possible, either because it would take too much time, or because only parts of the object are accessible. Thus, blind individuals acquire only a partial knowledge of many objects.

The problem of part-observation and incomplete ideas assumes great importance when dealing with the education and training of the blind. This distortion of reality may not be apparent during a superficial examination because the congenitally blind are taught the same language symbols, somewhat in a "parrot" fashion, as used by the sighted. However, a word may not necessarily mean the same thing to the blind as it does to the sighted. Even granting that the word carries the same connotation for both groups, the amount of information acquired and its reality value is certainly greatly inferior for the blind.

Restriction in the control of the surrounds and the self in relation to it profoundly affects the development of congenitally blind children. Among the sensory receptors, visual perception is the one which overcomes distance and gives at the same time details and relationships of form, size and position. Visual experiences, therefore, permit a contact with, and control of the environment of a far greater magnitude than that achieved by the use of other sensory receptors.

The detachment from the physical environment affects the blind individual in still another way during his development. The congenitally blind infant does not reach for or crawl towards objects, as the sighted child does because nothing entices him to do so. Auditory impressions may make him aware of some objects for which he reaches, but such stimulation occurs infrequently in comparison with the stimuli affecting sighted children.

From infancy onward the congenitally blind individual cannot acquire behavior patterns on the basis of visual imitation. This factor plays an important role in the child's

development, particularly in regard to walking, talking, and other kinds of behavior usually learned by imitation. Many of the daily activities which the child must learn assume different proportions when they are not controlled by sight. For example, eating a meal is not only a greater strain for a blind person, but it also takes more time.

A lack of visual perception causes a detachment from the physical and, to a lesser degree, from the social world. A blind person who finds himself in unaccustomed surroundings, cannot become informed about his situation within the environment by any very rapid process. The cues he receives from auditory and tactual stimuli provide meager information that can assist him in controlling his environment, and himself in relation to it.

NEED FOR THE STUDY

An effort has been made to outline some of the aspects of the problem when considering the congenital lack of visual perception in the human organism, particularly as it applies to space perception. There seems to be a common conception held by many that the congenitally blind are psychologically, "sighted people who cannot see", but as it has been explained, the sighted person utilizes a global approach to space perception and the congenitally blind individual uses a sequential procedure within a molecular frame of reference.

It was felt that space perception of the blind is of sufficient and theoretical interest to warrant experimentation on this fundamental problem. By a systematic and carefully controlled study of the spatial perceptions of the congenitally blind and sighted individuals, it should be possible to ascertain the different variables of spatial experiences.

PROBLEM TO BE INVESTIGATED

The purpose of this exploratory study was to investigate the characteristics of space perception in congenitally blind and sighted individuals. The primary emphasis was aimed at disclosing one of the deficiencies of the congenitally blind; namely, the lack of a molar framework or a simultaneously appreciated extensional domain, which the sighted population possesses in the form of visual imagery. It is this visual imagery that enables the sighted to transpose objects from one plane to another when the demand arises.

Three different psychophysical tests were designed, taking into consideration the complex and multiple nature of spatial perceptions such as extensity, spatial order, figures, directions, positions, magnitudes, distances, and spatial relations. Since photic stimuli is the most important of the four sensory receptors used in the development of space

perception, a group of subjects who have never experienced such stimulation were used as experimental subjects.

This basic investigation was an attempt to establish the foundation for a psychological theory applicable to blind individuals, which would have important implications for the education, training and rehabilitation of such a group. In the past educational and training procedures have, for the most part, been adaptations of procedures used with sighted individuals. This is even true of present-day psychological tests. If a general theory can be constructed and substantiated by valid research, then educational and training methods can be designed specifically to develop adequate spatial perceptions.

STATEMENT OF HYPOTHESES

This research project was an attempt to overcome certain methodological problems within an empirically sound framework, and answer questions to which previous investigations have given either incomplete or inconsistent answers.

The following hypotheses were developed in order to test some of the implications arising from the previous discussion of the problem.

Hypothesis I: The blind and sighted differ significantly in their ability to manipulate a curved surface to a flat surface.

Hypothesis II: The blind and sighted differ significantly in their ability to orient themselves to objects in space.

Hypothesis III: The blind and sighted differ significantly in their ability to orient themselves in space.

DEFINITION OF TERMS

The integration and interpretation of stimuli by the brain of the organism is referred to as a "perception." The stimulus is defined as an event occurring outside the organism. To illustrate, when an individual "feels" an object, this is a psychological occurrence taking place in the brain; the mechanical contact of the hand with the object is the stimulus.

LIMITATIONS OF STUDY

The major limitation of the study was the inability to directly measure the use of visual imagery in the subjects. Since it was impossible to measure visual imagery directly, tasks were developed which, on a success or failure basis, would infer the presence or absence of this particular ability. An effort was made to establish experimental procedures in which the congenitally blind could be expected to succeed, but would fail if lacking in visual imagery. However, the experimental tasks were not completely effective because the congenitally blind subjects did partially succeed in accomplishing them.

A second limitation involved the small number of subjects and the limited statistical inferences that can be derived from such a sample of the blind population. As a sample becomes larger, it can be assumed to be more representative of the parent population. However, large numbers of congenitally blind subjects were not available for this study. The present group of subjects represented the screening of the entire student body of the Michigan State School for the Blind.

A third limitation was the lack of means to adequately establish the reliability and validity of the tasks used to measure space perceptions. The tasks were developed from tentative theories held by Dr. Bartley as a result of his prior experimentation in the area of the blind and other visual research.

A fourth limitation was the fact that the experimenter inadvertently allowed the sighted group to gain knowledge which gave them an advantage over the blind group. When the blind children were brought into the College of Education building, they gained no information concerning the height of the ceiling and tended to overestimate this distance because the acoustical ceiling did not reverberate in the same manner as the plastered walls. On the other hand, the sighted group entered the building in full use of their visual properties and saw that the hall ceilings were between eight and ten feet high. They knew it would be very unlikely for them to pass through a door and find a fifty foot ceiling as one of the blind children estimated. The sighted should have been blindfolded prior to entering the building.

ORGANIZATION OF THESIS

The thesis is organized according to the following plan: Chapter I outlines the general background and need for such a study. Chapter II presents a review of the prior research on the problem.

Chapter III is concerned with the methodology and procedures used in the study. The subjects, aparatus and statistical procedures are described. In addition, Chapter III outlines the operational hypotheses and defines the terms used in these hypotheses. Chapter IV presents the results of the experimentation and a discussion of the findings. Chapter V is a summary of the study with appropriate conclusions. Chapter VI deals with the implications of the study on educational and rehabilitation practices.

CHAPTER II

REVIEW OF LITERATURE

HISTORICAL BACKGROUND

The functioning of the blind in the use of their remaining senses has been the subject of speculation for many years. Much of the early thinking on the subject utilized a metaphysical approach to the problem. The question was raised whether vision or touch is the primary spatial modality. Is space a characteristic of tactual impressions, the spatiality being transferred by association to vision, or vice versa?

Berkeley (5:40), an advocate of the former position, felt there is only a world of "real" objects. This "real" world is accessible to touch and kinesthesis; our visual impressions are merly "signs" of the real world. The opposite view was hypothesized by Goldstein and Gelb (49:73) in 1920. As a result of intensive observations on brain-injured individuals, these authors attributed spatiality primarily to vision. Kant (2) "solved" the problem by stating space is composed of both visual and tactual impressions.

Revesz (21) is of the opinion that the question of the origin of spatiality is insoluble empirically, but the operations performed by the blind leave no alternative to the

assumption that the blind do not function in a space-free world. It would appear that questions of spatiality are answered in line with the philosophical orientation of the one who answers them.

The first systematic study dealing with the psychological patterns of blindness was accomplished by Theodor Heller in 1895, which he reported in Studien zur Blinden-Psychologie (16). Psychological research in the field of the blind has dealt primarily with problems of sensory experiences of the blind as compared with that of the sighted, with the ability to perceive obstacles, and with the measurement of intelligence. Samuel P. Hayes (14) has made an outstanding contribution to the latter field.

In 1933, Cutsforth's book, The Blind in School and Society (9), was the first major effort to deal with the personality problems of the blind. Since that time, the emotional, social, and educational implications of blindness have received increasing attention in the professional literature.

Gestalt Theories of Blindness

German psychologists have considered the phenomenon of unification the central problem of blindness. Steinberg (23:139) assumes, as a result of experimentation in which Gestalt psychological principles were applied, that there is a mental process of "expansion of tactual space."

Heller (16:68) is of the opinion that there is a contraction of tactual space in which large objects are reduced by a special mental manipulation until a simultaneous idea of the total object is achieved. He distinguishes two types of tactual pprception. The first is an enveloping use of the hand or hands in which small objects are enfolded and is referred to as "synthetic touch" since the form of the object is perceived as a whole, more or less simultaneously. The second type of tactual perception defined by Heller applies to large objects which extend beyond the limited scope of one or both hands. A sequential process of exploration is followed, and this method is called "analytic touch" because of the successive impressions necessary to achieve some type of unification or meaningful concept of the environment.

A third theory (18:224) hypothesizes the perseveration of earlier perceptions until, in some manner, they combine with the more recent ones in a spatial and temporary continuum resulting in a spatial Gestalt.

Tactile Experiences

Tactual perception results not only in spatial experiences, but also in a number of other touch sensations. The surface of the skin has specialized nerve endings which are the receptors for pressure, pain, warmth, and cold. Sensitive spots for these sensations are dispersed over various parts of the body in varying density. Experiments reported by Hayes (14:16) on the auditory, olfactory and tactual receptors of the blind have shown that these individuals have no better sensory discrimination than the sighted.

Brown and Stratton (39) investigated the spatial threshold of touch in groups of blind and sighted children. Their conclusions were that the spatial threshold of touch for the blind group was lower than for the sighted group. The degree of blindness affects the spatial threshold in that the totally blind have a lower threshold than the partially blind. The final conclusion stated that the longer the individual possessed sight, the higher his spatial threshold.

Gutsforth (42) made an analysis of the relationship between tactual and visual perception and found that under all experimental conditions, discrepancies occurred between the tactual perception and visual perception of the same size. In addition, the discrepancy between tactual and visual perceptions of the same form occurred in all individuals with the different forms and sizes of standards, and under all methods and positions employed in the investigation.

A review of the historical evolution of space perception as it pertained to the sighted was made in an effort to locate theoretical findings which would be useful in establishing hypotheses concerning the development of space perception in the congenitally blind (1, 6, 8, 17, 26, 31, 37, 46, 59, 68). The useable results of this endeavor were negligible.

CURRENT EMPIRICAL INVESTIGATIONS

A review of the experimental literature revealed few investigations on the development of space perception in congenitally blind individuals. The problem, until recently, has been regarded as not amenable to experimental study. However, the area of space perception in the blind has not been the only area to suffer from a lack of adequate research. Barker and associates (3), in their systematic review of research on the social behavior and personality of the blind, found little had been done, and much of what had been attempted foundered because of methodological inadequacies. These inadequacies are not inherent in research on problems of the blind, although many of them are not easy to remedy. The comparatively small number of blind children, with the resulting wide scatter in age, intelligence, socio-economic background, and geographic location, has retarded research on the blind. It has made research based on large or matched groups difficult and often impossible.

Worchel (70), who has conducted one of the few recent studies on space perception in the blind which employed modern scientific methodology, found that sighted subjects were superior to the blind in tactual form perception, in imaginal manipulation of space relations, and in space orientation. The blind subjects did as well as the sighted in the recognition of tactual form.

He used the techniques of graphic reproduction, verbal report, and recognition in testing for tactual perception of simple geometric forms. One of the experiments involved the imaginal construction of a total form from tactually perceived parts of the form. The role of age at blinding appeared to be highly correlated with the manipulation of space relations.

In 1954, Hunter (52) tested the tactual-kinesthetic perception of straightness in blind and sighted humans. The method required the blind and sighted subjects to tactually perceive the straightness of a "plus curved" edge. The blind subjects' judgments corresponded more closely to the objective straight and, both individually and as a group, their judgments were significantly finer and more consistent. The conclusion was that the blind person's tactual-kinesthetic perception is apparently more highly developed than that of sighted individuals.

Drever (43) using Worchel's apparatus, continued the investigation of space perception in the blind during 1955. He found that his "late blind" group achieved better than the congenitally blind group. There seems to be a generalized defect of space perception associated with early blindness. His conclusions were that space perception for both the blind and sighted seems to require a long apprenticeship, either in the visual or in the taetüal-kinesthetic modalities, and once this apprenticeship has been served, different amounts of practice have no appreciable effect.

Visual Imagery

Studies on visual imagery of the blind tend to support the above findings conerning the age of onset of blindness. Sylvester (67), in 1913, concluded that those blind persons who have had visual experience are materially assisted in the interpretation of their tactual impressions over those who have not had such experiences. Toth (25) stated in 1930, that individuals who lose their sight before five years of age do not retain any useful visual imagery. In a more recent study by Schlaegel (64), it was found that the imagery of blind individuals was affected significantly by two factors: (1) present visual acuity and, (2) age at onset of blindness. He concluded that if onset of blindness was prior to six years of age, visual imagery tended to disappear.

There has been much speculation in the past as to whether visual imagery was important or necessary in tactual space perception. Costa (41) reported conclusions which tend

to support the hypothesis that visual imagery was involved. In a later study, Bartley (33) documented the fact that visual imagery does assume an important role during tactual and kinesthetic space perception. Another study accomplished by Bartley and associates (32) revealed that, for the sighted individual, the distance of the stimulus object had a significant effect on perception.

Gibson and Walk (48) investigated height perception, a particular phase of space perception, and found that infants could discriminate to a significant degree, dangerous heights by the time they were able to locomote. The last statement tends to challenge Drever's finding that the development of space perception is a relatively long, drawn-out process of five or six years.

Sensory Deprivation

A review of the literature on sensory deprivation was conducted to ascertain what information, if any, might be applicable to the present study. The general consensus of opinion was that the nervous system of the human organism requires constant extrinsic sensory input to function normally and efficiently (29). Lily (54) investigated sensory deprivation by reducing the absolute intensity of physical stimuli received by his human subjects. This was accomplished by suspending the subject, wearing only a blacked head mask for breathing, in a tank of water maintained at 34.5° centigrade. With this technique, visual, auditory and tactual stimuli were reduced to a minimum. The behavior resulting from this experience was characteristic of psychotic individuals.

Solomon and associates (66) reviewed the experimental data on perceptual and sensory deprivation and reached the conclusion that the stability of an individual's mental state is dependent on adequate perceptual contact with his environment. Observations of sensory deprivation have shown two common features: (1) an intense desire for extrinsic sensory stimuli and, (2) bodily motion.

If the last statement can be accepted as true, then such behavior in the blind as habitual "rocking" is fairly easy to explain. The individual is using body movement as a means of receiving external stimuli in order to properly maintain his emotional equilibrium. The sighted individual is not forced to utilize body motion to the extent required by the blind person because of almost continual photic stimuli.

Animal Experimentation

There have been several recent studies of sensory deprivation using animals. These have been an attempt to verify Hebb's theory. Hebb, a contempory theorist, regards early perceptual learning as crucial for later perceptual and intellectual skills. Riesen and others (61,62,63) have raised chimpanzees and cats in darkness, and have found them retarded in learning visual discriminations. Hebb's interpretation is that the animal, on first vision, must undergo a slow process of learning to see. However, there is another possibility with respect to Riesen's animals. Lack of normal visual stimulation may adversely effect the structure of the receptors and visual pathways.

Ophthalmoscopic examination has revealed abnormalities of the retina and optic disk in some of Riesen's chimpanzees, and such effects are irreversible if the animal is deprived of light for sixteen months, even if deprivation begins after eight months of normal stimulation. Brattgard (38) has demonstrated that the neuroretinal ganglion cells of rabbits atrophy after light deprivation during early post-natal life.

Human Optic Structure

Two recent reports by Guillaumat and Girard (50), and Bouzas (36) indicated that human congenital cataract cases have rather poor post-operative visual ability, but the deficit may be due to structural malformations, either accompanying or resulting from the lenticular opacity.

It is also possible, even in the absence of ophthalmoscopically-detectible abnormality of the retina, for visual accuity in humans to suffer as a result of "disuse." In cases of unilateral stabismus, especially when developed in childhood, the squinted eye appears to be functionally suppressed. Treatment consists in occluding the good eye and forcing the deviating eye to perform (69).

Such treatment does not appear to be effective if instituted after age eight and if inhibition has been present from birth (10), although some success with adult amblyopes has recently been reported (53). Clark (40) suggests that an amblyopia which does not improve might be due to an atrophy of disuse among the cells of the lateral geniculate body which depend both on retinal and cortical activity for their continued vitality.

Summary of Review of Literature

Assumptions as to the primacy of the various sensory spaces seem untestible. Nevertheless, a denial of spatiality to the blind appears untenable on a pragmatic basis.

It was noted that some investigations of the "blind" included subjects with considerable vision, but it was usually impossible to distinguish the information on them in the reports. This lack of distinction between the totally and congenitally blind and those who are only partially or adventiously blind, is responsible for the ambiguity in the results of many studies and for contradictions between the results of some of them. For this reason, the present study included only totally congenitally blind individuals in the experimental group.

Neither the reports on animals raised in the darkness, nor those of humans gaining their sight after a period of disuse, has demonstrated the complete lack of spatial organization. Under these circumstances, an investigation of the manner in which a blind person performs on various nonvisual tasks would seem to have merit.

If the organization of impressions in the blind person's residual sensory spheres is an different from that of the sighted as is sometimes claimed, then one could logically predict measurable differences in the nonvisual performances of blind and sighted subjects.

CHAPTER III

METHODOLOGY AND PROCEDURE

A series of spatial tasks was designed for this investigation since the congenitally blind and sighted were expected to differ significantly in what they are able to accomplish in so-called novel situations. If a task is required of both a sighted person and a congenitally blind individual, the latter may or may not be able to perform it, depending upon whether the task is one in which he has had quite similar kinesthetic experience.

Since the task is a motor one, it was possible to devise spatial experiences which were quite novel for the blind. However, if the same task is required of a sighted person, he need not necessarily have had any motor experience quite like it, and yet still be successful. The sighted person has another totally different faculty available to him. He possesses visual imagery which has a number of essentially different properties than those involved in tactual-kinesthetic imagery.

The general course of the research was one of expanding on the above principle to ascertain what spatial tasks were relevant and useable in the study and testing the two experimental groups.

DESIGN OF THE STUDY

Upon an analysis of the basic problem, it was decided that an experimental design would be the most fruitful approach, and to utilize sampling statistics in the analysis of the data. The method of average error was the psychophysical method selected, since it is one of the oldest and most respected designs in the behavioral sciences (12).

The true value of anything can never be measured, but a large number of measurements can be made of a thing. These measurements will differ from one another by small amounts, and by finding an average of these measurements, a value can be obtained that is representative of them all. The average, however, is not necessarily the true value that is being sought; it is merely the best value obtainable from all the measurements, and only approximates the true value.

Every measurement that is made is, in a sense, an error, for it deviates from the true value that is being sought, and it even deviates from the average. Only in very rare cases does any one measurement actually coincide with the average.

The statistical procedures connected with the method of average error consist in computing (1) the mean, a measure of central tendency, (2) the variance, a measure of dispersion of the measurements around the average, and (3) testing these mean differences to ascertain if the are significantly different.

The five per cent level of confidence was chosen as a compromise between Type I and II errors.

Muller has criticized the method of average error on the score of muscular participation. In other words, average measurements are partially dependent upon the uncertainty of the hand. It is possible that the subject in this study was occasionally unable to place his fingers or the experimental object on the exact spot he desired. However, it is felt that such error did not greatly influence the results of the study.

Instrument Development

The instruments used in this study were developed jointly by the investigator and Dr. S. Howard Bartley. An attempt was made to start with tentative theories concerning the behavior patterns of the blind and move in a concise manner to methods which could logically be assumed to test these theories.

The design of these instruments proceeded from a theoretical analysis of space perception and was formulated in terms of inferred psychological functions for which no objective verification was available. To determine the validity of such instruments was extremely difficult, particularly in this area which has had little research expended upon instrumentation. Face and content validity appeared to be the only types available.

SUBJECTS

The blind children included in this study were drawn from the population of the Michigan School for the Blind located in Lansing, Michigan.

The criteria for selecting subjects to participate in the research were as follows:

1. A chronological age of twelve years or higher;
2. Ophthamologically diagnosed as possessing no light perception;
3. Onset of blindness at birth;
4. Absence of evidence of brain damage;
5. Normal intelligence as measured on an individually administered intelligence test.

From the total school enrollment of 250 students, 22 were screened as being appropriate. Intensive scrutiny of medical, social and psychological records; discussions with administrative personnel; and rigid application of the above criteria reduced to twelve the number of acceptable subjects.

Criterion 1 was adopted because prior research has shown that younger children are sometimes unable to adequately comprehend experimental instructions or to maintain sufficient interest and motivation in the tasks.

Criterion 2 represented an effort to be as specific as possible concerning the characteristics of the blind subjects included in the study. The lack of reliability of such classifications as "travel vision", and"5/200 Snellen" is such that inclusion of cases described in these terms would have lead to uninterpretable results.

Criterion 3 was considered extremely important for theoretical reasons. A number of investigations have found systematic differences between congenitally and adventitiously blind, both human and animal, on a variety of tasks (25,39, 43,62,64,70). In cases where the age of onset was not available from the records or school personnel, the student was excluded from the study.

Criterion 4 was included because brain damage can exert an effect in the area of spatial perceptions. Bender and Teuher (34) found, in a study of brain injured patients, abnormal spatial organizations and perceptions. On this basis, cases of brain tumor, inherited syphilis, meningitis, hematoma, cerebral palsy, and postnatal head truma were excluded.

Criterion 5 was originally defined as ranging from 90 to 110 on an individually administered intelligence test. However, the number of children available in this category and still fulfilling the other criteria was so small that the range was expanded to include subjects with intelligence quotients from 90 to 118.

The IQ scores were the result of using either the Performanse Section of the _Wechsler Intelligence Scale for Children_ or the _Interim Hayes-Binet Intelligence Test for the_

Blind. The IHB is a combination, into a single, individually administered scale, of items from the L and M forms of the 1937 Stanford-Binet Intelligence Test. Hayes, who devised the scale, has accumulated evidence of its reliability and validity. In published investigations, Hayes has reported fairly high correlations between the IHB and the WISC. He has found fairly symmetrical distributions of IHB IQs with central tendencies around 100 for blind population.

Through the cooperation of the East Lansing, Michigan, public schools, records and students were made available for this study. Each of the twelve blind subjects was matched with a sighted individual for age, sex and intelligence. Table I lists the sex, IQ and birthdate for both groups. A blind subject was considered matched if the control subject's age was not more than a plus or minus three months, and his intelligence quotient fell within a plus or minus five points.

The IQ scores for the sighted subjects were derived from a group intelligence test, the California Test of Mental Maturity. These paper-and-pencil test scores are not an absolute equivalent to the individually administered intelligence test scores. However, since the two groups being dealt with were of normal intelligence, the group test scores were considered to be a valid enough measure.

Drever (43) stated in his conclusions, that intelligence did not appear to exert any significant effect within the IQ

TABLE I

SEX, IQ AND BIRTHDATE OF SUBJECTS

Subject	Sex	IQ	Birthdate
1 Blind	F	91	4-27-42
1a Sighted	F	94	3- 3-42
2 Blind	F	108	8-11-44
2a Sighted	F	107	10- 3-44
3 Blind	M	100	1-24-42
3a Sighted	M	102	3- 4-42
4 Blind	M	112	3-10-47
4a Sighted	M	116	3-24-47
5 Blind	F	111	10- 4-47
5a Sighted	F	109	7-27-47
6 Blind	M	114	5-25-42
6a Sighted	M	114	2-27-42
7 Blind	M	118	7-10-43
7a Sighted	M	113	7- 3-43
8 Blind	M	111	8-18-42
8a Sighted	M	113	10-29-42
9 Blind	M	113	8-17-43
9a Sighted	M	118	11- 2-43
10 Blind	M	114	1- 2-48
10a Sighted	M	115	3-10-48
11 Blind	M	103	9-12-46
11a Sighted	M	99	8- 4-46
12 Blind	M	94	1- 4-47
12a Sighted	M	99	2-26-47

range he studied. However, Fils (45) found correlations between space perception and non-language intelligence which were sufficiently high to suggest the latter includes space relations ability as a significant item. Since there seemed to be a difference of opinion, it was considered appropriate to control the variable of intelligence to the extent described.

The age range of the subjects selected was twelve years, one month to eighteen years, two months. The mean age for both groups was fifteen years, six months. The mean IQ of the blind group was 107, with a range of 91 to 118. For the sighted, the mean IQ was 108, with a range of 94 to 118. All of the subjects in both groups were Caucasian. A breakdown of the sample by sex showed nine boys and three girls in both groups.

From prior research accomplished by the investigator and Dr. John E. Jordan, the causes of blindness were known for the experimental subjects and are shown in Table II.

TABLE II

CAUSES OF BLINDNESS

Cause	Number	Cause	Number
Retinal blastoma	4	Congenital abnormality	1
Retrolental fibroplasia	2	Congenital glaucoma	1
Congenital cataracts	1	Phthisis bulbi	1
Congenital myopia	1	Congenital absence of eyeballs	1

EXPERIMENT I - ANGULATION MANIPULATION

Purpose

The purpose of this particular experiment was to ascertain if the congenitally blind group would be able to manipulate a curved surface into a flat surface as accurately as the sighted group.

Apparatus

The angulation manipulation equipment consisted of three, different sized cylinders, 21.5 centimeters, 33 centimeters, and 48.5 centimeters in circumference, and all being 17.8 centimeters in height. A 90 centimeter measuring stick was nailed to a 2½ inch by 3/4 inch board. This board was calibrated so that it could be read in centimeters beginning at either end.

Procedure

The subjects were individually tested, at a single sitting lasting from twenty to thirty minutes, depending upon the speed of performance.

The testing room was a small cubicle in the Human Research Laboratory located in the College of Education building. This room contained a table and two chairs. All subjects were blindfolded prior to entering the room. A standard set of directions for the experiment is listed below.

Instructions for Angulation Manipulation Experiment

1. Place subject at table, place meter stick so that doweling is facing toward subject.
2. Referring to "Random Presentation of Cylinders Table" developed for this experiment, place the correct size cylinder in the ceter and two inches away from the meter stick on the experimenter's side of the stick.
3. Guide the subject's hands so that they encompass the circumference of the cylinder. As you do this, say, "I want you to feel the distance around this cylinder. Do not pick the cylinder up from the table." Allow five seconds for orientation.
4. Place the subject's hands on the doweling according to the predetermined order and say to him, "Move your (right) (left) hand (in) (out) until the distance between your hands is the same as the distance around the cylinder you just felt." Record answer.
5. Allow each subject two, unrecorded trials.
6. Upon completion of all observations, ask him the methods he used in the task.

The order in which the small, medium, and large cylinders were presented the subject was determined by using a table of random numbers. The sighted control received the same order of cylinders as did the blind person to whom he was matched. A sample of the individual record sheet for this experiment was included (Appendix A).

EXPERIMENT II - OBJECT ORIENTATION

Purpose

The purpose of this portion of the study was an attempt to ascertain how successfully the two groups under investigation would be able to manipulate objects from one plane to another when all of the variables i.e., objects, plate and the individual, had been reoriented.

Apparatus

The equipment for the object orientation experiment consisted of a fifteen inch square metal plate fabricated of twelve gauge steel with a one-half inch metal rod welded to the bottom surface. This metal rod was flush with one side of the plate, but extended one-half inch beyond the plate on the opposite side. Upon the top surface of this metal plate were affixed eight three-dimensional objects designed by the experimenter with the assistance of Dr. S. Howard Bartley. (Figure 1).

These objects varied from relatively simple to rather complex forms. The composition of the objects was either wood or plastic, and they were attached from the underneath side with screws.

An attempt was made to design objects which did not resemble anything and would be unfamiliar to both groups of subjects. Also, the objects were placed on the plate in a non-vertical and non-horizontal position, and were lacking in any systematic relationship to each other.

The remainder of the apparatus was composed of an identical fifteen inch square metal plate with the same arrangement of the metal rod on the underneath side. The only difference in this plate was a clamp and thumb screw welded to the side opposite the protruding metal button. This clamp was necessary to secure the metal plate to a one-half inch pipe nine feet long.

Photograph of Master Plate

Figure 1.

When the pipe was held in a vertical position, the metal plate could be moved up and down using the clamp and thumb screw to hold it in the desired position. A rubber crutch tip on the bottom end of the pipe assured that it did not slip on the floor when being used. With the pipe held in a vertical position, the metal plate was elevated five degrees above the horizontal position and rotated five degrees clockwise with the metal rod being the axis of rotation. Both metal plates had black plastic tape affixed to the edges to prevent injuries to the subjects.

Procedure

Both groups of subjects were individually tested at a single sitting lasting from twenty to thirty minutes. The testing room was in the Human Research Laboratory located in the College of Education building, and contained two six feet long tables and two chairs. All subjects were blindfolded prior to entering the room. A standard set of directions was developed for the task and is outlined below.

Instructions for Object Orientation Test

1. Seat the subject in a chair before the table upon which is placed the standard experimental plate one inch from the front edge, and in the middle of the table.
2. Place the subject's hands on the plate and say, "Before you is a square piece of metal. You can tell the bottom from the top because there is a metal rod on the bottom." Lift the plate and rub subject's hand across rod. "On the side of the square away from you, the end of the metal rod extends beyond the edge of the metal piece. Remember this because you

must use the information later. On this square piece of metal, there are eight objects. I want you to get to know the position of these objects on the piece of metal, the relationship of the objects to each other, and to the end of the metal rod sticking out. Feel each object very carefully, paying strict attention to such details as form, right and left, top and bottom, the direction each one lays on the metal square, size and shape. Remember the position of the objects on the metal square and their relationship to each other because in a few minutes, you will be asked to put another set of these objects on another metal square which may be turned to a different position from this one. You will have three minutes to work on this task. Are there any questions as to the instructions?"

3. After the orientation periòd is over, assist the subject to the other table and place him in a horizontal position. Place the pipe containing the second metal plate at the edge of the table even with the subject's waist. Lower the metal plate to within one inch of the subject's chest and secure thumb screw.
4. Place subject's hands on the metal plate and say, "Here is an identical piece of metal to the first one. Remember that on the first metal square the rod extended beyond the edge of the piece of metal on the side away from you. Find the side on this piece of metal with the rod extending from it so you will know how the position of this piece of metal differs from the one at the desk. After you have done this, I willhand you the objects, one at a time, and you put them in the same place as they were in relation to the end of the metal rod that sticks out on the metal square at the desk. Are there any questions as to what you are to do?"
5. Repeat the experiment four times. Each time rotate the master plate 90° to the right. Say to the subject, "I have turned the square piece of metal at the table 90° to the right. Check this by feeling the end of the metal rod. You will have three minutes to explore the new position of the eight objects."
6. Trace around objects and affix a blank page to the metal plate.
7. Alternate from one side of the subject to the other, never having the plate on the pipe in the same position as the one at the table. After placing the subject in the horizontal position say, "The position of this piece of metal may have been changed since the last time you worked on it, so use the end of the rod that sticks out and see how this piece is now positioned in relationship to the one at the table. When you

have done this, I will give you the objects and you place them on the metal square in their correct positions."

8. Ask each subject for an introspective report.

EXPERIMENT III - SPACE ORIENTATION

Purpose

It was the purpose of this experiment to learn the methods used and accuracy of the congenitally blind and sighted in orienting themselves in a spatial area such as a room.

Apparatus

The equipment for the experiment consisted of three rooms located in the Human Research Laboratory, College of Education building which were emptied of all furniture and equipment. The dimensions of the rooms are listed in Table III.

TABLE III

DIMENSIONS OF EXPERIMENTAL ROOMS
(In Feet)

	Height	Length	Width
Large Room	8.5	31.17	30.25
Medium Room	8.5	30.33	10.75
Small Room	8.5	11.50	6.50

Each of the rooms contained overhead microphones, and outlets for the earphones worn by each subject. The earphones were covered with thick, foam rubber pads to eliminate as much auditory stimuli as possible. The remainder of the equipment consisted of a pair of earphones for the use of the experimenter, a hand microphone and a stop watch.

Procedure

The order of presentation of rooms was determined by using a table of random numbers. Each subject was tested individually, with the three rooms requiring twenty to thirty minutes depending upon the speed with thich the subject performed the requested behavior. The sighted person received the same order of room presentation as the blind person to whom he was matched.

The subject was blindfolded in a reception room removed from the experimental area; then he was led to the door of the appropriate room and a set of directions read to him to insure an identical procedure was used with each subject.

Instructions For Space Orientation

1. Tell the subject, "I am going to place you in a room by yourself. However, I will be able to see you through a window and we will be able to hear and speak to each other. Be sure to talk distinctly. Now I'm going to place some earphones on you and place you in the room. Just stand there until you hear my voice in the earphones and them I will give you further instructions. Do you have any question as to what you are to do?"
2. Place earphones on subject, position him inside the door of the experimental room, and connect earphones.
3. Proceed to the control room, put on own earphones, and ask if the subject can hear you.
4. Ask the subject, "How big would you say the room you are now in is - small, medium, or large? Use as a guide:

a bathroom would be considered a small room, an average sized kitchen would be considered a medium room, and any room larger, would be considered large." Record answer. "What were the clues that you used to arrive at this answer?" Record verbatim answer. "Now guess the length, height, and width of the room you are now in." Record answers. "Now explore this room in any fashion you desire and tell me when you are done." Record time of exploration in seconds and mark on room diagram how he proceeds in his exploration. When he has finished his exploration, say, "How big would you say this room is - small, medium, or large?" Record answer. "Estimate the length, height, and width again." Record answer.

5. Ask each subject for an introspective report.

The procedure herein described was followed for each of the three rooms.

OPERATIONAL HYPOTHESES

As it has been pointed out in the review of literature, prior experimentation accomplished on the blind in the area of space perception has many times included subjects possessing varying degrees of sight. This fact has tended to produce conflicting results, so only congenitally blind individuals were included in this investigation.

The general hypothesis was that the characteristics of space perception in the congenitally blind differs significantly from that of the sighted. This hypothesis must now be stated in operational terms.

Hypothesis I: The congenitally blind group of subjects is less accurate than the blindfolded, sighted group in estimating the circumference of three different sized cylinders.

Hypothesis II: The congenitally blind group of subjects is less accurate than the blindfolded, sighted group in the correct orientation of geometric forms on a metal plate while the subjects are in a horizontal position.

Hypothesis III: The congenitally blind group of subjects is less accurate than the blindfolded, sighted group in estimating, both concretely and subjectively, the size of three empty rooms.

DEFINITION OF TERMS USED IN HYPOTHESES

In order to insure complete understanding of the operational hypotheses and to delimit their meaning, the following terms were defined.

The term "congenitally blind" was defined as an individual who was born lacking light percpetion or attained this status within thirty days of birth. "Less accurate" was defined as meaning the arithmetic mean of the congenitally blind group would be lower than the sighted group, and this difference was not likely to happen by chence more often then five times in a hundred.

In Hypothesis I, "estimating" consisted of the subject indicating with his fingers the circumference of three cylinders on a board ninety centimeters long.

In Hypothesis II, "correct orientation" was defined as the placement of eight objects on a metal plate by the subject in the same spot, right side up and in proper relation to the orientation button.

In Hypothesis III, "size" of the room was estimated, both in feet and subjective terms, "large, medium, and small."

PROCEDURES FOR ANALYSIS OF THE DATA

The statistical universe for this study was arbitrarily defined as the total enrollment of the Michigan School for the Blind on March 1, 1960. As in most investigations, it was impossible to obtain the parameters for the defined universe.

A selected, nonrandom sample was chosen using the criteria outlined in the section of this paper dealing with the subjects. Under these circumstances, the process of computing the mean and standard error of the difference had to be modified. A method which can be used is to calculate the actual error differences individually and find their mean and standard error of the mean of the differences. Then the ratio of this mean to its standard error can be accepted as a valid critical ratio (12).

One of the problems encountered in the analysis of this study was the fact the observations were not independent of each other. The different trials accomplished by one individual

tended to be somewhat homogeneous, having been derived from a single source. The above-mentioned statistical method was used, with one modification, in order to circumvent the problem of observation independence. Instead of testing the significance of a difference between the two standard errors, the ratio of the two variances that correspond to them was tested.

Since there was a possibility for extreme positive and negative deviations, the use of a two-tailed test of significance was deemed necessary.

The investigator felt it was wise to adopt a standard of significance in advance of the experiment. This established the rule for decision-making and made it easier to resist the temptation to modify the acceptable standards after the results were known.

The choice of a standard of significance depends very much on the risk taken in being wrong when making a statistical inference. Two statistical errors are possible in this connection: Type I: rejecting the null hypothesis when it is true, and Type II: accepting the null hypothesis when it is false. As the chance for one type of error decreases, the other increases in direct proportion. The crux of the dilemma was how to weigh the two kinds of error, since some kind of balance must be reached. Consideration of external factors made it impossible to reach a decision on purely statistical grounds.

For the purposes of this research, the null hypothesis was rejected at the five per cent level of confidence.

Due to the small N, the small-sample statistical test of t was utilized. t is defined as the ratio of a deviation from the mean or other parameter, in a distribution of sample statistics, to the standard error of that distribution (12).

The difference between z and t is one of degree of generality. Statistic z is normally distributed, is so interpreted, and applies when samples are large. Statistic t, on the other hand, applies regardless of the size of the sample. Student's t distribution becomes increasingly leptokurtic as the number of degrees of freedom decreases. As the df becomes very large, the distribution of t approaches normal distribution.

For very small samples, the t test of differences is not satisfactory, even with the availability of Student's distribution for t. In the present study it was deemed necessary to determine if it was reasonable to assume that the two groups of subjects had the same variance. Hartley (23) has devised a method called the Fmax test which can be used in this study and is computed by dividing the larger variance by the smaller and consulting a special probability table. In cases where the tested variances were significantly different, a modified formula for computing t was used.

CHAPTER IV

RESULTS AND DISCUSSION

The basic results of this study are presented in a series of tables. Each experiment is introduced and explained separately. All of the data are based on the two matched groups of twelve individuals each.

EXPERIMENT I - ANGULATION MANIPULATION

Results

Every estimate made by a subject was subtracted from the true circumference of the particular cylinder and the mean of the error and variance computed. Since there were two trials for each estimate, it was necessary to ascertain if there existed any significant differences between the trials within each experimental group of subjects.

The t tests and Fmax tests presented in Table IV revealed no significant differences, either in error means or variances. Therefore, it was found to be acceptable to combine the two trials for further analysis.

Table V shows the actual error means with variances for the two experimental groups. It revealed that on all three cylinders, the congenitally blind group underestimated the

TABLE IV

t TESTS OF ACTUAL ERROR MEANS AND VARIANCES BETWEEN FIRST AND SECOND TRIALS FOR BLIND AND SIGHTED EXPERIMENT I - ANGULATION MANIPULATION

	Blind			Sighted		
	t	df	Fmax	t	df	Fmax
Small Cylinder	.33		1.25	.18		1.15
Meduim Cylinder	.52		1.45	.03		2.22
Large Cylinder	.24		1.09	.10		1.02

*Significant at the 5% level of confidence

TABLE V

ACTUAL ERROR MEANS WITH VARIANCES OF BLIND AND SIGHTED EXPERIMENT I

	Blind		Sighted	
	$\bar{x}$	s^2	$\bar{x}$	s^2
Small Cylinder	-65.25	121.18	27.42	2,133.86
Medium Cylinder	-101.33	2,812.52	-12.37	360.53
Large Cylinder	-188.46	3,609.75	-33.12	1,025.01

circumference. There was a consistent trend in the variance of the blind viz., the larger the cylinder, the greater the variance.

The actual error means for the sighted group revealed they over-estimated the circumference of the smallest cylinder, but underestimated the circumference of the medium and large cylinders. However, the underestimation of the sighted group was less than that of the blind. The variances of the sighted group did not show the consistent, one-way trend as in the blind.

In order to compare the two groups in another manner and to compare the error means of one sized cylinder directly with another within the same group of subjects, each actual error figure was transposed into a percentage error and means computed.

Table VI gives percentage error means, by direction, with appropriate variances for the two groups. The blind underestimated approximately the same percentage on the small and medium cylinders, but their error increased ten per cent on the large cylinder. The sighted over-estimated the small cylinder and underestimated the other two, but were a great deal closer to the actual circumference than the blind. As a group, the blind were more consistent in their variance estimates than the sighted.

Moving a step further, Table VII shows what happened when only magnitude of error was considered and direction

TABLE VI

PERCENTAGE ERROR MEANS BY DIRECTION WITH VARIANCES FOR THE BLIND AND SIGHTED ANGULATION EXPERIMENT

	Blind		Sighted	
	$\bar{x}$	s^2	$\bar{x}$	s^2
Small Cylinder	-37.94%	409.63	15.94	721.19
Medium Cylinder	-38.38%	403.56	- 4.69%	517.28
Large Cylinder	-48.57%	239.77	- 8.54%	680.96

TABLE VII

PERCENTAGE ERROR MEANS DISREGARDING DIRECTION WITH VARIANCES FOR THE BLIND AND SIGHTED ANGULATION MANIPULATION

	Blind		Sighted	
	$\bar{x}$	s^2	$\bar{x}$	s^2
Small Cylinder	38.42%	369.23	20.84%	524.85
Medium Cylinder	38.38%	403.56	18.32%	174.97
Large Cylinder	48.57%	239.77	19.30%	354.16

disregarded. The error means of the blind did not change appreciably, but those of the sighted group increased. The variance of the blind remained the same, but the sighted decreased on all three cylinders.

To ascertain if the percentage mean error differences observed between cylinders within groups was due to something other than chance, t tests were computed against zero. Table VIII lists the results. In the blind group, the difference between the per cent of error on the small and medium cylinders was not significantly different from zero. The per cent of error on the small versus large cylinder and the medium versus large cylinder was significantly different from zero at the five per cent level of confidence.

In the sighted group, the percent of error for the small versus large and small versus medium cylinder was significantly different from zero at the one per cent level of confidence.

All of the t tests of significance for both groups were significantly different from zero when direction of error was not considered.

Table IX shows t tests of error means between the blind and sighted. All of the tests were significant at least at the five per cent level of confidence, with the exception of the small cylinder in which direction of error was not considered.

TABLE VIII

t TESTS OF PERCENTAGE ERROR MEAN DIFFERENCES
BETWEEN BLIND AND SIGHTED GROUPS
ANGULATION MANIPULATION

	Blind		Sighted	
	t	df	t	df
By Direction (error)				
Small vs Large	2.40*	11	4.93**	11
Small vs Medium	1.96		7.19**	11
Medium vs Large	2.61*	11	1.02	
By Magnitude (error)				
Small vs Large	2.73*	11	3.90**	11
Small vs Medium	6.17**	11	4.86**	11
Medium vs Large	2.89*	11	5.08**	11

* Significant at the 5% level of confidence
** Significant at the 1% level of confidence

TABLE IX

t TESTS OF ERROR MEANS BETWEEN
BLIND AND SIGHTED GROUPS
EXPERIMENT I

	Actual Error			By Direction			By Magnitude		
	t	df	Fmax	t	df	Fmax	t	df	Fmax
Small cyl	6.76**	12	17.61*	5.55**	22	1.76	2.04		1.42
Medium Cyl	5.47**	14	7.80*	3.85**	22	1.28	2.89**	22	2.31
Large Cyl	7.91**	18	3.52*	4.57**	22	2.84	4.16**	22	1.48

* Significant at the 5%level of confidence
** Significant at the 1%level of confidence

Discussion

Since there was no significant difference in the results of performance between the first and second trials, it was assumed that no practice effect or learning had taken place. In the design and development of this particular experimental task, learning was one of the variables an attempt was made to control.

The results appeared to substantiate the hypothesis that the congenitally blind are not as efficient in manipulating a curved surface into a flat surface. It should be pointed out, however, that an attempt was being made to force the subject to use visual imagery if he possessed such an attribute.

From a review of the introspective reports, the blind were not being forced to use visual imagery, but were utilizing other methods in an effort to meet the demands placed upon them by the experimental task. Many of the blind subjects stated they used their hands as some type of measuring device. Another method for determining dimensions reported by the blind was the use of time. From the observations of the experimenter, he was of the opinion that the "time method" was less successful then the use of the hands as a measure.

The fact that the blind were not forced to use visual imagery does not negate the usefulness of certain information which was gleaned from the experiment and is applicable to the education and training of this particular group.

It was evident that the blind habitually underestimated the types of dimensions used in this experiment. It is possible that since their total environment is more restricted than that of the sighted, the blind tend to be more restrictive in their estimates of dimensions.

The results of this experiment also highlighted the fact that the less total, encompassing tactual stimuli the blind group received, the more prone they were to make error. As long as the blind could encompass the entire cylinder within the hands viz, the small and medium cylinders, the percentage of error was approximately the same, but when the large cylinder was presented, the percentage of error increased. Practically all of the blind subjects remarked, many of them spontaneously, that the largest cylinder was the most difficult for them to manipulate. This kind of behavior was not observed in the sighted group.

Teachers and rehabilitation workers dealing with the congenitally blind should be aware that a certain dimension or distance for the sighted probably does not hold the same meaning, in operational terms, for the blind. The more acute the problem of accuracy in dimensions, the more difficult it may be for the blind to succeed. An example might be the measuring of dimensions found in a machine shop or manufacturing plant.

EXPERIMENT II - OBJECT ORIENTATION

Results

To insure complete understanding of the results, the procedures which were followed for scoring this portion of the study were included.

A master scoring sheet was constructed by placing a piece of clear plastic on the "standard" metal plate, installing the objects and cutting around each one with a sharp knife and then removing the objects. This master was then placed on each paper showing the tracings of the placement of each object by the subject. Using a red pencil, the correct placement was shown. A point was arbitrarily selected on each object which was used as a point for measuring error. By the use of a T-square and protractor, it was possible to measure the amount of error existing in the placement of each object of each trial by each subject.

Four different dimensions were checked for error: (1) vertical (X), (2) horizontal (Y), (3) angulation (XY), and (4) top and bottom (XZ). A copy of the scoring sheet used in this experiment has been included (Appendix A). Each type of error is discussed separately.

Vertical and Horizontal Error. The first analysis consisted in determining if any significant differences existed between vertical and horizontal error by objects and by trial within the blind groups. No significant differences were found to exist (Appendix B). The computations derived from the t tests of the blind were used as a basis to check for significant differences between vertical and horizontal error within the sighted group. None were observed in this group.

Vertical and horizontal error for all trials within each group of subjects was combined. Following this, tests of significance were computed for the total error of Trials I and II, by object, within each experimental group, against Trials III and IV. No significant differences within either experimental group were forthcoming (Appendix B).

Finally, t tests of significance of error means between the blind and sighted were computed by object. Table X shows that five of the eight objects had significant differences in error between the blind and sighted groups. In other words, the blind made significantly more vertical and horizontal error than the sighted.

Angulation Error. Tests of significance of error means by trial and object were computed between the blind and sighted on angulation error (Appendix B). Four of the thirty-two t tests were found to be significant at the five per cent level of confidence. To determine if the errors shown on angulation could be attributed to chance, a selected number of the error means of objects from Trials I and IV for both the blind and sighted were tested against zero. (Appendix B). These computations indicated that none of the selected error means were the result of chance.

TABLE X

t TESTS OF ERROR MEANS BY OBJECT BETWEEN BLIND AND SIGHTED GROUP ON ANGULATION EXPERIMENT II

Object No.	t	df	Fmax
1	3.14**	22	3.06
2	2.24*	17	4.10*
3	2.37*	22	2.27
4	1.44		2.31
5	1.50		1.08
6	3.01**	17	3.75*
7	2.35*	22	2.53
8	1.96		1.96

* Significant at the 5% level of confidence
** Significant at the 1% level of confidence

<u>Top and Bottom Orientation</u>. There was a possibility for each group to make 384 errors in top and bottom orientation. The blind group was responsible for 116 incorrect orientations or thirty per cent error. The sighted made sixty-eight errors or eighteen per cent error.

Combined Results. In order to gain a more complete perspective of the results of this experiment, "total error by trial within each group" and the "total error for the groups" combined was computed and translated into percentages.

Table XI gives the percentages of error made within each group by trial. The total error made in the four trials by each group was indicated by the "100%" figure at the bottom of each column. By comparing the error percentages from Trial I to IV for each group, it can be seen that in all types of error, the sighted tended to improve their efficienty as they progressed from trial to trial. The blind revealed a tendency to maintain status quo in their error patterns. They not only did not seem to profit from the repeated exposures to the experimental stimuli, but in some cases, made a greater percentage of errors on the fourth trial than on the first trial.

Table XII outlines the percentage of the total error contributed by each of the experimental groups for each trial. In all types of error, the percentage contributed by the blind increased as the trials progressed, again indicating that the blind were seemingly not benefiting from extrinsic stimuli to the same extent as the sighted group.

Upon noting the variance between percentage errors for different trials, it seemed essential to investigate if these differences were actually significant or were merely due to chance.

TABLE XI

PERCENTAGE OF TOTAL ERROR MADE"WITHIN EACH EXPERIMENTAL GROUP"BY TRIAL ON OBJECT ORIENTATION

Trial	Comb Vert & Horizon Error		Angulation Error		Top and Bottom Error	
	Bld	Std	Bld	Std	Bld	Std
I	20%	26%	24%	27%	32%	34%
II	22%	29%	25%	30%	23%	26%
III	30%	23%	27%	23%	23%	22%
IV	28%	22%	24%	20%	22%	18%
	100%	100%	100%	100%	100%	100%

TABLE XII

PERCENTAGE OF "TOTAL ERROR MADE BY EACH GROUP" EACH TRIAL ON OBJECT ORIENTATION

Trial	Comb Vert & Horizon Error		Angulation Error		Top and Bottom Error	
	Bld	Std	Bld	Std	Bld	Std
I	60%	40%	55%	45%	62%	38%
II	60%	40%	53%	47%	59%	41%
III	72%	28%	62%	38%	67%	33%
IV	71%	29%	61%	39%	68%	32%

In order to accomplish this task, it was necessary to rework the original data into error figures for each individual for each trial. The trial containing the highest degree of error was checked for significance against the lowest within each group. The results of these tests of significance appear in Table XIII and revealed that the obtained differences were significantly different from zero for angulation error and top and bottom orientation. The vertical and horizontal error for both groups was not significantly different from zero and was possibly due only to chance factors.

TABLE XIII

t TESTS OF ERROR MEANS BETWEEN THE HIGHEST AND LOWEST TRIAL WITHIN EACH GROUP FOR THREE TYPES OF ERROR

	Blind Trial	Sighted Trial
Combined Vertical and Horizontal Error	I vs III t = 1.65	II vs IV t = 1.36
Angulation Error	I vs III t = 3.04*	II vs IV t = 2.81*
Top and Bottom Orientation	I vs IV t = 2.42*	I vs IV t = 4.00**

df = 11 for all tests

* Significant at the 5% level of confidence

** Significant at the 1% level of confidence

Discussion

Combined vertical and horizontal error was investigated in two ways viz., analysis by object error and by individual subject error. The former method indicated there was significant difference between the two groups, while the latter showed the observed differences to be due to chance. Analysis of angulation error and top and bottom orientation did appear to show a difference between the two groups with the blind performing in an inferior manner in comparison to the sighted.

The above findings would seem to substantiate prior research that stated blindness does not necessarily develop tactual abilities to a higher level than that of the sighted (14). It may be possible that the blind received even less useable information from the same amount of stimuli than the sighted. Tables XI and XII appeared to indicate that some learning was taking place in both groups, but the sighted were learning more readily and at a faster pace.

The investigator observed that the blind subjects tended to take more time in the placement of the objects and verbalize more doubts concerning the accuracy of their performance than did the sighted group.

To summarize this portion of the study, the overall results tended to support the stated operational hypothesis, but the results were not as clear and conclusive as the findings of Experiment I.

The investigator would like to see the object orientation test administered to a large number of blind individuals. It might be possible with a large N to develop suitable norms which could be used to ascertain the level of spatial development in a blind child. The scores could be used as general guides, i.e., above average, average, or below average.

From a vocational point of view, the results of this experiment can be interpreted as meaning the blind, as a group, will probably require more training in the manipulation of objects to acquire the same degree of proficiency as the sighted. Also the blind will need a great deal of emotional support and encouragement during the initial training period.

EXPERIMENT III - SPACE ORIENTATION

Results

Temporal Considerations. Analysis of the space orientation experiment began by investigating the amount of time spent by each experimental group in the exploration of the three rooms. Tests of t computed between the two groups on the small, medium and large rooms revealed no significant differences in time. In fact, the t scores were very low: (1) small = .86, (2) medium = .35, and (3) large = .04.

Subjective Estimates. Table XIV gives the percentages of the two groups in their subjective error of the three rooms for the first and second trials. This data revealed that the two groups made approximately the same percentage of errors on the first trial, but the sighted improved their subjective estimates on the second trial to a greater extent than the blind.

TABLE XIV

PERCENTAGE OF ERROR IN SUBJECTIVE ESTIMATES OF ROOM SIZES BY THE BLIND AND SIGHTED IN SPACE ORIENTATION EXPERIMENT

	Blind						Sighted					
Room	1st Trial %			2nd Trial %			1st Trial %			2nd Trial %		
	L	M	S	L	M	S	L	M	S	L	M	S
Large	83	17	0	92	8	0	67	25	8	92	8	0
Medium	42	50	8	50	50	0	8	59	33	8	92	0
Small	17	58	25	0	50	50	17	33	50	0	8	92

Objective Estimates. Table XV outlines the actual error means for both groups by room and trial. The blind group tended to underestimate the length and width of rooms, but overestimate the height. As has been pointed out elsewhere in this paper, the sighted group gained knowledge of the building structure

TABLE XV

ERROR MEANS IN OBJECTIVE ESTIMATES OF ROOM SIZES BY THE BLIND AND SIGHTED - SPACE ORIENTATION EXPERIMENT

	Large Room			Medium Room			Small Room		
	H	L	W	H	L	W	H	L	W
Blind									
Actual Error									
First Trial	5.58	-10.25	-11.58	2.71	-16.91	2.08	1.67	1.79	.58
Second Trial	5.58	- 8.92	-10.58	3.29	- 8.70	- .92	1.17	-2.25	- .46
Sighted									
Actual Error									
First Trial	1.08	4.83	-11.08	- .42	-10.58	2.00	- .46	2.42	4.83
Second Trial	.66	.91	- 3.75	0	- 4.16	1.25	- .25	- .08	.50

which the blind were lacking. There appeared to be no significant trend in the errors made by the sighted group. They did tend to estimate closer to the true dimensions than the blind. To test the significance of these observed differences between the two groups, t tests were computed by trial, room, and dimension (Appendix B). The length of the large room on Trial II was the only computation significant at the five per cent level of confidence.

Tests of t were computed to ascertain if there were any significant improvement in accuracy between the first and second trials within each group. (Appendix B). There were no significant improvements for the blind between the first and second trials for any room. The sighted improved their accuracy of estimation significantly on the length of the medium room, and the width of the small room.

Discussion

Of the three experiments, the one presently under discussion probably contributed the least amount of information concerning the behavior of the two groups being investigated. Some of this was due to a lack of control of important variables.

The sighted individuals should have been blindfolded prior to entering the building in order that clues concerning the height of the hall ceiling would not have been gained by this group. Another problem was the lack of complete control over air-conducted auditory stimuli. Even though the subjects wore large, padded earphones, auditory clues were obtained by both groups. It is well-known that the blind employ a "doppler-effect" to gain cues concerning their environment.

The acoustical ceiling was misleading for the blind in that it did not reflect sound to the same degree as the plastered walls. The sighted group possessed a fair degree of knowledge about the height of the ceiling, so the acoustical properties of the rooms did not distort their estimates to any large extent.

A review of the introspective reports of the experiment revealed that the criteria given the groups to judge the size of the rooms was not in the best possible form. This shortcoming in the design was not discovered until completion of the experiment.

Taking into consideration the above-mentioned faults, there were certain results which the investigator considered important. In observing the explorations of the blind group, they seemed to require more stimuli before being satisfied, i.e., walking around the perimeter of a room as many as six times before coming to any conclusions as to its dimensions. Some of the blind did not appear to know how to "pace off" the dimensions of a room and their second estimate would be less accurate than the one made prior to exploration. There was also a lack of confidence displayed by the blind group.

One blind girl was unable to locate a wall in the large room, and became so disturbed, it was necessary to remove her from the experimental environment. Another blind subject who was evidently receiving very little extrinsic stimuli stated via the two-way communication system, "I feel like I'm out in space, and it is real scarey!"

The results revealed a significant improvement between the first and second estimates of the sighted in the length of the medium room and the width of the small room. It was noted that subjects of both groups tended to make their estimations of rooms fairly square. The large room was square, but the medium and small rooms were long and narrow. The sighted group estimated these rooms as square on the first estimate, but were somewhat consistent in correcting the error after exploration. However, the blind were not as succesful in their correction process.

When the error of the blind was compared to the error of the sighted, no significant difference was revealed. Of the one significant t test, it can be explained by chance since one expects to find five significant tests in one hundred. Eighteen t tests were computed in this particular series and the probability of one being significant in the group was very high.

TENTATIVE INTERPRETATIONS

Throughout the course of this experimentation, there was observable behavior on the part of the blind group that seemed to show a lack of ability to utilize various types of stimuli to the degree accomplished by the sighted. Evidently, congenital blindness is associated with subtle, but significant, impairment. This was in accord with the results of earlier studies (15).

An effort was made to inquire into the nature of the impariment, and to consider whether the etiology was a matter of sensory deprivation, or some pathological process was to blame.

The deficiencies observed in the blind group are apparently not restricted to functions which are only spatial in nature. Axelrod (2) found similar deficits in a study of the blind using auditory tasks. The serious problem of the use of visual imagery was raised, but due to the present "state of the art" in psychological experimentation, it was impossible in this exploratory study to shed direct light on the question.

Visual imagery was not considered the only possible explanation for the present findings. The manner in which the congenitally blind learn from different stimuli may have been involved. Harlow (51) describes a "learning how to learn" which appears to be a complex function requiring the abstracting of principles from stimuli in problems and the utilization of these principles in new tasks. Congenitally blind subjects have been found to be impaired in the ability to form these types of intermodal learning.

From animal experimentation comes a study by Hebb (15) in which he found a group of rats who had had a high degree of early, positive stimuli experiences were better problem solvers than a group with little or no such experience. It is possible that the present group of congenitally blind, like Hebb's restricted animals, were less able to profit from new stimuli or experiences.

Another explanation might lie in the role "rigidity" played in the behavior of the congenitally blind. McAndrew (56) published evidence that blind children are more psychologically rigid than sighted persons. It was noted that the present blind group usually attempted one method of measuring the circumference of a cylinder, while the sighted shifted from one method to another in search for a more successful process.

The investigator also did not wish to disregard the possibility that the observed difference between the two groups was due to central nervous system damage caused by transneuronal degeneration. Transneuronal degeneration, atrophy, and chromatolysis are rare, but they are not unknown in the optic

system (11,20). Degeneration as a result of retinal lesion has been traced as far as the lateral geniculate body and the superior colliculus by Clark (40) and Polyak (19).

There is less evidence that degeneration might proceed as far as the cortex. Semmes <u>et al</u> (65) found that tactile tasks performed by subjects with penetrating lesions of the brain were less accurate than the control group. Of course, these lesions were much more extensive than the degree of atrophy ever found attributable to the effects of blindness. Nevertheless, atrophy remains a possibility.

Since the retina is embryologically and structurally part of the central nervous system, it could be hypothesized that congenital blindness is one symptom of generalized brain damage. While an effort was made to eliminate suspected brain damaged subjects from the study, it is possible that the brain dysfunction present was so small that it passed undetected. The deficits elicited by the tasks used in the present investigation were, in themselves, very subtle.

To summarize, it would be difficult and a rather tenuous move, pending further research in the area, to make a definitive decision between functional and structural explanations for the observed differences in behavior noted in this study.

The findings did attest to the importance vision plays in the educational and vocational potential of an individual. Vision is the relational and mediating modality for the organism.

Every waking moment photic stimuli is received by the individual giving opportunities for experiencing relationships such as higher, lower, top, bottom, right, or left. Persons whose sensoria are intact have a tremendously augmented experience of such relationships.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter summarizes the entire investigation in order to present an overall picture, and state the significant conclusions and implications of the findings.

SUMMARY

The purpose of this experimentation was an exploratory analysis of the characteristics of space perception in congenitally blind and sighted individuals.

A review of the pertiennt literature indicated that little research effort had been expended in the area. The findings of many of these studies were contradictory because individuals possessing varying degrees of vision had been included in the samples.

An attempt was made to develop novel tasks which would force the congenitally blind group to use visual imagery if they possessed it. This effort was not wholly effective because the blind group was partially successful.

Since it was impossible to directly measure the use of visual imagery, three experiments were designed from which it was hoped certain psychological phenomena could be inferred.

This work produced the hollowing hypotheses, and an attempt was made to verify or refute them.

Hypothesis I: The congenitally blind group of subjects is less accurate than the blindfolded, sighted group in estimating the circumference of three different sized cylinders.

Hypothesis II: The congenitally blind group of subjects is less accurate than the blindfolded, sighted group in the correct orientation of geometric forms on a metal plate while in a horizontal position.

Hypothesis III: The congenitally blind group of subjects is less accurate than the blindfolded, sighted group in estimating, both concretely and subjectively, the size of three different empty rooms.

The experimental model best suited to test the above hypotheses was felt to be the method of average error using sampling statistics in the analysis of the data.

The sample for the study was composed of twelve congenitally blind pupils, non-randomly chosen from the population of the Michigan School for the Blind located in Lansing, Michigan. Each blind subject was matched for age, sex and intelligence with a pupil of the East Lansing, Michigan, school system. Each blind subject was chosen using a very definitive criteria in the selection process.

The ages of the subjects ranged from twelve years, one month to eighteen years, two months. The mean age for both groups was fifteen years, six months. The mean IQ of the blind group was 107, with a range of 91 to 118; for the sighted, 108, with a range of 94 to 118. Both samples were composed of nine boys and three girls, respectively.

All of the experimentation was accomplished by the writer using the facilities of the Human Research Laboratory located in the College of Education building, Michigan State University.

Three different tasks were required of each subject. He was asked to manipulate an angular dimension into a flat dimension; to orient objects in space when situated in a horizontal position; and finally, to orient himself in space.

An anlysis of the results revealed the following information concerning the differences between the two groups.

1. Hypothesis I was substantiated in that the majority of t tests of error means between the two groups were significant at the five per cent level of confidence. It was evident from the results that the blind habitually underestimate the types of dimensions involved in this experiment.

2. In Experiment II, three types of error were considered: (1) vertical and horizontal combined, (2) angulation, and (3) top and bottom orientation. The blind did more poorly on all types of error than did the sighted. The results of the experiment substantiated Hypothesis II, but were not as conclusive as the first experiment.

3. Experiment III contributed the least amount of knowledge concerning differences between the two experimental groups. Three types of measurements were involved: (1) temporal, (2) subjective, and (3) objective.

Tests of significance between the groups for the time expended during exploration of three empty rooms revealed no significant differences. Percentages of error on the first subjective estimate were approximately the same for both groups. The sighted group improved on the second subjective estimate to a greater degree than the blind.

Considering objective error means, the differences between the two groups were not significant, but the blind, as in Experiment I, did underestimate the distances involved. There were some uncontrolled variables in Experiment III which undoubtedly influenced the results.

CONCLUSIONS

The results appeared to justify certain conclusions. Because of the limitations which characterize these findings, any attempt to generalize to all blind individuals should be done with caution.

The blind seemed to almost habitually underestimate space, both small dimensions and large distances. The blind, as a group, did not seem to receive as much useable information from stimuli of the same strength as did the sighted. Evidently congenital blindness results in very subtle, but significant, impairment of the organism's ability to function. From a psychological standpoint, the blind were much less confident of their ability to succeed and required more reassurance.

Several tenable explanations for the differences in observed behavior have been postulated, but because the present study was of an exploratory nature, it was impossible to definitely state the reason for the differences.

FURTHER RESEARCH

As a result of this investigation, there were some new hypotheses which the experimenter feels are worthy of further study and research.

In the angulation experiment involving the use of the cylinders, what would be the results if a temporal delay were introduced between the application of the stimulus and the request for the circumference estimation?

Kinesthesis appeared to have some bearing or influence in the angulation experiment. It would be interesting to observe the results if the arms of the subject were secured to the body at the elbows.

A third suggestion for research in Experiment I - Angulation Manipulation, is to construct a second series of cylinders using the largest of the first set as the smallest of the second set; then administer the test using both sets on two new groups of subjects.

As has been mentioned heretofore, it would be advantageous to obtain more subjects and administer the object orientation test to them.

CHAPTER VI

IMPLICATIONS OF STUDY ON EDUCATIONAL AND REHABILITATION PRACTICES

It is a generally recognized principle that organisms whose potential adaptations to the environment are the most complex also require the longest period of development or maturation. Experimental data seems to point up the fact that a long period is also essential for the adequate organization of perceptual processes whether they are gleaned from visual or tactual stimuli. The problem which first confronts the teacher of the blind and ultimately the rehabilitation worker, is to determine the best educational methods and schedule of training which will bring the blind person to his optimum level of performance.

EDUCATION OF THE BLIND CHILD

A child does not walk or talk just because the normal process of maturation prepares him physiologically to perform these acts. An appropriate stimulus must be presented to him within a reasonable length of time, or the opportunity to acquire these skills with a fair degree of ease will have passed, and they can be learned only upon the expenditure of much effort at a later date.

A good example of the problem is the case of the "Wolf Boy" in India. This boy spent several years of his early childhood exclusively in the company of wild animals. When he was returned to civilization attempts were made to teach him language skills, but these were only moderately successful.

Pre-School Experiences

The blind infant has nothing to replace the energizing, synthesizing attributes of vision. Individuals in the child's environment must, in some manner, bridge the gap between the highly restricted blind infant and the active world about him. It is a serious responsibility that society cannot deny.

It is possible and probable that the blind child may object strenuously and attempt to withdraw from new experiences, but this resistance must be tolerated and overcome since his spatial perceptions should be acquired within the proper developmental period.

One has only to consult any elementary educational psychology text to be aware of the fact that modern educational theories place much emphasis on the importance of developmental needs during the first six years of a sighted child's life. It seems obvious that these same years are even more vitally important to the blind child but, at present, he receives little or no instruction in the adequate development of spatial perceptions.

The importance of direct experiences in the educative process cannot be overemphasized. The deepest and most fundamental needs of blind children are a rich and intimate experience with common objects, and a direct acquaintance with persons representing a cross-section of skills and professions encountered during the activities of daily living. No verbal substitutes can suffice for these; the blind child must learn to know individuals and objects in terms of his own sensoria. Only the first-hand experience will enable him to face confidently the world that awaits him when he emerges from the protected environment of the school.

Teaching Methods

Teaching methods should stress unified instruction, since an experience can only be understood as a totality. If one subscribes to the theories of Gestalt psychology, an experience is not a sum of the parts, but a totality of the stimulating conditions.

The blind child must be guided into organizing discrete experiences and facilitating schematization of spatial forms. Introspective data obtained from the blind during studies of auditory, air currents, time sequences, and kinesthetic changes, have shown that they are discrete impressions and tend to remain so unless teaching lends organization and structure to them.

The blind child's concept of his environment will probably be incomplete and distorted, so an effort must be made to encourage him to extend himself into his environment and secure spatial experiences. Training and instruction in foot travel and other spatial concepts should be an integral part of his curriculum and very early in his life. Exercises in mental orientation of the classroom, playground and community are also essential.

The Teacher of the Blind Child

As is true in any educational setting, the teacher determines to a large extent the success or failure of a pupil's learning. There are many fine details and common-sense deviations which can be employed successfully in teaching one person, but these may fail miserably or be ignored by another. The teacher, her knowledge of space perception, methods of presentation, improvision, and interest, plus the blind person's age, temperment and motivation, are all crucial factors in determining the acquisition of effective spatial perceptions.

The teacher of the blind is confronted with an entirely different task than the teacher of the sighted. The former must be aware that it is almost entirely her responsibility to provide her pupils with experiences which will help them gain a realistic knowledge and understanding of the culture in which they live.

The teacher can accomplish this task in two ways; the pupils must either be taken to the experience or the experience must be brought to them. In the first category are study excursions, field trips and visits to industry; in the second, are visits by personnel who can make a contribution, such as a fireman, a doctor, or a foreign visitor.

REHABILITATION PRACTICES

Research Findings

Studies of sighted individuals have shown wide differences in their ability to deal with spatial concepts. Thurstone (24) regards spatial perception as a primary ability, and therefore, by implication, not improvable through practice. There are, on the other hand, research findings which refute Thurstone's stand, and which the writer feels substantiate a theory that more effective spatial perceptions can be taught the congenitally blind.

Plate (60), as a result of his experimentation was of the opinion that tactual imagery is inferior to visual imagery, which accounts for the poorer performance of the blind. He goes on to point out, however, that with proper training the differences between the blind and sighted disappeared. Mann and Boring (55) conducted a study of the role of instruction in experimental space perception. Their findings indicated that

the type of instruction and amount of practice influenced the precision with which subjects, when placed in various degrees of lateral inclination, set a target rod to the gravitational vertical. The sighted, as well as the blind, have been found to be able to increase their proficiency in the area of spatial relations. Blade and Watson (35) found significant increases in spatial visualization test scores of a sighted group during an engineering study.

Research has indicated that the initial sensory acuteness of the blind is no better than that of the sighted, and whatever they achieve is the result of necessity, concentration and increased practice and skill (4).

Need for More and Better Training Techniques

A common problem is a general unfamiliarity with the techniques and methods employed by the blind in overcoming some of the inconveniences accompanying blindness. Although experienced personnel engaged in working with the blind have recognized the importance of these activities, there exists no substantial body of information about the most frequent and effective methods employed by the blind. It is not only the absence of this type of information, but also of the most efficient methods of acquiring these skills, that has resulted in confusion when attempting to train the blind in spatial perceptions.

In the teaching of spatial relations by manual tactual exploration, the problem arises as to the best method of exploration. Studies of tactile recognition of objects by the blind, such as those of Steinburg (23), and of Merry and Merry (57), allowed the subject to devise his own methods. They reported considerable improvement without supervised practice.

The general success of modern motion study techniques in improving the efficiency of experienced sighted workers is fairly good evidence that the unguided individual is not very likely to discover the most effective methods. It would seem justifiable to expect that training the congenitally blind in systematic manual exploration and interpretation would greatly improve their spatial relations.

The Development of Automatic Responses

The effective use of the sensory receptors, which is taken for granted by the normal individual, is actually the result of many years of practice during infancy and childhood. There is a small degree of innate organization of the sensory-motor systems, but the perception and immediate recognition of visual objects or of sounds are developed only by long practice. The few congenitally blind individuals who have had their vision restored in later years found that learning to see is a slow, arduous process. At first, such simple figures as a triangle and a square were not recognized, though a difference was perceived. Sometimes the newly sighted person found it necessary to count the corners in order to identify the figures. Only after considerable training were such figures immediately perceived and identified without the necessity of following their outlines with movements of the eyes (27).

Riesen has confirmed the above-mentioned clinical observations on slow acquisition of vision by experimentation (61). Two chimpanzee infants were restricted to a totally dark environment during the first months of life. One, kept in darkness for the first eighteen months, began to depend on vision only after a year of exposure to daylight. The other, two years in darkness, showed no spontaneous use of vision after six months in daylight, although his visual acuity was not significantly defective. He apparently evaded visual tasks by sleeping the greater portion of the day and being active at night.

Normal visual perception thus appears to be the result of a long period of learning, and the effective use of vision is possible only when the synthesis and interpretation of sensory clues have become automatic. Therefore, in the instruction of spatial perceptions in the blind, the problem of habituation and automatization becomes of prime importance.

As long as the cues received by the blind individual must be consciously analyzed and interpreted, his efficiency will be greatly restricted.

Suggested Training Procedures

An adequate development of spatial perceptions cannot be expected without a period of training corresponding to the acquisition of normal visual spatial perceptions. The properties of objects must be learned, and characteristics which permit rapid identification must be discovered. For example in the identification of contours, the best method must be evolved to translate tactile and kinesthetic cues into meaningful concepts of relative position and form. Close supervision of practice will be necessary to insure satisfactory results. It would be wise to maintain quantitative records of achievement and make them available to the student, thus helping to sustain interest when progress is slow.

Spatial orientation training should include all types of moving the body through space, and the manipulation of the hands in eating, shaving, dressing, working, and playing. Operation of machinery, weaving, piano playing, dancing, and fly-tying can be utilized in teaching basic spatial perceptions. Sports and physical education should likewise be included in spatial orientation training. Successful orientation is required during swimming, bowling, horse-back riding, and golf.

Obstacle Sense

It has been established through experimentation that obstacle perception is possible in the blind (4). Through instruction, the blind individual can be made aware of this ability and make use of it in detecting and avoiding certain obstacles in his path. These will include flat walls, thin vertical strips like open doors, overhangs like shop awnings, steps down and up, openings such as windows, horizontal bars as found in railings, etc.

The testing and training of obstacle sense, in all of its possible forms viz., aural, pressure, temperature, and air currents should be seriously undertaken and vigorously conducted in institutions responsible for the training of the blind. Each blind person should be tested with respect to his ability to handle each type of cue that proves to be relevant.

The present study has shown that attention should be paid to the auditory acuity of a blind individual. Auditory cues tell the blind person many things concerning his environment, therefore, his hearing should be tested periodically to ascertain the functioning level of this important sensory modality.

Psychological Impact of Training

The blind individual should realize that it will be difficult to learn and master spatial relations having to use sensory receptors other than vision. It will be grueling and boring, require ceaseless training and independent exploration. Depending upon the emotional makeup of the blind person, there may be a tendency for him to reject spatial orientation training and resort to dependency on others. It is doubtful that any really adequate results can be obtained under six months of daily training.

Summary

The blind person must learn to face his lack of sight squarely and unemotionally, overcome sensitiveness, develop techniques for offsetting the inconvenience of blindness, and put his sighted friends at ease when in his company.

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APPENDIX A

CYLINDER ESTIMATION EXPERIMENT

Name____________________ Age_____ Sex______ IQ_______ Date_______

(_____)	(_____)	(_____)
RO________________	RO________________	RO________________
LI________________	LI________________	LI________________
LO________________	LO________________	LO________________
RI________________	RI________________	RI________________
LI________________	LI________________	LI________________
RO________________	RO________________	RO________________
RI________________	RI________________	RI________________
LO________________	LO________________	LO________________

REMARKS:

SCORE SHEET FOR OBJECT ORIENTATION TEST

Name____________________________________ Age_______ Sex___ IQ____

	1	2	3	4	5	6	7	8
X								
Y								
XY								
XZ								
X								
Y								
XY								
XZ								
X								
Y								
XY								
XZ								
X								
Y								
XY								
XZ								

SMALL ROOM EXPERIMENT

Name____________________ Age___ Sex___ IQ___ Date___________

1st Estimate: Large Medium Small

2nd Estimate: Large Medium Small

1st Estimate: Height___ Length___ Width___

2nd Estimate: Height___ Length___ Width___

Description & Introspection:____________________________________

____

____

____

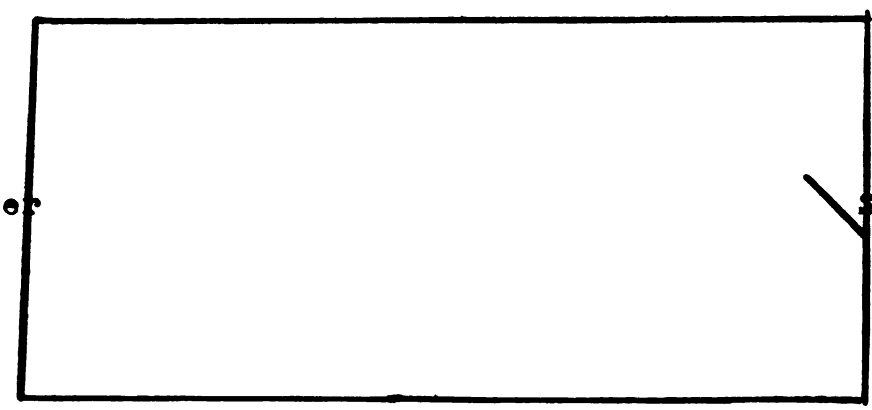
LEGEND:

Fairly sure, straight movement ____________ Stop X

Hesitant, insecure . . . . Speak O

Very slow, hesitant

Experimenter



Subject Enters

MEDIUM SIZED ROOM EXPERIMENT

Name________________ Age____ Sex____ IQ____ Date__________

1st Estimate: Large Medium Small

2nd Estimate: Large Medium Small

1st Estimate: Height___ Length___ Width___

2nd Estimate: Height___ Length___ Width___

Description & Introspection:________________________________

____

____

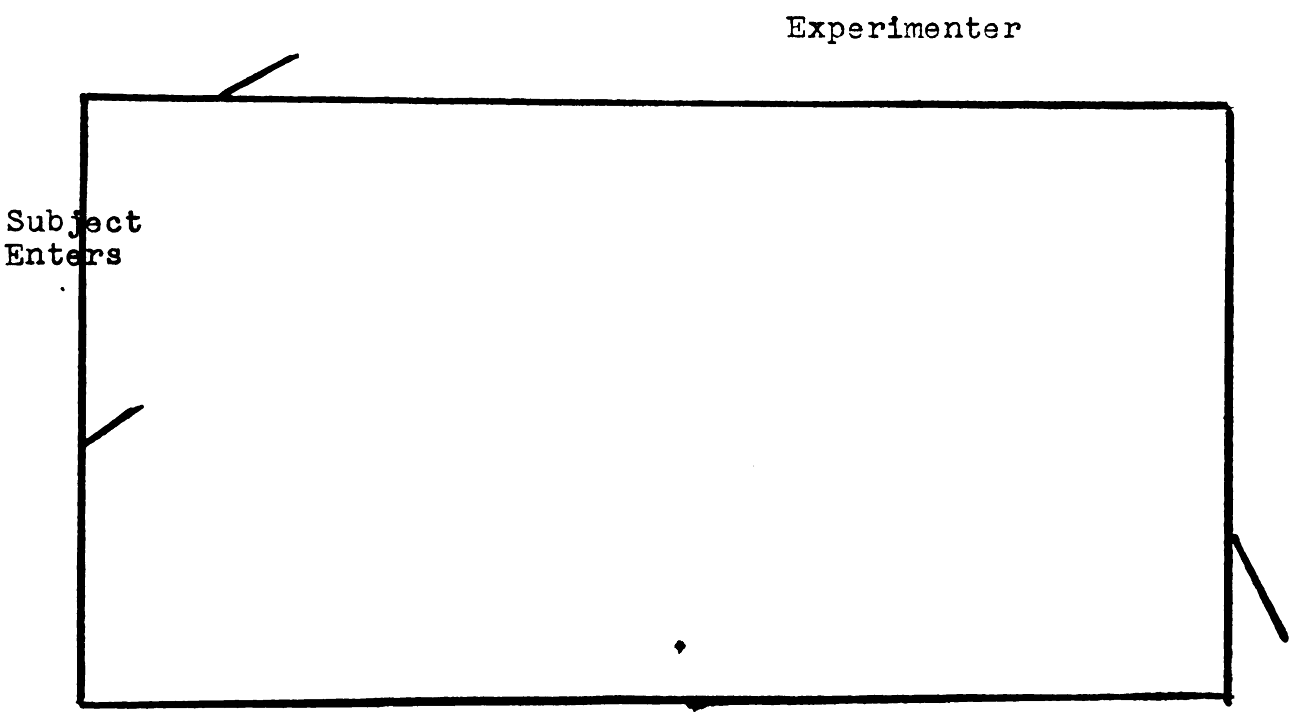
____

LEGEND:

Fairly sure, straight movement__________ Stop X

Hesitant, insecure . . . . Speak O

Very slow, hesitant ~~~~~~~~~~



LARGE ROOM EXPERIMENT

Name____________________ Age____ Sex____ IQ____ Date__________

1st Estimate: Large Medium Small

2nd Estimate: Large Medium Small

1st Estimate: Height___ Length___ Width___

2nd Estimate: Height___ Length___ Width___

Description & Introspection:____________________________________

____

____

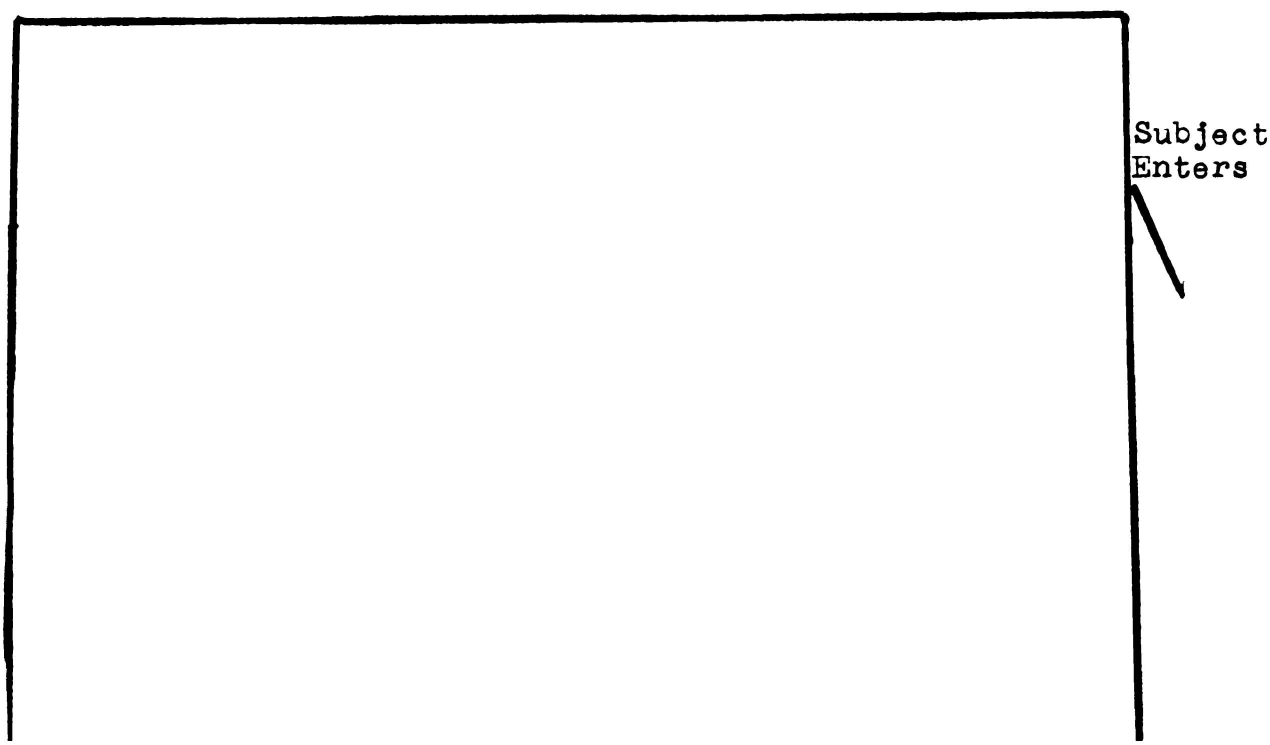
____

LEGEND:

Fairly sure, straight movement____________ Stop X

Hesitant, insecure . . . . Speak O

Very slow, hesitant



APPENDIX B

TABLE XVI

t TESTS OF MEANS BETWEEN VERTICAL AND HORIZONTAL ERROR BY TRIAL AND OBJECT FOR THE BLIND - OBJECT ORIENTATION EXPERIMENT

Object	t	Fmax
	Trial I	
1	.61	1.03
2	1.70	7.03*
3	.61	3.89*
4	.04	2.21
5	.33	1.51
6	1.34	2.60
7	2.04	13.11*
8	1.16	5.34*
	Trial II	
1	1.26	1.60
2	.51	1.63
3	.42	2.87
4	.33	3.32*
5	.15	1.15
6	.87	1.97
7	.94	1.29
8	1.42	9.90*
	Trial III	
1	1.44	1.93
2	.87	1.75
3	.11	1.63
4	1.15	3.22
5	.19	1.09
6	.15	1.26
7	.83	1.97
8	.90	3.40*

*significant at the 5% level of confidence

TABLE XVI (continued)

Object	t	df	Fmax
	Trial IV		
1	1.05		1.63
2	.73		2.25
3	1.00		1.64
4	1.58		4.25*
5	1.70		1.84
6	.91		1.07
7	.23		1.83
8	1.98		4.28*

*significant at the 5% level of confidence

TABLE XVII

t TESTS OF COMGINED VERTICAL AND HORIZONTAL ERROR MEANS BY OBJECT BETWEEN TRIALS I AND II COMBINED AND III AND IV COMBINED

Object	t	Fmax
	Blind	
1	.33	1.06
2	1.21	2.28
3	1.72	2.21
4	1.65	6.54*
5	.74	2.59
6	.59	2.54
7	1.60	3.67
8	.30	1.38
	Sighted	
1	.34	1.04
2	2.05	82.98*
3	.39	1.40
4	.95	4.45*
5	.49	1.35
6	.88	2.37
7	.05	6.23*
8	1.11	11.22*

*significant at the 5% level of confidence

TABLE XVIII

t TESTS OF ERROR MEANS BY TRIAL
BETWEEN BLIND AND SIGHTED
ON ANGULATION BY OBJECT

Object	t	df	Fmax
		Trial I	
1	2.00		6.08*
2	.45		1.27
3	2.13*	15	7.04*
4	1.32		1.89
5	.22		1.11
6	1.16		1.77
7	.77		2.99
8	1.10		1.07
		Trial II	
1	.26		1.10
2	.34		1.64
3	.33		1.28
4	2.46*	13	11.05*
5	.06		1.94
6	.09		1.90
7	.30		1.49
8	.15		1.26
		Trial III	
1	.78		1.87
2	.22		1.29
3	2.15*	22	3.11
4	1.42		3.61*
5	1.38		3.07
6	2.72*	14	9.38*
7	1.83		1.17
8	.30		1.27

*significant at the 5% level of confidence

TABLE XVIII (continued)

Object	t	Fmax
	Trial IV	
1	.49	1.40
2	1.94	2.74
3	2.05	3.21
4	1.73	2.21
5	.72	1.90
6	.17	1.10
7	.53	1.03
8	2.15	27.87*

*significant at the 5% level of confidence

TABLE XIX

t TESTS OF ANGULATION ERROR MEANS AGAINST ZERO
FOR A SELECTED NUMBER OF OBJECTS
BY BLIND AND SIGHTED

Sighted			Blind		
Object	t	df	Object	t	df
		Trial I			
1	3.77**	11	1	3.69**	11
2	4.14**	11	2	3.07*	11
3	4.09**	11	3	3.82**	11
4	3.16*	11	4	3.99**	11
		Trial IV			
5	3.98**	11	5	3.77**	11
6	2.50*	11	6	2.37*	11
7	2.75*	11	7	3.56**	11
8	4.65**	11	8	3.06*	11

* significant at the 5% level of confidence
** significant at the 1% level of confidence

TABLE XX

t TESTS OF ERROR MEANS BETWEEN BLIND AND SIGHTED BY TRIAL IN THE ESTIMATION OF ROOM DIMENSIONS

	Large Room			Medium Room			Small Room		
	t	df	Fmax	t	df	Fmax	t	df	Fmax
				Trial I					
H	1.24		19.93*	.38		16.74*	.48		9.18
L	1.19		6.67*	1.30		1.69	.56		2.65
W	.09		1.28	.003		3.63*	.44		4.92*
				Trial II					
H	1.20		24.54*	.08		16.62*	.42		7.05*
L	2.46*	22	1.46	1.37		2.36	1.51		2.57
W	1.76		2.33	1.47		2.55	1.60		1.66

*significant at the 5% level of confidence

TABLE XXI

t TESTS OF ERROR MEANS BETWEEN FIRST AND SECOND OBJECTIVE ESTIMATES OF ROOM SIZES BY BLIND AND SIGHTED

	Blind		Sighted	
	t	df	t	df
Large Room				
Height	0.00		1.00	
Length	.40		.39	
Width	.27		1.90	
Medium Room				
Height	1.23		0.00	
Length	2.20		2.33*	11
Width	1.05		.63	
Small Room				
Height	.88		.88	
Length	.77		2.08	
Width	1.89		3.23**	11

* significant at the 5% level of confidence
** significant at the 1% level of confidence