TACTILE STIMULATION AND PERCEPTION OF THE VERTICAL

I. Effects of diffuse vs. specific tactile stimulation

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NYBORG, H. Tactile stimulation and perception of the vertical. I. Effects of diffuse vs. specific tactile stimulation. *Scand. J. Psychol.*, 1971, *12*, 1–13. — It was found that tactile stimulation influenced perception of verticality. Perception of verticality was tested by means of Rod-and-Frame Test, standard procedure. During tilted standing, subjects were exposed to diffuse tactile stimulation (DBR) or specific tactile stimulation (SBR) by means of a specially built apparatus. On the average, subjects scored closer to the physical vertical during SBR than during DBR.

One way to maintain an orientation relative to the vertical is to use visual information. Another way is to profit by the effect of gravitation on the body, especially on the vestibular apparatus. A third way is to attend to unilateral tactile stimulation of the body surface.

By experimental exclusion of the other in animal research each of the cues has proved to be sufficient, but normally they cooperate (Magnus, 1924).

The retinal representation of the main lines in the actual visual field and the effective direction of the force of gravitation are normally coincident. However, in order to establish whether the visual or the bodily cues were the more important, Wertheimer (1912) tilted the optical field by means of a mirror. From this now classic experiment he concluded that the visual information dominated the bodily. Later, Gibson (1938) drew attention to postural stimuli as more effective than visual. On this contradictory ground Asch & Witkin (1948*b*) started extensive studies in perception of the vertical. They concluded that the visual frame was the more powerful. But in 1952 Gibson reformulated his first statement by saying 'the question is no longer which mode is decisive when they are set in conflict, but simply how do they interact?' (Gibson, 1952, p. 372). A body of evidence seems to support Gibson's point of view.

On studying the interaction, however, we find that most of the experiments in the field lacked sufficient control over the situational variables and in some cases the individual differences had been neglected. It is no surprise, therefore, that results have been contradictory. Cues from the highly developed visual apparatus might be more influential for most people than bodily cues in perception of the vertical under normal daylight conditions and inferior for all in the dead of night; but even under equalized conditions, people differ in their capacity to draw information from available cues.

No experimenter has sufficiently demonstrated the effect of changes in tactile stimulation on mans perception of the upright, although everyone admits that tactile stimulation must have some importance. On the one hand the experimental designs have been multivariable, but they have favoured the 'powerful' visual, vestibular and kinæsthetic modalities and neglected the relatively unarticulated information derived from the tactile receptors.

In some experiments the subject's head has not been adequately fixated in a firm headrest, or the construction of the tilting chair has allowed the body to move relative to the headrest. This is serious in an experiment on tactile stimulation because it leaves information from neck and trunk muscles uncontrolled. When man is required to sit erect in a chair, considerable muscular effort is necessary to keep his spinal cord straight (Åkerblom, 1948). On tilting him, the effective direction of gravitational forces cause modifications in muscle strain because of weight displacement and because his body is not uniformly supported in most tilting chairs. This change in muscular involvement has not been accounted for, but it might interfere in unknown ways. Few experimenters have made effort to eliminate auditive directional cues, although these might be of some help to the disorientated subject (Jeffress & Taylor, 1961) and they are easily eliminated by use of ear-phones (Young, 1931). Moreover, there are no registrations of accelerative and decelerative forces on the subject in any of the investigations, and so it is particularly difficult to know the degree of actual vestibular stimulation.

One of the first experiments on body cues in perception of the vertical was performed by Bourdan (1904). He concluded that skin deformations caused by tilt of body and head give rise to delicate sensational differences and result in information about the spatial position of the body and head. Unfortunately, he did not present clearcut experimental evidence. In an experiment with a tilting chair, Garten (1920) anæsthetized the buttocks which contacted the chair, but it had no effect on the subjects' performance. Similarly, Arndts (1924) anæsthetized standing and sitting subjects in those areas of the skin which touched the support under tilt. No significant differences were found in relation to unæsthetized subjects.

The experiments confirmed that the tactile stimulation plays little role, if any, in determination of upright. But it is important to remember that the experimental designs lacked sufficient control of certain main factors. Thus, the result that local anæsthetizing of subjects did not have any effect relative to unæsthetizing is probably due to the fact, that the deep layers of the skin were only partly anæsthetized or not at all.

In part these studies were designed to show what effect a change in tactile stimulation would cause in interaction with input from other modalities involved in perception of the vertical. The following study is an example of an experiment in which effort was made to exclude as far as possible all other modalities except the tactile one.

By use of padded, non-padded seats respectively, Mann et al. (1949) varied the tactile condition to see its effect on postural adjustment. Reduced tactile stimulation increased the average error. This result might be due to more comfortable position of the subject under padded condition with less active muscular involvement, and as claimed by Howard & Templeton (1966) this relaxation rather than reduced tactile stimulation might be responsible for the increased error. Tactual cues in determining one's own body tilt depend on the extend and direction of asymmetrical stimulation of the body surface. Thus it is clear that when straightening up one's own body, small deviations from vertical give less tactile information of body tilt than greater deviations; subjects under high degree of tilt are stimulated heavily on one side and slightly on the buttocks; subjects sitting upright are stimulated slightly, bilaterally, as they are supported by both armrests, but mainly on the buttocks. The nonlinear shift in intensity of stimulation of one side under straightening and the sudden change in areas stimulated when the chair is close to the vertical might confuse subjects and obscure the results.

At this stage, then, no studies have demonstrated the effect of tactile stimulation on perption of the vertical with the exception of Mann et al. which on the other hand could be iticized; and as might be seen from the above, more strict control over the experimental riables is needed.

The following criteria must be fulfilled:

The tactile stimulation must be clearly defined with regard to body area, and it must be changeable.

Head and body support must be adequate, allowing a low and constant level of muscular participation.

Effects of acceleration and deceleration must be eliminated.

Directional auditive cues must be excluded.

These requirements are met in the following experimental set-up, which has been dened for a series of experiments on factors considered to be important for man's perception the upright.

The main purpose of the present experiment was to eliminate, as far as possible, all infortional input with regard to perception of the upright, and then intensify tactile stimulation see if it had any effect in a Rod-and-Frame Test. It was expected that the effect would 'er among the subjects.

THE EXPERIMENT

paratus

e experimental set-up was composed of a Rod-and-Frame Test and a tilting stand.

Rod-and-Frame Test

The Rod-and-Frame apparatus was constructed of a square frame, the sides of which were cm long and 2.5 cm wide. Within this frame was a rod, 98 cm long and 2.5 cm wide. frame and rod were pivoted on the same centre, but mounted on separate shafts so that could be rotated independent of each other. A protractor mounted on the shaft to which frame was fastened moved with the frame against a stationary scale permitting direct readof the position of the frame. A similar arrangement allowed measurement of the position ie rod. Frame and rod were coated with luminous paint, and were the only items visible ie subject in the compleately darkened room. Readings and operation were performed in a -proof controlroom, isolated from the testroom.

tilting stand

he tilting apparatus is shown in Figs. 1–2. It consisted of a 70 × 40 × 190 cm tilting stand ended on the rear in a two-dimensional gyro arrangement which permitted tilt to left/right forward/backward around the centre of the tilting stand. Only left and right tilting was in the present experiment. The tilting stand was constructed of a heavy steel framework rm of an upright box with a gate in the front. It was so dimensioned that a person with a it of 185 cm could stand inside easily.

ie box was equipped with five body/head supporters. First, adjustable headrests were ited on level with the subject's ears. The remaining four supporters were placed just under lderjounts (M. latissimus dorsi), opposite hip-joints (os illium), contrary to the middle of highs (femur-diafys) and to the central parts of the small of the legs (fibula-diafys); they adjustable up-down and out-in relative to the subject. The number of supporters and position relative to the head-body was supposed to eliminate displacement between head

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The Rod-and-Frame Test

The Rod-and-Frame apparatus was constructed of a square frame, the sides of which were 100 cm long and 2.5 cm wide. Within this frame was a rod, 98 cm long and 2.5 cm wide. The frame and rod were pivoted on the same centre, but mounted on separate shafts so that they could be rotated independent of each other. A protractor mounted on the shaft to which the frame was fastened moved with the frame against a stationary scale permitting direct readings of the position of the frame. A similar arrangement allowed measurement of the position of the rod. Frame and rod were coated with luminous paint, and were the only items visible to the subject in the compleately darkened room. Readings and operation were performed in a light-proof controlroom, isolated from the testroom.

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The tilting apparatus is shown in Figs. 1–2. It consisted of a 70 × 40 × 190 cm tilting stand suspended on the rear in a two-dimensional gyro arrangement which permitted tilt to left/right and forward/backward around the centre of the tilting stand. Only left and right tilting was used in the present experiment. The tilting stand was constructed of a heavy steel framework in form of an upright box with a gate in the front. It was so dimensioned that a person with a height of 185 cm could stand inside easily.

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The body supporters were provided with relatively sharp horizontal, bodyformed alumi bands upon which the subject rested under tilt, an experimental condition called specifi reference (SBR).

Between the subject and the supporters were two rubber cushions which could be ir either simultaneously or independently; during inflation the subject was raised from the supporters and rested softly on the rubber cushion, an experimental condition called body reference (DBR).

It should be stressed that when the subject was exposed to diffuse tactile condition situation was designated DBR (diffuse body reference condition), whether he was standi right or standing tilted. In situations where he was supported not by the rubber cushions upright standing, but slightly by four sharp supporters, or where he was supported by bands under tilt, this conditions were called SBR (specific body reference condition).

Footrests of different heights could be inserted to compensate for individual body- variations. Communication with the subject was maintained through earphones mc in the headrests which, covered with foam rubber and sound-isolating materials, exclu unwanted auditive stimulation. A microphone allowed the subject to contact the experin

A black-painted circular plate was mounted just above the subject's head and serv visual block. It could be turned on a spindle in the frontal plane of the subject to preve wanted visual stimulation. When the experimenter released the visual block the subject see the rod and frame at a distance of approximately 2.25 m. The centrepoint of the frar about eye level of the subject.

The degree of tilt, acceleration and speed could be controlled by either the subject experimenter by means of transistorized automatics. By means of a servomechanism possible to accelerate or decelerate the subject stepless to any given degree beween $0 \leqslant a$ $\sec^{-2}$ (tolerance 1 %) within sideward tilt up to 90° to left or right, and 45° forward or bacl and any combination within these limits. In the present experiment the stand was only sidewards and by the experimenter alone. Degree of tilt was read continually within 1°. of speed was 0–1°/sec.

Subjects

The experiment was done with 48 subjects who were employees at the State Mental H in Risskov. Half of them were female nurses; the other half were male nurses. None kne thing in advance of the purpose of the experiment.

The experimental design

The 48 subjects were devided into six groups consisting of four men and four women they proceeded according to the scheme presented in *Table 1*.

Half the subjects started under the diffuse body reference conditions (DBR) i.e. sup by blown-up rubber cushion; the other half started under the specific body reference conc (SBR) i.e. supported on one side by the four sharp supporters. All subjects finished the sion under the opposite body reference condition. Each group had its own characteristic sition to possible combinations of tilt of the body (left, right, and upright), tilt of the (left, right) and tilt of the rod (left, right).

Each symbol in Table 1 (U = upright standing; L = tilted standing 28° to the left; R = standing 28° to the right) represents a series of eight trials in which the subjects, the fran the rod were tilted to the left and right at random. All possible tilt combinations oc twice. In doing so, the experimental design appeared symmetrically balanced in order t weigh as far as possible systematic errors.

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A black-painted circular plate was mounted just above the subject's head and served as a visual block. It could be turned on a spindle in the frontal plane of the subject to prevent unwanted visual stimulation. When the experimenter released the visual block the subject could see the rod and frame at a distance of approximately 2.25 m. The centrepoint of the frame was about eye level of the subject.

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The 48 subjects were devided into six groups consisting of four men and four women each; they proceeded according to the scheme presented in *Table 1*.

Half the subjects started under the diffuse body reference conditions (DBR) i.e. supported by blown-up rubber cushion; the other half started under the specific body reference conditions (SBR) i.e. supported on one side by the four sharp supporters. All subjects finished their session under the opposite body reference condition. Each group had its own characteristic exposition to possible combinations of tilt of the body (left, right, and upright), tilt of the frame (left, right) and tilt of the rod (left, right).

Each symbol in Table 1 (U = upright standing; L = tilted standing 28° to the left; R = tilted standing 28° to the right) represents a series of eight trials in which the subjects, the frame and the rod were tilted to the left and right at random. All possible tilt combinations occurred twice. In doing so, the experimental design appeared symmetrically balanced in order to outweigh as far as possible systematic errors.

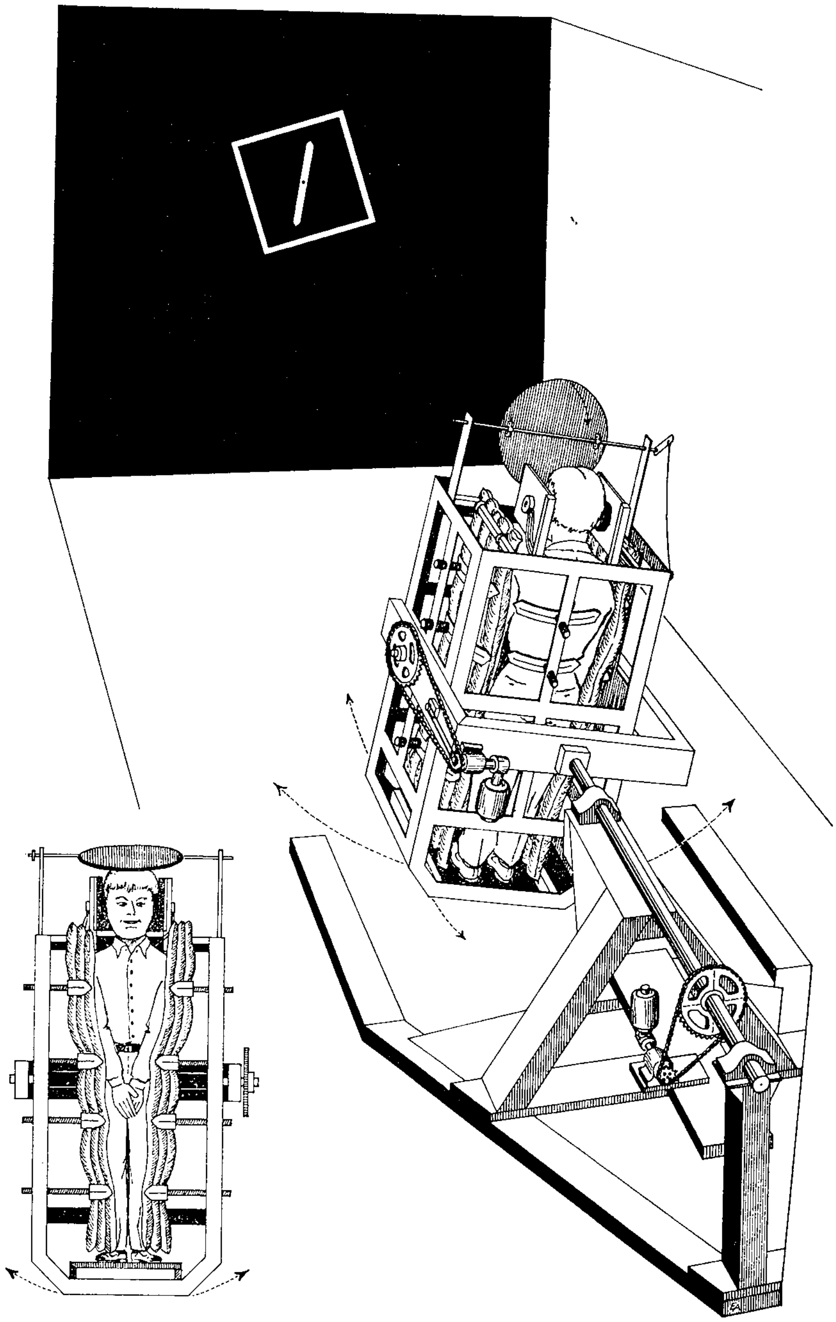

Fig. 2

Fig. 1

. A schematic representation of the experimental situation.

. A schematic representation of front view of the tilting stand with gate removed. During the ex-
ent, it was controlled that the subjects were standing as shown by their feet in Fig. 1; there is
or in the drawing of Fig. 2 with respect to the position of the feet.

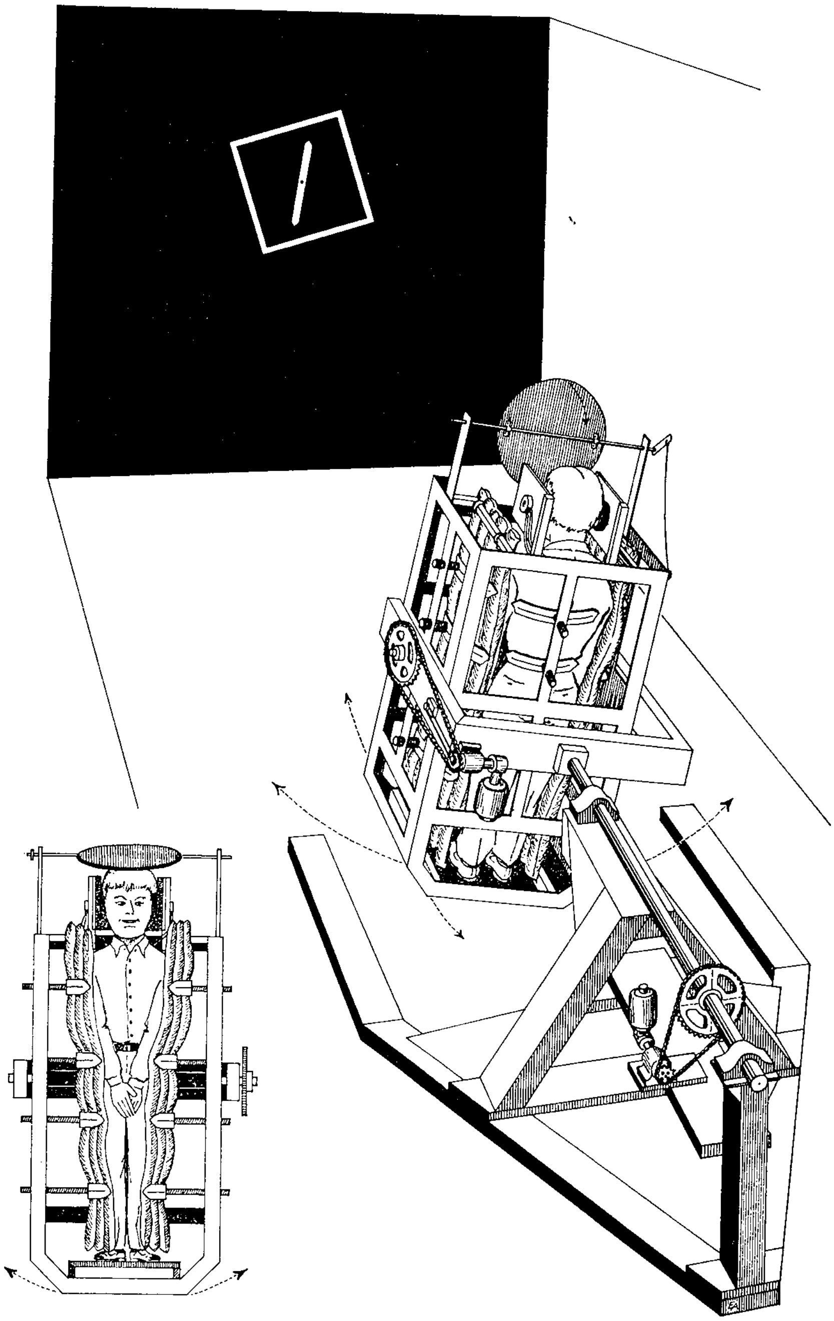

Fig. 2

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FIG. 1. A schematic representation of the experimental situation.

FIG. 2. A schematic representation of front view of the tilting stand with gate removed. During the experiment, it was controlled that the subjects were standing as shown by their feet in Fig. 1; there is an error in the drawing of Fig. 2 with respect to the position of the feet.

Procedure

Before the subject was allowed into the experimental room the footrest in the tilting s was adjusted corresponding to his height. The subject was then blindfolded and placed i tilting stand. The headrests were tightened, so that the subject could not move his l and he was asked to keep his arms along his body but slightly forward. The body suppo were adjusted, and the gate was closed. Two built-in flashlights activated the rod and fram all light in the test room was turned off. The subject was then asked to take off his dark gla

TABLE 1. *Procedure in Rod-and-Frame Test. Six groups were tested in RAF test in cou balanced order under upright standing conditions (U); under tilted standing 28° to left (L right (R); and under specific body reference condition (SBR) or under diffuse body refe condition (DBR). For explanation of specific vs. diffuse body reference, see text.*

First group		Second group		Third group	
DBR	SBR	DBR	SBR	DBR	SBR
U	L	L	R	R	U
L	R	R	U	U	L
R	U	U	L	L	R
Fourth group		**Fifth group**		**Sixth group**	
SBR	DBR	SBR	DBR	SBR	DBR
U	R	L	U	R	L
L	U	R	L	U	R
R	L	U	R	L	U

Some of the subjects were now told that the rubber cushion on their left or right side w be inflated; In the upright standing series both cushions were inflated simultaneously. All jects were required to relax and move as little as possible. A highly sensitive sound det recorded small movements; if the subject moved more than once in a series he was requir relax.

He was now instructed that when he opened his eyes he would see a square frame, and w it a rod. The possible tilt combinations of the rod and frame and of himself were explained he was instructed that his job was to adjust the rod to vertical. It was ensured that he ur stood clearly what was meant by 'vertical' through definitions like 'vertical as the wal this building'; 'like a flagpole'; 'like a plumb-line hanging just before your nose' and s At the beginning of each trial, he was to state whether the rod was in the required position if not, which way it was tilted. When these instructions had been given, the rod and frame placed in position for the first trial.

He was then tilted according to Table 1 with speed of acceleration and deceleration a time exceeding $0.036°/\text{sec}^2$.

The visual block was released, and the subject was asked to report on the position of the If he at once perceived the rod as vertical, he was examined very carefully, to ascertain th really perceived the rod as physically upright and not in relation to the frame or himself. reported that the rod was tilted, he was told that the experimenter would move it a little time in the preferred direction. He was required to say 'more' after each turn, until he ceived it as vertical, when he was to say 'enough'. At this point the subject could ask for fu adjustments if he wanted.

The subject was now again questioned, to make sure that he perceived the rod as upright

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TABLE 1. *Procedure in Rod-and-Frame Test. Six groups were tested in RAF test in counter-balanced order under upright standing conditions (U); under tilted standing 28° to left (L) and right (R); and under specific body reference condition (SBR) or under diffuse body reference condition (DBR). For explanation of specific vs. diffuse body reference, see text.*

First group		Second group		Third group	
DBR	SBR	DBR	SBR	DBR	SBR
U	L	L	R	R	U
L	R	R	U	U	L
R	U	U	L	L	R
Fourth group		**Fifth group**		**Sixth group**	
SBR	DBR	SBR	DBR	SBR	DBR
U	R	L	U	R	L
L	U	R	L	U	R
R	L	U	R	L	U

Some of the subjects were now told that the rubber cushion on their left or right side would be inflated; In the upright standing series both cushions were inflated simultaneously. All subjects were required to relax and move as little as possible. A highly sensitive sound detector recorded small movements; if the subject moved more than once in a series he was required to relax.

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He was then tilted according to Table 1 with speed of acceleration and deceleration at no time exceeding $0.036°/sec^2$.

The visual block was released, and the subject was asked to report on the position of the rod. If he at once perceived the rod as vertical, he was examined very carefully, to ascertain that he really perceived the rod as physically upright and not in relation to the frame or himself. If he reported that the rod was tilted, he was told that the experimenter would move it a little at a time in the preferred direction. He was required to say 'more' after each turn, until he perceived it as vertical, when he was to say 'enough'. At this point the subject could ask for further adjustments if he wanted.

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In the first trials and in the beginning of the second series, the questions of vertical were reeated to ensure that the subjects really understood the meaning of physical vertical.

ANALYSIS

The scores were handled in the following way: all unsigned deviations from physical vertical n adjusting the rod to vertical were recorded. The adjustment of the rod to physical vertical vas noted in all trials, without regard to the direction of the deviation, i.e. whether it deviated o the left or to the right in relation to physical vertical.

Then the mean scores under DBR and SBR conditions were calculated for each subject vhen standing upright and when leaning. By collecting data in this way a general survey of rrors was obtained.

The mean scores were based on 2,304 estimations made by the 48 subjects with a total of ,152 estimations under identical conditions (test-retest correlation was as high as 0.93).

RESULTS

DBR vs. SBR, upright standing

Table 2 presents the mean errors for subjects under DBR and SBR upright standing conditions.

When the tactile stimulation conditions changed from DBR to SBR when standing upight, a change to a lower mean score, i.e. a more correct setting of the rod to physical vertical, was seen for men as well as for women. This change does not seem to result in large displacenents, of the groups' mean deviations, neither for the male nor for the female subjects, and east for the female. However, the distribution of subjects along the scoring continuum (cf. Figs. 3–4) showed that the mean scores should not be overemphasized.

TABLE 2. *Mean errors in degrees of deviation from physical vertical for body upright standing under DBR and SBR conditions.*

	DBR	SBR	Decrease from DBR to SBR
Men	7.46	6.65	0.81
Women	5.75	5.67	0.08

The distribution in Fig. 3 is seen to cover a mean score area from less than 1° to more than 16° deviation from physical vertical with two characteristic peaks about 3° and 8° for men and women, respectively. On the average, women scored lower than men. Seven men were among the nine highest scoring subjects.

Comparing the distribution presented in Fig. 3 with the distribution in Fig. 4, there was a if he meant that the rod now was parallel to the walls of the building. He was told to close his eyes and the visual block was then set to prevent the subject from seeing the rod and frame under adjustment for the next trial. The position of the rod relative to physical vertical was read in the control room, which was fully enlightened under all trials. Rod and frame were adjusted for the next trial, the visual block released and the subject asked to open his eyes and proceed again.

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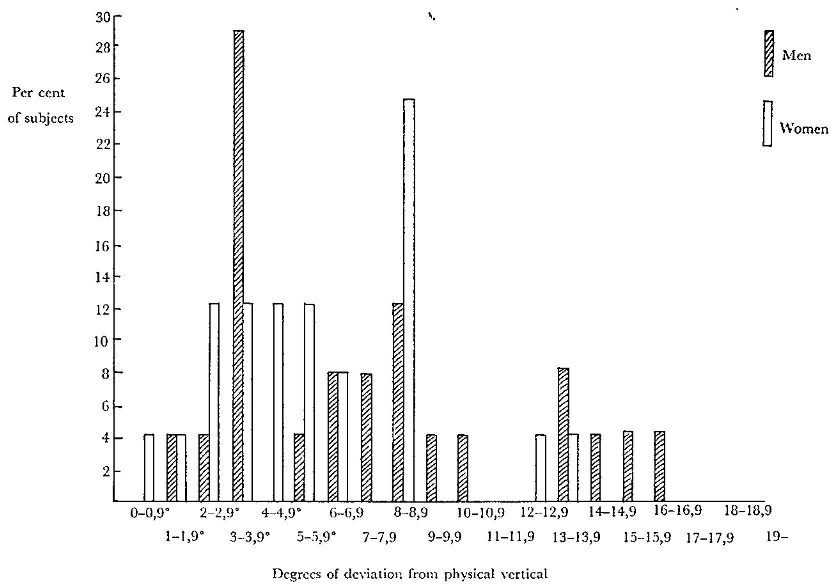

FIG. 3. Distribution of unsigned mean deviation scores for subjects in upright standing and
condition.

DBR vs. SBR, tilted standing

The difference between DBR and SBR was expected to be higher, when the su
stood tilted because the difference in tactile stimulation in DBR vs. SBR would be
pronounced during tilt. During tilted standing, DBR would mean that the body wou
supported homogeneously; also there would be a diffuse mass pressure stimulation o
side of the body. When SBR condition was introduced the body was given a puncti
support in form of four sharp supporters which caused a very specific one-side stimu
of the body.

Table 3 presents the mean scores for DBR and SBR during tilted standing. Since s
for left- and right tilt of the subjects showed no significant differences the direction of
disregarded and all scores are included in the comparison of the DBR and SBR under
standing.

As expected, a remarkable decrease in mean score deviation is seen when comparing
and SBR conditions under tilted standing with the same conditions under upright star
The effect of tactile stimulation was clear both in the male and the female subjects.
groups showed an increased capacity to adjust the rod nearer to physical vertical
SBR relative to DBR condition.

general tendency to move away from the middle score area in SBR relative to DBR. Under DBR, seven subjects had less than an average of 3° deviation from physical vertical. Under SBR, thirteen subjects were found in this part of the continuum. Among the high scoring subjects in DBR conditions two moved to more than an average of 17° deviation from physical vertical in SBR.

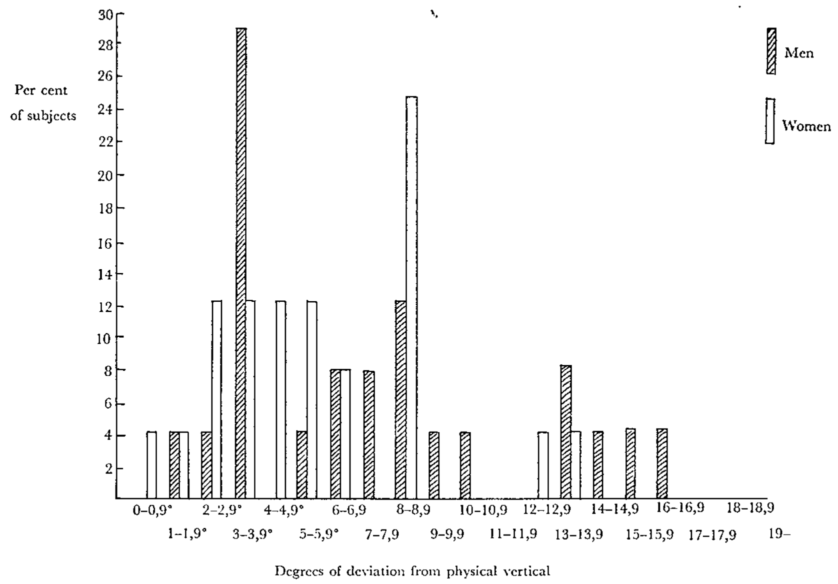

FIG. 3. Distribution of unsigned mean deviation scores for subjects in upright standing and DBR condition.

DBR vs. SBR, tilted standing

The difference between DBR and SBR was expected to be higher, when the subjects stood tilted because the difference in tactile stimulation in DBR vs. SBR would be more pronounced during tilt. During tilted standing, DBR would mean that the body would be supported homogeneously; also there would be a diffuse mass pressure stimulation on one side of the body. When SBR condition was introduced the body was given a punctiforme support in form of four sharp supporters which caused a very specific one-side stimulation of the body.

Table 3 presents the mean scores for DBR and SBR during tilted standing. Since scores for left- and right tilt of the subjects showed no significant differences the direction of tilt is disregarded and all scores are included in the comparison of the DBR and SBR under tilted standing.

As expected, a remarkable decrease in mean score deviation is seen when comparing DBR and SBR conditions under tilted standing with the same conditions under upright standing. The effect of tactile stimulation was clear both in the male and the female subjects. Both groups showed an increased capacity to adjust the rod nearer to physical vertical under SBR relative to DBR condition.

ɲparing the scores in upright standing (cf. Figs. 3–4) vs. tilted standing (cf. Figs. 5–6) ɔres were more dispersed under tilted standing than under upright posture.

DISCUSSION

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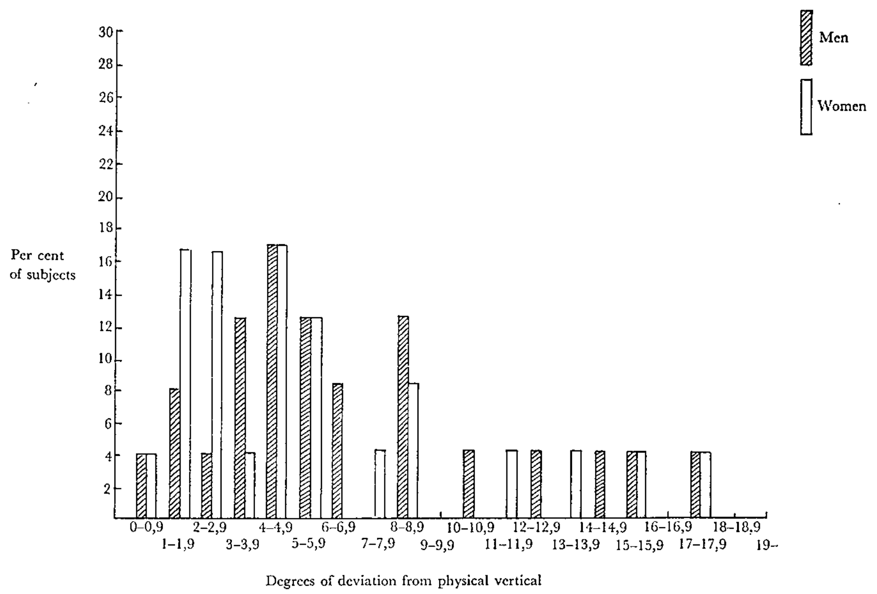

Distribution of unsigned deviation scores for subjects in upright standing and SBR condition.

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3. *Mean errors in degrees of deviation from physical vertical for body tilted standing under DBR and SBR conditions.*

	DBR	SBR	Decrease from DBR to SBR
Men	13.03	11.18	1.85
Women	12.22	10.09	2.13

l succeeded it was hypothesized that specific tactile stimulation would improve per- ı of the vertical.

Comparing the scores in upright standing (cf. Figs. 3–4) vs. tilted standing (cf. Figs. 5–6) the scores were more dispersed under tilted standing than under upright posture.

DISCUSSION

Most studies on tactile cues in perception of the vertical have aimed at investigating if these cues play any role in interaction with the other modalities which contribute to perception of spatial directions. So far the tactile stimulation has been shown to have no or a questionable effect. As mentioned in the introductory remarks, however, it is argued that the lack of effect might be due to insufficient control of the tactile stimulation as well as other variables. One purpose of the present study was to reduce, as far as possible, all cues for spatial perception and then change the tactile stimulation conditions in a controlled way. If the control succeeded it was hypothesized that specific tactile stimulation would improve perception of the vertical.

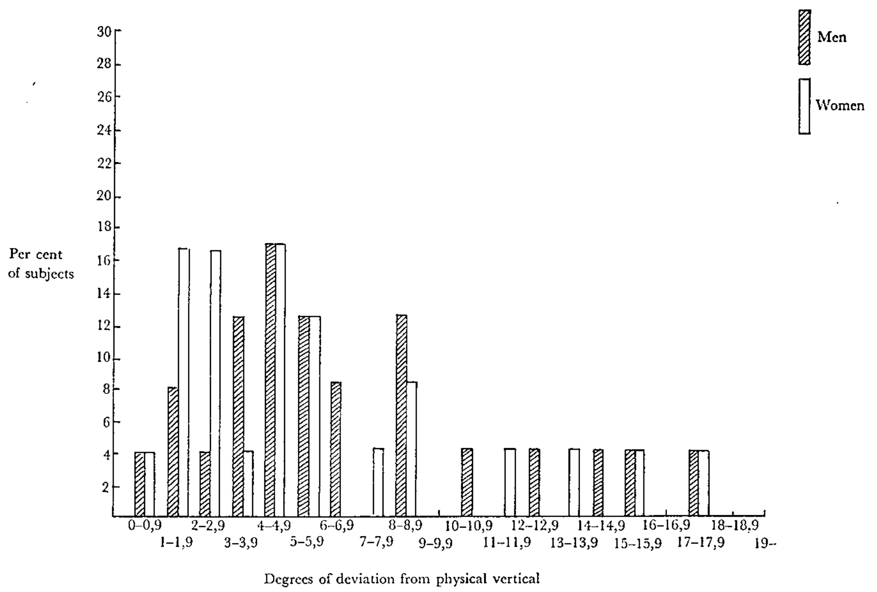

FIG. 4. Distribution of unsigned deviation scores for subjects in upright standing and SBR condition.

TABLE 3. *Mean errors in degrees of deviation from physical vertical for body tilted standing under DBR and SBR conditions.*

	DBR	SBR	Decrease from DBR to SBR
Men	13.03	11.18	1.85
Women	12.22	10.09	2.13

This hypothesis was verified. For tilting subjects, there was a clear effect in perception o the vertical when input from other modalities were reduced, and the tactile stimulation wa: changed radically.

In the present study the subjects tended to adjust the rod nearer to physical vertical wher tactile stimulation was increased. The tendency was even more pronounced when the sub jects were tilted and, consequently, the tactile stimulation was even greater.

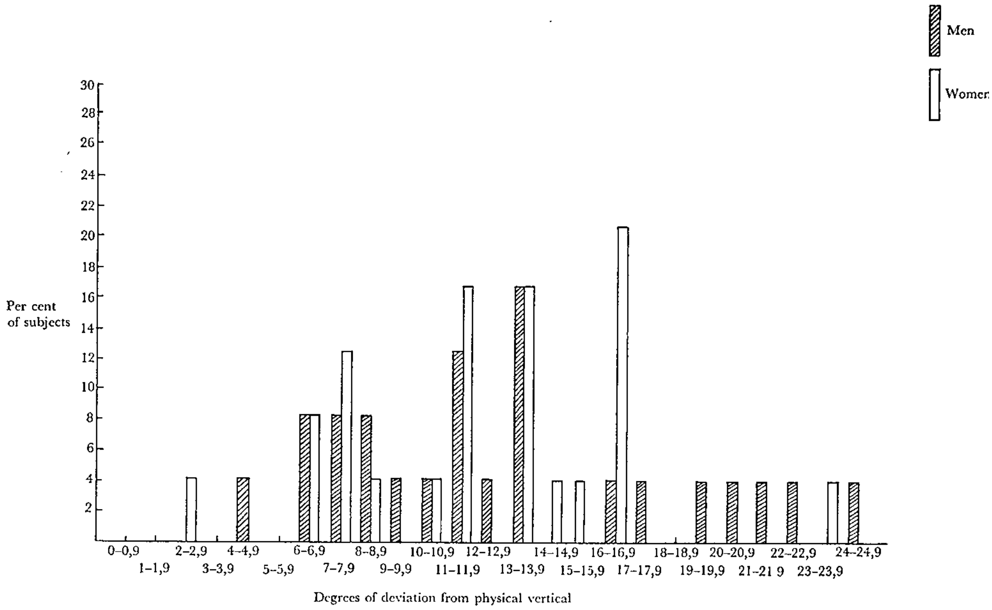

FIG. 5. Distribution of unsigned deviation scores for subjects in tilted standing and DBR condition

It does not seem sufficiently precise, however, to use words like '*increased*' or '*greater* tactile stimulation.

An examination of the data showed that there was no connection between the subject's weight and what effect the change from DBR to SBR caused to him under tilt. On this basi: it seems reasonable to suppose that the specificity rather than the intensity of tactile stimula- tion was important for more adequate perception of verticality. This assumption is also sup- ported by the fact that it was the women, whose average weight was lower than the men's who gained most from the SBR condition; however, the sex differences were not too great

Actually, in the present study the subjects tended to adjust the rod nearer to physica vertical when tactile stimulation was made more *specific*. This trend was seen with tiltec posture as well as with upright but the latter condition requires further attention.

DBR vs. SBR, upright standing

Under upright standing the subjects shifted between support by two simultaneousl inflated rubber cushions (DBR) and light contact with the sharp supporters (SBR). Mos subjects diminished the mean deviation score under SBR relative to DBR. However, unde

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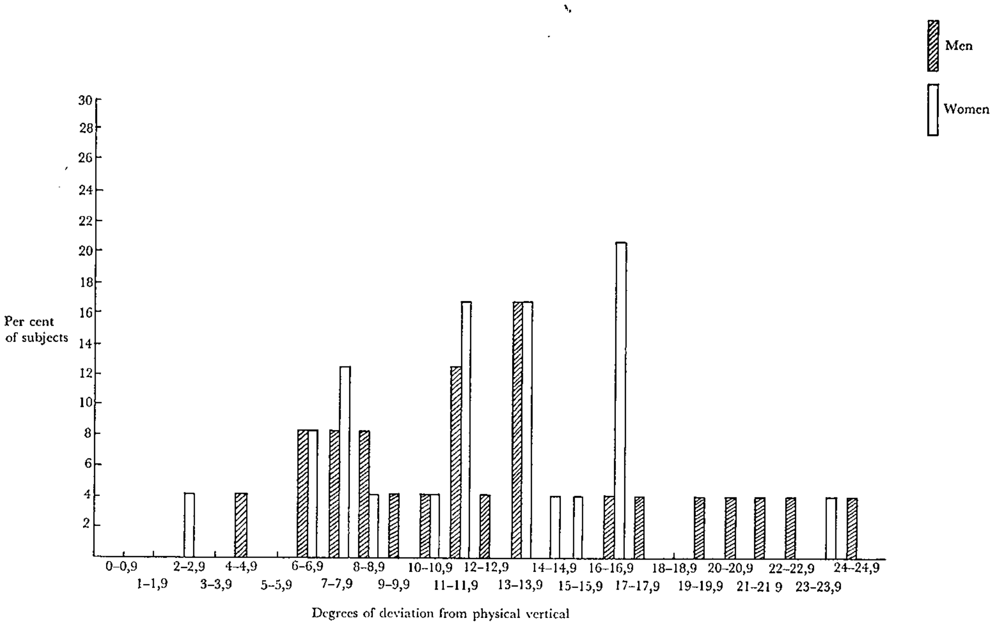

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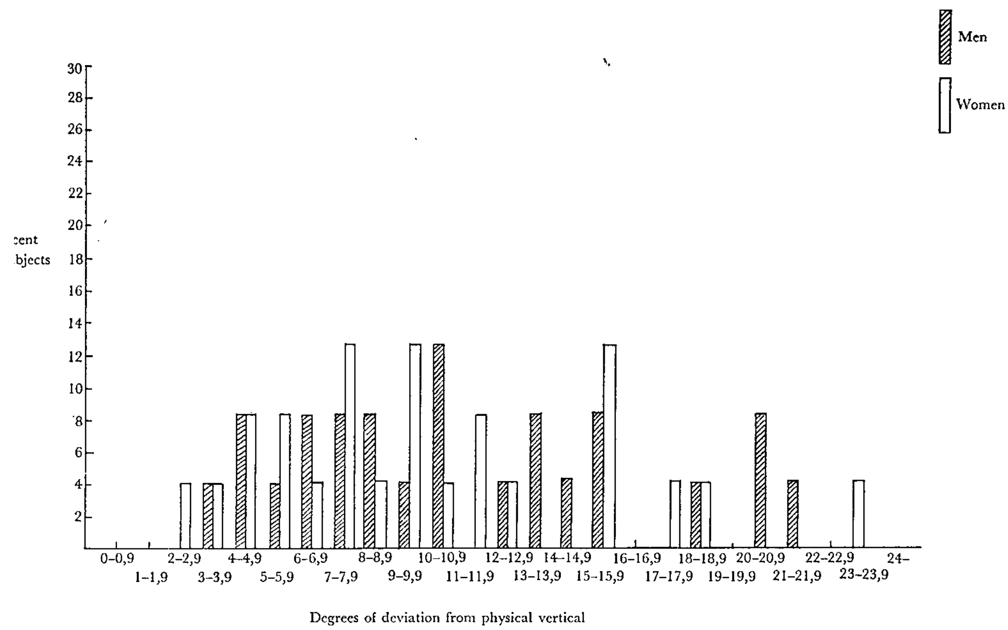
Actually, in the present study the subjects tended to adjust the rod nearer to physical vertical when tactile stimulation was made more *specific*. This trend was seen with tilted posture as well as with upright but the latter condition requires further attention.

DBR vs. SBR, upright standing

Under upright standing the subjects shifted between support by two simultaneously inflated rubber cushions (DBR) and light contact with the sharp supporters (SBR). Most subjects diminished the mean deviation score under SBR relative to DBR. However, under

BR upright standing the whole explanation might not be found solely in terms of change ι tactile stimulation, but also in increased information from other modalities involved. It is ellknown that the erect body is never still, but sways from side to side particularly in the ıterior–posterior plane. Edwards (1946) found that the sway is about 50 % more pronounced ι the dark than in daylight, and he also observed that body sway increased considerably



ιG. 6. Distribution of unsigned deviation scores for subjects in tilted standing and SBR condition.

hen the subjects looked at a picture hung 15° askew. The combined effect of these conditions ιight be relevant for the present Rod-and-Frame Test situation. It is therefore reasonable › suppose that when the subjects was given a chance to perform body sway in the present st situation, it actually occurred. Under DBR upright standing the inflated rubber cushions ı both sides of the subject prohibited even the slightest possible body sway. Under SBR pright standing on the other hand the subject was stabilized to some degree bilaterally by ιe supporters; this condition allowed the subject to sway a little, apparently enough to gain ıfficient information from resulting change in tactile stimulation, from stimulation of neck-ıd trunk muscle receptors (due to the small displacement between the fixated head and the ightly variable body axis) and probably also from tonus-controlling reflex mechanisms, that resulted in the tendency to adjust the rod nearer to physical vertical under SBR standing ›ndition, than under DBR standing condition.

All subjects were asked if body sway had occurred. None of them reported anything about ›dy swaying during the experiment, and the sound detector did not record any of these nall sways. Still the body sway interpretation seems reasonable although it must be admit-:d that it is surprising that small body sway would result in a measurable effect on setting rod to physical vertical. However, in an experiment on perception of the vertical, Neal

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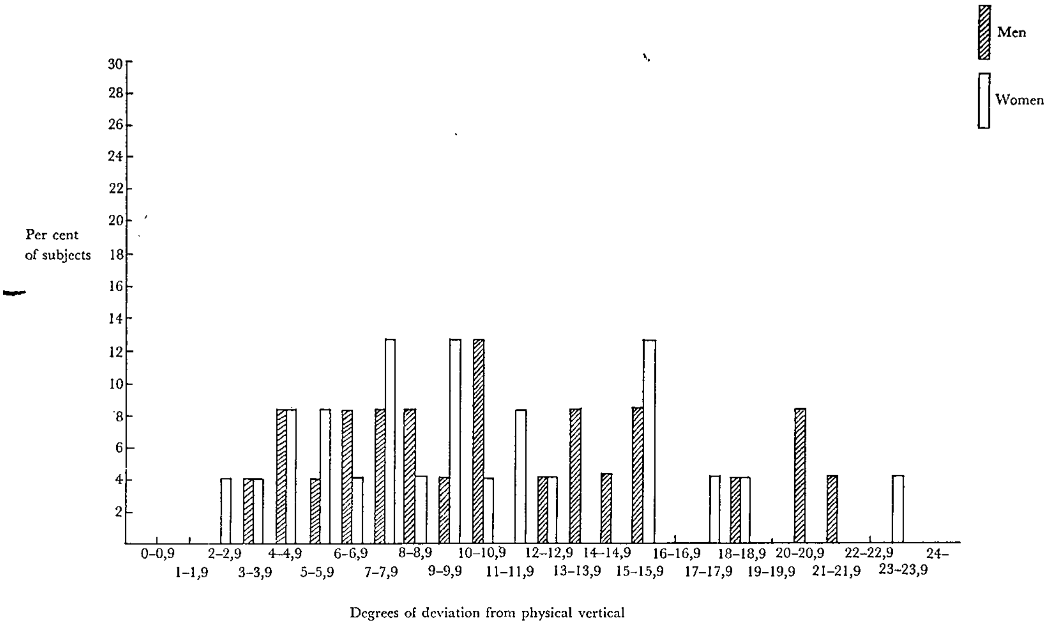

FIG. 6. Distribution of unsigned deviation scores for subjects in tilted standing and SBR condition.

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(1926) found that a displacement between head and body axis even as small as $\frac{1}{2}°$ exerted a significant influence on setting a rod to physical vertical.

As seen in Table 2 men decreased their mean score more than the women, indicating tha the information aroused by the body sway must be more real for men; this observation is i accordance with the discovery that men sway somewhat more than women (Wapner & Witkin, 1950). For these reasons the series in which the subjects stood upright should not b taken as 'pure' experiment on the effect of tactile stimulation. From a tactile point of vie it is more relevant to see that the change from DBR to SBR had greater effect for the tilte person.

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The general decrease of average error for both men and women when going from DBR to SBR condition justify the conclusion that the hypothesis is confirmed to a reasonable de gree: for leaning subjects, there was clear effect in perception of the vertical when input fro other modalities was reduced, and the tactile stimulation was changed radically (made mor specific).

However, a provisional analysis of intersubject variations showed marked individua differences in capacity to profit from the change in tactile stimulation when going from DBR to SBR: furthermore, these differences seemed to depend upon whether a given subject wa characterised by being a high-, low-, or intermediate scorer.

A review of the literature on individual differences in response to tactile stimulation seem to reveal some disagreement between various investigators; this warrants further analysis o the character of these differences (Nyborg, in press).

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