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SUMMARY PAGE

THE PROBLEM

It has been known for many years that head and body position are important variables in the perception of the visual horizontal or vertical when an observer is seated in darkness. More recently it has been shown that the constant errors in the perception of the visual horizontal increase in a seated observer when he is required to maintain his body position rather than being passively tilted. It was the purpose of the present experiment to investigate active body tilt further by studying the perception of the visual horizontal in normal and labyrinthine-defective observers with five combinations of head and body position using tilts of 20 degrees. All of the observations were made with the observer standing and maintaining his own head and body in the appropriate position. The observer made five settings to the visual horizontal for each condition using a goggle device which presented a collimated line of light to the right eye while the other eye was covered. Body, head, and goggle position were monitored by levels.

FINDINGS

The results showed no significant constant errors in setting the line to the visual horizontal; i.e., the E-phenomenon was not observed. It is suggested that the contact cues from the feet and kinesthetic cues from the legs, body, and neck were adequate to produce more veridical perceptions than are usually reported during passive bodily tilt. The data also make it clear that vestibular information is not a requirement for veridical perception of the visual horizontal under these experimental conditions.

INTRODUCTION

This study is concerned with the perception of the visual horizontal in normal and labyrinthine-defective (L-D) observers under five combinations of head and body position. It has been known for over 100 years that when an observer is passively tilted away from the gravitational vertical, his perception of the visual horizontal is subject to constant errors (4,5,7,8). Posturally induced distortion of the visual vertical has also been reported recently in humans and pigeons (6). It has been shown that both the direction and the amount of these errors vary with body position, the most commonly reported finding being the E-phenomenon for small bodily tilts from the vertical and the opposite effect, the A-phenomenon, with the body at or near the horizontal position. Most of these studies have been made with the observer seated, but Witkin and Asch (8) have reported similar results with the observer standing. More recently it has been shown that other factors than body tilt per se contribute to the effect. Werner, Wapner, and Chandler (7) have reported that the E-phenomenon is significantly increased if a seated observer tilts his own body rather than being tilted passively in a chair. The present study explored the perception of the visual horizontal in normal and L-D observers while they stood and maintained their head and body in five combinations of alignment with the gravitational vertical and 20 degrees of tilt.

PROCEDURE

SUBJECTS

Five normal and five deaf, L-D observers were studied. The normal observers were medical students who showed normal responses to caloric stimulation (3) and to an ataxia test (1). The L-D observers had acquired their deafness in childhood as a sequelae of meningitis and showed abnormal responses to the caloric and ataxia tests. All of the observers had had experience in making observations in rotating devices and in the use of the goggle device to measure the perception of the visual horizontal.

APPARATUS

The observers viewed a collimated luminous line in a self-contained apparatus mounted in a goggle which he held snuggly in position before his eyes. The apparatus presented the red luminous line to the right eye while light was completely occluded from the left eye. The luminous line could be rotated either clockwise or counterclockwise by means of a knurled knob which was easily reached by either observer or the experimenter. The digital readout was in degrees of deviation from the horizontal axis of the device itself. The goggle was easily held in place by the observer, and a flexible rubber fitting prevented light leaks under the operating conditions used.

Three levels were used to monitor the alignment of the goggle apparatus, observer's head, and observer's body. The first level was located on the goggle itself, a second on a band over his head, and the third on his back.

METHOD

All measurements were made with the observer standing, with his head and body in one of the five different combinations of positions with respect to gravity. Each trial was begun by an experimenter who offset the line from the horizontal, and observer's task was merely to set it to the gravitational horizontal. Three experimenters were required for every trial: one observed the level on the observer's back to monitor his body position; a second monitored the levels on the head and on the google and offset the luminous line before each setting; and the third made and recorded the settings. No setting was recorded unless both monitors were satisfied that the proper head and body positions were maintained to within a half degree. An attempt was made to make the readings promptly on all trials because two of the positions were somewhat uncomfortable to maintain for prolonged periods. Nevertheless, the observer was permitted to take as much time as he felt he needed to make an accurate setting. The light was turned off while the line was offset. The observer made five successive settings to the horizontal for each of the following five conditions: I. head and body erect; II. head and body tilted 20 degrees to the right; III. head tilted 20 degrees to the right and body erect; IV. head erect and body tilted 20 degrees to the right; V. head tilted 20 degrees to the right and the body tilted 20 degrees to the left. Subsequently, a second series of observations was made with the right and left tilts reversed with respect to the first series. An interval of several hours elapsed between the two series.

RESULTS

CONSTANT ERRORS

The data were analyzed first to note any constant errors in setting to the visual horizontal associated with body position and second with respect to the average error from the gravitational horizontal without taking account of the direction of the error. For the normal observers the constant error varied from $+0.9^{\circ}$ to -1.5° for all five conditions and the two series (Table I). An inspection of the constant errors makes it clear that these errors were all very small when compared with those found in other similar studies, (4,5,7,8). Furthermore, the direction of the mean setting was not clearly related to the direction of the bodily tilt. Similarly, the L-D observers produced very small constant errors which varied from $+1.7^{\circ}$ to -1.4° and also were not consistently related to the direction of the head or body tilt. Furthermore, an analysis of variance of each of the two series of observations for both groups showed no difference between the five body conditions and no difference between the two groups. The P values in every case were greater than 0.25. It should be noted that comparisons were not attempted across the two series of trials for the E-phenomenon because it was not possible to make an unequivocal decision whether to relate the setting of the line

Table I

Mean Constant Error in Degrees in Setting a Luminous Line to the Horizontal in Darkness by Normal and Labyrinthine-Defective Observers*

Condition		Normals (N=5) Series A	Normals (N=5) Series B	L-Ds (N=5) Series A	L-Ds (N=5) Series B
I. Head & body erect	Mean	-0.5	-0.3	-0.1	+0.6
	S.D.	1.9	2.8	2.5	1.1
II. Head & body tilted	Mean	+0.5	0.0	-1.4	+0.2
	S.D.	5.3	3.4	5.2	3.9
III. Head tilted & body erect	Mean	-1.5	-0.1	-0.5	+0.9
	S.D.	5.1	2.5	5.1	1.7
IV. Head erect & body tilted	Mean	+0.5	+0.5	+0.8	+1.1
	S.D.	1.4	1.8	2.5	1.7
V. Head & body tilted opposite	Mean	+0.6	+0.9	+1.7	-0.2
	S.D.	3.1	3.3	3.7	8.3

* + = clockwise deviation

− = counterclockwise deviation

to the head or the body position. The data for the constant errors can be summarized by saying that since the constant errors do not differ significantly from zero, the E-phenomenon did not occur under the conditions of this experiment for either the normal or L-D observers.

AVERAGE ERRORS

An analysis of the average errors was made by combining the data for similar body tilts and disregarding the direction of the setting (Table II). An analysis of variance for these average errors revealed no significant difference between the normal and the L-D observers ($P>0.25$); however, there was a significant difference across the five body positions ($P<0.01$). Individual comparisons were then made between the five head and body positions using a difference t. For the normals Condition V (head 20° in one direction and body 20° in the other) showed a significantly greater ($P<0.02$) average error than Condition I (head and body erect) and Condition IV (head erect and body tilted). There were no significant differences among any of the other conditions. For the L-Ds, again Condition V produced a mean average error greater ($P<0.05$) than Condition I. There were no other significant differences. The primary finding for the average errors then was that when the head was tilted in one direction and the body in the other direction, the average error was significantly greater than when the head and body were both erect.

DISCUSSION

The primary finding of this experiment was that there was no significant constant error in the perception of the visual horizontal for any of the various combinations of head and body position for either group. It is particularly noteworthy that in Condition II in which the head and body were tilted in the same direction, head and body positions were identical with the head and body positions typically reported as producing the E-phenomenon; i.e., the setting to the visual horizontal would be in a direction opposite to the direction of the tilt of the head and body (8). Constant errors have also been reported for L-Ds during passive tilt (5). It is also of importance to note that, at first glance, these results would appear to be in direct conflict with the data of Werner, Wapner, and Chandler (7) who reported that the constant error increased when an observer actively tilted his head and body 15 degrees and 30 degrees. Interpolating from their data, we would find that supported tilts of 20 degrees would be expected to produce about 3.5 degrees of the E-phenomenon and unsupported tilts of the same amount, about 5.6 degrees.

In considering the differences between this study and the earlier studies, several methodological differences should be noted. In the present experiment:

1. Observer actively tilted his body from the waist and the head from the shoulders rather than being passively supported.

2. Observer's feet were firmly planted on the horizontal floor.

Table II

Mean Average Error in Degrees in Setting a Luminous Line to the Horizontal in Darkness by Normal and Labyrinthine-Defective Observers

Condition		Normals (N=5)	L-Ds (N=5)	Difference
I. Head & body erect	Mean	2.1	1.7	-0.4
	S.D.	1.7	0.7	
II. Head & body tilted	Mean	3.2	3.3	+0.1
	S.D.	1.6	2.3	
III. Head tilted & body erect	Mean	3.3	2.3	-1.0
	S.D.	1.0	1.3	
IV. Head erect & body tilted	Mean	2.2	2.0	-0.2
	S.D.	1.3	0.8	
V. Head & body tilted opposite	Mean	4.1	3.6	-0.5
	S.D.	0.9	1.3	

3. Observer was not supported in any way.

4. Observer perceived his head and/or body as being tilted away from the gravitational vertical.

5. Observer set a collimated luminous line viewed monocularly, while in earlier studies (7, 8), observer viewed the line binocularly at a distance of about 5 feet and experimenter made the settings on direction from observer.

In view of these marked differences in methods of testing, the differences in the results are less surprising, but they raise the question regarding the specific cues which make the more veridical perception possible. The lack of a difference between the normals and the L-Ds makes it clear that vestibular information is not crucial in producing these more verdical results. It is suggested that the absence of the E-phenomenon under the conditions of this experiment was due primarily to two rich sources of information available to the observers in this experiment. First, the feet were firmly planted on a solid horizontal surface and thus gave unequivocal contact cues to the gravitational horizontal. Additional data on this point have been reported by Hewes and Spady (2) in their studies of locomotion in simulated lunar gravity fields. Their observers attributed certain difficulties in locomotion to the reduction of pressure cues to the feet. Thomas and Lyon (6) have also reported evidence that contact cues from the feet are of importance in visual perception. They reported that there was an induced distortion of the visual vertical when human observers "...perceived as vertical an inclination of the bar in the direction toward which the floor was sloped." Second, there were clear kinesthetic cues from the legs, body, and neck, giving information regarding the amount of the tilt of the body. The tactual cues from the feet would appear to be of particular importance in the light of the findings of Werner, Wapner, and Chandler (7) which show that kinesthetic cues associated with active body tilt increase the constant error. These results give further evidence that the E-phenomenon occurs only under very limited experimental conditions.

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Perception of the visual horizontal by observers in five different combinations of head and body position was studied to determine the effect of 20-degree body tilts. Both normal and labyrinthine-defective observers made five settings to the visual horizontal for each condition using a goggle device which presented a collimated line of light to the right eye while the other eye was covered. The results showed no significant constant errors in the settings by either group, and it is suggested that the absence of the E-phenomenon was due primarily to adequate contact cues and kinesthetic cues. The data also make it clear that vestibular information is not required for veridical perception of the visual horizontal under these experimental conditions.

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