THE EFFECT OF TRAINING AND OF STRUCTURAL AIDS ON PERFORMANCE IN THREE TESTS OF SPACE ORIENTATION

(AAF Technical Report No. 92)

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THE EFFECT OF TRAINING AND OF STRUCTURAL AIDS ON PERFORMANCE IN THREE TESTS OF SPACE ORIENTATION

by

H. A. Witkin

A report on research conducted at Brooklyn College, Brooklyn, New York, under the auspices of the National Research Council Committee on Aviation Psychology, with funds provided by the Civil Aeronautics Administration.

October 1948

CIVIL AERONAUTICS ADMINISTRATION
Division of Research
Report No. 80
Washington, D. C.

National Research Council

Committee on Aviation Psychology

Executive Subcommittee

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National Research Council

1948

LETTER OF TRANSMITTAL

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, Washington, D. C.
Division of Anthropology and Psychology

Committee on Aviation Psychology

October 28, 1948

Dr. Dean R. Brimhall
Director, Office of Research
Civil Aeronautics Administration
Room 5217, Commerce Building
Washington 25, D. C.

Dear Dr. Brimhall:

Attached is a report, entitled The Effect of Training and Structural Aids on Performance in Three Tests of Space Orientation, by H. A. Witkin. This report is submitted by the Committee on Aviation Psychology with the recommendation that it be included in the series of Technical Reports issued by the Division of Research, Civil Aeronautics Administration.

The investigation described in this report represents research on fundamental aspects of space perception which have many theoretical as well as practical implications. It is of interest to note that these implications are being investigated in studies which are being conducted at the Naval Air Training Station, Pensacola, Florida, under the joint sponsorship of the United States Navy and the United States Air Force. Moreover, the investigation described in the attached report, conducted under the auspices of the Committee on Selection and Training of Aircraft Pilots (now the Committee on Aviation Psychology), with funds allotted by the Civil Aeronautics Administration, has led into additional extensive research in the form of basic investigations of space orientation which are now under way at Brooklyn College, under the auspices of the Office of Naval Research. The significance of the study described in the report may well be enhanced through the integration of the results of this investigation with those developed in these investigations.

Cordially yours,

Morris S. Viteles, Chairman
Committee on Aviation Psychology
National Research Council

MSV:maf

EDITORIAL FOREWORD

The investigation described in this report grew out of earlier studies by H. A. Witkin and S. E. Asch, ~~in the course of which the orientation tests employed in this investigation were developed.~~ The investigation was initiated by H. A. Witkin under a research fellowship from the National Research Council and was later continued by the same investigator through a subcontract with Brooklyn College. In addition, studies of the effectiveness of the tests as predictors of flight proficiency were undertaken during World War II under the auspices of the Army Air Forces in close coordination with the Committee on Selection and Training of Aircraft Pilots (now the Committee on Aviation Psychology).

The present report is concerned primarily with the investigation of the influence of training and structural aids upon spatial orientation. The results of this study indicate that performance in the Stability of Orientation Test is improved both by training and by "structural aids" to orientation and that the improvement effected by training shows transfer to another test of orientation. However, it cannot be inferred, from the results of this investigation, that the training procedures employed would lead to improved orientation in other situations. In other words, it cannot be inferred that the training procedures, involving the use of the Stability of Orientation Tests, would improve orientation during instrument flight. Further investigations of the practical implications of the findings of this study would be required before generalizations of this nature could be made. Acknowledgment should be given to Dr. David Bakan, Ohio State University, who contributed to the statistical design of the study and who was largely responsible for the statistical analysis.

October 28, 1948

M. S. Viteles, Chairman
Committee on Aviation Psychology

CONTENTS

SUMMARY

The purpose of this investigation was to determine the effect of training and of structural aids on performance in three tests of space orientation. The three tests employed were: the Stability of Orientation Test, the Dark-Room Test, and the Rotating-Room Test. Four basic groups of 49 subjects each were employed.

The three tests were administered at least twice to members of each group. Subjects in Group I, the "Training Group" were subjected to a training program between the first and second administration of the tests, designed to furnish insight into the problem of orientation, and to afford further supervised training in the Stability of Orientation Test. Group II represented the "Structural Aids Group." Upon the second administration of the test to this group certain structural features of the test situation (i.e., the enclosed room in which the subject sat) were changed, in order to render the structure of the visual field less compelling as a visual cue to orientation. Group III, the "Interpolated Testing Group," represented the first of two control groups. Subjects in this group were given two additional one-hour periods of standard testing in the Stability of Orientation Test, administered between the official test and retest periods. Group IV, the second control group, was designated the "Test-Retest Group." These subjects merely were tested, and later retested, on all three tests. The length of time between test and retest was comparable for subjects in all groups.

Subjects in the four groups were matched in terms of initial performance on the Stability of Orientation Test. Nevertheless, in evaluating the performance of subjects in the various groups on retest, to determine the effect of the differential treatment accorded to subjects in the four groups, analysis of covariance was used.

The results of the analysis indicated that:

1. The training procedures used in these experiments produced general improvement in orientation in the situation in which the training was administered, and it also led to improvement in one of two transfer situations, (the Dark-Room Test) involving a rather different kind of orientation problem.

2. The structural changes made in the external situation to aid orientation also produced significant improvement in orientation in the situation in which they were used. The improvement achieved by the structural aids group was not transferred to other types of orientation situations. This was to be expected, since the structural aids are of help only in the situation in which they are present, and only during the time that they are present.

3. When the task was to adjust the body to the upright, the structural aids group even did slightly better than the group which received training. However, when the task was to adjust the visual field itself to the upright, the training group was found to have improved more than the structural aids group.

4. Practice in a variety of orientation tasks in the Stability of Orientation Test, even without instruction, led to improvement in the standard Stability of Orientation Test, and there was some tendency for this improvement to be transferred to a different type of orientation situation. However, the improvement accomplished through such self-learning was not as great as that achieved when instructions were given, as in the training group.

In comparing the training and structural aids approaches to improving orientation it is indicated that whereas the effectiveness of training may be transferred to other situations, the effectiveness of structural aids is not. On the other hand, whereas the training procedures apparently produce a more valid interpretation of sensory experiences, the structural aids tend to alter the perceptions themselves. This may be more valuable to an individual than an improved facility for "figuring out" the true state of affairs. Furthermore introduction of structural aids is less time consuming than is the administration of a training program. In view of the advantages and disadvantages of the two techniques for improving orientation, a combination of both is suggested.

THE EFFECT OF TRAINING AND OF STRUCTURAL AIDS ON PERFORMANCE IN THREE TESTS OF SPACE ORIENTATION

INTRODUCTION

Under ordinary circumstances, the maintenance of proper orientation presents no problem whatever. The individual has at all times a correct conception of the vertical and horizontal axes of space, which is arrived at quickly and without deliberation. Orientation is a continuous process, and enters in the perception of all objects; for objects, including the body itself, are perceived as having a given direction--as being upright or tilted. Orientation is also a basic process, affecting the movement of the person's own body as well as his adjustment to objects in the environment. For these reasons it is most fortunate that proper orientation is achieved effortlessly and with great precision.

The fact that disorientation rarely occurs in the experience of the man on the street is an indication of the stability of the factors responsible for the maintenance of orientation. Under certain conditions, however, it may become difficult to maintain one's bearings and severe disorientation may occur. Conditions leading to disorientation may occur in aircraft during flight, and because of this, that situation presents some of the most challenging problems to be found in the literature on space orientation. From the standpoint of the sensory sources available for orientation, the situation in the plane is extremely complicated and unstable. In place of the single visual field normally found in our surroundings, there are in the case of the plane two fields--that of the cockpit and that of the earth below--and these may be in conflict. Also, the centrifugal force generated in making a turn presents a further problem in the plane; for the upright indicated by the earth, may also be in conflict with the upright indicated by the cockpit. It is thus possible for the environment to present as many as three different "uprights," and these must be properly integrated in establishing one's position in space. Finally, in contrast with the very stable conditions normally found in our environment, during flight a constantly changing situation is presented. It is not surprising that under these conditions it is at times difficult to maintain one's bearings. In fact, even instruments may not be of much help at moments of disorientation, for the cues they provide may remain as "intellectual data" which cannot readily be brought into relation with more direct sensory experiences. In the disorientation, or vertigo, which may result in the absence of proper sensory integration, the individual could be upside down and believe he is upright, or be falling off in a left bank and feel that he is in straight and level flight or suddenly see the sky where he believes the earth should be, and so on. Occurrences such as these lead to an appreciation of the marked stability that normally characterizes our orientation in space.

In 1941 a systematic investigation of problems of space orientation was begun at the psychological laboratories of Brooklyn College. Since the main determinants of orientation are closely interrelated, it was first of all necessary to develop special laboratory techniques to separate them. In particular, orientation is based upon two types of sensory experiences, visual

and postural. Through vision we see an environment which is filled with verticals and horizontals; and by comparing the position of any object, and even the body itself, with these strongly indicated main axes of space it is possible to judge its direction. Another basis for establishing the upright is provided by gravity, which again represents the true vertical. As a result of the postural adjustments made to this downward-acting force, its direction is readily detected. Since the visually presented vertical and the gravitational vertical coincide, a study of the contribution of each demands their separation. A variety of techniques was developed to achieve this purpose. In one type of experiment, the entire visual field was tilted while the body remained erect; and the manner of determining the upright under these conditions was observed.[1] In another experiment, the visual field was eliminated entirely, by working in a completely darkened room, so that only the postural basis for judging the upright remained.[2] In still another experiment, the subject was rotated in a small, enclosed chamber.[3] As a result of the centrifugal force generated by rotation, the force exerted on the body was no longer downward but at an angle. At the same time, the chamber in which the subject was contained presented an upright visual field. Orientation under these conditions of a displaced gravitational vertical and an upright visual vertical was investigated.

With these and other techniques it was established that orientation in man has, primarily, a visual basis. The judgment of direction of objects in the environment and of the body itself is based for the most part on the perceived relation between these objects and the vertical and horizontal axes of the prevailing surroundings. Postural factors were found to play a secondary role in judging the upright. When visual factors were eliminated, and postural factors alone remained, they permitted a correct determination of the upright only when the body was erect, with large errors resulting when the body was tilted. In addition to demonstrating the influence of visual factors in orientation, these early studies also established the existence of striking individual differences in mode of orientation and in the ability to maintain one's bearings.

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[1] Asch, S. E., and Witkin, H. A. Studies in space orientation: I. Perception of the upright with displaced visual fields. J. exp. Psychol., 38, 1948, 325-337.

Asch, S. E., and Witkin, H. A. Studies in space orientation: II. Perception of the upright with displaced visual fields and with body tilted. Ibid., 38, 1948, 455-477.

Witkin, H. A., and Asch, S. E. Studies in space orientation. IV. Further experiments on perception of the upright with displaced visual fields. Ibid., 1948. (In press.)

[2] Witkin, H. A., and Asch, S. E. Studies in space orientation: III. Perception of the upright in the absence of a visual field. J. exp. Psychol., 1948. (In press.)

[3] Witkin, H. A. Perception of the upright during rotation. (In preparation.)

The investigation of these individual differences was taken up intensively in 1943, through a grant from the Committee on Selection and Training of Aircraft Pilots.[4] In view of the importance of orientation in flying, the objective was to develop a standardized test of orientation ability, which could be used to predict this aspect of flying performance. In preliminary experiments[5] there was developed a situation which more nearly simulated natural conditions of orientation, as compared with the situations used in the earlier work. This finally led to the Stability of Orientation Test, which is described later in this report.

PURPOSE OF THE STUDY

This research was directed toward investigation of methods for improving the individual's space orientation.[6] Two principal methods were employed: (a) training the individual to make more effective use of sensory cues available for orientation; (b) introducing into the situation certain structural features designed to serve as aids to orientation. In terms of the first method the problem of improvement of orientation is approached by dealing primarily with the individual; in terms of the second method the objective situation is manipulated.

DESCRIPTION OF APPARATUS

A description of the apparatus and test methods used will supply the background necessary for an understanding of the experimental procedures employed in the investigation. Space orientation of subjects was investigated by means of three test situations: the Stability of Orientation Test; the Dark Room Test; and the Rotating Room Test.[7] These tests are described briefly below. Detailed directions covering the standard operating procedures for administration of these tests are presented in Appendix 1.

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[4]Now the Committee on Aviation Psychology.

[5]Witkin, H. A. 1949. Perception of body position and of the position of the visual field. (In preparation.)

[6]It was originally planned that this investigation of methods for improving space orientation would follow a study of the efficiency of the Stability of Orientation Test as a predictor of success in flight training. Validation data were collected from approximately 3000 flight cadets, at the San Antonio Aviation Cadet Center during 1944-1945. However, because of the curtailment of the flight training program most of these cadets failed to go on into flight training, and insufficient criterion data were available to make possible validation of the test as a predictor. A validation study is being carried on at present, however, under the joint auspices of the United States Air Force and the United States Navy.

[7]Witkin, H. A. Individual differences in perception of the upright and their measurement. (In preparation.)

The Stability of Orientation Test. This test, a photograph of which is presented in Figure 1, represented the principal test of orientation ability; the other two tests being employed primarily as transfer situations. The test apparatus consists of a small room 5' 8-3/4" long x 6' wide x 5' 10-1/2" high, pivoted at the front center and back center so that it can swing freely from left to right about its anterior-posterior axis. By means of a worm gear arrangement which is activated in turn by an electrical drive, it is possible to tilt the room from left to right. Into this room through a rear opening is projected a chair mounted at the end of a shaft in an overhanging type of arrangement. A worm gear, again provided with an electric drive, permits tilting of the chair to left or right. The room and chair are essentially independent systems so that either may be tilted alone or both may be tilted together, to the same side or to opposite sides, at the same speed or at different speeds.

With this apparatus it is possible to displace the chair or room, or both, and require the subject to adjust either or both to what he believes to be the true upright. The salient feature of this situation is that the subject cannot see outside the room in which he is contained. Judgments of the upright must therefore be based on whatever information can be obtained from his own body and from the visual field provided by the surrounding room. Since either or both may be tilted, this is not an easy task. The essential nature of the situation is such that it provides a measure of the extent to which the subject is able to use sensations from his own body as a basis for judgment, and the extent to which he relies on the prevailing visual field.

The test procedure consists of tilting the room and chair to standard positions and then requiring the subject, on some trials, to adjust the room to the upright, and on other trials to adjust his own chair to the upright. Three series of trials, representing these different conditions are employed in the standard test:

Series 1: Room and chair are initially tilted to the same side, and the task is to adjust the room to the upright. Four trials are given under this condition.

Series 2: Room and chair are initially tilted to opposite sides, and again the room must be adjusted to the upright. Four trials also are given here.

Series 3: Room and chair are initially tilted to the same side, but now the chair must be brought to the upright. Three trials are given under this condition.

Series 1 and 2 are analogous in that they involve adjustment of the room, while Series 3 involves adjustment of the chair. Series 2 is more difficult than Series 1.

The score on each trial is represented by the difference in degrees, between the final position of room or chair as established by the subject, and the "true" upright. The score for a single series, is the sum of the scores for the trials constituting the series and the score for the test as a whole is the sum of the scores for the individual series.

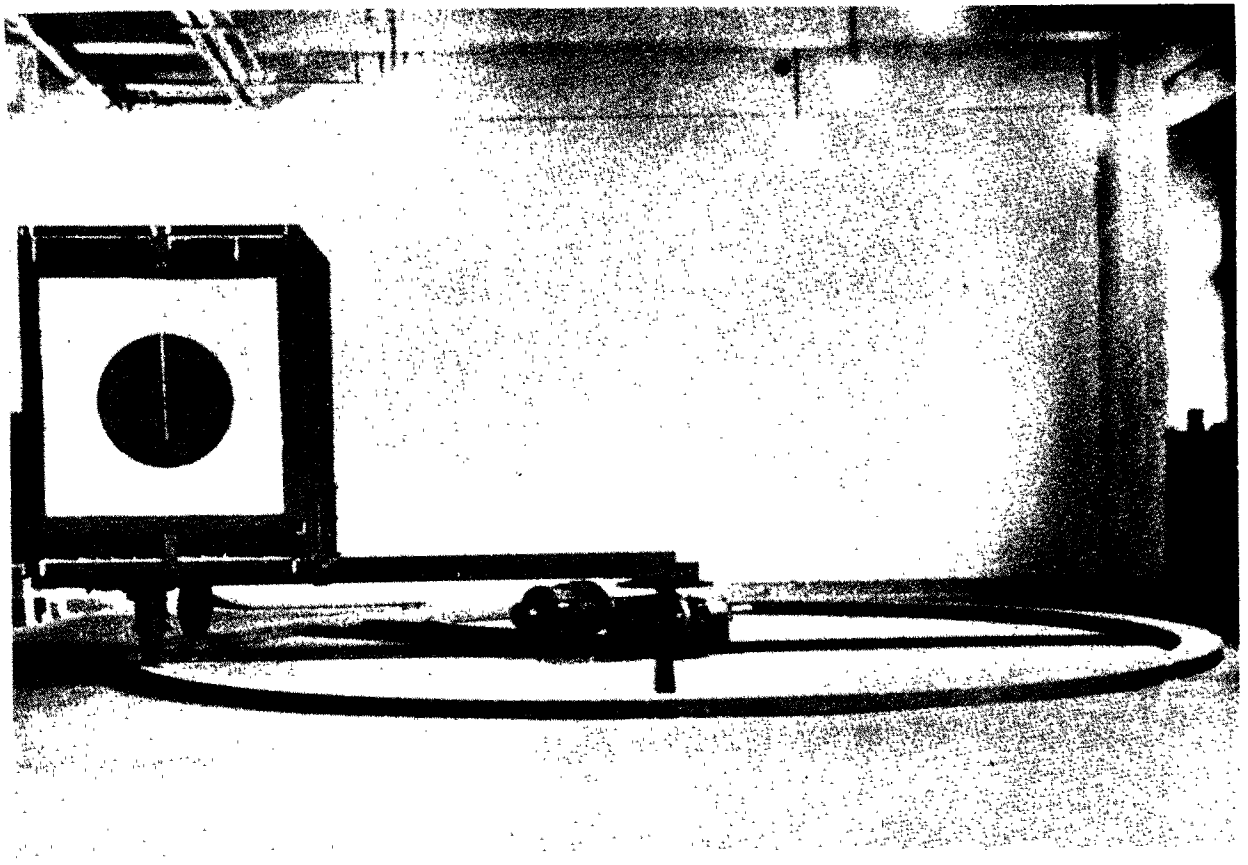

FIGURE 2

THE ROTATING-ROOM TEST

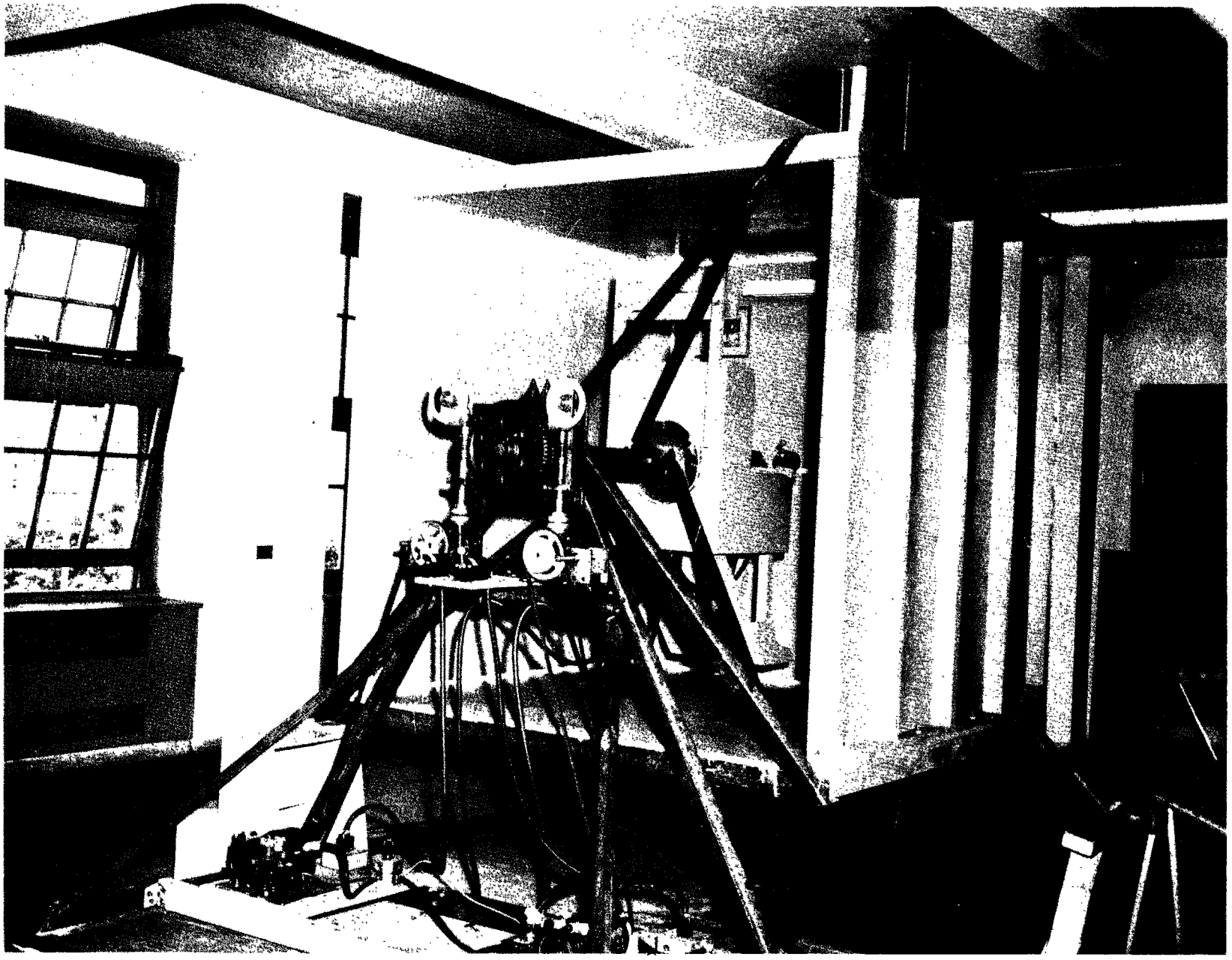

FIGURE 1

THE STABILITY OF ORIENTATION TEST

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Page 7, line 1, Figure 2 should read "Figure 3."

Page 7, line 6 from the bottom, Figure 3 should read "Figure 2."

The Dark-Room Test. This test, illustrated in Figure 2, was one of the two used in investigating effects of transfer, following training in the Stability of Orientation Test. The orientation problem presented to the subject here is different from that involved in the previous test in that here the cues available for judging the upright are much more ambiguous. The apparatus required for this test consists of a luminous square frame which is pivoted at its center and may be tilted about this center to left or right. Pivoted at the same center but moving independently of the frame is a luminous rod. Since the test is conducted in a completely darkened room, all the subject can see is the frame and the rod. The test consists of presenting the subject with the frame and rod in displaced positions and requiring him to adjust the rod to the true upright while the frame remains in its initially tilted position. Essentially, the nature of the task is such that it provides a measure of the influence of the prevailing visual field upon perception of the upright. As a further variable, this task is carried out with the body upright on some trials and tilted on others. It is, of course, much more difficult to make use of the body in judging the position of a distant line when the body is tilted than when it is erect. Accordingly, it becomes possible in this test to determine the extent to which the subject is able to involve the body in adjusting the rod, more particularly in overcoming the influence of the visual field; at times when it is easy to use the body and at times when it is difficult to use the body. In all, the test provides a measure of the success the subject has in integrating his bodily experiences and the visual impressions provided by the luminous frame in forming a judgment of the visual upright.

Three series of trials, each consisting of eight trials, comprise the standard test:

Series 1: The subject is tilted to one side, and the frame is initially tilted to the same side, while the rod is adjusted to the upright.

Series 2: Body and frame are tilted to opposite sides.

Series 3: The body is erect while the frame is tilted to one side or the other.

The order of difficulty of these three conditions in terms of increasing difficulty is 3, 1, 2.

The score on this test is again established in terms of the difference between the established upright and the true upright.

The Rotating-Room Test. This test situation was also employed in investigating the effects of transfer, and is illustrated in Figure 3.

The body and the visual field represent the two main bases for determining the upright, for through body sensations, it is possible to establish the gravitational vertical, and through viewing the field it is possible to establish the visual vertical. In the two previous tests, the procedure was followed of tilting the field and tilting the body. While tilting the field

did fundamentally change the direction of the visual vertical, tilting the body did not at all change the direction of the gravitational vertical. Even with the body upright, it is still possible to deduce the direction of gravity through bodily sensations arising from postural adjustment to this pull.

In the present test, through actually altering the forces acting on the body, the postural factors were changed in a more fundamental way than can be accomplished by tilting the body. To accomplish this, an outward acting centrifugal force provided by rotating the body was added to the downward pull of gravity yielding a resultant with a direction intermediate between the two forces. The apparatus employed for this test consisted of an enclosed room 5' high x 4' wide x 6' long, driven about a circular track 17.2' in diameter by a 2 horsepower motor at a speed of 809' per minute. On the front wall of this room, facing the subject, was a rod which he had to adjust to his conception of the upright. In this way, the effect of changing the forces acting on the body upon the person's conception of the upright could be quantitatively determined.

The test administered to the subject in this apparatus consisted of two series of four trials each:

Series 1: The subject adjusted the rod to the horizontal.

Series 2: The subject adjusted the rod to the vertical.

The two series are of about equal difficulty.

The score on this test is established as in the previous tests, in terms of the difference between the upright position, as determined by the subject, and the true upright.

PROCEDURES IN THE INVESTIGATION

The investigation utilized four basic experimental groups, each group consisting of 49 subjects. Subjects were Brooklyn College students. Of the total, 180 were females and 16 were males. The preponderance of females resulted from the fact that the study was carried out during the war years when very few male students were available. None of the subjects had had any flight training. The four groups were designated as: Group I, the Training Group; Group II, the Structural Aids Group; Group III, the Interpolated Testing Group; and Group IV, the Test-Retest Group. Groups III and IV were essentially control groups. In assigning subjects it was endeavored to equate members of the four groups in terms of scores on the first administration of the Stability of Orientation Test.[8]

Each of the three tests were first administered to subjects in the four groups, as indicated in Table 1, Schedule of Testing. Following the initial

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[8] A test of the adequacy of this matching will be considered subsequently under the section devoted to "Results."

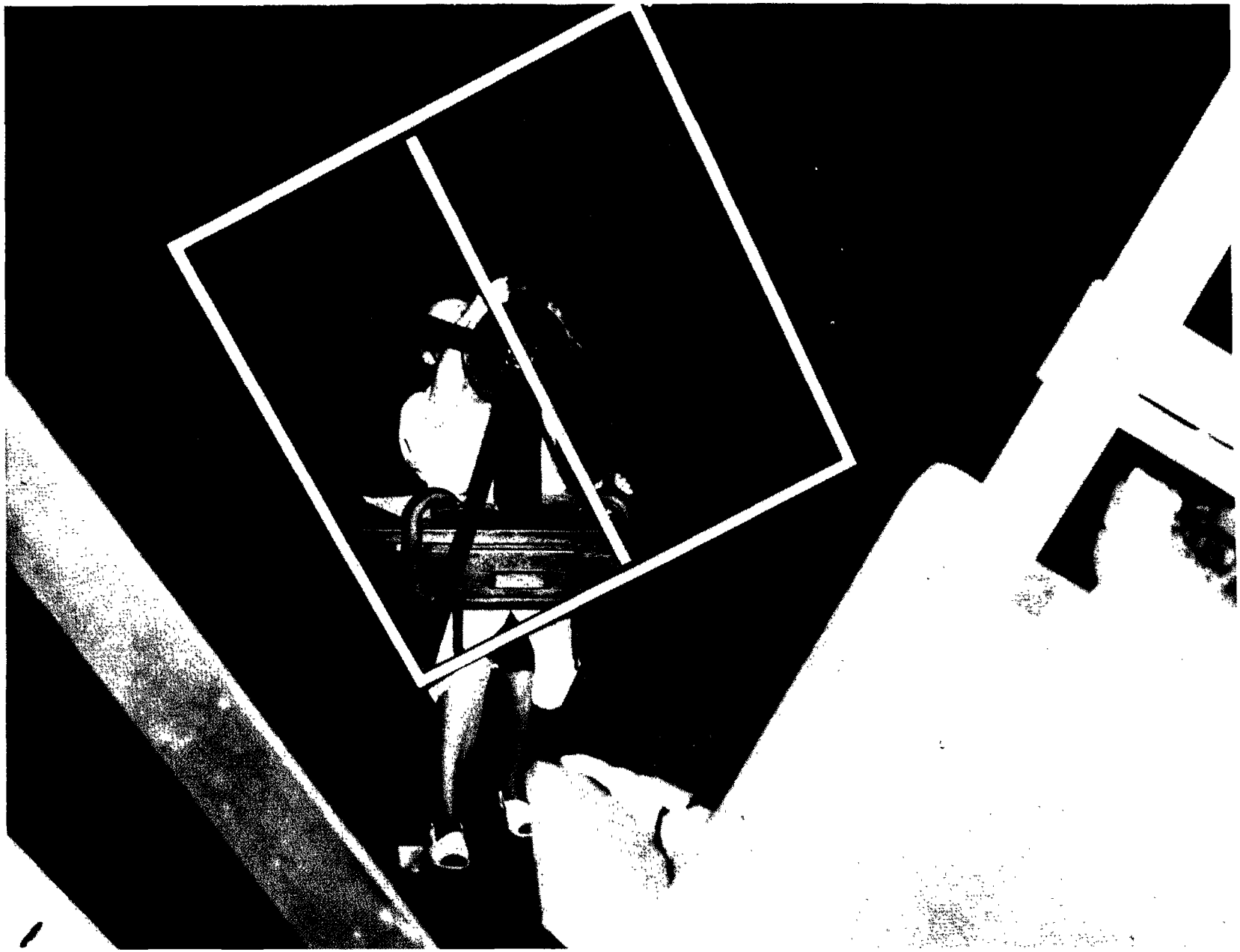

FIGURE 3

THE DARK-ROOM TEST

TABLE 1

SCHEDULE OF TESTING

	Group I Training Group (N = 49)	Group II Structural-Aids Group (N = 49)	Group III Interpolated-Testing Control Group (N = 49)	Group IV Test-and-Retest Control Group (N = 49)
a Initial Tests	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test
b Intervening period	(a) One-hour lecture on space orientation (b) Two one-hour periods of training in tilting-room-tilting-chair apparatus		(a) Two one-hour periods of standard testing in Stability of Orientation Test	
c Retests	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test	(a) Standard Stability of Orientation Test with Structural Aids added (b) Standard Dark-Room Test (c) Standard Rotating-Room Test	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test	(a) Standard Stability of Orientation Test (b) Standard Dark-Room Test (c) Standard Rotating-Room Test

Note: The interval between period a, the initial testing period, and period c, the retesting period, was approximately the same for all four groups, averaging about five weeks.

tests subjects in the various groups received differential treatment, and then were again tested, as indicated in Table 1, and as outlined below.

Group I, the Training Group. Essentially, the procedure followed with this group was, first, to test each member in the standard Stability of Orientation Test to determine his initial status, then to administer a regime of training in orientation, and finally, to retest him on the Stability of Orientation Test, to determine whether any improvement had taken place. In addition to evaluating improvement through changed performance in the Stability of Orientation Test, the extent of transfer of the training to other kinds of orientation situations was also determined. The transfer situations employed were, as indicated previously, the Dark-Room Test, and the Rotating-Room Test. As is evident from the description of these situations they entail rather different kinds of orientation tasks than does the Stability of Orientation Test. The members of this group were thus tested in the standard Stability of Orientation Test, the Dark-Room Test, and the Rotating-Room Test before and after training.

The training procedure developed was based on earlier findings that poor orientation in the type of situations represented by the three tests results from an excessive reliance upon visual impressions, with the result that these overwhelm other types of sensory experience. Consequently, sensory integration is poor. The task of training accordingly became one of teaching the subjects to give more attention to sensory experiences other than visual ones, and to give adequate weight to these in the final integration. The specific training procedure consisted of a one-hour lecture on space orientation, followed by two one-hour training sessions in the tilting-room-tilting-chair apparatus used for the Stability of Orientation Test. The lecture was given to the entire group at the same time and included a discussion of the sense modalities employed in orientation; the manner in which they are normally used in getting one's bearings; the consequences of excessive reliance upon one kind of sensory experience; an analysis of several specific orientation situations and the vertigo effects occurring in each; and so on. The training sessions carried out in the tilting-room-tilting-chair apparatus, involved the presentation of the following series of demonstrations, among others: various illusions which occur in orientation; situations in which it is particularly difficult to get one's bearings; the manner in which reliance upon visual experiences will lead to one judgment of the upright while reliance upon postural experiences will lead to a very different judgment; the kinds of situations in which the subject experiences particular difficulty and the basis for the difficulty; and so on. The subject was provided with an opportunity both to make observations and to perform himself. A detailed syllabus of these training procedures is presented in Appendix 2.

Group II, the Structural Aids Group. With this group, improvement in performance was attempted through making changes in the external situation. As noted earlier, poor orientation in the situations represented by the tests being used here results primarily from excessive dependence upon the visual field. In instances of poor orientation, the upright of the prevailing visual field is taken to represent the true upright even when the field is very much displaced and its vertical considerably removed from the real

vertical. To the extent that visual impressions have primacy in such modes of orientation, postural experiences tend to be neglected. In fact, often, in such cases, the tendency to judge the upright in accordance with the prevailing visual field applies even to the body itself. That is, the body is judged to be straight when it looks straight in relation to the surrounding field, rather than when it feels straight. To be made erect, it is displaced from the true upright in the direction of the tilt of the field, to a position where it looks straight, to the disregard of bodily sensations of tilt which result.

It was clear from such observations that to improve orientation, it would be best to change the objective situation so that visual impressions are minimized and bodily sensations emphasized. To accomplish the former, the framework presented by the visual field must be weakened. To weaken the visual field, some of its main lines and some of its regions of articulation need to be eliminated. Accordingly, the square room of the tilting-room-tilting-chair apparatus used in the Stability of Orientation Test was converted to a circular form, with the axis of the resulting cylinder running through the anterior-posterior axis of the room. Further, some of the prominent verticals and horizontals on the front wall of the room were eliminated. In this way, the framework of the visual field was considerably weakened. It should be noted, however, that the vertical-horizontal and the top-bottom dimensions of the room were adequately indicated through a number of lines on the front wall of the room, and the light at the top of the front wall.

In addition to weakening the visual field so that there would be less of a tendency to use it as a frame of reference for judging the upright, an effort was made to provide more effective body sensations which might be used in judging the upright. To this end, the upholstery in the seat, sides, and back of the chair in which the subject is seated in the Stability of Orientation Test was removed. This accomplished two results; first, it permitted the readier detection of pressure changes, particularly in the seat, resulting from tilting of the chair. Secondly, by increasing the width of the chair somewhat it permitted more sliding from side to side as the chair was tilted.

In summary, the changes in the room and the changes in the chair were directed at minimizing visual impressions and strengthening bodily impressions.

The 49 subjects constituting this group were first tested on the standard Stability of Orientation Test with the room of the apparatus in its initial square form. They were subsequently retested with the same procedure as before, but with the room and chair altered as described above. In addition, to make conditions comparable with the other groups, these subjects received initial tests and retests on the Dark-Room and Rotating-Room Tests. The interval between the time when the initial tests were given and the time when the retests were given was about the same as in Group I, averaging approximately five weeks.

The testing schedule of Group II is summarized in Table 1.

Group III. The Interpolated Testing Group (Control Group). This was the first of two control groups and was introduced for the following reason. Group I, the training group, was given an opportunity to spend two hours in the tilting-room-tilting-chair apparatus used in the Stability of Orientation Test. These two hours represented the period of instruction administered in that apparatus. Accordingly, whatever improvement appears from initial test to retest on the Stability of Orientation Test may conceivably be due to extra experience with the apparatus, interpolated between the two tests. To check on this possibility, Group III was used. As in the case of Group I, each member of this group initially received the Stability of Orientation Test, the Dark-Room Test and the Rotating-Room Test. Then each subject also was permitted to spend two one-hour periods in the tilting-room-tilting-chair apparatus. In these periods, instead of receiving instructions of the kind given to the training group, he was simply submitted to an extended version of the Stability of Orientation Test. That is, the subject was given a lengthy series of trials in which he had to adjust the room or the chair to the upright. The initial settings of room and chair employed in this series were those used in the demonstrations given to the training group. Following this interpolated testing on the Stability of Orientation Test, the subject, as in the case of the subjects in Group I, was retested on the Stability of Orientation Test, the Dark-Room Test, and the Rotating-Room Test. Improvement shown on the retest would provide a measure of the extent to which the experience with the orientation test situation itself, in the absence of any instructions, aids orientation. Whatever additional improvement Group I shows over Group III on retesting, may be attributed to the instructions given.

Essentially, Groups I and III differ in that the former was given, by an outsider, information that might improve orientation, while the latter was provided an opportunity to acquire at least some of this information on its own, through additional contact with the situation.

The schedule of testing for Group III is summarized in Table 1.

Group IV. The Test-Retest (Control Group). This was the second of two control groups. Its members received the initial battery of three standard tests (the Stability of Orientation Test, the Dark-Room Test, and the Rotating-Room Test) and, after an interval which averaged approximately five weeks, was retested on these three situations. This group accordingly provides a standard of performance on retesting in each of the three situations against which to compare retest performance on each of the three previous groups. The schedule of testing for this group is also to be found in Table 1.

RESULTS

The data collected in this investigation were treated by means of analysis of covariance, thereby controlling initial test performance (on the pre-test) among subjects in the four experimental groups. In addition an attempt was made to match subjects in the various groups as well as possible in terms of pre-test scores on the Stability of Orientation Test.

Adequacy of Matching

Despite the fact that analysis of covariance was employed, it is pertinent to consider the adequacy of matching in terms of the raw pre-test scores. This follows since, if subjects in one of the groups were markedly superior in performance on pre-test to subjects in another group, improvement of this superior group upon retest (e.g., following training) might well be negligible because of the fact that the superior performance on pre-test represented a "ceiling" beyond which further improvement could not be expected to be evident on retest. Therefore, despite statistical control through use of covariance procedures, a test of the adequacy of experimental control, through matching, was appropriate.

The means of the pre-test scores (and the retest scores) are presented in Table 2, and the results of an analysis of variance of these pre-test scores in Table 3. It will be noted from Table 2 that for the Stability of Orientation and the Dark-Room Tests, differences between means among the various groups, are negligible, although for the Rotating-Room Test the differences between means are somewhat larger. Reference to Table 3 indicates that the variance attributable to experimental groups, in means of the Stability of Orientation and Dark-Room Tests, respectively, are not significant, as indicated by application of analysis of variance. It can, therefore, be assumed with reference to these tests, that matching in terms of pre-test scores was adequate, and that use of analysis of covariance in the main analysis merely added a measure of statistical control.

With reference to the Rotating-Room Test, however, analysis of variance yielded significant Fs in terms of all three scores, and application of the t test indicated that, in terms of all three scores from this test, significant differences were evident between the means of Groups I and IV and Groups II and IV, Group IV exhibiting greater proficiency on pre-test than did Groups I or II. The implications of this analysis will be discussed in a subsequent section.

Reliability of the Tests

The reliability of the tests was determined on the basis of the correlations between test and retest scores for Group IV. As will be recalled this group engaged in no controlled activity between test and retest. The coefficients, based on the 49 subjects in this group, are presented in Table 4.

It will be noted that the reliability coefficients for the Stability of Orientation and Dark-Room Tests are of a magnitude associated with relatively satisfactory reliability for this type of test. The coefficients for the Rotating-Room Test are, however, markedly lower. These lower reliabilities may be accounted for by the extreme complexity of the sensory experiences which must be integrated, i.e., by the fact that in this test situation there are a number of different bases for judgment of the upright. Given subjects may not have employed the same bases for judgment on retest as on the original test. Furthermore, slight variations in conditions can markedly influence the results on this test. For example, if

TABLE 2

MEAN SCORES ON PRE-TEST AND ON RETEST SCORES

Test Parts	Groups:	Pre-test I	Pre-test II	Pre-test III	All Groups Combined IV	All Groups Combined (Pre-test)	Retest I	Retest II	Retest III	Retest IV
Stability of Orientation Test Sum of Series 1		64.6	64.6	65.4	67.6	65.5	40.1	49.2	57.7	74.4
Stability of Orientation Test Sum of Series 2		122.9	121.4	125.0	118.7	122.0	48.3	96.7	102.7	125.6
Stability of Orientation Test Sum of Series 3		37.6	39.8	34.5	40.0	38.0	19.4	15.5	32.2	37.1
Stability of Orientation Test Sum of Series 1.2		187.5	185.9	190.4	186.3	187.5	88.4	145.9	160.3	200.0
Dark-Room Test Part 3		76.6	75.6	79.6	91.7	80.9	70.4	79.2	82.3	97.7
Dark-Room Test Part 1,2,3		369.8	350.3	362.1	372.9	363.8	360.2	351.2	373.0	383.7
Dark-Room Test Part 1		140.7	121.6	130.8	133.8	131.7	127.2	123.1	145.0	129.0
Dark-Room Test Part 2		152.4	153.1	152.4	147.5	151.4	162.6	148.8	145.8	156.9
Rotating-Room Test Total Score Horizontal		38.2	33.4	28.6	19.3	29.9	47.5	26.3	31.6	18.0
Rotating-Room Test Total Score Vertical		38.0	31.4	27.2	19.4	29.0	50.7	26.2	30.7	19.2
Rotating-Room Test Total Score Horiz. - Vert.		76.2	64.7	55.8	38.7	58.8	98.1	52.5	62.2	37.2

TABLE 3

RESULTS OF ANALYSIS OF VARIANCE ON PRE-TEST ABSOLUTE SCORES

Score	F	P	M_1M_2 t	M_1M_2 P	M_1M_3 t	M_1M_3 P	M_1M_4 t	M_1M_4 P	M_2M_3 t	M_2M_3 P	M_2M_4 t	M_2M_4 P	M_3M_4 t	M_3M_4 P
Sum of Series 1 S.O.T.	0.053	> .20												
Sum of Series 2 S.O.T.	0.138	> .20												
Sum of Series 3 S.O.T.	0.587	> .20												
Sum of Series 1&2 S.O.T.	0.033	> .20												
Sum of Part 1 D.R.T.	0.676	> .20												
Sum of Part 2 D.R.T.	0.127	> .20												
Sum of Part 3 D.R.T.	0.902	> .20												
Sum of Parts 1,2&3 D.R.T.	0.237	> .20												
Sum of Horizontal Scores R.R.T.	4.015	.01-.001	0.847	.50-.40	1.693	.10-.05	3.333	.01-.001	0.847	.50-.40	2.487	.02-.01	1.640	.20-.10
Sum of Vertical Scores R.R.T.	3.654	.05-.01	1.144	.30-.20	1.872	.10-.05	3.224	.01-.001	0.728	.50-.40	2.080	.05-.02	1.352	.20-.10
Sum of Horiz. & Vert. Scores R.R.T.	4.109	.01-.001	1.042	.40-.30	1.850	.10-.05	3.400	.01-.001	0.807	.50-.40	2.357	.05-.02	1.550	.20-.10

TABLE 4

TEST-RETEST RELIABILITY COEFFICIENTS
(Group IV, N = 49)

Test		Reliability Coefficient
Stability of Orientation Test	Series 1	.69
	Series 2	.77
	Series 3	.81
	Series 1 and 2	.75
Dark-Room Test	Sum of Part 1	.87
	Sum of Part 2	.78
	Sum of Part 3	.88
	Sum of Parts 1, 2, and 3	.91
Rotating-Room Test	Series 1 (Horizontal judgments)	.50
	Series 2 (Vertical judgments)	.43
	Series 1 and 2	.54

(All coefficients significant at .01 level of confidence)

during rotation the subject changes the position of his head even slightly, despite the head rest, stimulation from the semi-circular canals can be the cause of great confusion.

Effect of Training on Performance

Stability of Orientation Test. The effect of training on performance in the Stability of Orientation Test can be determined by comparing the performance of the four groups on retesting. The performance of the respective groups on retesting, in terms of mean adjusted scores,[9] and the results of the analysis of covariance, are presented in Table 5.[10]

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[9]Means are expressed in terms of the total deviation in degrees of the subject's established upright (in terms of adjusted score) from the true upright, over the trials given during the part of the test in question. To obtain the average per trial it is necessary to divide the figure in the table by the number of trials included in the part of the test under consideration. Thus, with reference to Table 4, in Series 1 of the Stability of Orientation Test the mean total deviation of Group I is 40.5 for the four trials of Series 1. Therefore, the average deviation of the group per trial is 10.1 degrees. (In terms of adjusted scores.)

[10]It should be mentioned that the adjustment of retest scores, through analysis of covariance procedures, represents a correction for differences in original performance, as indicated in the pretest, which remained despite

TABLE 5

ADJUSTED MEAN SCORES ON RETEST

Stability of Orientation Test

Part of Test	Adjusted Mean Retest Scores: Group I Training Group	Group II Structural Aids Group	Group III Interpolated Testing Group	Group IV Test-Retest Group	P
Series 1 (4 trials)	40.5	49.6	57.8	73.4	$<.01$
Series 2 (4 trials)	47.6	97.2	100.5	128.1	$<.01$
Series 1 + 2 (8 trials)	88.5	147.0	158.4	200.8	$<.01$
Series 3 (3 trials)	19.6	14.7	33.8	36.2	$<.01$

Following is a comparison between pairs of groups, indicating parts of test for which differences in scores are significant at less than the 1% level of confidence:

Groups Compared	Parts of test for which scores are significantly different
Gr. I vs. II	Series 2, 1 + 2
Gr. I vs. III	Series 2, 1 + 2, 3
Gr. I vs. IV	Series 1, 2, 1 + 2, 3
Gr. II vs. III	Series 3
Gr. II vs. IV	Series 1, 2, 1 + 2, 3
Gr. III vs. IV	Series 2, 1 + 2

It may be seen from Table 5 that Group I did very much better in all parts of the test.[11] The differences between the two groups are in every case significant at less than the one per cent level of confidence. The differences between the two groups will perhaps be made more meaningful if the total scores are converted into mean errors per trial. In Series 1, members of Group I deviated from the true upright in their adjustment of the box by an average of 10.1° per trial while the members of Group IV deviated by an average of 18.4°. In Series 2, again involving box adjustment, Group I was off in each of its judgments by an average of 11.9°, Group IV by an average of 32.0°. This difference is very striking. Combining the results for Series 1 and 2, Group I deviated from the upright by 11.1°, Group IV by 25.1°. In Series 3, where the subject had to adjust his own body, Group I was off in its judgments by an average of 6.5°, Group IV by an average of 12.1°. What the latter figure means is, that in the absence of training, the members of Group IV were tilted at an angle of 12.1°, on the average, at the time they reported their bodies to be upright. These large errors were made under the influence of the tilted visual field, which caused the subject to look tilted when objectively upright, and therefore to move his body in the direction of the tilt of the field.

The values just cited have been in terms of adjusted retest mean scores. However, for the Stability of Orientation Test the raw and adjusted mean scores were practically identical, as is evident from Table 6. None of the means for single trials based on adjusted scores for Groups I and IV, just presented, differs from the means for single trials based on raw scores by more than .6 degree.

TABLE 6

RAW AND ADJUSTED MEAN SCORES

Stability of Orientation Test

	Mean Retest Score				Adjusted Mean Retest Score			
Group	Series 1	Series 2	Series 1+2	Series 3	Series 1	Series 2	Series 1+2	Series 3
I	40.1	48.3	88.4	19.4	40.53	47.63	88.47	19.59
II	49.2	96.7	145.9	15.5	49.63	97.15	146.96	14.66
III	57.7	102.7	160.3	32.2	57.75	100.45	158.38	33.83
IV	74.4	125.6	200.0	37.1	73.39	128.07	200.79	36.17

10 (Continued) the attempt to match subjects experimentally. In other words, with the adjustment, it is as though the four groups were fully equated in initial test scores. Thus differences evident on retest can be attributed to the effect of experimental conditions intervening between pre-test and retest.

[11] That is, the scores for Group I were lower. Low scores denote good performance in that they indicate less difference between the "perceived" and "true" upright.

The tendency shown by Group I in Series 1 and 2 to move the room nearer to the upright from its initial tilted position reflects a less ready acceptance of the prevailing visual field. The tendency of this group in Series 3 to bring their own bodies nearer to the true upright indicates that they tended more to adjust the body to a position where it felt straight, rather than where it looked straight. The total performance in the Stability of Orientation Test on retesting thus demonstrates less dependence upon the prevailing visual field as a basis for judging the upright. This is essentially what the training instructions were intended to accomplish.

It is necessary to compare performance of Group I with the other control group, Group III. For the latter, two hours of experience with the apparatus were interpolated between test and retest, providing an opportunity to acquire some information that might improve orientation. This group may, for convenience, be designated the "self-learning" group in contrast with Group I, which is really the "instructed" group. From Table 5 it may be seen that Group I did better than Group III in all parts of the Stability of Orientation Test. Except for Series 1, all differences between the two groups are significant at less than the one per cent level of confidence. When Series 1 is combined with Series 2, the resulting differences become significant, too. It is thus indicated that the instructions received by the subjects in the training given to Group I did lead to improvement beyond that which the subject could achieve on his own simply through repeated experience with the test.[12]

A comparison (see Table 5) of the two control groups, Groups III and IV, shows that the former did considerably better. This indicates that there was improvement through the self-learning achieved by Group III, although the improvement was considerably less than for the instructed group, Group I. For Series 2, and for Series 1 and 2 together, the differences between Groups III and IV are significant at less than the one per cent level of confidence. This indicates that there was improvement in the room adjustment part of the test. In Series 3, the chair adjustment series, there was very little difference between the two groups, indicating no improvement in Group III in the ability to make the body straight. Thus Group III, as a result of the interpolated testing, did show some improvement in orientation, but this improvement was limited to tasks involving adjustment of the outer field. To the extent that the improvement manifested is based upon less dependence upon the visual field, it is indicated that subjects of Group III did learn to some

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[12]The two hours of interpolated testing given to Group III correspond to about four retests on the Stability of Orientation Test. If the initial test is also included, the retest would represent the sixth test on the apparatus. The fact that the two hours of interpolated testing involved a variety of settings, other than the ones used in the standard test, provides the subject with more varied experience than he would receive if simply repeating the standard test. This more varied experience undoubtedly enhances the self-learning that may take place. It may be assumed from this that the improvement found on the retesting of Group III is probably greater than that which would result from taking the Stability of Orientation Test a sixth time.

degree to resist the influence of the visual field. Of course, the improvement resulting from self-learning is not nearly as great as that achieved through training and is limited to the room-adjustment type of task.

Transfer of Training to the Dark-Room Test. The next question is whether the improvement in performance on the Stability of Orientation Test, shown by Group I after training, was transferred to other test situations. The answer to this question again requires a comparison of retest performance of Groups I and IV in the two other test situations. In Table 6 are presented the adjusted mean scores on retest in the Dark Room Test. It is evident from Table 7 that while the mean retest scores tend to be smaller for Group I than for Group IV (thus indicating better performance for Group I), the differences between retest scores for Group I and Group IV are not statistically significant. Thus the training regimen in the Stability of Orientation Test apparently does not improve performance of subjects in the Dark-Room Test.

Transfer of Training to the Rotating-Room Test. In interpreting the results for this test, it is necessary to recognize that in this situation the relation between the visual and the gravitational verticals was the opposite of that found in the Stability of Orientation Test and the Dark-Room Test. In the rotating-room situation the visual field remained upright and the force acting on the subject's body was displaced. Consequently, if the subject tended to orient on the basis of the visual field, the deviations of the "perceived" from the "true" upright would be small, while if he tended to base his judgments on the forces acting on his body, the deviations would be large. The converse is true in the Stability of Orientation Test and in the Dark-Room Test. In the latter two tests because the visual field was displaced, while the downward pull on the body remained unchanged in direction, large deviations reflect visually dependent performances while small deviations reflect bodily dependent performances.

It should be noted further that though going by the visual field in the Rotating-Room Test will lead to objectively better judgments, it is not necessarily the case that such a performance is indicative of good orientation. Actually, people who perform in this way are not taking account at all of the rather large force pulling their bodies to one side. It is perhaps only because in this particular situation the visual field happens to represent the true upright, and not because their orientation is generally superior, that visually-dependent people tend to give more correct judgments in the rotating room. In view of the fact that the subject is cut off from the outside and has no basis for evaluating the validity of the visual and gravitational forces, the most effective integration that could take place is one where a compromise is made between these forces, so that the judgment of the upright is intermediate between them. On such a basis it may be taken to represent improvement if a person who initially adjusts the rod to the visual field, neglecting the forces tending to pull his body to one side, later displaces the rod from the visual field, out of a greater awareness of postural experiences.

With these considerations in mind, it is possible now to evaluate performance in the Rotating-Room Test, data for which are presented in Table 8.

TABLE 7

ADJUSTED MEAN SCORE ON RETEST

Dark-Room Test

Part of Test	Adjusted Mean Retest Scores: Group I Training Group	Group II Structural Aids Group	Group III Inter-polated Testing Group	Group IV Test-Retest Group	P
Series 1 (8 trials)	119.3	132.0	145.8	127.2	$>.05$
Series 2 (8 trials)	161.8	147.4	144.5	160.4	$>.05$
Series 3 (8 trials)	74.0	83.6	83.2	88.8	$>.05$
Series 1 plus 2 plus 3 (24 trials)	354.7	364.9	373.5	375.2	$>.05$

As may be seen from the P values in the last column, there are no significant differences among the scores for any part of the test.

From Table 8 it may be seen that Group I had higher scores than Group IV in every instance, with the differences significant at less than the one per cent level of confidence. Considering the results for adjusted mean scores[13] in terms of the mean errors per trial, it is found that in Series 1, Group I deviated from the true upright on each judgment by an average of 10.3°, Group IV by only 7.5°. In Series 2 the mean errors are 10.9° and 6.8°, respectively, for the two groups, while in the combined scores for Series 1 and 2, the mean errors are 10.5° and 6.7°, respectively. In view of the fact that the gravitational vertical was displaced by about 33° and the visual vertical by 0°,

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[13]The difference between Groups I and IV in terms of mean raw scores were somewhat larger than were the differences in terms of mean adjusted scores. Mean raw scores for Group I were somewhat larger than were the mean adjusted scores. For Group IV the converse was true.

TABLE 8

ADJUSTED MEAN SCORES ON RETEST

Rotating-Room Test

Part of Test	Adjusted Mean Retest Scores: Group I Training Group	Group II Structural Aids Group	Group III Interpolated Testing Group	Group IV Test-Retest Group	P
Series 1 (Horizontal Judgments- 4 trials)	41.2	23.8	32.6	26.0	<.01
Series 2 (Vertical Judgments- 4 trials)	43.4	24.3	32.2	27.0	< .01
Series 1 + 2 (Total, H + V Judgments- 8 trials)	83.7	47.6	64.7	53.8	< .01

Following is a comparison between pairs of groups indicating parts of the test for which differences in scores are significant at less than the 1% level of confidence:

Groups Compared	Parts of test for which scores are significantly different
Gr. I vs. II	Series 1, 2, 1 + 2
Gr. I vs. III	None
Gr. I vs. IV	Series 1, 2, 1 + 2
Gr. II vs. III	None
Gr. II vs. IV	None
Gr. III vs. IV	None

judgments in both groups are clearly closer to the visual vertical. However, Group I shows significantly larger deviations from the visual vertical, or tends to come closer to the gravitational vertical. Group I thus tended to be less influenced by the visual field after training. In view of the nature of the situation, as considered earlier, it may also be said that after training, Group I gave a "better" performance in that the final integration took greater account of postural experiences, and was based less exclusively upon visual impressions.[14]

In comparing Group I with Group III, the other control group, it is found that in all instances, Group I gave larger deviations from the true upright in adjusting the rod. However, the differences between adjusted means of Groups I and III are not statistically significant. Comparing Group III with Group IV, it is found that while Group III gave larger deviations from the true upright than Group IV, again the differences are not large enough to be statistically significant. It thus seems that Group III occupies a position intermediate between Groups I and IV, and while showing differences from both groups, these differences are not large enough to be significant. However, the tendency toward a change in performance in the Rotating-Room Test on the part of Group III, should not be neglected, particularly in view of the consistency in the direction of the change. The fact that the trend in each instance is toward larger deviations points to less dependence upon the visual field or more use of postural experiences. The statement seems justified that not only did Group III tend to show less reliance on the visual field in retesting on the Stability of Orientation Test, but there was some tendency for this reduced influence by the field to be shown in the Rotating-Room Test as well. However, the effect in this direction was again considerably less than in the case of Group I.

The question arises as to why Group I showed transfer of training to the Rotating-Room Test but not to the Dark-Room Test. The answer is to be found in certain characteristics of the dark-room situation. It is to be noted that the luminous frame employed in the dark room experiment lacks definite structure in that any side may be the top, bottom, right side, or left side. In contrast with the visual field of the Stability of Orientation Test and the Rotating-Room Test, there are in the luminous frame no intrinsic indications of "topness," "bottomness," etc. It is only the relation of the given side of the frame to the external world, which the subject cannot see, or to his body that causes one side to be perceived as the top, for example, rather than the bottom.

It has been found that as a result of this kind of ambiguity the frame undergoes perceptual shifts, so that, though remaining in the same position, the true top side of the frame may suddenly be perceived as the left side, for example. Most often the subject is not aware that the shift has taken place, and though perceptually displaced through as much as 90°, the frame

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[14] Regardless of whether or not the performance of Group I may be termed "better" the effect of training in the Stability of Orientation Test is evident in performance on the Rotating-Room Test.

looks as "proper" in the second orientation as it did in the first. Some subjects tend to adjust the rod principally with reference to the frame, i.e., in the perceived upright the rod, for these subjects, is approximately perpendicular to the side of the frame perceived as the "top." Of course, since under these conditions the visually oriented subject is identifying the wrong side of the frame as its top in adjusting the rod, the magnitude of the deviation from the "true" upright would be very much greater in the second orientation of the frame.[15] This would be true even if the subject made an effort to displace the rod farther from the axes of the frame than before.[16] In this connection, it is indicated from previous work that an effort to resist the influence of the frame seems to induce these spontaneous shifts in its apparent orientation. Since the training given encourages such an attitude of resistance, these shifts are consequently apt to be more frequent for the training group.

As a result of these shifts in the orientation of the frame which are very likely facilitated by an attitude of resistance to the frame, the possibility for improvement in this situation with training is small. In instances of shift, even if the subject should tend to displace the rod farther from the axes of the frame as a result of training, he would be displacing it from the wrong side of the frame, so that his errors would still be large and no absolute improvement indicated.

Intercorrelations

Intercorrelations among parts of each test, and between the various parts of the three tests, are presented in Tables 9, 10, 11, and 12. In Table 9 are presented the intercorrelations for the entire group of 196 subjects in terms of pre-test scores. In Table 10 are presented the intercorrelations of retest scores for Group I, the Training group, in Table 11 the intercorrelations of retest scores for Group III the "Self-Learning" group, and in Table 12 the intercorrelations of retest scores for Group IV, the "Test-Retest" control group.

Inspection of Table 9 indicates that the coefficients based on pre-test scores for all four groups combined are in general low, except for intercorrelations among various parts of the same test. Even the coefficients representing intercorrelations among independent parts of the Stability of Orientation Test are not markedly high. Of the correlations between parts of different tests few are as great as .30. Also of interest is the fact that the correlations between Rotating-Room Test measures and other tests are low and

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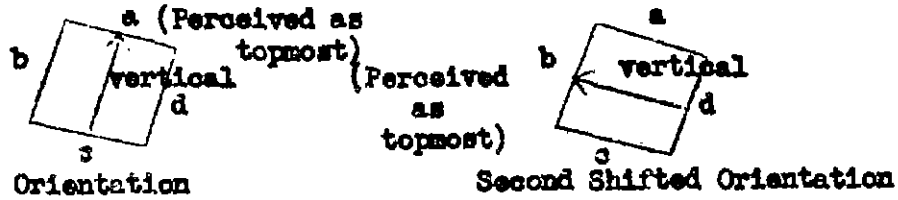
[15] This point may be illustrated with a case where the frame is initially tilted 28° right, and where the subject aligns the rod with the frame both in its first orientation and in its second perceptually shifted orientation.



[16] It should be noted that these shifts occur principally when the subject himself is tilted.

TABLE 9

INTERCORRELATIONS ON PRE-TEST FOR ALL FOUR GROUPS COMBINED
(N = 196)

	Stability of Orientation Test (Series 1)	Stability of Orientation Test (Series 2)	Stability of Orientation Test (Series 3)	Stability of Orientation Test (Series 1 and 2)	Dark-Room Test (Sum of Part 3)	Dark-Room Test (Sum of Parts 1,2,3)	Dark-Room Test (Sum of Part 1)	Dark-Room Test (Sum of Part 2)	Rotating-Room Test (Horizontal)	Rotating-Room Test (Vertical)	Rotating-Room Test (Horizontal and Vertical)
Stability of Orientation Test (Series 1)		.376	.361	.806	.312	.202	.152	.031	-.059	-.093	-.079
Stability of Orientation Test (Series 2)			.098	.851	.036	.210	.221	.250	.060	.063	.064
Stability of Orientation Test (Series 3)				.267	.412	.290	.222	.077	-.180	-.224	-.210
Stability of Orientation Test (Series 1 and 2)					.199	.248	.227	.177	.005	-.012	-.004
Dark-Room Test (Sum of Part 3)						.794	.507	.472	-.172	-.201	-.194
Dark-Room Test (Sum of Parts 1,2, and 3)							.858	.796	-.075	-.132	-.107
Dark-Room Test (Sum of Part 1)								.525	-.012	-.071	-.044
Dark-Room Test (Sum of Part 2)									-.010	-.058	-.035
Rotating-Room Test (Horizontal)										.866	.965
Rotating-Room Test (Vertical)											.966
Rotating-Room Test (Horizontal and Vertical)											

TABLE 10

INTERCORRELATIONS ON RETEST FOR GROUP I
(N = 49)

	Stability of Orientation Test (Series 1)	Stability of Orientation Test (Series 2)	Stability of Orientation Test (Series 3)	Stability of Orientation Test (Series 1 and 2)	Dark-Room Test (Sum of Part 3)	Dark-Room Test (Sum of Parts 1,2,3)	Dark-Room Test (Sum of Part 1	Dark-Room Test (Sum of Part 2	Rotating-Room Test (Horizontal)	Rotating-Room Test (Vertical)	Rotating-Room Test (Horizontal and Vertical)
Stability of Orientation Test (Series 1)		.479	.542	.824	.353	.428	.104	.540	-.146	-.017	-.078
Stability of Orientation Test (Series 2)			.036	.892	.438	.353	.170	.286	-.275	-.157	-.215
Stability of Orientation Test (Series 3)				.302	.221	.364	.105	490	.052	.100	.079
Stability of Orientation Test (Series 1 and 2)					.464	.448	.163	.463	-.253	-.110	-.179
Dark-Room Test (Sum of Part 3)						.668	.246	.512	-.233	-.229	-.234
Dark-Room Test (Sum of Parts 1,2, and 3)							.771	.875	-.176	-.129	-.154
Dark-Room Test (Sum of Part 1)								.461	-.238	-.237	-.241
Dark Room Test (Sum of Part 2)									.003	.092	.051
Rotating-Room Test (Horizontal)										.943	.984
Rotating-Room Test (Vertical)											.988
Rotating-Room Test (Horizontal and Vertical											

TABLE 11

INTERCORRELATIONS ON RETEST FOR GROUP III
(N = 49)

	Stability of Orientation Test (Series 1)	Stability of Orientation Test (Series 2)	Stability of Orientation Test (Series 3)	Stability of Orientation Test (Series 1 and 2)	Dark-Room Test (Sum of Part 3)	Dark-Room Test (Sum of Parts 1,2,3)	Dark-Room Test (Sum of Part 1)	Dark-Room Test (Sum of Part 2)	Rotating-Room Test (Horizontal)	Rotating-Room Test (Vertical)	Rotating-Room Test (Horizontal and Vertical)
Stability of Orientation Test (Series 1)		.654	.716	.867	.488	.608	.591	.422	-.220	-.265	-.246
Stability of Orientation Test (Series 2)			.416	.944	.438	.577	.482	.570	-.057	-.085	-.072
Stability of Orientation Test (Series 3)				.887	.630	.651	.635	.360	-.240	-.289	-.268
Stability of Orientation Test (Series 1 and 2)					.488	.645	.575	.560	-.134	-.172	-.155
Dark-Room Test (Sum of Part 3)						.760	.510	.572	-.392	-.416	-.410
Dark-Room Test (Sum of Parts 1, 2, and 3)							.905	.842	-.129	-.166	-.149
Dark-Room Test (Sum of Part 1)								.618	.009	.049	-.020
Dark-Room Test (Sum of Part 2)									-.064	-.059	-.062
Rotating-Room Test (Horizontal)										.945	.986
Rotating-Room Test (Vertical)											.986
Rotating-Room Test (Horizontal and Vertical)											

TABLE 32

INTERCORRELATIONS ON RETEST FOR GROUP IV
(N = 49)

	Stability of Orientation Test (Series 1)	Stability of Orientation Test (Series 2)	Stability of Orientation Test (Series 3)	Stability of Orientation Test (Series 1 and 2)	Dark-Room Test (Sum of Part 3)	Dark-Room Test (Sum of Parts 1, 2, 3)	Dark-Room Test (Sum of Part 1)	Dark-Room Test (Sum of Part 2)	Rotating-Room Test (Horizontal)	Rotating-Room Test (Vertical)	Rotating-Room Test (Horizontal and Vertical)
Stability of Orientation Test (Series 1)		.574	.480	.867	.462	.278	.098	.167	-.364	-.441	-.412
Stability of Orientation Test (Series 2)			.136	.905	.232	.257	.100	.333	-.349	-.415	-.391
Stability of Orientation Test (Series 3)				.332	.494	.331	.172	.185	-.195	-.251	-.229
Stability of Orientation Test (Series 1 and 2)					.381	.300	.132	.289	-.401	-.481	-.451
Dark-Room Test (Sum of Part 3)						.800	.517	.508	-.163	-.287	-.232
Dark-Room Test (Sum of Parts 1, 2, and 3)							.856	.808	.021	-.143	-.064
Dark-Room Test (Sum of Part 1)								.538	.116	-.040	.038
Dark-Room Test (Sum of Part 2)									.068	-.054	.006
Rotating-Room Test (Horizontal)										.915	.978
Rotating-Room Test (Vertical)											.980
Rotating-Room Test (Horizontal and Vertical)											

predominantly negative, even on retest.[17]

The intercorrelations on retest, for Groups I, III, and IV, presented in Tables 10, 11, and 12, tend to be somewhat higher than are the intercorrelations of pre-test scores presented in Table 9, although the intercorrelations for Group IV (Test-Retest), presented in Table 12, are in general considerably lower than are the intercorrelations based on Groups I and III (see Tables 10 and 11). These latter groups had additional experience on the Stability of Orientation Test, between test and retest. These findings suggest that with experience in the Stability of Orientation Test subjects tend to work out procedures for orientation which they apply generally to the several tests. As a result performance within a given test, and from test to test, tends to become more consistent.[18]

Effect of Structural Aids on Performance

It will be recalled that the structural changes made in the tilting-room-tilting-chair apparatus in order to aid orientation consisted of converting the square room into a cylinder, eliminating some of the prominent horizontals and verticals from the front wall of the room, and removing the upholstery from the seat in which the subject sat. The first two changes were intended to weaken the visual framework so that it would be less compelling as a frame of reference for judging the upright. The third change aimed at accentuating bodily cues which might aid in judging position and, therefore, the upright.

To determine whether the structural changes aided performance on the standard Stability of Orientation Test, it is necessary to compare retest performance of Groups II and IV in the Stability of Orientation Test. It is evident from Table 5 that in every instance Group II did better than Group IV, with all differences significant at less than the one per cent level of confidence. Thus the structural changes led to improvement in performance both, when the task was that of adjusting the room and when the task was that of adjusting one's own body. The superiority of Group II over Group III is particularly evident in Series 3, the series in which the body had to be adjusted to the upright. Where the members of Group IV were tilted by an average of 12.1° on each trial at the time they said they were upright, the members of Group II were able to bring their bodies to within 4.9° of the upright.[19]

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[17]These correlations tend to be negative because subjects who depend on the visual field, for example, will have small errors in the Rotating-Room Test and large errors in the Dark-Room and Stability of Orientation Tests.

[18]This result suggests that extending the length of the Stability of Orientation Test, and counting the initial trials as practice runs, may increase the reliability of the test.

[19]These deviations are expressed in terms of adjusted scores. In terms of raw scores the corresponding values are 9.3° and 3.9°.

It is interesting to compare Group II with Group I, the training group. First of all, it is found that Group II did even better than Group I in Series 3, the chair adjustment series, although the difference is not statistically significant. This indicates that the structural aids were as effective, or perhaps, even more effective in leading to improvement in the ability to make one's own body straight than was more formalized training. In the case of the room adjustment part of the test, however, training proved more effective than the structural aids. The differences in favor of Group I are significant at less than the one per cent level of confidence for Series 2 and Series 1 plus 2, but not for Series 1.

A comparison of Group II with Group III which has been designated the "self-learning" group, shows that Group II was very much superior in Series 3, the chair-adjustment part of the test. The difference is significant at less than the one per cent level of confidence. This means that the changes made in the situation for Group II resulted in immediate improvement in this part of the test which was significantly greater than that achieved by Group III after the self-learning, which came through two hours of practice in the situation. As concerns the room-adjustment part of the test, Group II did somewhat better than Group III, both in Series 1 and Series 2, although the differences are not significant. This would indicate that the insights gained by Group III in the course of the interpolated practice on the Stability of Orientation Test were about as fruitful in producing improvement in this part of the test as were the structural aids provided Group II.

As may be seen from Tables 7 and 8, Group II showed no transfer of the improvement achieved in the Stability of Orientation Test to the Dark-Room and Rotating-Room Tests.

AN EVALUATION OF THE TRAINING AND STRUCTURAL-AID PROCEDURES

It is clear that improvement in orientation may be accomplished both through training and through certain changes in the structure of the situation. At the same time, the improvement achieved by each method is accomplished in a rather different way. It was found that the training given in the present study rarely altered the subject's perception of the situation. Its effect was rather to enable him to interpret his perceptual experiences in an intellectual way, and thereby arrive at a more nearly correct estimate of his own position and the position of the field. This observation is consistent with the findings of previous studies,[20] that knowledge does not typically alter the person's preferred mode of orientation, its role being rather one of making possible a more correct approximation of reality. Whereas training produced improvement primarily through facilitating an interpretation of perceptual experiences, the structural aids employed led, on the other hand, to changes in the perceptions themselves. To illustrate: removing the upholstery from the chair, and converting the square room into a circular form, actually caused the body to appear tilted and to feel tilted in positions where it had previously seemed upright. In contrast, the training procedure mainly helped the subject to figure out that the body was tilted in positions where it had previously seemed upright, although it typically continued to feel upright and to appear upright as it had before the training was given.

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[20] Witkin, H. A. 1948. Perception of body position and of the position of the visual field. (In preparation.)

In view of the manner in which training accomplished improvement in orientation, it is in certain regards less satisfactory than the structural-aid procedure. To the extent that training does not alter the impressions themselves, but relies on a more effective intellectual analysis of these impressions, there exists a possibility that the impressions may win out in a given case, or that the required analysis may for some reason be prevented. This is especially true since the perceptions are more immediate in a person's experience and therefore have priority as a basis for judgment and action. This is seen very dramatically in the performance of a subject in the training group who actually did worse in the retest on the Stability of Orientation Test than on the original test, despite the lengthy training given. This was a subject who tended to be very much affected by visual impressions, and who in trying to counteract these impressions with analytical procedures became very confused. The resulting performance was therefore poorer than the original one, which had been based more straightforwardly on visual impressions. The same kind of difficulty in overcoming perceptual experiences by the use of intellectual data may often be found during instrument flight. It has frequently been reported that the vertigo effects which set in during instrument flying are not typically alleviated by reference to instruments. Thus there may be a strong impression of falling off in a left bank, and though the instrument readings indicate straight and level flight, the impression persists. In fact, so strong is this effect that the validity of the instrument reading may be placed in doubt and a genuine dilemma develop as to whether the instruments or one's own impression should be followed. Because these impressions are part of the person's direct experience, it is understandable that they should be favored over something as external as an indication on a panel "out there."

It is suggested by these observations that changes in the structure of the situation which affect the perceptions themselves are to be favored as techniques for improving orientation. Thus an instrument to help a person determine his position might be much more valuable if it actually influenced in some way the perception of his position than if it simply gave him a number on a dial which through analysis had to be translated into a form where it gave usable information about position. Not only is the latter procedure time-consuming, but the results can often not be integrated with more direct sensory experiences. While the goal of achieving improvement in orientation through influencing the perceptions themselves is certainly a desirable one, practical circumstances may often prevent its attainment. In such cases, training may prove most useful, as the results of the present study strongly suggest.

The second important advantage of the structural-aids approach to the improvement problem is that it is much less time-consuming than training. Thus in the present study as simple an operation as removing the upholstery from the subject's seat, and eliminating some of the directionalized lines from the surrounding field, led to significant improvement in orientation. In fact, in Series 3 of the Stability of Orientation Test, where the position of the body had to be judged, the structural-aids group tended to do even better than the training group. This happened although the training procedure consumed three hours of the subject's time. This was very much more than the time required to alter the apparatus for the structural-aids group, an alteration which once made sufficed for all subjects.

It should be added that while the structural-aids procedure does have the advantages indicated it has the limitation that changes introduced in the field are effective for a given circumstance only and do not lead to general improvement. This is to be expected, since changes in the field affect the perceptions occurring in relation to that field; they cannot influence the perception of other field conditions, nor can they lead to the derivation of general principles that will be useful under other conditions. As evidence of the limited improvement accomplished through structural aids, one of the results of the present study may be cited. It was found that, where the training group showed some transfer of its improvement to the Rotating-Room Test, the structural-aids group did not. In view of these observations, it would seem that the most effective and enduring improvement in orientation may be achieved by a combination of structural aids, which alter the perceptions themselves, and training, which provides a more general understanding of the basis of one's perceptual experiences.

CONCLUSIONS

1. The training procedures used in these experiments produced general improvement in orientation in the situation in which the training was administered, and it also led to improvement in one of two transfer situations, involving a rather different kind of orientation problem.

2. The structural changes made in the external situation to aid orientation also produced significant improvement in orientation in the situation in which they were used. The improvement achieved by the structural aids group was not transferred to other types of orientation situations. This was to be expected, since the structural aids are of help only in the situation in which they are present, and only during the time that they are present.

3. When the task was to adjust the body to the upright, the structural-aids group even did slightly better than the group which received training. However, when the task was to adjust the visual field itself to the upright, the training group was found to have improved more than the structural-aids group.

4. Practice in a variety of orientation tasks in the Stability of Orientation Test, even without instruction, led to improvement in the standard Stability of Orientation Test, and there was some tendency for this improvement to be transferred to a different type of orientation situation. However, the improvement accomplished through such self-learning was not as great as that achieved when instructions were given, as in the training group.

APPENDIX 1

Directions for administration of:

Stability of Orientation Test
Dark-Room Test
Rotating-Room Test

APPENDIX I

DIRECTIONS FOR ADMINISTRATION: STABILITY OF ORIENTATION TEST

Conditions of the Test

1. Seating subject in apparatus and instructing subject. No practice.

2. Two test periods, the first consisting of nine trials, the second of six trials. In the first period the subject adjusts the box to the vertical; in the second he adjusts the chair to the vertical.

3. Administration to one subject in about 30 minutes.

4. Score is deviation of box or chair from vertical, expressed in degrees.

Instructions to Examiner

1. During the test the overhead lights outside the apparatus should be turned off. There should be no other outside light source which might cast a shadow into the box.

2. Do not permit the subject to bring into the box any object (as dog-tags) which he might suspend to help give him an idea of the true upright.

3. Before the subject enters the box, make sure that the support on the right side is in position. Unlock the support at the beginning of the test, and be sure to replace it before you start helping the subject out at the end.

4. Have the subject enter and leave the box through the door on the left side.

5. Throughout the test, except when seating the subject, stand directly behind the subject. Be sure not to stand to one side of him. Do not make any unnecessary noises.

6. In turning the chair and the box between trials, observe the following precautions:

a. Move the box and chair simultaneously.

b. As soon as the subject has lowered his mask at the end of a trial, start moving the chair. Do not ask the subject to lower his mask until you are ready to start turning the chair.

c. Keep the chair moving during the time the subject's eyes are closed. Particularly do not allow the chair to rest in its initial or end position while subject's eyes are closed.

d. In adjusting the chair to the 22° tilt required on each setting, go about 8° too far (to 30°), and then return the chair to the required position.

e. Ask the subject to raise his hand soon after you start turning the chair back toward the required position after overshooting the mark, when the chair is about passing through the 25° position.

f. If the chair is tilted to the same side on two successive trials, do not simply go from one position to the other, but return the chair to 0°, and then return it to the required position.

g. In the first part of the test, in which the box is to be adjusted, move the box 4° at a time opposite to the direction in which the subject says it is tilted.

h. In the second part of the test, in which the chair is to be adjusted, move the chair 2° at a time.

i. If the subject asks you to move the chair or box back after reaching a certain point, do so 4° at a time in the case of the box, and 2° at a time in the case of the chair. If the subject asks you to move back a little, do so, 2° at a time in the case of the box, and 1° at a time in the case of the chair. In any case, record the position at which he asked you to move back.

j. If the subject accepts the box as straight at the very outset (i.e., at 56°), or if he brings the box to a position where it is tilted more than 56°, say to him: "Would you point to the floor that you stood on when you came in?" Record whether the subject identified the floor correctly. (If he does not identify the floor correctly, point it out to him.) Then ask him: "Is that floor now straight with the floor out here the way it was when you came in?" Record the subject's reply. If the subject should reply that it is not straight with the floor outside, but that he has been trying to make some other wall of the box straight with the outside floor, say to him: "The objective here is to make the floor of the box that you stood on when you came in, straight with the floor out here, so that the box is standing the way it was at the beginning, when you came in. Let's make the box straight, so that its floor is straight with the floor out here. Which way shall I move it?" The position to which the box is now brought should be counted as the subject's score for this trial. However, under "Comments" record what happened.

k. If the subject takes more than 5 seconds for a response, say to him: "Please make your decisions quickly."

l. If the subject reports a given position for his chair or box, and changes his mind before or after turning begins, record the second position under comments.

m. If, after the subject has accepted the box (or chair) as straight, he should then change his mind and ask that it be moved some more, do so. Record only the final position of the box (or chair), but indicate under "Comments" the first point at which he stopped.

n. If, at the end of the first trial in Part I (or Part II), the subject says that the box (or chair) is not straight when asked if it is straight with the building, move it further. Record only the final position of the box (or chair) but under "Comments" record the position at which he first stopped.

o. In recording subject's report of positions of chair and box, use the following symbols: "L" for left, "R" for right, "S" for straight. After the box (or chair) is adjusted, record its degree of tilt.

p. In Part II only, when adjusting the chair for settings 2-6, tilt the chair about 5° further toward the side to which it had been left by the subject on the previous trial, before returning it to 0°, and then to the 22° position required for that trial. If on the previous trial, the subject had brought the chair to 0° tilt the chair at once to the 22° position required for the trial.

q. If the subject continually says "more" before the turn is completed, when the chair or box is being straightened, say to him: "Please wait until I finish the turn before saying 'more' or 'enough'."

r. If the subject on any trial of Part II says he is straight when tilted 22° or more to either side, ask him again: "Is your chair now straight with the walls of the building out here the way it was when you came in?"

s. If on any trial of Parts I and II the subject gives an incorrect report of his position or the position of the box, underline the incorrect item. Thus, if the subject says he is tilted right, when he is actually tilted left, enter the R under the report for the chair and underline it.

t. Whenever the box or chair is moved from its initial position past 0° so that it ends up tilted to the opposite side from which it started, underline the score. For example, if on a given setting, the box is initially tilted 56°L and the subject has it moved to 24°R to make it straight, the 24°R score should be underlined.

u. If on any trial of Part I the subject has the box up approximately with his body, ask him "Are the walls of the box now straight with the wall of the building out here, and the floor of the box now straight with the floor out here, the way they were when you came in?"

7. Instructions for seating the subject:

a. While the subject is getting into the seat, lower the shaft in front of the chair, and hold it down until he is seated.

b. Caution the subject not to stand on the bar at the bottom of the chair while getting into it. Say to him: "Do not stand on the bar. It will not support your weight." After the subject is seated, say: "Now place your feet on the bar."

c. Place the mask on the subject's face. Allow him to keep the mask raised on his forehead while you are giving him the instructions. The mask should be raised before the head rest is adjusted.

d. Adjust the head rest: First, lower it until the side supports actually touch the top of the subject's ears, and then lower it a little further so that it actually depresses the ears slightly. Now tighten these supports until it is impossible for the subject to move his head from side to side. It is essential that there be no head movement possible. Be sure to tighten the wing bolt on the head rest.

e. Instruct the subject to keep his arms on the arm rests, and his hands in his lap during the test.

8. If the subject asks a question, reply if possible by repeating an appropriate part of the instructions.

9. Check from time to time to determine whether the subject's head is in proper position in the head rest. If the subject slumps down in his chair or moves forward in head rest, instruct him to sit up straight, and to sit back in the chair.

10. If it seems advisable to determine further the basis of something the subject did during the test, question him further after the test is over.

Procedure and Instructions to Subject

(In the following, all instructions are for the operator, except those underlined, which are for the subject.)

PART I

1. Seat the subject.

2. Step out of the box, take up your position behind the turning mechanism, and give the subject the following instructions:

"In this test we want to find out how well you can determine when you are sitting straight up and down, and when the box around you is straight up and down. By the box I mean the room you are in now.

"I can tilt your chair and the box to either side. I can tilt the chair alone or the box alone. Or, I can tilt them both, either to the same side or to opposite sides.

"When you raise your mask at the beginning of each test period, I want you to tell me two things: (1) First, tell me whether you are sitting straight up and down the way you are now, or whether you are tilted to the left or to the right. (2) Second, tell me whether the box is straight up and down the way it is now, or whether it is tilted to the left or to the right. In other words, tell me whether in relation to the walls of the building out here your chair and the box are tilted, or straight the way they are now.

"Tell me these two things as soon as you raise your mask. Make up your mind quickly in this test. Are there any questions?

"Lower your mask, and close your eyes."

3. Move the chair to 22°L and the box to 56°L for the first trial.

4. When you start moving the chair back after overshooting the mark, say to the subject: "Raise your mask, open your eyes and tell me your position and the position of the box." Record the subject's responses.

If the subject leaves out one of the items called for, request this information from him. Thus, if he neglects to tell you his position, ask what his position is.

5. If the subject reports that the box is tilted, say to him:

"I will now move the box slowly until you think it is straight with the walls of the building out here, the way it was when you came in. After each turn, tell me whether the box has been moved enough or whether you want it moved some more. Just say 'more' or 'enough' after each turn."

Move the box 4° at a time, opposite to the direction in which the subject says it is tilted, until he reports "enough." Record this position. On this first trial only, ask the subject after he reports the room to be straight: "Are the walls of the box now straight with the walls of the building out here, and is the floor of the box that you stood on when you came in straight with the floor of the building out here, the way it was when you came in?"

If on the first trial the subject reports that the box is straight at the outset, record its degree of tilt. Then question the subject according to the procedure given in paragraph j, page 38. In such a case give him the instructions concerning straightening of the box, contained in the previous paragraph, on the next trial. If on the next trial the subject also states that the room is straight, give him these instructions on the first trial on which he says the box is tilted.

Then say to the subject: "We will now proceed to the next trial. Remember, when you raise your mask, I want you to tell me two things: (1) First, whether you are straight, or tilted left or right. (2) Second, whether the box is straight or tilted left or right.

"Lower your mask, and close your eyes."

6. Adjust the chair to 22°R and the box to 56°L for the second trial.

Then say to the subject: "Raise your mask, and open your eyes."

Record the subject's report of the position of the box and chair. Then, if he says the box is straight, proceed to the next trial. If he says it is tilted, move it as before, 4° at a time.

7. Say to the subject: "Lower your mask, and close your eyes."

Give trial 3 with the chair at 22°R and the box at 56°R.

8. Using the above procedure, give trial 4 with the chair at 22°L and the box at 56°R.

9. Give trial 5 with the chair at 22°R and the box at 56°L.

10. Give trial 6 with the chair at 22°R and the box at 56°R.

11. Give trial 7 with the chair at 22°L and the box at 56°R.

12. Give trial 8 with chair at 22°L and the box at 56°L.

13. Give trial 9 with the chair at 22°R and the box at 0°.

If at the end of trial 8 the box is at a position below 15°, move it to 15°L or R, whichever is nearer, and then bring it to 0°.

14. Now have the subject lower his mask and bring the chair and the box to the upright position. Allow the subject to remain this way for one minute while you give him the instructions for Part II. Have the subject raise his mask during the minute.

PART II

1. Say to the subject:

"In this next part of the test we are going to do exactly what we did before, except that now we are going to straighten the chair instead of the box. When you raise your mask, tell me again your position and the position of the box. If you think the chair is not straight with the walls of the building out here, I will move it until it is straight. Are there any questions? Lower your mask, and close your eyes."

2. Adjust the chair to 22°L and the box to 35°L for the first trial.

Then say to the subject: "Raise your mask and open your eyes. What is your position and what is the position of the box?" Record his report of his position and the position of the box.

If the subject reports that his chair is tilted, say to him:

"I will move your chair now until you think it is straight with the walls of the building out here, so that you are sitting straight up and down.

"Also, I want you to tell me something more each time. I may move the box very slightly while we are making the chair straight. Watch the box very carefully throughout each trial and notice whether it moves. At the end of each trial I will ask you whether the box moved at all.

"I will now turn the chair. Say 'more' or 'enough' after each turn."

Move the chair 2° at a time, opposite to the direction in which the subject says he is tilted, until he says "enough." Record this position.

On this first trial only, say to the subject: "Is your chair now straight with the walls of the building out here, the way it was when you came in?"

If the subject reports that his chair is straight at the outset, ask him: "Is your chair now straight with the walls of the building out here, the way it was when you came in?" Record the position of his chair, and proceed to the next trial. In such a case, give the subject the instructions for straightening up the chair on the very next trial on which he reports it to be tilted.

Then say to the subject: "Did the box move while we were making the chair straight?" Record his response, using the symbol "Y" for "Yes" and "N", if he says "No." Repeat question after each trial and record.

3. "Lower your mask and close your eyes." Adjust the chair to 22°R and the box to 35°R for the second trial. Proceed as on the first trial.

4. Give trial 3 with the chair at 22°L and the box at 35°L.

5. Give trial 4 with the chair at 22°R and the box at 35°L.

6. Give trial 5 with the chair at 22°L and the box at 35°R.

7. Give trial 6 with the chair at 22°R and the box at 35°L.

8. Help the subject out of the chair.

DIRECTIONS FOR ADMINISTRATION: STANDARD TEST IN DARK ROOM

I. Special Instructions to Experimenter:

1. The subject should be brought into the dark room with his eyes closed and with the mask over his eyes. Place the mask in position before he reaches the door of the dark room so that he cannot see into it.

2. The subject must have his eyes closed whenever the lights in the dark room are on, so that he will never see the room. At the conclusion of each trial, ask him to close his eyes and lower his mask, and wait several seconds before turning on the lights to be sure that he had had a chance to close his eyes. At the beginning of each trial, turn off the desk light and then wait several seconds before requesting the subject to raise his mask and open his eyes.

3. Do not have any bright objects in the room which might reflect the luminous frame and rod.

4. Check from time to time to make sure that the subject is seated in the proper position. Check particularly on the subject's head position, making sure that his head has not been freed from the head rest and straightened up. He should also be required to sit up erect and not slouch, either down or to one side.

5. If the subject on any trial gives a deviation larger than 28° or sends the rod in a direction opposite to the frame, or does anything else that seems "strange," do the following: Run your hand across one side of the frame in the dark, and say to him: "Do you see my hand moving across part of the frame? Is that the top, bottom, left side or right side of the frame? In other words, is it nearest the ceiling, the floor, the left wall, or the right wall of the room?" Record the subject's response. This will be known as the disorientation test.

6. Activate the frame and the rod by passing the desk light across their surfaces. Do this just before testing each subject.

7. If at any time after the rod has been adjusted on a given trial the subject should say that he wants it moved some more in either direction, do so.

8. If the subject should take more than 5 seconds on any trial before saying "more" or "enough," say to him: "Please make your decisions quickly."

9. If the subject should repeatedly say "more" or "enough" before the turn of the rod is completed, say to him: "Please wait until I have completed the turn."

II. Procedure:

Bring the subject into the room with his eyes closed and with the mask lowered over his eyes. Then seat him in the chair while it is in the upright

position. In seating the subject do not permit him to stand on the foot rest as it will not support his weight.

Part A:

1. As soon as the subject is seated, start your stop watch. The subject is required to sit in the upright position with the mask over his eyes for four minutes before the first trial is given. During this four-minute period the subject should be given the instructions for the test and the head rest should be adjusted. Since these operations will not consume all of the four minutes, wait a little while after the subject is seated before beginning the instructions.

2. Now adjust the head rest, taking the following steps:

a. Make sure that the subject is sitting back in his seat.

b. Lower the head rest until its side supports depress the tops of the ears a little.

c. Tighten the head rest, making completely sure that the subject cannot move his head at all.

d. Instruct the subject to keep his arms on the arm rests during the test.

3. Read the following instructions to the subject:

"In this test we want to find out how well you can determine the upright -- i.e., the vertical -- under various conditions.

"When you open your eyes, you will see a square frame and within this frame you will see a rod. Except for the frame and rod the room will be in complete darkness.

"It is possible for me to tilt the frame to left or right. I can also tilt the rod to left or right. I can tilt the frame alone or the rod alone; or I can tilt them both at the same time, either to the same side or to opposite sides.

"When you open your eyes at the beginning of each trial, I want you to tell me whether the rod is straight up and down -- i.e., vertical -- or whether it is tilted. In other words tell me whether the rod is straight with the walls of Ingersoll or whether it is tilted.

"Are there any questions?

"It is of the utmost importance that you keep your eyes closed at all times, except when I specifically ask you to open them. Also, when I ask you to close your eyes, please do so promptly."

Check from time to time to determine whether the subject's head is in proper position in the head rest. If the subject slumps down in the chair or moves forward in the head rest, instruct him to sit up straight and to sit back in the chair.

4. Now tilt the subject 28° to the left, and give him eight trials under the following conditions:

a. Trial 1: Adjust the frame to 242° and the rod to 242°. Then turn off the desk light, and say to the subject: "Raise your mask and open your eyes. Can you see the frame and the rod? What is the position of the rod?"

If the subject says the rod is not vertical, say to him:

"I will now turn the rod slowly until you think it is straight with the walls of Ingersoll. As I said, I will turn it slowly, and after each turn, tell me whether it has been turned enough or whether you want it turned some more. Just say 'more' or 'enough' after each turn. Please make your decisions quickly, and don't be too finicky.

"Which way shall I move the rod to make it vertical -- clockwise or counterclockwise?"

Now move the rod about 3° at a time opposite to the direction in which the subject says it is tilted, until he reports "enough." On this first trial only ask the subject after he reports that the rod is vertical: "Is the rod now vertical -- that is, is it straight with the walls of Ingersoll? In other words, is it straight up the way the flagpole outside is?" If the subject should now say that he wants the rod moved some more in either direction, do so. Then ask the subject to close his eyes, turn on the lights, and record the position of the rod.

If on this first trial, the subject reports the rod to be straight at the outset, ask him the question: "Is the rod now vertical, that is, is it straight with the walls of Ingersoll?" In such an instance, give the subject the instructions concerning straightening of the rod, as listed above, on the next trial. If on the next trial, the subject again states at the outset that the rod is straight, give him these instructions on the first trial on which he says the rod is tilted.

b. Trial 2: Leave the frame at 242° and adjust the rod to 298°. Turn off the light and ask the subject to raise his mask and open his eyes. Then say to him: "Would you tell me now and at the beginning of all subsequent trials whether the rod is straight with the walls of Ingersoll, or tilted; and if it is tilted, whether it should be moved clockwise or counterclockwise to be made straight." If the subject asks you to turn the rod, do so until he says "enough."

Ask him again: "Is the rod now vertical -- that is, is it straight with the walls of Ingersoll?" (Do not ask him this question on subsequent trials.)

Now ask the subject to close his eyes and lower his mask and proceed to the next trial.

c. Trial 3: Now the frame is at 298° and the rod at 298°. Proceed as on Trial 2.

d. Trial 4: For this trial the frame is at 298° and the rod at 242°.

e. Trial 5: The frame is 242° and the rod at 242°.

f. Trial 6: The frame is again at 242° and the rod 298°.

g. Trial 7: The frame is at 298° and the rod at 298°.

h. Trial 8: The frame is at 298° and the rod at 242°.

Part B:

1. Now bring the subject to the upright position and allow him to sit with his eyes closed for one minute.

2. Then tilt him 28° to the right, and give him the following eight trials, using the same procedure as above.

a. The frame is at 242° and the rod at 242°.

b. Trial 2: The frame is at 242° and the rod at 298°.

c. Trial 3: The frame is at 298° and the rod at 298°.

d. Trial 4: The frame is at 298° and the rod at 242°.

e. Trial 5: The frame is at 242° and the rod at 242°.

f. Trial 6: The frame is at 242° and the rod at 298°.

g. Trial 7: The frame is at 298° and the rod at 298°.

h. Trial 8: The frame is at 298° and the rod at 242°.

Part C:

1. Now bring the subject to the upright position and after allowing him to sit this way with eyes closed for one minute, give him the following trials:

a. Trial 1: The frame is at 242°, the rod at 242°.

b. Trial 2: The frame is at 242°, the rod at 298°.

c. Trial 3: The frame is at 298°, the rod at 298°.

d. Trial 4: The frame is at 298°, the rod at 242°.

e. Trial 5: The frame is at 242°, the rod at 242°.

f. Trial 6: The frame is at 242°, the rod at 298°.

g. Trial 7: The frame is at 298°, the rod at 298°.

h. Trial 8: The frame is at 298°, the rod at 242°.

3. After this, help the subject out of the chair, asking him again not to stand on the foot rest. Lead him out of the room with his eyes closed and the mask over his eyes.

DIRECTIONS FOR ADMINISTRATION: STANDARD TEST IN ROTATING ROOM

I. Special Instructions to Experimenter:

1. Before the subject enters the laboratory containing the rotating room ask him to close his eyes and place the mask over his face. He should also wear the mask while he is being seated in the rotating room. When he is being led out of the rotating room and out of the laboratory after the experiment is over, he should also have his eyes closed. In this way he will be prevented from seeing at any time the structure of the rotating room and the track on which it moves.

2. Be sure the door of the box is fastened before starting rotation, so that it will not fly open while in movement.

3. When starting rotation of the box, speed it up slowly by running it at each speed for about half a revolution (that is, half way around the track). If the box does not start moving when set at the first speed, give it a slight push.

4. In stopping the box, slow it down gradually, again by running it at each speed for about half a revolution. When the power has been cut off, stop further rolling of the box by catching it with your hands. Try to have the box come to a halt near the laboratory door, so that it will be easy to lead the subject out at the end of the experiment.

5. The rod on the front wall of the box should be made exactly vertical before the subject opens his eyes at the beginning of the test.

6. Readings of the pointer on the outside of the box should be taken to the nearest degree. Before recording the reading, be sure that the subject has completed his adjustment. To make sure of this, wait for a little while after the pointer has stopped moving.

II. Procedure:

1. Bring the subject into the laboratory and seat him in the rotating room, leaving the mask over his eyes.

2. With the mask still over his eyes, give the subject the following instructions:

"You are seated in a box to which we can do various kinds of things. In a little while I will take the mask off your eyes, and set the box in motion. Your job is to observe just what happens to the box, so that after the test is over, you will be able to give me an account of everything that took place. During the time that the box is in motion, pay close attention to your body, noting how it feels and whether anything happens to it. Also pay close attention to the appearance of the room -- the floor, the walls, and the ceiling. Notice, for example, if there is any slope in the floor, whether the box moves or remains in the same place, whether or not it rotates, whether or not it tilts either left or right or forward or backward.

"After you have had a chance to observe the motion of the box for a while, I will ask you to do something else while the box continues in motion. There is a rod on the front wall of the box, which you will see when you open your eyes. This rod can be turned from where you are sitting by means of the knob in front of you." (Direct the subject's hand to the knob.) "Now when I call out to you, 'Begin', I want you to turn the rod clockwise -- remember clockwise -- until you think it is horizontal. That is, turn it until you think it is straight with the floor and ceiling of Ingersoll. This is the first trial. After you have made the rod horizontal, leave it there until I have been able to record its position. When I have done so, I will call out, 'next'. Then I want you to make the rod vertical, again by moving it clockwise. This time, in other words, you must make the rod straight with the walls of Ingersoll. This is the second trial. When you have made the rod vertical, leave it there until I have called out 'next,' as before. Thus on these first two trials, you will make the rod horizontal and vertical, respectively, by moving it clockwise.

"Now, on the next two trials, you will do the same thing, except that now you will make the rod horizontal and vertical by moving it counterclockwise. Thus, on the third trial, you will make the rod horizontal by moving it counterclockwise, and on the fourth trial, you will make the rod vertical by moving it counterclockwise.

"Finally, there will be four more trials, in which you will repeat the first four trials in exactly the same sequence. In other words, on the fifth and sixth trials you will make the rod horizontal and vertical, respectively, by moving it clockwise again. And on the seventh and eighth trials you will make it horizontal and vertical by moving it counterclockwise.

"Let me summarize: There will be eight trials in all, in which you will alternately have to make the rod horizontal and vertical, starting with the horizontal on the first trial. Also, on the first two trials you will move the rod clockwise, on the next two trials counterclockwise, on the next two trials, clockwise again, and finally on the last two trials counterclockwise again. So it will be clockwise, counterclockwise, clockwise, counterclockwise. Is that clear?

"Let me remind you again: Don't start turning the rod for the first trial until I say 'begin,' and don't change its position after you have made an adjustment until I call out 'next.'

"So this is what will happen now: I will remove your mask and set the box going. You will observe the box carefully to determine whether or not it moves, turns, tilts, and so on. After you have had a period in which to observe the box, without stopping it, I will call out 'begin.' You will then start the series with the rod. First you will give me a horizontal and vertical, clockwise; then a horizontal and vertical, counterclockwise; then another horizontal and vertical clockwise; and finally, another horizontal and vertical, counterclockwise.

"Are there any questions?"

3. Now remove the subject's mask, but ask him first to continue to keep his eyes closed. Then adjust the head rest. In carrying out this operation, observe the following:

a. Make sure that the subject is sitting back in his seat.

b. Lower the head rest until the side supports depress the tops of the ears a little.

c. Tighten the head rest, making completely sure that the subject cannot move his head at all.

After the head rest is adjusted, say to the subject: "It is of the utmost importance that you do not move your head at all after I start the box. Keep your head in exactly the same position that it is in now. Also keep your arms on the arm rests and your feet squarely on the floor throughout the test.

"Another thing: If you want me to stop the box for any reason, just knock against the wall of the box with your hand.

"Now I am stepping out of the box. When I call out to you, open your eyes."

4. Now step out of the box, bolt the door, and call out to the subject to open his eyes.

5. Start the box, speeding it up gradually. When the box is moving uniformly at top speed, start your stop watch.

6. After a minute and a half, call out to the subject: "Begin, horizontal." After the rod has finally come to rest, record its position, and call out, "Next." Record the position at which the subject now adjusts the rod. Continue in this way, until the eight trials have been completed.

7. Stop the box, stepping down the speed gradually.

8. Open the door of the box, sit down on the threshold, and close the door as much as you can to prevent the subject from seeing out. Then ask the subject the following questions, recording his replies:

a. "How do you feel now, and how did you feel during the test?"

b. "What happened to the box while it was in motion?" If in reply, the subject does not indicate whether the room was tilted, ask him: "Was the room straight throughout, or did it tilt at any time?" If he says it tilted, ask him in which direction, and for how long. Be sure to get a clear statement from the subject as to whether or not the box was tilted.

c. "Did anything happen to your body?" If in reply to this question the subject does not indicate whether his body was tilted to one side, ask

him: "Did you remain sitting up straight throughout, or were you tilted?" If he says he was tilted, ask him which way, and for how long.

9. Now ask the subject to close his eyes, and lead him out of the box, and out of the laboratory.

APPENDIX 2

TRAINING PROCEDURES EMPLOYED FOR STABILITY OF ORIENTATION TEST

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I. First Session - General Discussion of Cues Employed in Space Orientation

The following lecture is given to all members of the Training Group (Group I) at the same time:

I want to speak to you for a little while about these tests in which you have been a subject. Our purpose in doing these experiments has been to find out just how good your space orientation is. That is to say, we want to know whether you are good at keeping your bearings, so that you can at any moment determine where up and down and left and right are, or whether you lose your bearings easily. To find this out, we placed you in situations where the cues you normally use to get your bearings were either changed or eliminated. We found in these tests that while some people become so disoriented that they literally cannot tell where up and down are, others are not thrown off at all and can make the box or themselves or the rod straight, quickly and easily.

What we are interested in doing with you people is to see whether something can be done about improving your performance. We are going to give you some specific training in space orientation to see whether it is possible to raise your scores on these tests. For the moment I will not say which of you did well and which of you did poorly on these tests, but we have found that no one ever gets a perfect score so that there is room for improvement in all of you.

Most of the training you are going to get will involve "learning by doing." In other words we will put you back in the apparatus and actually let you practice with special instruction. But before we do that, it might be helpful if we spoke for a while about some of the difficulties you had in the tests you took, and if we also discussed the cues you normally use to keep your bearings. That is what we are going to do today. Next time I will work with each one of you individually in the apparatus itself.

Let us begin by considering the trouble you had in the test you took upstairs, where you were seated in a box and your task was to make the box or yourself straight. Now the real difficulty in this situation was that you had nothing very definite to go by in deciding just where the vertical direction was. Since your body was not always straight, you could not go by that very easily, and since the box was not always straight, you could not go by that very easily either. On those trials where you had to make the box straight, you must have felt that if you were only sitting up straight, you would have no trouble at all. Then all you would have to do would be to line up the box with your own body. You must have felt too that if you could only look out of the box, for even an instant so that you could get an idea of where the walls of Ingersoll were, you would have no trouble either.

Actually, the problem you were faced with is very similar to one that the pilot of a plane frequently comes up against. That in fact, is why we are doing these experiments. Sometimes a flier may get into a fog bank and think he is flying along in straight and level flight. Suddenly, when he emerges from the fog bank, he may find that his plane is not flying straight at all, but is tilted at a sharp angle. In other words, he became disoriented in the fog bank. And this happens for the very same reason that you get disoriented in the tilting box. Specifically, when the earth below is blotted out, the pilot can see only the inside of the cockpit. Since he cannot see the horizon and the landscape, he has nothing very definite to go by in deciding whether the plane is actually straight or not, and he may therefore lose his bearings. However, the very instant he sees the earth again, he can immediately gauge his position.

Thus it may happen that both the pilot in the fog bank, and you in the tilting box, may sometimes have a very mistaken notion of where the vertical is. At such times we may say that you have lost your sense of bearings -- or have become disoriented. That is the specific sense in which we will be using these terms.

Now it may have been a very surprising discovery to you when you took part in these tests to learn that we may sometimes have trouble in getting oriented, for in ordinary circumstances we have no difficulty of this kind whatever. You never have trouble in deciding whether something is straight -- that is, vertical, or horizontal. In fact you can quickly and easily and without any thought at all, see that a picture on the wall is not hanging straight. You can do this even if the picture is off by just a couple of degrees. Or you can tell that the road you are walking on has a slight slope, or that a tree on the street is growing at a slight angle. The fact that we are all able to make these judgments so easily and so correctly means that our ability to determine the vertical and horizontal directions of space is a very quick-functioning and exact one. As a matter of fact everybody is able under normal circumstances to determine the vertical and horizontal to within a fraction of a degree--and without any hesitation whatever.

The question that arises now is: How do we do this? And there is a closely related question which should be asked here: What happens to this very smooth-functioning and reliable ability of ours in those cases where our conception of the upright is badly off--for example in the plane or in the tilting box apparatus? If we answer the first question we will automatically get the answer to the second question. And in answering these questions you will get an idea of what you must do to improve your performance in these tests.

Let us consider these questions in relation to your experience in the tilting box. As I mentioned before, you must have felt while you were being tested that if you could only look out of the box for an instant you would have no difficulty whatever in deciding whether it was straight or not. Well, that means that the "outside" could give you something to go by, or some cue as to what is straight. Well, just what does seeing the outside give you? Obviously, the outside has a large number of stable vertical and horizontal lines, and if you could see any of them you would be able to judge the position of the box at once. And there you have the answer to the question, of how it is that we

normally can determine the true upright so quickly and accurately: It is because no matter where we are, the environment is just filled with verticals and horizontals and we judge the uprightness of a line we have to decide about, according to them. This may be belaboring the obvious, but let us stop for a moment and list just a few of the more prominent verticals that we can see right here around us: there are the walls of the room, which are the most prominent verticals of all. There are the upright borders of the blackboard; the rod from which the light up there is hanging; the bars on the window; the sides of the chair; the doors; the moulding on the walls; our own bodies. And we could easily list hundreds of other vertical lines and surfaces in the room. We could do the same for the horizontal, of course. In other words, it is as though space were a container, whose form essentially is that of a box. As in the case of a box, the main lines of space are verticals and horizontals, and its framework is composed of these verticals and horizontals. We may say that every scene about us has a vertical-horizontal framework.

It should be noted that it is not at all an accident that verticals and horizontals are so much more plentiful in space than, let us say, diagonals or curved lines. And it should also be noted that this state-of-affairs is not a man-made matter either. The predominance of proper verticals and horizontals in nature is based upon the same fact that causes an architect to make a building go straight up, rather than at an angle. And that fact is gravity. Getting back to our main point, whatever the origin, it is the case that our environment does have vertical-horizontal axes or a kind of vertical-horizontal framework. And the important thing for us is that this gives us a basis for judging whether something is straight or not. If something we are looking at is in line with, or "fits in with," the verticals and horizontals around us, we say it is straight. That is how we know the picture on the wall is slightly off, or that the tree is growing at an angle and not straight up. In a real sense the vertical-horizontal framework characterizing every scene we see gives us a "frame of reference" for judging the upright.

From this you can see why it is that we normally have no trouble at all in getting our bearings -- why we can do it so quickly without any hesitation or thought. It is because the vertical and horizontal toward which we must get our bearings are so clearly indicated in our environment. Also, we can account for the <u>accuracy</u> with which we are able to determine the vertical and horizontal in terms of the accuracy with which these directions are presented in our environment. The verticals about us, for example are not at 87° or 93° but they are at exactly 90°.

You can see now why the pilot flying in clouds gets into trouble. It is because he cannot see the stable vertical-horizontal axes of the environment which normally give him his bearings. It is for the very same reason that you have trouble in the tilting-box -- that is, you cannot see the outside world.

But that is not the worst of it, as far as getting disoriented goes. More serious than not being able to see the outside, is the fact that you <u>do</u> see the inside of the box. And this is more serious because in the box you do as you always do in getting your bearings -- you tend to go by the vertical-

horizontal axes of the scene before you. In other words, you always tend to judge the upright as being the vertical of the scene before you, and you tend to do the same in the box. That is all right when the box is straight, but if the box is tilted, you can be thrown off. Now even if you know that the box is tilted, you are still influenced by it, in the sense that whether you want to or not its axes become a basis for judging the upright. For example, if while you are seated in the tilted box, I handed you a plumb line hanging straight down, or if I hand you a stick in the upright position, they would both look tilted. And that is because against the walls of the box the plumb line and the stick, though objectively straight, are "out of line" or "don't fit." The vertical-horizontal framework of the box becomes your frame of reference for judging whether the plumb line and the stick are straight, and since they are not in line with it they appear tilted. And I repeat this happens whether you know that the axes of the box are tilted or not. The framework of the box is so very pervasive and outstanding that it is difficult to escape its influence.

In fact so strong is this tendency to judge something as straight when it fits in with the vertical-horizontal axes of the environment, and tilted when it does not, that even our judgment of the position of our own bodies is affected by it. You probably remember from your experience in the tilted box that it is sometimes pretty difficult to decide whether you are sitting up straight or not, when the box is tilted. That is because your body is not only something you feel, it is also something you see. And just as the straight plumb line looks tilted in the tilted box, so does your body look tilted in the tilted box. At the same time it may feel straight, or it may even feel tilted the other way. In other words, you have difficulty making yourself straight when the box is tilted because there is a conflict between what you feel about your body and what you see about your body. We will have more to say about this later, but I cite this fact here to show you to what extent you are influenced by the prevailing vertical-horizontal framework of the scene before you -- in this case the box -- in getting your bearings concerning the vertical and horizontal.

What all this adds up to is that if you want to improve your performance you have to be very critical about what use you make of the vertical-horizontal axes of the box in getting your bearings. If you take the naive and passive and uncritical attitude you normally assume in judging the upright -- that is, just going by the verticals and horizontals around you -- you may be thrown way off. You have to be very critical and analytical in these tests. You cannot simply go by the appearance of things. You should not necessarily accept the box, or your chair, or the rod as straight, just because it "looks all right." In fact, that is precisely what is responsible for poor performances in these tests -- a tendency to "go along with" the visual framework too readily.

These things I have just said concerning what you must do to improve your performance in these tests are mainly a negative affair. I have told you not to go too much by the visual cues you get from the vertical-horizontal framework before you. But what can you do in a more positive way to get your bearings in these situations, and thereby improve your performance? Fortunately, there are other things you can use aside from visual cues in getting oriented. You can use cues from your body. And in these present tests your

own body will give you a much more reliable basis for judging the upright. If we speak of the aids you normally get from the scene before you as visual cues, and aids from your body as postural cues, we may say that in these situations you should give primary attention to postural cues.

Well, how can you make use of your body in the tilting box to get your bearings, to determine where the vertical is? I am sure that what I am going to say now on this point is not entirely new to you, for probably most of you did try to some extent to make use of your body for this purpose. It is obvious that if you know exactly what your own position is, it is possible to decide which way the vertical runs. For example, if you are tilted to the left, the true upright must be to the right of your body. If you are tilted slightly to the left, the upright is slightly to the right of you; if you are tilted a great deal to the left, the upright is very much to the right of you. So you see if you can establish your own position, you can deduce from that the position of the vertical, and once you know where the vertical is, you know where to put the box to make it straight.

Now normally, you do not have to work in this indirect way to decide whether something is straight, for you can judge it directly against the vertical-horizontal framework of the environment. Of course, even under these normal conditions you do make use of your body to some extent, comparing the line to be judged with your own body position, as well as with the verticals and horizontals in the environment. But at such times the involvement of the body is only secondary and indirect. However, in the tilting box, where the outer normal environment cannot be seen, and where the verticals in the box that can be seen may be tilted, you cannot use the direct method of comparing with the verticals in the environment. You must use the indirect method of comparing with your own bodies. In fact the only thing you can go by is your own body.

Now it is important to point out that using bodily cues to determine the upright does not mean that your judgment need be poorer than when you use visual cues. In fact, it has long been known that by using the body alone it is possible to determine the upright very exactly. For example, experiments have been done in which a person is placed in a totally darkened room and presented with a luminous rod while he is standing up straight. All he can see is this rod. Under these conditions it is possible for him to make the rod vertical or horizontal with an average error of only a fraction of a degree. And everybody is able to do this. In this test, all the subject can go by in making the rod vertical and horizontal is his own body, since the verticals and horizontals of the environment which might be used for comparison have been blacked out. In other words, what he does to make the rod vertical is to line it up with his own upright body; what he does to make it horizontal is to place it at right angles to his body. It has also been found that if a person is placed in a tilting chair and asked to make himself erect with eyes closed he can do so and not be off by more than a fraction of a degree.

Actually, you do not need these experiments to prove to yourself that your own body gives you adequate cues for establishing the vertical. You know it from your own everyday experience. For example, if you close your eyes right now, you know that you are sitting up straight. You feel it in your own body. In a real sense you actually "feel the upright" in your body.

Also if you lean over to one side, you know without looking at the environment that you are no longer straight. If you are leaning to the left, you can feel that you are displaced in that direction, and the vertical must therefore be to the right of you.

Let us stop for just a moment and consider the bodily cues we use in determining our own position. Then we can go on and consider the next step -- how we use our own position to decide whether something we are looking at is straight or not. Well, the most important cue we get for judging our own position is change in pressure against our body. Normally, when erect, we feel equal pressure -- or absence of pressure -- on both sides of our body. If we should however, feel more pressure on the right side than on the left side, we know at once that we are tilted to the right. There are many areas of the body where these pressure changes are experienced: the side of the body, the head, the elbows, the buttock, the soles of the feet etc. Not only do these pressure changes help us determine which way we are tilted, but they also help us decide how much we are tilted. If the pressure differences between the two sides of the body are great, then we must be tilted a great deal. If the differences are only slight, then the tilt of the body must be small. I am sure that you know these things because you experience them all the time, but the important thing is that you must learn to pay more attention to them in these tests. You must learn to be more sensitive to differences in pressure in the head rest, in the seat of your pants, against the side of your body.

Pressure against the body is not the only kind of cue you use to determine your position. There are other cues of which you are usually not aware. For example, we have a special sense in our muscles called the kinesthetic sense, which makes us aware of each movement of our body, and hence the position of our body. Everytime you move a part of your body muscular contraction is involved and you become aware of the change through this muscle sense. So, for example, while standing up, you can lean toward one side; through the muscular contractions which you experience you can immediately tell to which side you are tilted. Notice that this "muscular cue" is something that you get in addition to the pressure cue caused by your body pressing against something. There is still another sense which we have for determining our position. In each ear we have a system of canals known as the semicircular canals. Whenever we move our heads the fluid in these canals is displaced, and though we do not consciously experience it, this becomes another cue for determining our position. There are still other cues which we need not go into now. The important thing is that there are many, many cues that are consciously experienced that we get from our own bodies which help us determine our position. You must learn to pay very close attention to these cues, so that you will be able to determine your position accurately.

Now let us consider very specifically how all this can be applied to the tilting-room test in which you were a subject. Let us take up first of all the second part of the test, in which your task was to make your <u>chair</u> straight. We will take that up first because it is easier. Now I would suggest that you perform as follows in this part of the test: As soon as you open your eyes at the beginning of the trial concentrate on your body, and avoid looking at the box around you. You can do this without closing your eyes -- by just narrowing your field of vision to your own body. That is, just look down at your

own body, trying to exclude the box as much as you can. If you do this, it will be easier to decide what your position is. Now the reason why it is easier to determine your position if you do not look at the box is this: As I told you before, in a tilted box your body looks tilted, even though it feels straight, and this throws you off. So, since the box may at times be tilted, it is necessary that you try to escape its influence, and this you can do by trying to limit your vision to your own body.

Now, limiting your vision in this way you decide what your position is. Decide not only which way you are tilted, but how much you are tilted. You can judge this from the intensity of the pressure against the side of your body. Having determined this, indicate which way the chair should be turned to become straight. Then look at the box. You have to look at the box because, as you remember, you have to report on whether or not the box moves while the chair is being straightened. This is part of the test, and if you fail to report on box-movement when it occurs, you will lose credit. But even though you do look at the box while the chair is being made straight, give your attention to your body. Concentrate on your body at every instant and go by that and not by what you see. "Hold on to your body," as it were. If there is any difference between what you see and what you feel, you must go by what you feel. For example, upon looking at the box your impression of your position may seem to change. Don't be taken in by this. Stick to the decision you first made on the basis of what you felt before looking at the box. While the chair is being straightened, concentrate on what is happening to the pressure on the side of your body and in the seat of your pants. If the pressure against your side and against your head is diminishing, it means that you are getting straighter. When there is no longer any difference in pressure between the two sides of your body, or between the two sides of your head, you will know that you are straight. In other words when you are not slipping at all to either side, you are straight. When you think you are about straight, wiggle about in your seat a bit, to make sure that there are actually no differences in pressure on the two sides. Make sure particularly that you are not yourself pressing your body against one side of the chair, or your head against one side of the head rest, thereby getting the impression that you are tilted, though actually straight. The important thing to remember in making your chair straight is to go by what you feel and not by what you see. Concentrate on what you feel against the side of your body, against your head, in the seat of your pants, and so on; and avoid going by the framework of the box. If there is a conflict between how your body looks and how your body feels, go by how it feels. As I said, even if your body does not look straight, leave your chair where it is, if your body feels straight in that position. Remember that whenever your body is not actually lined up with the box, no matter what the position of the box, it will look tilted.

We have just talked about what you must do in the second part of the test, where your job is to make the chair straight. Let us turn to the first part of the test, where your job is to make the box straight. Now making the box straight is a visual task, for it involves adjusting something you see. However, it cannot be based upon visual cues alone, for reasons we have already considered. Here too, you must make primary use of your own body. What this means is that you must involve what you feel in your body in your decisions about the box. You must relate what you see to what you feel.

Let us be more specific now about how you can use your body in making the box straight. Just as in the part of the test where you must make your chair straight, the important thing is to determine your own position first of all. As before when you are asked to open your eyes at the beginning of the trial, try to get your own bearings before attending to the box. In other words, do not look at the box at the outset, but restrict your gaze to your own body until you have decided whether you are straight or tilted, and if tilted, which way and how much. Having done this, decide still without looking up at the box, where the vertical of the box should be, if the box is to be straight. Then look at the box and see if its vertical is in the position you thought it should be for it to be straight. If it isn't, decide which way the box is tilted.

Let us be still more specific about this, and consider how the box would appear to you in various relations between yourself and the box. Take first of all the simplest situation, where you are sitting erect. If when you open your eyes you decide on the basis of what you feel, that your body is straight, you know that the vertical of the box must be in line with you, if the box is to be straight. If this is true at the outset, then the box is straight, and there is nothing more that you have to do. If the vertical of the box is slanting to the left of your body, then the box is tilted to the left, and it must be moved to the right to be made straight. Or, if the vertical of the box is to the right of your body, it is tilted to the right, and therefore to make it straight you must have it moved to the left.

Let us consider now the situation where your body is tilted rather than erect. Well, if you have decided that you are tilted a good deal to the left, let us say, and if upon looking at the box you find that it is about lined up with you, then you know at once that it is also tilted a good deal to the left. This is the case even though the box looks all right. Therefore to be made straight, it must be moved to the right. Let us consider another situation where you are tilted to the left and the box is to the left of you. Obviously, in such a case the box must be even more tilted to the left than you are. Therefore to be made straight, it must be moved a great deal toward the right. Then there may be another situation where you are to the left and the box is to the right of you. This is the most difficult situation of all because when you are to the left and the box is to the right of you, the box may be still tilted to the left, or it may be straight, or it may even be tilted to the right. (Demonstrate these possibilities on the blackboard.) To decide which it actually is requires that you know exactly how much you are tilted. If, as we said before, you have decided that you are tilted a good deal to the left, then the box to be straight must be tilted a good deal to the right of you. If it is, then you know that it must be about straight. On the other hand if it is only slightly to the right of you, then it is not enough to the right to be straight, and therefore it must be moved some to the right. Finally, if the box is very much to the right of you, its actual position must be such that it is tilted to the right.

Now it is important to point out again that in all these cases the box may look "all right" and actually be tilted. However, it is possible for you to figure out at such times that though it looks straight it cannot possibly be straight. Take the case where you are a good deal to the left and the box

is very much to the right of you. The box may look quite all right -- that is straight, but if it actually were straight, it would mean that all of the difference between your axis and the axis of the box would have to be due to your being tilted. But if that were the case, you would have to feel much more tilted than you actually do. Therefore, since all of the difference between your axis and that of the box cannot be due to your being tilted, some of the difference must be due to the box being tilted. It is hard when you are tilted and the box slants the other way from you, to determine whether both you and the box are tilted or whether you alone are tilted, but it can be done. And to do it requires that you know exactly what your position is.

It is also important to remember at all times that the job of deciding what your own position is, is complicated by the fact that being in a tilted box gives you the illusion of being tilted yourself. If you are already tilted, you may get the illusion that you are straight or that you are more tilted or less tilted than you actually are, depending on the relation between yourself and the box. Or if you are straight, you may get the illusion that you are tilted. Because of this it is essential that you stick to the decision you make about your position at the beginning of the trial, before you look at the box. If looking at the box changes your impression of your own position, you will know that you are being thrown off by an illusion, and therefore you must stick all the more to your original decision. I would like to give you an illustration which shows how much you may be thrown off if you depend too much on what you see. It may happen that the individual is tilted to one side -- to the right let us say -- and the box is tilted even more than he is to the right. Now we have people who under this condition say that they are tilted to the left, and that to be made straight they must be moved to the right. In other words, they ask that they be tilted even more to be made straight. The basis for this very paradoxical behavior is really very simple. We find that these people also tend to say that the box is straight or almost straight. This means that they tend to accept the axes of the box as representing about the true vertical and horizontal. Hence, if they take the upright of the box as being about the true upright, then in relation to it they are tilted to the left. In other words, they <u>look</u> to the left of the vertical of the box, and because they look to the left they say they are tilted to the left. They give credit to what they see and disregard what they feel. This is what may happen if you depend uncritically upon what you see. Instead of judging their own bodies according to the axes of the box, they should have judged the axes of the box according to their own bodies. Then they could easily determine that since they felt tilted to the right, and the box was to the right of them, it must be even more tilted than they. So remember, go by what you feel, rather than what you see, and if there is a conflict between what you feel and what you see, stick to what you feel.

Let me summarize now the main points that I have given you in this talk. Remember them because they will be of great help to you when you get back into the apparatus. Think them over between now and the next session:

In these situations you cannot determine the upright from the vertical-horizontal framework of the environment, since you are not able to see the environment. Further, the vertical-horizontal framework that you can see -- for example, the inside of the box, cannot be relied upon since it may be tilted. Therefore, you cannot go by what you see. What you see may throw you off.

It follows from this that you must [illegible] your own body in getting your bearings. Whether your task is to make the box straight or to make yourself straight, you must at the beginning of each trial determine what your own position is. In doing this remember that if the box around you is tilted, it will tend to throw you off, and make it hard for you to decide how you are sitting. Therefore, try to disregard the box as much as you can when you open your eyes at the beginning of the trial. To accomplish this concentrate your gaze on your own body at first, and avoid looking at the box.

Now, when your task is to make yourself straight, even though you must look at the box continue to concentrate on how your body feels while you are being straightened. Notice whether the pressure on the side of your body toward which you are tilted is diminishing. When you can feel that there is no longer any difference in pressure between the two sides of your body, you will know that you are straight.

If your task is to make the box straight, you must also first of all determine what your own position is. In other words here too, as soon as you open your eyes at the beginning of the trial, concentrate your gaze on your own body, and get your bearing. Before you look at the box, decide approximately where its vertical axis should be for the box to be straight. Then look at the box. If the vertical of the box is not where you figured out it should be, then you know it must be tilted. Now you must decide which way it is tilted and how much. This you can determine from what you know of your own position.

Remember that as soon as you look at the box, you come under its influence, in the sense that your body may look differently than it feels. However, since you know that this visual illusion operates, you must guard against it. What you must do is to stick to your original decision you make before you look at the box. Do not change your mind about your position just because the tilted box makes you look tilted. This means that whenever there is a conflict between what you feel and what you see, go by what you feel. Go by what you feel no matter how much the looks of things contradict what you feel.

In a word, in these situations you must give priority to what you feel over what you see. You must be "body-conscious" at every moment in these tests. That is, keep attending to your body and remain aware of your position. Do this even if your task is a purely visual one -- as is the case when you must make the box or the rod straight.

Be body-conscious is our slogan here.

All of this means that you must adopt a highly analytical and critical approach. You cannot go by the appearance of things. You must figure things out, and not accept something because it looks all right. If the box looks straight, but you have figured out from what you know of your position that it is not straight, then the chances are that it is not straight. Go by what you figure out, not by appearances.

When the experiments are completed, we will show each of you all of your results.

II. Second Session - Training in Apparatus

The subject is seated in the Stability-of-Orientation-Test apparatus as usual.

1. The first "demonstration" consists of showing the subject that with his eyes closed it is possible to determine the position of his body very accurately, and thereby establish the vertical.

Say to the subject: You remember in the talk you heard last time, you were told that it is possible to get your bearings very precisely from your body alone. In other words, without using visual cues from the environment at all, it is possible to get a very exact idea of where the vertical direction is.

I would like to show you first of all that on the basis of cues from your body alone you can distinguish slight differences in your body tilt, in fact differences of just a few degrees.

Would you close your eyes now? You have no trouble at all in determining that you are perfectly erect. You can feel it. And you are able to determine this even though you are not getting any visual cues from the environment.

Keep your eyes closed. (Now tilt the subject 10° L.) What is your position now?

(The subject replies.)

As you see, you can gauge your position correctly. Now would you say that you are tilted much or a little?

(The subject replies.)

That's correct. Actually, you are tilted 10°. So you see without vision you can determine both which way you are tilted, and how much you are tilted.

Keep your eyes closed and we'll do something else. (Now tilt subject to 15° L.) Did I change your position?

(The subject replies.)

Did I make you more tilted or less tilted?

(The subject replies.)

Did I move you much?

(The subject replies.)

I moved you just 5° then and you were able to determine both the amount and direction of the change. 5° is a very small amount. That shows how sensitive your body is in detecting small changes in its position.

Keep your eyes closed. (Now move subject to 40° R.) What is your position now?

(The subject replies.)

Are you more tilted or less tilted than you were just before - that is, when you were tilted to the opposite side?

(The subject replies.)

Actually, you are tilted 40°. So you see from these few examples that you can gauge your position very accurately on the basis of what your body tells you.

Now just what did you go by in deciding that you were tilted and which way you were tilted? What cues did you use? (If the subject does not list all of the pressure points in which he detects changes, point them out to him.) Now remember these specific cues and pay particular attention to them when you are tested again: (1) difference in pressure on the two sides of the head rest, (2) difference in pressure against the sides of the chair, (3) pressure changes in the seat of your pants, (4) pressure changes in your elbows, (5) whether you feel your feet slipping to one side on the foot rest, (6) whether you feel yourself slipping to one side of the chair. Each of these cues should be carefully noted. Do not simply be satisfied with a <u>general</u> impression of how your body feels, but pay attention to each of these cues separately and specifically. If you do this you will be better able to detect very slight tilts in your body and to gauge more accurately the intensity of the pressure against your side. For example, your body tilt may be so slight that you will not feel any pressure against your side, but by attending to your head, you may detect a very slight pressure there. Or, if your feet are slipping markedly to one side you can tell that you must be more tilted than when you only feel pressure against your head. So, when you are determining the position of your body be sure to take note specifically of each of the parts of your body which we have listed as giving you cues as to your position.

Keep your eyes closed. Do you have a feeling as to about where the vertical is? Hold up your left hand now and place it in the vertical position.

(Subject responds.)

That's right. So you see that not only can you get the position of your body without visual aids, but once you know your own position you can very accurately determine where the vertical is. Thus, when you are tilted with your eyes closed you do not lose your bearings with regard to the outside world. You are able to determine very easily how the vertical and horizontal axes of the environment run.

(Now straighten the subject up and ask him to open his eyes. Before proceeding, make sure that subject feels erect again.)

2. Now proceed with the second demonstration which consists of showing the subject that it is very easy to determine his body position in an upright visual field.

Say to the subject: You have just seen that it is very easy to determine your position when your eyes are closed. I would like to show you now that it is even easier to do this when your eyes are open, provided that the box around you is properly upright. That provision is important, because if the environment is tilted, it becomes quite difficult to get your bearings, as we shall see.

Let us begin by considering your present position. You have no difficulty at all in deciding now that you are erect because you do not feel any pressure on either side. But in addition, because your eyes are open now, you have another way of determining that you are straight -- namely, you are lined up with the upright box. Because you have this extra visual help now, it is easier to determine your position than when your eyes were closed, even if you do not need this extra help.

Would you close your eyes? (Tilt subject to 10° L.) What is your position now?

(The subject replies.)

You see, there is no difficulty at all. This is exactly what I did to you before, -- the first time I tilted you when your eyes were closed. While you did not have any difficulty in gauging your position before, you can probably do it even more exactly now. And that is because in addition to feeling tilted, you look tilted. That is, your body looks slightly off to the left of the box.

(Now tilt subject to 15° L.) What did I do to you then?

(The subject replies.)

This again is what I did before when your eyes were closed. As before it was easy to tell that I moved you a little bit more to the left. Except that now again, you not only feel more tilted, but you look more tilted, in relation to the vertical-horizontal framework of the box.

So you see, it's really the easiest thing in the world to get your bearings when you are in an upright environment which you can see. The bodily cues and the visual cues you get can together help you establish your position to within a degree. All of this must seem terribly obvious and elementary to you, and actually it is. But I am showing this to you as a basis for comparison with what we are going to do next.

Well, so far you have seen that with your eyes closed, or with your eyes open in an upright field, your body alone can give you completely adequate cues for determining your position.

9. In this next demonstration we will show you how to show the effect of a tilted visual field upon his judgment of his own position.

Straighten subject.

Say to the subject. You will recall that in the talk I gave you last time, I said that the effect of the vertical-horizontal framework of the environment you are in is so great that it even influences your judgment of your position. Thus, if you are in a tilted environment, you get the impression that you are tilted too. That is because, as I said, your body is not only something you feel, it is also something you see. Just as an upright rod in a tilted environment looks tilted, so does your body look tilted. And because it looks tilted you are apt to judge that it is tilted, actually disregarding the fact that it and feel perfectly upright.

I would like to show you how an upright line actually looks in a tilted environment. (Hand the subject a plumb line and tell him not to suspend it until instructed to do so.) Close your eyes.

(Tilt subject to 15° L and the box to 40° R.) Now open your eyes. Suspend the plumb line directly in front of you. What is the position of the plumb line?

(The subject replies.)

Move the bottom of the line until you think it is straight. Well, actually that line was perfectly vertical originally, when you first suspended it. The weight attached to the string is acted upon by gravity and it is therefore pulled straight down, making it vertical. Now why does it look so tilted if it is actually straight? Obviously it has to do with its relation to the box. Now do you think the box is straight or tilted?

(The subject replies.)

(If he says it is straight, say: Actually it is tilted to the right.) Well, even if you know that the box is tilted, as you do now it is still the case that the plumb line looks tilted, so your knowledge about the position of the box is not the important thing. That means that the tilted appearance of the plumb line must have something to do with its relation to the walls of the box. Specifically, the plumb is out of line with the walls of the box, and because you tend to judge the direction of the plumb against the vertical-horizontal axes of the box, it appears tilted. To put it more simply, because the plumb seems displaced to the left of the vertical axis of the box, it appears tilted to the left. And I repeat again, you get this illusion even if you know perfectly well that the box is tilted.

Keep the plumb line suspended and I will show how it looks when the box is straight. (Straighten the box while the subject's eyes remain open.) Now the plumb line appears perfectly straight, even though we have not done anything to it. So you see the appearance of a line -- any line -- depends on the framework against which it is viewed.

Now getting back to the matter of your body, you get exactly the same illusion with your body as you get with the plumb line. And you get it even though in the case of your body you also feel its position, where in the case of the plumb line, you do not.

Let me show you that this is actually so. (Straighten up the subject.) You are sitting up straight now aren't you? Well, close your eyes. (Now move the box to 40° L and move the subject to 20° L, and then back to 0°.) Open your eyes now and tell me what your position is.

(The subject replies.)

Well, actually, you are sitting up perfectly straight, just as you were before. You think you are tilted because you look tilted. (If the subject reports that he is straight, say to him: Many people in this position say they are tilted to the right. If you concentrate on the box, and forget about your body, you can also get the illusion that you are tilted to the right.) As in the case of the plumb line you examined before, you seem tilted in a direction opposite to the tilt of the box, and for the same reason. Because you are displaced to the right of the vertical of the box, you appear tilted to the right.

Now close your eyes and we will try something else. (Tilt the room to 40° R and the subject to 20° R, and then to 0°.) Open your eyes and tell me what your position is now.

(The subject replies.)

Well, actually you are still sitting up straight. (Or, if the subject says he is straight, say to him: Some people under this condition think they are tilted to the left. If you concentrate on the box and forget about your body, you will be able to get the illusion too.) It seems to you that you are tilted to the left, because you are displaced to the left of the axes of the box. And notice again that you get this illusion even though you know that the box is tilted. That is how compelling the vertical-horizontal framework of the environment you are in can be.

Let me show you some more. Close your eyes. (Make the box erect, and tilt subject to 15° L, going up to 25° and then back to 15°.) Open your eyes, and tell me your position.

(The subject replies.)

That's right. You are tilted to the left. Remember this position, so that you can compare it with the position you will be in on the next trial. Now close your eyes again. (Tilt the box to 40° R and return subject to 0°, then to 30° L and back to 15° L.) Open your eyes. What is your position now?

(The subject replies.)

Are you more tilted than before, or less, or just about the same?

(The subject replies.)

Actually you are in exactly the same position you were in before. (If the subject reports that he is in the same position as before, say to him: Many people in this situation say that they are much more to the left than they were before. If you concentrate on the box, and forget how your body feels, you will be able to get this illusion too.) Now the question is: Why do you get this illusion of thinking you are more tilted than you were before? Before we answer this, tell me what the position of the box is.

(The subject replies.)

Actually it is tilted a good deal to the left. But whether you know that it is tilted or not, it is the case that your body is much more to the left of the vertical axis of the box than it was before. Before, you were tilted 15° to the left and the box was straight, so that you were 15° off the vertical of the box. Now, you are still tilted 15° to the left, but the box is 40° to the right so that you are 55° off the vertical of the box. Because you appear so much further away from the upright of the box than you did before, you get the illusion that you are much more tilted. Of course, if you give careful attention to how your body feels, you can tell that you are in the same position now as you were in before, and in that way you can overcome the illusion.

One more thing now. Close your eyes again. (Tilt the box to 40° L and subject to 15° L again going up to 30°.) Open your eyes now and tell me what your position is as compared with the position you were in just before. Are you more tilted, less tilted, or tilted just about the same?

(The subject replies.)

Actually, you are again in exactly the same position, but you seem less tilted because of the present position of the box. (If subject says he is tilted as much as before, say to him: Usually people feel less tilted in this position. If you again concentrate on the appearance of the box and forget about your body, you can get this same impression.) That is, now the box is even more tilted to the left than you are. Therefore in relation to the axes of the box, you are actually displaced to the right. What I mean simply is that your vertical is to the right of the box's vertical. This makes you look to the right, though you feel to the left. The consequence of this peculiar combination of visual and postural cues is to make you judge yourself as less tilted than you actually are.

If you concentrate very much on the box, and forget about the sensations from your body, you may actually get the illusion that you are leaning to the right rather than the left. Try it. As I told you, we have many subjects who under this particular condition say that they are tilted to the right. In order to have themselves straightened they actually ask that they be moved to the left, with the result that they end up even more to the left than they were before. They think they are straight when they look about lined up with

the box. The trouble with these people is that they are too strongly influenced by what they see and not enough by what they feel.

(Straighten up the chair and the box.)

You can see from what we have just done how important the visual cues from the scene before you are in getting your bearings. To put the matter in a nutshell, you tend to gauge the position of something you must judge according to whether or not it "fits" the vertical-horizontal framework of the immediate environment. If it fits, you judge it to be upright, if it does not, you judge it to be tilted. And as you have just seen, this applies even to your own body. You can understand now why in the talk I gave you I stressed so much the importance of not going by what you see in a naive way. And why, to put it more positively, it is important to go by what you feel. In these situations you will be very much misled if you do what you always do, simply accept the vertical of the scene before you as the upright, and get your bearings accordingly.

I think I can prove to you in particularly dramatic fashion how strongly your judgment of your own body position is determined by what you see around you. Keep your eyes open. (Now set the box in motion, from 40° L to 40° R.) What is happening?

(The subject replies.)

(Continue moving the box. If the subject reports self-movement ask him to close his eyes and to report on what is happening. Then ask him to open his eyes.)

Actually you were not moving at all. It was the box alone that was moving and you were perfectly stationary. (If the subject has said that only the box moved, say to him: Practically everybody gets the illusion under these conditions that he is moving opposite to the direction in which the box is moving. And you can easily get it too, if you forget about your body and concentrate on the box. Particularly if you look at the bar in front of you and the floor below you will get this impression. Try it. (Then tilt the box back and forth from 40° L to 40° R.) Let me show how it feels when you do move. (Now move subject alone back and forth from 40° R to 40° L.) Did you feel anything like this before?

(The subject replies.)

You see there is quite a difference between real movement of your body and the illusory movement of your body which occurs when the box turns around you.

Well by now, you should have no trouble at all in figuring out why you get the illusion that you are moving, when you are perfectly stationary. It is for the very same reason of course that you think you are tilted when you are sitting erect in the tilted box. It is because when the box is moving, your relation to the box keeps changing, and at each moment of the movement,

you tend to judge your own position in relation to the axes of the box. Hence when the box is tilted to the right, you get the illusion that you are to the left. And as the box keeps going to the right, you get the illusion that you are more and more to the left. So, since the box keeps going to the right, you get the illusion that you are more and more to the left. So, since the box keeps moving steadily, you get the impression of moving steadily yourself, in the opposite direction. In fact, when we do this to some people, they tell us that the box did not move at all, and that only they themselves moved. I know this is hard to believe, but it is so. And actually, if you try to forget about your body, and concentrate on the scene before you--particularly the post on your chair and the floor under you--you may be able to get it too. (Move the box from 40° L to 40° R.) It occurs in these people because they depend so much on the visual environment in getting their bearings, and so little upon what they feel in their own bodies. They accept the vertical-horizontal framework as properly upright at every point in its movement. Of course, if you do that, then all the change between yourself and the box must be due to your own movement.

What I have just said makes very clear what must be done to avoid this illusion of self-movement when the box is set in motion. You must concentrate on your body at every moment. Hold on to your body, keep the "feel" of your body constantly in mind. Keep asking yourself: Is there any change in pressure in my body? Am I falling to one side? Am I pressing on one side of the head rest, or on one side of my seat? If you do not feel any pressure changes or any sliding in your seat, then you know you are not moving, no matter what you see. In other words, you must keep your body sensations in mind at every moment, and not simply "attach" yourself to the box, as it were. Remember particularly the difference in how your body felt when it was actually moving, and how it felt when it seemed to be moving due to the illusion created by the movement of the box.

Let's try it. I'll move the box again, and while I am doing it you keep concentrating on your body, watching out particularly for pressure changes. "Look right through" the front wall of the box, as though it were not there. (Move box from 40° L to 40° R again.) Is the illusion reduced now?

(The subject replies.)

Of course, you can see in most dramatic fashion that this induced body movement depends completely upon the movement of the box, if you just close your eyes. That is making it a little ridiculous, but it is worth noting. Try it for a moment.

You see here again how much more reliable cues from your body are in these situations. You see too how a naive veridical going along with the visual environment can throw you off.

Let me just summarize what we have done to this point. You have seen first of all that when your eyes are closed, you can get your bearings quite perfectly. Through the cues from your body, you can gauge your own position, and once you know that you can easily tell about where the vertical is. We

have also seen that when your eyes are open, and the box around you is straight, you can again get your bearings very easily. In fact under such conditions you can not only feel how much you are tilted but you can also see how much you are tilted, by noting how much you are off the vertical of the box.

Finally, we have seen that when you are in a tilted field, you can run into real difficulty, and this kind of situation therefore requires the greatest caution. The tilted field may have the effect of making your body appear tilted when it is straight, or of appearing more tilted or less tilted when it is actually tilted. In such a case, you must rely upon your body and be careful as to what use you make of visual cues.

This is the main point that has emerged so far. Under all possible conditions -- when your eyes are closed, when your eyes are open in a tilted field, or when your eyes are open in an upright field - your own body gives you an adequate and reliable basis for getting oriented.

4. In this next demonstration, the subject is given instructions in judging the angle of his own body tilt.

Say to the subject: It might be an idea to take a few minutes now to show you just what it feels like to be tilted at various angles. If you learn just what a 10° tilt feels like, what a 20° tilt feels like, and so on, it will undoubtedly help you to come to a more correct decision. It should be helpful not only in terms of getting the "feeling" of these different positions, but also in terms of seeing how much you are away from the vertical of the box in each of these positions. Let's do the following: I will tilt you at different angles, and tell you just what these angles are. Then, when you think you have learned them well enough, I will put you in different positions, and you will tell me at what angle you are.

Close your eyes now. (Tilt subject to 10° L.) Open them. You are now tilted 10° to the left. Notice that this is a very mild tilt, and does not involve any great pressure against your side. Also look at the box, and notice that you are not very much away from the vertical of the box which is straight. Now compare this with a really large tilt. Close your eyes. (Tilt subject to 40° L.) Open your eyes. You are now tilted 40° to the left. Note how very much greater the pressure against your side is now. Also, looking at the box, you can see that you are a good deal away from its vertical. Try to remember this for later use. Try to remember particularly how very much tilted you feel when you are off the vertical of the box by this amount. You can realize for the future, that if you ever see your body displaced from the vertical of the box by this amount and you do not feel as tilted as you do now, then the box must be tilted the other way.

Let's continue. But first I will make you straight to get over the effects of being tilted. (Straighten the subject, and after a little

while, tilt subject to 20° R.) Open your eyes. Now you are tilted 20° to the right. Can you feel the difference between this amount of tilt and the two previous positions? Notice particularly how the box looks in relation to you -- in other words by how much you are away from the vertical of the upright box when you are tilted 20°. If in the future, you feel tilted by about this amount, but the box looks further away from you than it is now, then the box must be tilted the other way. In other words, you must learn to associate a certain amount of felt tilt with a certain amount of seen displacement of the box.

Close your eyes again. (Make the subject straight, and after a little while tilt him to 30° R.) Now you are tilted 30° to the right. Take a moment to compare this with the other three positions you were in. Remember both how it feels and how it looks. Close your eyes again. (Straighten the subject and after a little while, tilt him to 30° L.) Now you are 30° to the left. In other words you are tilted by the same amount as before, but to the other side. Observe this position for a moment. (Make the subject straight for a little while, then tilt him to 20° L.) Open your eyes. You are now 20° to the left. Before you were tilted to the right by this same amount. Observe how tilted you feel, and how the box looks in relation to you from this position. (Make the subject straight for a little while, then tilt him to 40° R.) Now you are 40° to the right. Remember how very marked the pressure against your body is here. In fact you almost feel as if you are going to fall out. Also remember how much the box is away from you. (Make subject straight for a little while, then tilt him to 10° R.) You are now tilted 10° to the right. Learn this position.

I have shown you some of the major positions. Now let us see if you can identify them when you are placed in these positions. I will tilt you while your eyes are closed. Then you will open your eyes, and tell me which way you are tilted, and by how many degrees.

(Run through the following series: 30° L; 10° R; 40° R; 20° L; 20° R; 40° L; 10° L; 30° R. Correct the subject if he makes an error, and re-do that position at the end of the series.)

If you remember how you felt in each of these positions, and how the upright box looked to you in each of them, you will have specific information that will be very useful to you when you are tested later. Remember, if the box is further away from you than it should be for the amount of tilt you feel, then the box cannot be straight.

In the future, whenever you are tilted, try to determine your position specificially in terms of degrees of tilt.

III. Third Session - Further Training in Apparatus

5. In this next demonstration the subject is given specific training in making his chair straight.

Say to the subject: Before going ahead, let me review very briefly what you have learned so far. First, you have learned that with your eyes closed, with your eyes open and the box upright, or with your eyes open and the box tilted, your body provides you with adequate and reliable cues for getting your bearings. You have learned too that when the box around you is tilted, it influences the appearance of your body. This may create the illusion that your position is different from what it really is and may lead to an incorrect judgment. For this reason, it is important that you get your bearings on the basis of how your body feels rather than on the basis of how your body looks, or on the basis of how the box looks. Finally, we taught you just what it feels like to be tilted at various angles, and how the box should look to you when you are at each of these angles.

Now let us go ahead. The specific problem we must tackle next is this: Just how should you proceed when given the task of making your own chair straight? In light of everything we have said, the most important thing to do in order to make a correct judgment is to emphasize the cues from your body and minimize the cues from the box. Well, how can you do that? My advice is that when you must straighten the chair, the first thing to do upon opening your eyes at the beginning of each trial is to restrict your view to your own body, and not look at the box. Do not permit yourself even a glimpse of the box, for that may be enough to throw you off. If you do not look at the box, you will naturally not be influenced by it, and in addition you will be able to give the fullest attention to your own body. Once you have done this, looking at the box will not throw you off. (Remember, by the way, that even though your job is to make the chair alone straight, you cannot avoid looking at the box. That is because when you take the test, you must report on whether the box moves while your chair is being straightened.)

So, when your task is to straighten the chair, the first thing to do at the beginning of the trial is to get your bearings on the basis of your body alone. There is another thing which is equally important. Once you have made your decision stick to it. You must do this, because, as you already know, when you look at the box your impression about your position may be changed due to the appearance of your body in the tilted box. There is still another point to remember. Since seeing your body against the background of the box may cause it to look as if it has a different position from what you feel, there may be a conflict between what you feel and what you see. Whenever there is such a conflict, go by what you feel and not by what you see.

Give your main attention to the things you feel in your body. Thus, while you are being straightened, notice particularly whether the pressure on the side to which you are tilted is diminishing as you move. When you feel that the pressure on both sides of your body is equal, you will know

you are straight. If you begin to fall over to the other side, and find that pressure is beginning to build up on that side, you will know you have been moved too far and must go back.

There is one final thing to be noted when your chair is being straightened, particularly if you want to make your judgments fairly accurate. When your chair is upright in the tilted box, and you suffer the illusion that you are tilted opposite to the box, there is actually a tendency for you to press your body involuntarily toward the side to which you appear tilted. This may create pressure against one side of your body which is not due to your falling over to that side, but to your pressing against that side. If this occurs, you will of course try to compensate for this pressure which you are yourself creating, and therefore your determinations will be off. Consequently, when you are straightening your chair and think you are about straight, you ought to wiggle about in your seat a little before making your final decision. If you do this, you will probably get rid of this tendency to press your body to one side, and your decision will be a more accurate one.

Now let's see how accurately you can make <u>yourself</u> erect. Remember all these points I have been talking about.

This is what we will do. Do you see those two blue knobs on the post in front of you? The knob on the left controls the chair. By pushing that knob to the left, you can make the chair go to the left; by pushing it to the right, you can make the chair go to the right. When you release the knob, the chair will automatically stop at the position it is in. There is one precaution: when you push the knob, move it rapidly and as far as it will go. Now I will change the position of the chair, and the box while your eyes are closed, and when you open your eyes, you will make the chair straight.

All right, close your eyes now. (<u>Tilt subject to 25° L and the box to 25° L.</u>) Remember when you open your eyes, concentrate on your body before looking at the box. Don't look at the box at all but restrict your gaze to your body. Open your eyes. Make the chair straight whenever you are ready.

If the subject is off by any amount, say to him: Is there now no difference in pressure between the two sides of your body? If he says there is not, say to him: Look down at your body and avoid looking at the box, and check again. Wiggle about in your seat again, as I told you to. Is there no difference in pressure? If the subject still says no, say to him: Close your eyes and try it. Allow the subject to remain with eyes closed for a little while to enable him to overcome the effects of the tilted field. If the subject now detects tilt in his body, tell him to make himself straight.

Before proceeding, say to the subject: Did you keep your eyes open while the chair was being straightened? Remember, you have to do this because when you take the test, you must notice whether the box moves at all while your chair is being straightened. If you do not report movement of the box when it takes place, you will lose credit on the test. It would hardly be worthwhile giving you all this training, if you then do something which makes you lose credit elsewhere, thereby cancelling the gain. You must learn to

adjust the chair under the same conditions that obtain during the test. In other words, you must learn to make yourself straight correctly, while looking at the box at the same time.

Close your eyes again. (Now adjust subject to 30° R and the box to 15° R.) Open your eyes and make yourself straight. If the subject is off in his final adjustment, repeat the above procedure.

Continue, requiring the subject to make himself straight under the following conditions:

1. (Subject 15° L, box 30° L)

2. (Subject 15° R, box 0°)

3. (Subject 0°, box 40° L)

4. (Subject 15° L, box 15° R)

If the subject has continued difficulty in making himself erect, review with him the specific pressure cues that he may use. Have him analyze each of them during the actual operation.

(Straighten the subject and the box.)

You are now able to determine your own position quite well, and you are able to make yourself straight regardless of the position of the box.

6. In the next demonstration, the subject is given specific training in adjusting the box.

Say to the subject: The next problem is to see whether you can make use of what you have learned, if your task is to make the box straight rather than the chair. Actually, this involves taking the problem one step further. When you make the chair straight, you simply have to determine your own position. When you must make the box straight, however, then in addition to determining your own position, you must use your knowledge about your position to determine the position of the box. In both instances, cues from your body play a central role.

Let us go into the problem of box-adjustment more specifically. Perhaps the best thing to do would be to analyze the various relations that may exist between yourself and the box. Let us consider all of the possibilities: First, you may be straight, with the box also straight, or with the box tilted to the left or tilted to the right. Or, you may be tilted with the box in any of the following positions: 1. the box may be tilted as much as you are; 2. the box may be tilted less than you are; 3. the box may be straight; or 4. the box may be tilted the other way. Let us consider each of these possibilities further.

It would be best to begin with the simplest set-up -- the one we have now, where you are straight. Now knowing that you are straight, you also know, even before you look at the box, that if the box is to be straight its vertical must be lined with you. If it is, as the case is now, the box is straight. If it is not, the box must be tilted, and to make it straight is a very simple matter -- you justhave to move the box until it is lined with you. Let's try it. Close your eyes.

(Now move the box to 30° L, and the subject to 15° L and back to 0°.)

Open your eyes, and before looking at the box, decide what your position is. Think in terms of degrees of tilt. What is your position?

(The subject replies.)

Now do you know where the vertical axis of the box should be if the box is to be straight?

(The subject replies.)

Now your problem is to decide which way the box is displaced.

I would like to make a suggestion here. When you have to decide which way the box is displaced, compare your body with some single prominent vertical on the front wall of the box -- for example, one of the sides of the square on the wall directly in front of you, or one of the white lines on either side of the front wall. Once you know your position it is easy to decide whether the vertical you pick is displaced to the left of you, to the right of you, or is actually straight with you. In other words, in deciding about the position of the box in relation to yourself, instead of comparing your body with the whole of the box, choose some single prominent vertical on the front wall of the box to compare it with.

Do that now. Which way is the box tilted in relation to you?

(The subject replies.)

That means that to make the box straight you must move it to the right. I will now move the box, and you tell me when to stop.

(Move the box steadily, until the subject says "enough".)

That was pretty easy, and the problem is exactly the same of course, when the box is to the right of you, instead of to the left, as it was just now. The important thing is that when you are straight, the box must be lined up with you to be straight.

Now let us consider another possibility. Let us take up the more difficult situation, where you are tilted. Though it is more difficult, the steps you take are exactly the same. You first determine your own position, disregarding the box. Then you decide where the box should be if it is to be straight. Then you look at the box, and determine where it actually is, and if it is not straight, how it should be moved.

Close your eyes now, and we will try it.

(Move the box to 20° R and the subject to 20° R.)

Open your eyes. Determine your position in terms of which way you are tilted, and by how many degrees.

(The subject replies.)

Now look at the box and tell me what its position is in relation to you.

(The subject replies.)

Actually you are tilted 20° to the right. Here you have a situation in which you are tilted and the box is lined up with you. Therefore, you know at once that the box must be tilted. It must be tilted even if it should look straight to you. Now do you know which way you should move the box and by about how much to make it straight?

(The subject replies.)

To be straight, the box must be displaced from you by as much as you are tilted. In other words, if you think you are tilted about 20° to the right, the box must be twenty degrees (20°) to the left of you to be straight. I will move the box now. Tell me when it is straight.

(Move the box.)

If the subject does well, proceed to the next demonstration. If he does poorly, question him as to what he went by in adjusting the box the way he did, and make appropriate suggestions for improvement.

Now let us consider another possibility which may arise when you are tilted. Close your eyes.

(Tilt the box to 30° L and the subject to 15° L.)

Open your eyes, and without looking at the box decide which way you are tilted and by about how many degrees. What did you decide

(The subject replies.)

Actually you are tilted 15° to the left. Now figure out about where the vertical of the box should be for the box to be straight. Look at the box. Is it where it should be in order to be straight? Compare the position of your body with the vertical on the wall, and decide which way the box is tilted.

(The subject replies.)

Here you have a situation where the box is tilted more than you are. Of course, if the box is displaced more than your body, and your body is

tilted, the box cannot be straight. Not only that, to be made straight, it must be moved past the point where it is in line with your body, because when it is in line with your body it is still tilted. Once the box is past your body it becomes a matter of moving it until it is displaced from you by about as much as you are tilted. Try it. I will move the box until you think it is straight.

(Move the box.)

(Again, if the subject does poorly, question him concerning the basis of his decision, and make appropriate suggestions for improvement.)

To this point we have considered the following possibilities: (1) Where you are sitting up straight. Then you must simply line up the box with your body. (2) Where you are tilted and the box is lined up with you. Then you must move the box away from yourself by as much as you feel tilted. (3) Where you are tilted and the box is even more tilted than you are to the same side. Then you must move the box past your body, and again displace it from you by as much as you are tilted.

Now we come to the kind of situation which is most difficult of all -- where you are tilted and the box is in a direction opposite to you. For example, you are to the left and the box is somewhere to the right of you. It is most difficult, because when this occurs there are several possibilities. First, there is the possibility that the box is less tilted than you are, but is still not straight. In other words, it is tilted in the same direction as you are, but not as much. For example, you are 30° to the left and the box is only 20° to the left. Or second, it may be that the box is actually straight. Or third, it may be that the box is opposite to you by such a large amount that it is actually tilted the other way. For example: you are 30° to the left and the box is 30° to the right, let us say. Let me show you.

(Tilt the subject to 30° L and place the box successively at 20° L, 0° and 30° R.)

Now in all these cases, the box is opposite to you. But the question is, how much of the difference between yourself and the box is due to your being tilted and how much is due to the box being tilted? It may be that only you are tilted. It may be that you are tilted, and the box is tilted some in the same direction you are. Or it may be that you are tilted, and the box is also tilted, but in an opposite direction. Now in order to decide which is actually the case, you've got to know just what your position is. For example, if the box is away from you by 30°, let us say, you have to decide whether this 30° difference is due to the fact that you are tilted 30°, the box being straight. Or whether the 30° difference is due to the fact that you are tilted 50° let us say, and the box by 20° in the same direction. In such a case too there would be a difference of 30° between yourself and the box. Or it may be that the 30° difference results from the fact that you are tilted only 10° to the left, let us say, and the box is tilted 20° the other way, to the right. Here again, the difference is 30°.

Now actually, you have a very good basis for deciding which is the case -- you can tell from your own body. You can tell by which of these amounts you are most nearly tilted: by 50°, by 30°, or by only 10°.

Let me show you the three positions we have been speaking about.

(Tilt the subject 30° L.)

Now you are tilted by 30° and the box is straight, so that there is a 30° difference between you and the box. Let me show you the next position.

(Tilt the subject to 50° L and the box to 20° L.)

Again there is a 30° difference between you, but now it's because you are tilted by 50° and the box by 20°. You feel more tilted now than you did before, and since the box is removed from you by the same amount as before, it must be tilted too. In other words, the box is not far enough away from you to be straight. Finally, let me show you the third position.

(Now tilt the box to 20° L and the subject to 10° L.)

Again there is a 30° difference between you and the box, but now it is the result of the box being 20° to the right, and your being 10° to the left. You can feel the difference between this situation and the other two. Here you feel much less tilted. You can tell that all of the 30° difference between yourself and the box cannot be due to your being tilted alone, because you do not feel tilted as much as 30°.

You see that in these situations, where the box and you are in opposite directions, the only way you can tell whether you alone are tilted, or whether the box is also tilted, is by means of your body. The thing to do is to determine your own position first. Once you know by how much you are tilted, you can decide that the box is over by such an amount that it must be tilted too, in your direction; or that it must be straight, or that it must be tilted, in a direction opposite to yourself.

I would like to give you a particularly striking illustration of a situation where you and the box are opposite, and where you can quickly tell from the position of your body that the box cannot be straight. Close your eyes. (Now tilt the subject to 20° L and the box to 70° R.) Open your eyes, and tell me your position and the position of the box.

(The subject replies.)

Here you are actually at right angles to the box. In other words, you are parallel with the floor. For the box to be straight, you would actually have to be lying flat on your side. In other words, you would have to be tilted at an angle of 90°, if all of the differences between yourself and the box, were due to your being tilted. However, since you do not feel that much tilted -- in fact, if you pay close attention to your body cues, you will find that you feel only slightly tilted. It must be that the box is also tilted, and the box must be tilted a very great deal. Actually you are tilted by

20° to the left, and the box by 70° to the right. So you see, whenever the box is opposite to you, you can tell from your own position what the position of the box must be.

Let us see how well you can do in a few of these situations, where you and the box are opposite. Close your eyes. (Tilt the box to 15° R and the subject to 30° R.) Open your eyes. Decide on your position in terms of degrees of tilt and then decide on the position of the box from that.

(The subject replies.)

I will now move the box until you think it is straight. Tell me when to stop. (Move the box.) (If the subject is off a good deal, question him as to the basis of his judgment, and make appropriate suggestions.)

Just now, the box was opposite to you, but still tilted some. Let us try another situation. Close your eyes. (Now tilt the subject to 15° R and make the box straight.) Open your eyes. What is your position and the position of the box?

(The subject replies.)

(If the subject fails to say the box is straight, find out the basis of his decision and make suggestions.) Here again the box was opposite to you -- that is, you were tilted to the right, and the box was to the left of you. But this time the box was straight. You could tell that it had to be about straight, since you felt only somewhat tilted, and the box was not very much to the left of you. If it had been very much to the left of you, for example, you could judge that it must actually be tilted to the left.

Let us try still another situation. Close your eyes. (Now tilt the box to 40° L and the subject to 15° R.) Open your eyes. Decide on your position and then the position of the box. What are they?

(The subject replies.)

Now, not only is the box away from you, but it is actually tilted in a direction opposite to you. There is a very large difference between yourself and the box, and since you feel only slightly tilted, you can tell that the box must actually be tilted the other way. It certainly cannot be that all of the difference between yourself and the box is due to your own tilt, since that would mean that you are tilted a very great deal. I will move the box now and you tell me when it is straight. (Move the box.)

Let us see now how well you can do by yourself at making the box straight. I will give you all of the box-chair combinations we spoke about so far. I will set the box and the chair in a given position while your eyes are closed, and then you will open your eyes and make the box straight by manipulating the right-hand knob on the post in front of you. If you turn that knob to the left, the box will move to the left; if you turn it to the right, the box will move to the right.

Let me repeat, finally, that the first thing to do when you open your eyes is to restrict your view to your own body and decide what your position is. Think actually in terms of degrees of tilt. Then decide where the box should be if it is to be straight. After that, look at the box, and see whether it is where it should be for it to be straight. Determine the relation of the box to yourself by comparing your body with the vertical line on the front wall of the box. If the box is not straight, move it away from you by as much as you think you are tilted. Remember, don't let the position of the box influence your judgment of your position. While making the box straight, remember your body at every moment. Avoid going by appearances.

Now present the subject with the following settings:

1. Subject 15° L, box 15° L.
2. Subject erect, box 30° R.
3. Subject 15° R, box 30° R.
4. Subject 30° L, box erect.
5. Subject 25° R, box 15° R.
6. Subject 15° R, box 40° L.

Again, if the subject is off, make appropriate suggestions.

7. Summary:

Let me summarize very briefly what we have been saying and doing in these training sessions.

The most important point to remember is that in these situations your body gives you the only adequate basis for orientation. Since the vertical-horizontal framework of the particular environment you are in -- that is the box -- may be tilted, you cannot orient by that as you normally do. In fact, going by what you see can throw you off so badly that it may even lead you to misjudge your own position, as you have seen. So what you must do is to go by what you feel, not by what you see. You must adopt what we have called a body-conscious attitude. You must be aware of the position of your body at every moment, and not allow yourself to be taken in by what you see. Be analytical. Don't simply go by appearances. Don't accept something because it looks "all right."

Regardless of whether your task is to straighten the chair or to straighten the box, the first thing to do is to get your own bearings. In other words, determine whether you are straight or tilted, and if tilted, which way and by how much. Try to think in terms of degrees of tilt. Get your position as soon as you open your eyes. Do it by paying attention to pressure differences in your body. In order not to be influenced by the box in making this judgment, avoid looking at the box at all until you have determined your position. Once you have made a judgment about your position,

stick to it. When you look at the box, it is very apt to change your impression of your position. This is probably an illusion created by the appearance of your body in a tilted field. Avoid this illusion by sticking to your original decision.

Once you have decided upon your position, it is an easy matter to make yourself straight. Just have yourself moved until you no longer feel any difference in pressure between the two sides of your body. As soon as the pressure on one side disappears, you will know you are about straight, even if you look tilted. If there is ever a conflict between what you feel and what you see, go by what you feel. Finally, for a more accurate decision, wiggle about in your seat a bit when you think you are about straight.

Now if instead of just making yourself straight, your job is to make the box straight, do the same thing. Determine your position before you look at the box, and decide just where the box should be if it is to be straight. Then look at the box and determine where it is in relation to you. We have already considered all of the possible relations between yourself and the box. If you are straight, then you simply line up the box with your body. If you are tilted, the box should be moved away from you toward the center by as much as you feel yourself to be tilted. While straightening the box, retain constant awareness of your position. Do not forget about your body for an instant, or you are apt to be excessively influenced by what you see. It is particularly important that you keep attending to your body when you are straightening the box, for straightening the box is a visual job, and you are therefore very apt to be too much influenced by visual factors.

The key point is that you must remain aware of your body at every instant and use your body to get and to keep your bearings.

Now when you are tested again, you will of course have to make your decisions quickly -- you will not have as much time to make up your mind as you have had here, while I have been training you. But actually, if you do the things I have been telling you, you should be able to make your decisions quickly.

There is one final thing about which I want to caution you. When we tell some people not to go by what they see in these situations, they develop a tendency to overcompensate. For example, in the dark room, in order not to be taken in by the luminous frame, they send the rod too far against the frame. That is, they try so hard not to line up the rod with the frame, which is their natural tendency even when they know the frame is tilted, that they move the rod away from the frame, but much too far. In the apparatus you are in now, they show similar kinds of overcompensation. For example, when they were tilted, and knew that the box must be moved in a direction opposite to them, they moved it too far. The result is that instead of making the box straight, they tilt it the other way. That is no improvement, for being off one way is no better than being off the other way. Another kind of overcompensation they show here involves such great suspicion about the box, that they will never believe it actually is straight, even if they have figured out that it is straight, and it looks straight to them.

You must learn to guard against such overcompensation for it will make a poor score.

In this training you have been getting, it has probably not been possible to change the way things feel to you or look to you. What we have tried to do has been to make it easier for you to figure out just how to interpret what you feel and what you see. For example, it is not possible to make you see as tilted a room which you see as straight. But it is possible to enable you to figure out that though appearing straight to you, the room must actually be tilted. We have tried to teach you how to analyze and separate what you feel and what you see, in a very specific way, and we have also tried to teach you how to integrate the things you feel and the things you see. Such learning is particularly useful when what you feel and what you see seem to contradict each other.

We have also tried to teach you when you may go by what you see and when you may not go by what you see. If what you see does not fit what you have figured out on the basis of your body sensations, then you cannot go by what you see. However, it is all right to go by what you see, if you have figured out that what you see is all right. For example, if the box or frame looks straight, and you have also reasoned out from what you feel that it is straight, then it is entirely safe to go by what you see. Should you, under such conditions, have the task of making the rod straight, you may safely line it up with the box or the frame. This, of course, could make your job vastly easier than working indirectly through your body each time.

We have concentrated in this training on the apparatus you are in now. You can easily see, however, that everything we have said and done applies to all the situations you have been in, for in all of them you really are faced with the same problem: namely, to integrate what you feel and what you see in order to determine where the vertical and horizontal are. At times, you may have to make the rod straight, at other times you may have to make your own chair straight, and at still other times you may have to make the box around you straight. But in every instance, what you do requires that you know where the vertical and horizontal are. And this in turn involves making some use of what you see and what you feel. When you are tested in any of these situations, always remember the things we have said here. You can see how very specifically the information you have obtained here applies to the dark room, for example. There you have the luminous frame corresponding to the box, and you must use your body sensations to determine the position of the rod.

We will test you further in these situations and on the basis of your performance in them, we will be able to determine how effective all this training has been.