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QUANTITATIVE EVALUATION OF OPTICALLY INDUCED DISORIENTATION

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I. Introduction.

It has been established that man as well as animals becomes disoriented in space when he is exposed to a moving optical environment which can be produced by a rotating optokinetic drum[1 4]. Recently the extent of such disorientation was measured by recording the motor reactions of subjects who deviated from walking in a straight path during optokinetic stimulation[2]. The conclusion from these findings was that under some flight conditions pilots could become disoriented when the optical environment moves and no cues from stationary optical targets are available. Though most flight accidents attributed to "vertigo" are caused by labyrinthine disorientation, some are probably caused by the loss of stable optical reference points only[5 8]. In that context, it has been implied that further investigations of optogenic causes of accidents are warranted[7 8]. During a recent study of altered motor activity in the optokinetic drum, it was established that the degree of disorientation increased with faster drum speeds[2]. In the present paper, the association between the speed of the drum and the extent of disorientation was determined with a large number of subjects at specifically selected speeds.

II. Methods.

A cylindrical drum was used in the experiments for eliciting disorientation as previously described[2].

Thirty-four normal subjects were tested and 112 tests of subjects' responses were made in the moving optical drum. Thirty-four tests were made in the nonmoving optical drum.

The subjects were tested at drum speeds ranging from 3 rad./min. (radians/minute) to 45 rad./min. to observe the effects of the drum speed on their walking behavior. Half the subjects started the series of tests with the faster speeds, whereas the other half started it with the slower speeds.

A pen was taped to the subject's left foot. As the subject walked forward and backward in the drum with a sliding motion, his path was traced on a paper which had been placed underneath the drum for the subject to walk on.

Before entering the drum all subjects were given the same instructions. First, they were told to slide their feet slowly using small steps so that the pen remained constantly in contact with the recording paper. When the subject moved in this manner, a walk from one side of the drum to the other took 6 (±2) seconds. Secondly, the subjects were asked to hold their heads with a small upward tilt so that they looked upward and had no stationary visual stimuli in view when the drum was moving. Thirdly, the subjects were instructed to walk in a straight line and to remain in the same path while walking forward and backward in the drum.

For each test, the subject was asked to walk across the drum nine times. In each test the subject walked forward five times and backward four times (5 seconds of standing still were allowed between walks). Before each series of tests in the moving drum the subject was required to walk in the drum while it was not moving. This test was used as a control measure to determine the ability of the subject to walk straight when he was not under the influence of the stimulation from the spinning drum.

The amount of disorientation of the subject was obtained by measuring the angle formed by two successive walks. The first angle in a test, for example, would be formed by a forward walk and a successive backward walk. Three points formed this angle. First, the point at which the subject began walking forward; second, the point at which he stopped walking forward, which was also the point at which he began walking backward; third, the point at which he stopped walking backward. The next angle is formed by the first backward walk and the second forward walk. The rest of the angles formed by the nine walks were measured according to the same procedure.

If the subject was disoriented, the second walk across the drum would not have been in the same path as the first walk across the drum. The farther the subject had deviated from the first walk with his second walk, the more his disorientation and subsequent angle of deviation of the first walk from the second walk would be.

For the control test all deviations of successive paths of walking from one another were measured and these angles of deviations were given absolute values. However, for the deviations occurring while the optical environment of the drum was moving, only those angles of deviation which deviated in the same direction as the movement of the drum were given positive values, and the angles which indicated that a subject's movement was in the opposite direction to the movement of the drum were assigned negative values.

III. Results.

The average angle of deviation for the control tests with a nonmoving drum was 3.1° (S.D.±3.5). A regression equation for the tests in the moving optical environment is shown in Figure 1. The average angle of deviation for each test was correlated with the speed of the drum. The angle of deviation may be determined by the equation $y' = .49x + 8.69 + 11.1$ standard error of estimate. In the above equation, y' equals the predicted angle of deviation for a test and x equals the speed of the optical environment in rad./min. At faster speeds of the optokinetic environment the subjects deviated more than they did at slow speeds, though the ratio of the predicted angle of deviation to the speed of the drum decreased as the speed of the drum increased. Only part of the decrease in the ratio is explained by regression effects. One may therefore state that the results indicate that disorientation, as measured by the subject's walking behavior, decreases relative to the amount of increase in the speed of the visual environment.

IV. Discussion.

At higher speeds of environmental stimulation more rad./min. are required to induce a given amount of disorientation, as measured by walking behavior. According to the subjective reports from the participants in the tests, however, more disorientation is experienced at higher speeds of optokinetic stimulation. It is postulated here that two factors may play a role in causing this apparent contradiction. First, if a subject deviates a great deal from a straight path of walking, he is more likely to become aware of his deviation through proprioceptor feedback and compensate for this deviation after he has been told to walk straight. Evidence for this is borne out by the fact that some subjects report that they feel they have deviated only when the drum is moving faster than 20 rad./min., whereas at slower speeds most of the subjects reported that they thought they had walked straight when in fact, they had not. Another factor to consider with reference to this apparent discrepancy is the increase in subjectively experienced disorientation which is described to be similar to vestibular effects with increases in angular acceleration. Awareness of an increase in subjective lack of knowledge of one's objective location in space, may cause the subject to compensate and thereby counteract the influence of the environment on his motor responses.

If it is true that a person is subjectively unaware of the disorientation he exhibits in a slow moving optical environment, then caution must be exhibited under such conditions. For flight conditions in which no stable optical references are available, pilots should become aware of their potential disorientation and learn to identify cues which would indicate that this type of disorientation has occurred.

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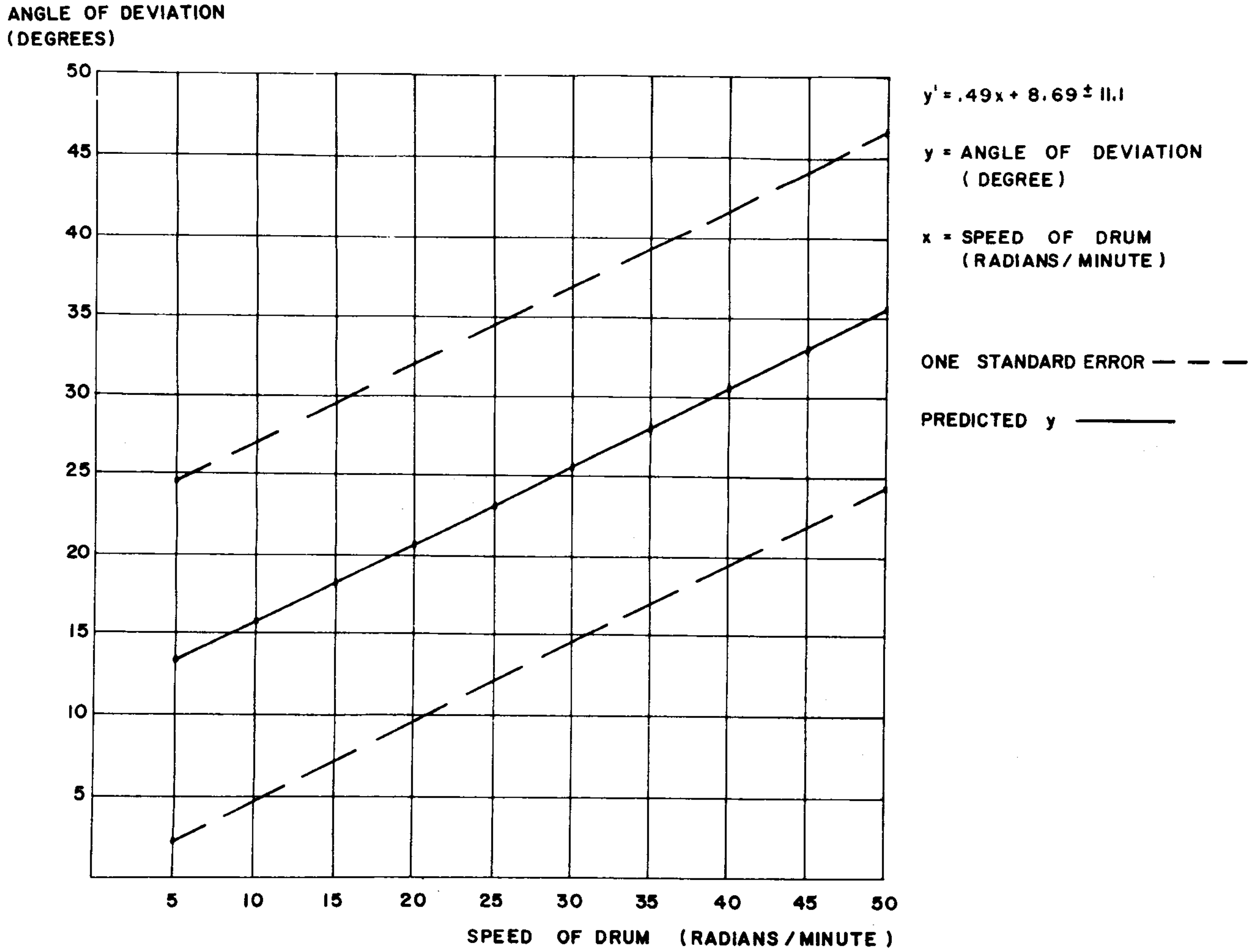

FIGURE 1. Angle of deviation for a walking path in a rotating optokinetic drum in relation to the speed of the drum. At higher speeds the degree of motoric disorientation becomes relatively less than the velocity increases of the moving optical environment.