Effect of Transient Weightlessness on Binocular Depth Perception

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Future space missions may have a requirement for critical distance judgements in performing rendezvous, docking and landing procedures. Since correlation between visual acuity and depth perception is high, depth perception might be adversely affected by transient weightlessness. The experiments reported here were conducted in a zero-G airplane to test the hypothesis, and, although the transitions from 2 G to 0 G and 0 G to 2 G tended to produce adverse effects on depth perception, statistical analysis of the data indicated that the effects were not significant.

IN FUTURE SPACE MISSIONS man may have to make critical distance judgments in performing rendezvous, dockings and landings. Pigg and Kama[2] have reported that transient weightlessness adversely affects visual acuity. Since the correlation between visual acuity and depth perception is typically high[1] depth perception might also be adversely affected by transient weightlessness. To test this hypothesis the following experiment was conducted aboard the zero-G research airplane.

METHOD

Subjects.—Five subjects participated in the experiment. Each had passed the required flight physical examination and had completed both the survival and altitude indoctrination courses.

Apparatus.—The viewing box was 98 cm long, 44 cm wide and 12 cm high. The opening at the front was 26 cm long and 6.5 cm high. The inside of the box was painted flat white and the outside flat black.

The three inspection rods were black anodized aluminum, 10 cm long and 1 cm in diameter. The center-to-center distance between adjacent rods was 6.5 cm. Each rod was screwed into an aluminum block that rode on two aluminum rails. Each block had a handle, projecting from the side of the box, by which the experimenter moved the rods.

One 150-watt, PR-38, photographic lamp, mounted 20 cm above the viewing box, provided the illumination. Ambient lighting within the test area was eliminated as nearly as possible by covering the airplane's windows. Figure 1 shows the testing apparatus mounted in the JC-131B airplane.

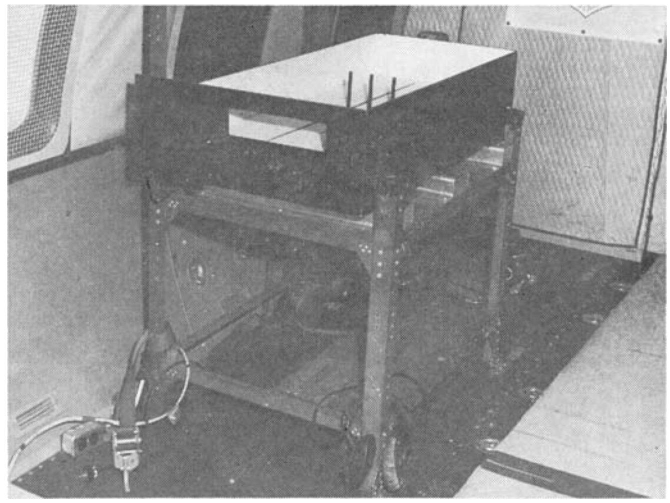

Fig. 1. Depth perception apparatus mounted in the zero-G research airplane.

Production of Weightlessness—The weightless state was produced by flying the JC-131B airplane through a O-G parabolic trajectory for an average weightless period of 12 seconds.[4]

Procedure—Three experimental conditions and one control condition were used. The 1-G conditions just prior to the 2-G entry and just after the 2-G recovery were collectively called the 1-G experimental condition. The 2-G entry and the 2-G recovery were collectively called the 2-G experimental condition, and the weightless period was called the O-G experimental condition. The control condition was straight-and-level flight and was called the 1-G control condition.

The subject was seated in a standard, rear-facing passenger seat equipped with a lap belt. The distance from the subject's eyes to the front of the viewing box was six meters.

For each trial the experimenter stood in front of the opening on the viewing box and positioned one of the three inspection rods either forward or backward 1, 2, 3, 4, 5 or 6 cm from the other two rods. When the experimenter moved to one side, the subject, using the airplane's interphone system, indicated to a recording monitor whether the rods appeared equally distant or whether one—the right, center or left—appeared in front of or behind the other two. The subject's responses were recorded manually by the monitor.

Each of the six distance intervals was assigned, in random order, to one rod position and direction of movement. The 1- and 2-cm distance intervals were

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the center post moved backward and forward, respectively, the 3- and 6-cm distance intervals the left post moved backward and forward, respectively, and the 4- and 5-cm distance intervals the right post moved backward and forward, respectively.

Only two different distance intervals, designated A and B, were presented during each O-G parabola—the first (A) during the 1-G experimental conditions and the second (B) during the 2-G experimental conditions and both A and B during the O-G experimental conditions. Figure 2 shows the O-G parabola with the points of presentation.

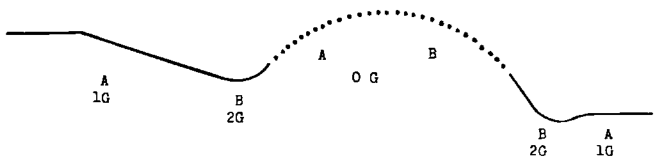

Fig. 2. The O-G parabola showing the six points of presentation of the two distance intervals A and B.

The six distance intervals were presented in a sequence of pairs A-B, A-B and B-A during each O-G parabola. The 30 sequences thus derived were presented in random order to each subject so that each of the six distance intervals was presented 10 times.

For the 1-G control condition the six distance intervals were presented in random order 10 times to each subject while in straight-and-level flight.

RESULTS AND DISCUSSION

The total frequencies of correct responses for each distance interval and gravity condition is shown in Table I and illustrated graphically in Figure 3.

TABLE I

Frequency of Correct Responses for Each Distance Interval and Gravity Condition (Six Distance Intervals, Each Interval Presented Ten Times to Each Subject per Gravity Condition)

Distance Interval (cm)	Frequency of Correct Responses			
	Control	Experimental		
	1 G	1 G	2 G	0 G
1	3	4	3	4
2	24	19	15	23
3	29	23	24	27
4	35	30	28	31
5	37	37	32	32
6	39	41	41	41

The nonparametric Friedman two-way analysis of variance by ranks[3] was used to test the data. The scores were not significantly different at the .05 level of confidence. Thus the transient gravity conditions of the O-G parabola did not have a significant effect upon depth perception. However, Figure 3 shows a trend. The 1-G control scores tended to be the best, the O-G experimental scores tended to be second best, followed by the 1-G experimental scores, and the 2-G experimental scores tended to be the worst. Although the control scores tended to be better than the experimental scores, comparison of the 1-G experimental with the O-G experimental scores shows that man may have at least equal depth perception under weightlessness.

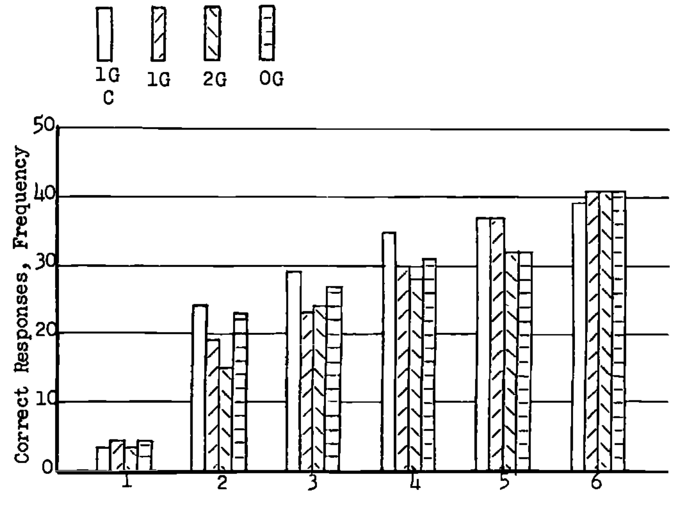

Fig. 3. Frequency of correct responses for each distance interval and gravity condition.

A further analysis of the data was done by comparing (A) the scores obtained at 1 G before the 2-G entry with those at 1 G after the 2-G recovery, (B) the scores obtained at the 2-G entry with those at the 2-G recovery and (C) the scores obtained during the first part of the weightless period with those during the latter part of the period. Any differences between each pair of scores were not significant at the .05 level of confidence. Very little difference existed between the scores obtained at 1 G prior to the 2-G entry and after the 2-G recovery. Although the overall 1-G experimental scores tended to be worse than the 1-G control scorês, the decrement was equally effective on both the scores obtained at 1 G prior to the O-G parabola and those after the O-G parabola. The scores obtained during the 2-G entry tended to be slightly better than those obtained during the 2-G recovery, and the scores obtained during the first part of the weightless period tended to be worse than those obtained during the latter part of the period. Thus dramatic transitions—i.e., 2 G to O G and O G to 2 G—tended to have adverse, but insignificant, effects upon depth perception.

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