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Effect of movement environment and sex on adaptation to a visually-inverted environment

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THE EFFECT OF MOVEMENT, ENVIRONMENT AND SEX
ADAPTATION TO A VISUALLY-INVERTED ENVIRONMENT

by

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INTRODUCTION

According to Ashby (1945) when the environment is no longer satisfactory the organism engages in adaptative behavior directed toward a more satisfactory adjustment. This behavior consists of transactions with the environment carried on through the organism's various sense modalities. In order for successful adaptation to occur the sense modalities and the environment must be in a coherent relationship. Coherence implies that the sensory input of all modalities must be integrated with the location and orientation of objects in the environment. If one sense modality, e.g., vision, is distorted a conflict arises within the organism due to the sensory input received by the distorted and undistorted sense modalities. The organism must then resolve this conflict by maintaining contact with the environment on the basis of the undistorted sense modalities. One method of distorting the familiar visual relationship between the organism and the environment involves the use of prisms which invert the visual field so that the environment is perceived as up-side down. The organism must then resolve the conflict between stimulation from the seen environment and stimulation from the felt or acted-toward environment, i.e., the environment as the other undistorted sense organs reflect it.

Since the study to be proposed is concerned with the role of action, environment and sex differences with tasks requiring different kinds of sensory-motor behavior under visual inversion, previous studies dealing with these factors will be examined. Specifically, the role of active movement versus passive or restricted movement; the effect of
having manipulable objects in an environment versus a homogeneous environment (one having no manipulable objects); and the role of sex differences.

**Activity vs. Passivity:** Studies by Stratton (1897), Snyder and Pronko (1952) and Held, et al. (1958, 1959, 1961) suggest the importance for adaptation of active movement by the subject but only partly indicate the mechanism whereby this might occur. These studies indicate that adaptation takes place more readily when the subject is actively rather than passively involved with the task. One of the first studies was done by Stratton (1897). He reported that "active movement" involving tactual stimulation in contrast to more "passive viewing" did much to reintegrate the visual sense with the other modalities, "...the most harmonious experiences were obtained during active operations on the scene before me. In rapid, complicated, yet practiced movements, the harmony of the localization by sight and that by touch or motor perception...came out with much greater force than when I sat down and passively observed the scene." Snyder and Pronko (1952) in a more recent study that also used one subject and involved a variety of motor tasks, found that activity in well practiced tasks (walking and eating) under visual inversion improved most rapidly in contrast to activity in less familiar tasks (card sorting, etc.).

A series of studies specifically emphasizing the role of activity versus passivity and which do suggest a mechanism for adaptation was conducted by Held and others. These studies suggest that active movement by the subject facilitates visuo-motor adaptation to a greater extent than when the subject is passively moved about or remains motionless.
Held's explanation of adaptation to visual inversion was based on Von Holst's (1962) theory of afference and efference. According to Von Holst, external stimulation produces afferent impulses in the central nervous system. These impulses in turn produce body movement which in turn create reafferent impulses which are a part of the motor responses of the organism. Both the afferent and the reafferent impulses leave an image on the central nervous system. If the input stimulation (afferent impulse) and the output stimulation (reafferent impulse from motor act) are not identical, the organism will engage in movement until these images are the same. The organism in a visually inverted field will engage in movement until the stimulation received from the eye (afferent impulse) and the motor output (reafferent impulse) are the same, that is, the hand will move until it can touch the object seen by the eye. Held's use of the "reafferent feedback" concept was that if the S actively moved about in an inverted or displaced field, this self-produced movement would enable the S to establish new visuo-motor coordinations. "Ex-afference" feedback, or sensory stimulation independent of self-produced movement would not aid the S in adapting to the distorted visual field.

The term "feedback" is used here in both a physiological and psychological sense. Thus, for an individual to correct his movements there must be "reafferent feedback" (physiological) as well as awareness of the incorrect movement (psychological). Knowledge of incorrect movements and adjustments to be made are gained through the kinesthetic, tactual and visual senses. Held and Hein (1958), for example, found that the S's active arm movement facilitated his ability to localize points in space under visual distortion. In this experiment Ss wore prisms that oriented base right or base left and the task was one of
localizing intersections of lines in a square. More accurate location identifications were done by Ss who actively moved their own arms in contrast to those whose movements were done by the E (passive movement) or who remained motionless. In a study by Held and Schlank (1959) dealing with adaptation in the distance-dimension, it was found that when the S moved his arm he was more accurate in locating target points than when the E moved his arm for him. Mikaelian and Held (1961) further investigated the activity variable by having Ss either walk along a fixed path or by having them pushed in a wheelchair (passive movement) along the same path for an hour while wearing prisms that rotated the visual field. They found that Ss that had actively moved about in the environment adapted or compensated for the prisms more readily than the Ss covering the same area in a wheelchair. Adaptation was measured by having the Ss make luminous line and point adjustments.

Environmental Patterning: Another factor which may be important in adaptation is the effect that a patterned environment, in contrast to a non-patterned (homogeneous) environment, has on facilitating the organism in reintegrating disrupted modalities. A patterned environment is defined as an environment containing objects normally found in the everyday surroundings. A non-patterned environment is one consisting of a homogeneous field of vision, i.e., an environment having no objects in view. Experiments conducted by Kohler (1962), Kottenhoff (1957), and Miller and Kemp (1962) indicate that the manipulable qualities of the objects making up the patterned visual field might have an effect on the rate of adaptation. Findings from various studies by Kohler, using inverting or distorting lenses, lead to the notion that objects that can be manipulated by the organism or give the feeling of manipulability lead to more ready
adaptation under inversion than is true for objects without this quality. For example, an individual could adapt to things that could be manipulated such as riding a bicycle more readily than he could adapt to reading.

Also supporting the importance of objects for adaptation are Kottenhoff's studies. He found in his experiments dealing with up-down inverted vision that training in using objects in an everyday environment was an important factor in adjusting to a distorted visual sense.

The Miller and Kemp study is consistent with Kohler's findings that certain aspects of the environment are more impressive than others. They found that objects that were classified as figural evoked more attention from subjects than objects considered as ground. Although this study did not involve visual inversion, the fact that figural objects elicited more attention by the Ss than background objects suggests that certain environmental aspects are more likely to be noticed by people and could, therefore, be an aid to adaptation.

**Sex Differences:** Investigations conducted by Witkin (1954) and another study by Miller and Kemp (1962) indicate that the S's sex plays a role in the way he reacts to visuo-motor tasks and should then affect adaptation to visual inversion. Witkin, for example, found that men were more able than women to rely on body position to adjust a luminous rod in a frame to true vertical. In the Miller and Kemp study, prior to performing a tracing task while wearing inverting prisms, subjects were pre-selected for their tendency to unwittingly imitate the motion (sway) of the experimenter. It was found that individuals who were rated high on the basis of imitative movements adapted more readily (better eye-hand coordination as shown by fewer markings outside the drawing) than those individuals rated as low on the basis of imitative movements. It is of
interest to note that the high movement group was composed of a nearly all male population while the low movement group consisted of nearly all females. Both studies indicate that in adapting to a visually inverted field that men might disregard visual cues to a greater extent than women and rely on kinesthetic cues in performing tasks where it is necessary to disregard stimuli at variance with the task.

Another factor that might affect adaptation to an inverted visual field is the type of activity engaged in by the organism. According to Werner (1957), the first response of an organism in an inverted field will be of a gross sensorimotor nature, that is, the organism will learn to move about in the disrupted environment. Werner then states, "The further development toward visual adaptation shows some remarkable features: the objects seem to fall into two classes, things-of-action and purely visual things. The observer conquers first the things-of-action and only later purely visual things." Therefore, if the activity or tasks require movements of a gross motor nature the individual will adapt or perform these tasks more effectively than a task requiring small visuo-motor movements or tasks that depend on vision alone.

The studies cited investigated the factors involved in adaptation but did not systematically vary or control for the influence of activity, individual differences or a patterned (manipulable objects) environment. The present study will systematically vary movement, pattern and sex variables with regard to functioning on three sensory-motor tasks performed in a visually inverted field. It is hypothesized that:

1. Individuals that actively participate will adapt more readily than those whose movements are restricted.
2. Subjects performing in a patterned (manipulable objects) environment will adapt to a much greater extent than individuals in a homogeneous (non-patterned environment).

3. Male subjects will show greater adaptation than female subjects.

4. Tasks requiring fine visuo-motor activity (reading) should be more susceptible to changes in environmental stimulation than tasks which require gross visuo-motor coordination.

**METHOD**

**Subjects.** One hundred Ss (50 male and 50 female) from introductory psychology courses at Montana State University participated in this experiment. Ages of Ss ranged from 18 to 23. Twenty Ss (10 male and 10 female) were run in each of the experimental conditions.

**Apparatus.** An experimental room, approximately 5' x 8', covered with acoustical tile (80% soundproof) was used for this study. The sides, ceiling and floor were covered with white sheets in a cylindrical fashion to block out the corners of the room so that Ss had no visual cues as to up-down, etc. (see Fig. 1). Diffused lighting was provided by eight 25-watt bulbs painted white and placed in the corners and sides of the room about 4' from the floor. The Ss were seated at one end of this room, approximately 6' from the opposite end where the objects were placed during the 2 conditions requiring environmental stimulation. The experimental room was designed so that the S could be isolated from contact with other individuals and stimulation from other sources. This set-up allowed the E to study changes occurring in adaptation that might be the result of varying amounts of environmental input.
An experimental chair with an adjustable head and leg rest was used (see Fig. 2) so that Ss could be held firmly but comfortably in position.

Leather-covered pads were placed over the hands and fore-arms and the front of the legs from the knee to the ankle to reduce tactual stimulation. Leather straps held these pads in place and reduced the movement of the S to a minimum.

A $90^\circ \times 45^\circ \times 45^\circ$ wedge prism mounted in a full-face welder's helmet (see Fig. 3) was used to invert the visual field.

Manipulable objects in the experimental room during Conditions 3 and 4 consisted of a desk, chair, vase of flowers, toy car and a butterfly mobile (see Fig. 4).

Other items used in the experiment consisted of a book having large, plain print (see Fig. 5), a stop watch, abstract and concrete drawings of a tractor and birds (see Fig. 6a, b, c, d), a C. H. Stoelting 10-form wooden formboard (see Fig. 7) and a time clock. An intercom system in the experimental room allowed the E to remain in contact with the Ss at all time.
Procedure. There were 20 Ss assigned to the control group and these Ss were run before the experimental groups. This control group was used to provide a baseline of the typical performance of Ss whose visual field had been inverted but who had not experienced the intervening isolation period. In this condition the Ss reported to the experimental room and put on the prism headgear. They were then presented the three tasks and upon completion of the tasks were told to return after an hour had elapsed. Upon their return to the experimental room, they again put on the prism headgear and were again given the three tasks.

Eighty Ss were randomly assigned to one of the following experimental conditions and were taken into the experimental room after they had removed their shoes and put on heavy, woolen socks:

Restricted-Unpatterned (RU) condition - Subjects in this condition were seated in the experimental chair and given the three tasks to perform while wearing the prism headgear. Immediately after completing the tasks, the S was strapped into the chair so that his head, arm and leg movements were restricted. The S was able to see approximately 6 ft. directly in front of him but his environment was unpatterned and there were no objects in his field of vision. Sensory input from tactual, auditory and proprioceptive modalities was held to a minimum and the headgear prevented the S from viewing his own body. The S was then given the following instructions: "Now you are to remain in this room for one hour. During that time I will be in constant touch with you on an intercom system. I will
contact you at three intervals during the hour and give further instructions. Should you need to contact me at any time during the hour you may do so. At the end of the hour I will contact you on the intercom system and give you further instructions before coming into the room. Do you have any questions? Keep your eyes closed until I leave the room and instruct you by intercom that you may open your eyes.

The E then removed all objects from the room and left the room, contacting the S immediately on the intercom, instructing the S to open his eyes and making certain that the S could hear the E. During the hour, while immobilized, the S received the following instructions: "When I tell you to begin, I want you to imagine or think about the motions that you would go through to perform these various activities that I am going to tell you to do. Imagine doing these tasks as I tell you: Imagine that you are approaching a chair, that you are lowering yourself into this chair, that you are now seated and that you are now getting up. Imagine reaching your (right, left, either) arm out, now you are picking up a toy car and moving this car back and forth in front of you. Imagine moving your (right, left, either) arm up, gently pushing with your hand as though setting a butterfly mobile in motion." All imagined tasks were repeated by the E four times in succession.

At the end of the hour the E contacted the S on the intercom and gave him the following instructions: "Your hour is now up, close your eyes and keep them closed until I enter the room and give you further instructions." The E then entered the room, removed the straps, placed the board across the chair arms and had the S repeat the three experimental tasks.
Movement-Unpatterned (MU) condition - In this condition the S was seated in the experimental chair and, while wearing the prism headgear, given the 3 experimental tasks to do. As soon as the tasks were finished all objects (including the experimental chair) were removed from the room. The S was permitted to move about in the room in a homogeneous environment. The S could see parts of his body, such as arms and feet, but was not permitted to touch the sides of the room so that tactual and auditory stimulation were eliminated as much as possible. The following instructions were given to the S: "Now you are to remain in this room for one hour. During that time I will be in constant touch with you on an intercom system. I will contact you at three intervals during the hour and give you further instructions. Should you need to contact me at any time during the hour you may do so. At the end of the hour I will contact you on the intercom system and give you further instructions before coming into the room. Do you have any questions? You may move freely about the room or sit on the floor but do not remove the headgear or touch the sides of the room. Keep your eyes closed until I leave the room and instruct you by intercom that you may open your eyes." The S was then asked to stand up, the experimental chair was removed and the E then closed the opening in the curtains and left the room. The E then contacted the S on the intercom and informed him that he could open his eyes. Also, the E checked to make certain that the S could hear the E.

The E gave the S the following instructions during the hour: "When I tell you to begin, I want you to go through the motions for the various activities that I am going to tell you to do. Go through the motions as I tell you: "You are approaching a chair, you are lowering yourself into this chair, you are now seated and now you are getting up. Reach out with
your (right, left, either) arm, pick up a toy car, move this car back and forth in front of you. Move your (right, left, either) arm up, gently push with your hand to set the butterfly mobile in motion, return your arm to your side." All tasks were repeated by the E four times in succession.

The E contacted the S at the end of the hour and gave him further instructions: "Your hour is now up, please stand, face the back of the room, close your eyes, keep them closed until I enter the room and give you further instructions." The E then entered the experimental room, brought the experimental chair back into the room, seated the S in the chair, place the board across the chair arms and gave the three experimental tasks to the S.

Restricted-Patterned (RP) condition - The Ss in this condition were seated in the experimental chair and asked to perform the three experimental tasks while wearing the prism headgear. When the tasks were completed the S was restricted to the experimental chair so that movement by the S of arms, legs and head was reduced and also viewing the body was eliminated. Directly in front of the S, approximately 6 ft. from him and within his range of vision were objects such as a table, chair, flowers, toy car and a mobile. Tactual, auditory and kinesthetic input were reduced as much as possible. The Ss in this condition were given the same instructions as the Ss run under the Restricted-Umpatterned condition.

Movement-Patterned (MP) condition - The Ss, wearing the prism headgear, were seated in the experimental chair until completion of the three experimental tasks. Upon completion of these tasks the experimental chair was removed from the room and the S was allowed to move about in the room.
The S could see a chair, table, flowers, mobile and toy car at one end of the room but was instructed not to use these objects unless told to do so by the E. The same instructions were given to the Ss in this condition that the Ss received in the condition allowing movement but having a homogeneous environment.

All Ss were contacted at 15-minute intervals during the hour experimental condition.

In all experimental conditions the Ss were told that the E was interested in finding out how people behaved in an inverted field and that they would be given three experimental tasks to test for adaptation. The E then asked the S to put the prism headgear on and made any necessary adjustments after which the S was told to close his eyes until the tasks were presented. A board was placed across the arms of the experimental chair to provide the S with a working space for the tasks. The tasks were then presented randomly to each S.

Three tasks were used to measure the amount of adaptation that had taken place during the experimental conditions. The tasks selected were reading, tracing, and a formboard task and were chosen on the basis of Werner’s (1957) developmental theory, that development follows an orderly sequence proceeding "...from a state of relative globality and lack of differentiation to a state of increasing differentiation, articulation, and hierarchic integration." In adapting to a visually inverted field this same progression would be followed, adaptation taking place first on a gross sensorimotor level involving large body movements and as the adaptation increased smaller sensorimotor coordinations would take place. The formboard task would involve a comparatively gross level of body activity, the S could make use of large body movements to perform this task. A finer visuo-motor coordination would be necessary for the tracing task and the S would engage in more limited and finer body movements.
The reading task would require the finest visuo-motor movements as only the eyes would be involved.

In the reading task the book selected was at the 12-year age level, with large, easy-to-read print. The measure for this task was the number of words correctly read. Two paragraphs of approximately equal difficulty and length (109 and 130 words) were selected for this task (see Fig. 5). The Ss were asked to read one paragraph before the hour experimental condition began and then read the second paragraph at the end of the hour. Two minutes were allowed for each reading task. All Ss were given the same paragraph for the first and second readings. Instructions given by the E to the S for this task were as follows: "This is a reading task and in front of you on the board is a book. I want you to read aloud to me and if you are unable to identify a word, leave that word and go on to the next word. Do not touch the book with your hands. Do you have any questions? Open your eyes, can you see the book? Begin reading where my pencil is pointing when I tell you to start and continue reading until I tell you to stop. Ready? Begin. Stop, close your eyes."

The tracing task consisted of four figures, one abstract and one concrete drawing of two birds and one abstract and one concrete drawing of a tractor (see Fig. 6a,b,c,d). The abstract drawings consisted of only the outline of the birds and tractor, while the concrete drawings had completed figures of the birds and tractor. Both the birds and tractor drawings were approximately 28" in circumference. A 2-line channel, 1/4" wide, made up the outline of all tracings and the measure for this task was the number of times the S crossed these lines while tracing the figure. All tracings were presented to the Ss before the hour experimental condition and at the end of the hour. Tracings were
presented in random order each time. Two minutes were allowed for completion of each drawing. Instructions given for this task were as follows: "This task is a tracing task. There will be four drawings that you are to trace around, keeping between the lines that make up the figure. Work as accurately and rapidly as you can until you have either completed the drawing or until I tell you to stop. Do you have any questions? Open your eyes, can you see the figure? Here is your pencil, place it where my pencil is pointing. You may go in either direction on the drawing, but once started continue in that direction. Are you ready? Begin. Stop, close your eyes."

The formboard task (see Fig. 7) consisted of having the Ss put 10 wooden forms back in the proper position on the Stoelting formboard. The measure for this task was the amount of time needed to complete the task. The Ss did the formboard task at the beginning and end of the experimental hour. The instructions given on this task were: "This task is a formboard task. I will place various forms in front of you. When I tell you to begin, pick up these forms one at a time and put them in the appropriate place on the board. Do you have any questions? Open your eyes and tell me if you can see the formboard. Ready? Begin. Close your eyes."

All tasks were presented to the Ss while wearing the prism headgear. Each S was tested in the experimental room while seated in the experimental chair. A board was placed across the chair arms to serve as a working area for the S so that all tasks were within range of the S's visual field and within easy reach of the S. The only portion of S's body that could be seen by the S during the tasks was the hand used to perform the activities.
RESULTS

Three experimental tasks were used to determine whether varying amounts of adaptation had resulted from the Ss experiencing different experimental conditions. Each task was analyzed separately and will be presented separately.

In analyzing the formboard task by a 3-way factorial analysis of variance with correlation on one measure the three factors included sex, the four experimental conditions and the pre and post conditions. Significant results were found between the pre and post conditions ($F = 4.50$, $df = 1/72$, $p < .05$). Table 1 indicates that no significant differences were found between males and females and that there were no significant main effects or interactions between the experimental conditions. This would indicate that performance on this task was not affected by sex differences, movement nor patterning of the environment.

Insert Table 1 here

The control group's results on the formboard task were analyzed by a Type I analysis of variance based on sex and pre and post conditions. This analysis showed a significant difference between the pre and post conditions ($F = 23.18$, $df = 1/18$, $p < .01$).

Figure 8 gives the pre and post performance means of all groups for the formboard task. It can be seen that all groups improved their performance on the post task but all groups scored similarly on the pre and post performance.

Insert Fig. 8 here
The reading task for the four experimental groups was also analyzed by a 3-way factorial analysis of variance with correlation on one measure. Results of this analysis show a significant difference between the pre and post conditions ($F = 13.47, df = 1/72, p < .01$), but no significant results were found for either the experimental conditions or between males and females (see Table 2). These results again indicate that varying the experimental conditions did not affect performance in reading nor did sex differences have an effect.

A Type I analysis of variance indicated a significant difference between the pre and post conditions ($F = 20.57, df = 1/18, p < .01$) for the control group on the reading task.

The pre and post performance on the reading task for all groups is shown in Fig. 9. Again, all groups improved between the pre and post performance but no significant differences resulted as a result of the experimental conditions.

A 3-way factorial analysis of variance was also used for the tracing task. When combined scores were used, significant results were found between the pre and post conditions ($F = 133.66, df = 1/72, p < .01$), and between males and females ($F = 12.08, df = 1/72, p < .01$). Table 3 shows that differences between experimental conditions were not significant, indicating that performance on this task was not affected by movement or patterning.
A Type I analysis of variance performed on the control group's scores on the tracing task found significant differences between males and females (F = 4.76, df = 1/18, p < .05) and between the pre and post performances (F = 54.03, df = 1/18, p < .001).

Figure 10 shows means for pre and post performances on the tracing task for all groups, indicating that all groups similarly improved on performance between the pre and post task.

The abstract-concrete factor in the tracing task was analyzed by a 3-way factorial analysis of variance (correlation on one measure). Table 4 shows that the only significant results were between the pre and post performances (F = 107.94, df = 1/72, p < .01). Performance on the tracing task was not significantly affected by the contents or lack of contents of the drawings.

DISCUSSION

This study was conducted to determine what effect the factors of body movement, environment and sex differences would have on adaptation to a visually inverted field.

The first hypothesis stated that individuals who actively moved their bodies in an inverted field would adapt to a greater extent than
Ss who were restricted or passive. This hypothesis was not supported when the performances on the experimental tasks of Ss in the four experimental conditions were compared. It was found that it apparently made no difference in an S's adaptation whether the S could move about or whether he was in a restricted situation. In contrasting the performances on the formboard, tracing and reading tasks of the experimental Ss with the control Ss (see Figs. 8, 9, 10) it can be seen that the intervening experimental condition between the pre and post performances had no effect on adaptation but that a practice effect was present for all groups between their pre and post performances.

The studies conducted by Held and others suggested that movement was an important factor in adaptation. In comparing this study with those by Held and others, similar results were not obtained although all studies had Ss that engaged in self-produced movements and Ss that were in a restricted or passive situation. In explaining the inconsistency of results in the studies, it is suggested that a difference in the activities required of the Ss in the restricted conditions of this study may have resulted in the role of movement not being a significantly facilitative factor in adaptation. In the present study, during the hour that the Ss were in the restricted experimental conditions they were required to actively think of the movements they would ordinarily go through to perform certain actions. The results obtained in this study may be an indication that actual movement is not necessary for adaptation but that thinking about intended activity will produce cues to reinteegrate visuo-motor coordinations.

The second hypothesis stated that a patterned environment, in contrast to a homogeneous (non-patterned) environment, might be a factor in
adaptation. In analyzing the results from the three experimental tasks, it was found that patterning or lack of patterning in the environment did not aid or hinder adaptation. Again, in looking at Figs. 8, 9, and 10, it can be seen that all experimental groups, regardless of whether in a patterned or homogeneous environment, showed an improvement in their post performance on all three experimental tasks. Since the control group showed similar performance records on these tasks, this would indicate that the results obtained were influenced by practice on the tasks rather than by experimental conditions.

The experimental tasks were selected on the basis of Werner's "systematic developmental progression," that gross motor performance develops first, followed by finer motor responses. The formboard task was considered to involve gross motor activity with the tracing task requiring finer visuo-motor coordinations while the reading task was considered to be the most complex and to require very fine visuo-motor movements. It was hypothesized that activities requiring very fine motor movements would be more sensitive to changes in the environment. However, while all experimental tasks revealed improvement in performance between pre and post records there was no indication that performance on any of the tasks was influenced by the variations in the experimental conditions. Possibly the tasks did not differ enough as both the formboard and tracing tasks involved movement of a hand and all three tasks required vision. If the gross motor tasks had required the use of the entire body and the very fine visuo-motor movement task had been one involving reading material at a more difficult level or a more demanding conceptual task perhaps performance on the tasks would have shown a more discriminatory response to environmental changes.
The study by Miller and Kemp, suggesting that some aspects of the environment attract more attention than others, suggested that type of tracing (abstract or concrete) might have an effect on adaptation. However, results from this analysis did not reveal any significant differences due to the characteristics of the drawings although it was felt that Ss would have less difficulty tracing the abstract drawings while the concrete figures would be more difficult. The general trend was for Ss to show an improvement with each successive tracing regardless of whether it was abstract or concrete, suggesting that practice alone facilitated performance. It is felt that the Ss concentrated on the outline of the tracings and on the movement of their hand and were not attending to the content of the figure as they were not required to make use of the meaning of the material.

Although it was hypothesized that males would show greater adaptation than females, the opposite results were found for one experimental task. It was felt that males would show greater adaptation on all three experimental tasks but the tracing task was the only task to indicate that sex differences might be a factor in adapting to a visually inverted field. Neither the formboard nor the reading tasks discriminated between male and female performances. On the formboard task where large body movements could be used both males and females did equally well. The reading task, dependent on eye movements only, was equally difficult for both sexes.

Witkin's study and the Miller and Kemp study suggested that men would be more able to disregard visual cues and rely on body cues in performing tasks involving both visual and kinesthetic cues but this was not the
finding of this study. It is suggested that the females either disregarded the body cues (arm movements) or were able to integrate both visual and body cues for a more effective performance.

One factor that may have influenced the results obtained in this study was the semi-isolation period between the pre and post performances on the experimental tasks. All Ss experienced this semi-isolation period for one hour. During this hour they were contacted by the E at three different intervals but had no other auditory stimulation. Also, the tactual and visual stimulation during the restricted conditions was very limited with slightly more stimulation existing during the movement conditions. However, in order to control the environment so that certain variables could be manipulated (movement, patterning) it was considered desirable to keep the Ss in semi-isolation. Studies by Stratton, Snyder and Pronko, Kohler, and Kottenhoff were conducted in a normal, stable environment which aided adaptation. It is suggested that in this study the effect of being partially isolated may have been a disrupting influence which counteracted the experimental conditions.

SUMMARY

In this study the roles of movement, environment and sex differences were related to adaptation to a visually inverted field. One hundred Ss were used, 20 (10 males and 10 females) in a control group and 20 (10 males and 10 females) in each of four experimental conditions. Three experimental tasks, reading, tracing, and a formboard, were used to measure the amount of adaptation that had taken place. All three tasks were analyzed separately by a 3-way factorial analysis of variance. Results indicated that all groups improved between the pre and post performances on the three tasks but adaptation was not affected by the experimental conditions.
REFERENCES


Held, R., & Schlank, M. Adaptation to disarranged eye-hand coordination in the distance dimension. Amer. J. Psychol., 1959, 72, 603-605.


Table 1

Analysis of Variance of Formboard Task
(Scores in Terms of Seconds Required to Complete Task)

<table>
<thead>
<tr>
<th>Sources</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp. Cond.</td>
<td>3</td>
<td>1714.57</td>
<td>0.56</td>
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<tr>
<td>Pre and Post</td>
<td>1</td>
<td>74,520.00</td>
<td>45.05*</td>
</tr>
<tr>
<td>Cond. x Pre and Post</td>
<td>3</td>
<td>2333.45</td>
<td>1.41</td>
</tr>
<tr>
<td>Male and Female</td>
<td>1</td>
<td>8599.56</td>
<td>2.83</td>
</tr>
<tr>
<td>Male and Female x Pre and Post</td>
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<td>6039.30</td>
<td>3.65</td>
</tr>
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<td>Male and Female x Cond.</td>
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<td>6147.90</td>
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<td>Male and Female x Cond. x Pre and Post</td>
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<td>1250.21</td>
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<tr>
<td>Subjects</td>
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<td>3036.00</td>
<td></td>
</tr>
<tr>
<td>Subjects x Pre and Post</td>
<td>72</td>
<td>1654.10</td>
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*P < .01
Table 2
Analysis of Variance for Reading Task
(Scores in Terms of Correct Words Read)

<table>
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<tr>
<th>Sources</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Exp. Cond.</td>
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<td>0.03</td>
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<tr>
<td>Pre and Post</td>
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<td>2472.76</td>
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<td>Cond. x Pre and Post</td>
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<td>71.30</td>
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<tr>
<td>Male and Female</td>
<td>1</td>
<td>486.51</td>
<td>0.03</td>
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<tr>
<td>Male and Female x Pre and Post</td>
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<td>Male and Female x Cond.</td>
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<td>4173.52</td>
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<td>Male and Female x Cond. x Pre and Post</td>
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<tr>
<td>Subjects</td>
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<td>1662.78</td>
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<tr>
<td>Subjects x Pre and Post</td>
<td>72</td>
<td>183.56</td>
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</table>

*p < .01
Table 3

Analysis of Variance for Combined Pre and Post Scores on Tracing Task

(Measure Was Number of Times Crossed Channel Lines)

<table>
<thead>
<tr>
<th>Sources</th>
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<th>MS</th>
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<tbody>
<tr>
<td>Exp. Cond.</td>
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<tr>
<td>Pre and Post</td>
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<td>133.66**</td>
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<td>0.07</td>
</tr>
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<td>Male and Female x Cond. x Pre and Post</td>
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<td>347.86</td>
<td>0.24</td>
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<tr>
<td>Subjects</td>
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<td>4783.87</td>
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<tr>
<td>Subjects x Pre and Post</td>
<td>72</td>
<td>1446.01</td>
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</table>

* p < .01
** p < .001
Table 4
Analysis of Variance for Abstract and Concrete Factor in Tracing Task
(Measure Was Number of Times Channel Lines Crossed)

<table>
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<th>Sources</th>
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<td>Pre and Post</td>
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<td>227.90*</td>
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<td>Abst. and Conc. x Pre and Post</td>
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<td>548.63</td>
<td>1.29</td>
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<tr>
<td>Exp. Cond.</td>
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<td>1228.43</td>
<td>0.41</td>
</tr>
<tr>
<td>Exp. Cond. x Pre and Post</td>
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<td>312.50</td>
<td>0.74</td>
</tr>
<tr>
<td>Exp. Cond. x Abst. and Conc.</td>
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<td>29.46</td>
<td>0.01</td>
</tr>
<tr>
<td>Abst. and Conc. x Cond. x Pre</td>
<td>3</td>
<td>157.59</td>
<td></td>
</tr>
<tr>
<td>Subjects x Pre and Post</td>
<td>72</td>
<td>2994.12</td>
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<tr>
<td>Subjects x Pre and Post</td>
<td>72</td>
<td>424.05</td>
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</table>

*P < .001
FIGURE CAPTIONS

Figure 1. Experimental room as it appeared for conditions requiring a homogeneous environment.

Figure 2. Experimental chair with movable head and leg rest.

Figure 3. Welder's helmet used to hold the inverting prism.

Figure 4. Experimental room and location of objects for patterned environment.

Figure 5. Paragraphs selected for the reading task.

Figure 6a. Concrete drawing of birds.

Figure 6b. Abstract drawing of tractor.

Figure 6c. Concrete drawing of tractor.

Figure 6d. Abstract drawing of birds.

Figure 7. C. H. Stoelting 10-form wooden formboard.

Figure 8. Pre and post performance (means) of all experimental conditions and the control group on the formboard task.

Figure 9. Pre and post performance (means) of all experimental conditions and the control group on the reading task.

Figure 10. Pre and post performance (means) of all experimental conditions and the control group on the tracing task.
CLOTH COVERED CEILING

WALLS AND FLOOR CLOTH COVERED TO FORM CYLINDER

FIGURE 1
FIGURE 2

ADJUSTABLE HEAD REST

PADS

ADJUSTABLE LEG REST
Morgan told every man in his outfit exactly what he wanted. The sharpshooters were to hide behind trees and wait till the enemy got to within 150 feet. Then they were to take careful aim and make every shot count. After only two volleys the sharpshooters could fall back to the second line—the militia—firing as they withdrew. The militia were asked to aim carefully and to stay as long as they could. But when they felt they had had all the punishment they could stand, they were to retreat. They were to march around behind the Continentals. There they could form up to fight again if they wished.

Green's remark may seem odd, since his small army was still pursued by a big army he didn't dare fight. But Greene knew from his own experience that there was practically no food and shelter in North Carolina. He knew how hard it was going to be to march across the sandy pine plains and through the swamps and rivers swollen by February rains. And his bold plan was to keep Cornwallis running after him, leading the British into exhaustion all the way to the Virginia border. Brave and well-trained though they were, Cornwallis' men were used to a well-managed army that fed them on time and kept them warm and dry. Greene was sure that the British would suffer much more under wretched conditions than his own men.

FIGURE 5
FIGURE 6a
FIGURE 8

MEAN CORRECT SCORES

EXPERIMENTAL CONDITIONS

PRE POST
Cond. I  Cond. II  Cond. III  Cond. IV  Control
45.35  43.70  43.00  43.55  34.85  46.50  22.00  35.00
Figure 9

Experimental Conditions

Mean Errors

Pre Post Cond. I 134.75 70.10
Pre Post Cond. II 117.75 54.70
Pre Post Cond. III 135.25 65.00
Pre Post Cond. IV 112.70 62.30
Pre Post Control 169.90 55.50

EXPERIMENTAL CONDITIONS