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16. Abstract

Most studies of the effects of alcohol on human performance involve static (absence of motion) situations. However, the addition of motion, involved in such activities as piloting an aircraft, might well produce impairments not usually obtained in static situations. The present study examined some of the effects of alcohol ingestion on visual tracking performance (eye-hand coordination) during angular acceleration. Following practice and base-line tests of tracking performance in both static (stationary) and dynamic (whole body angular acceleration) conditions, 10 subjects received orange juice which contained 2.0 ml of 100-proof vodka per kg of subject weight; another 10 drank orange juice with a few drops of rum extract added. Tests, conducted 1, 2, 4, 8, and 10 hours after drinking, were in total darkness with the exception of the visual display which was illuminated to recommended levels for cockpit instruments. Static tracking errors for Alcohol subjects were significantly higher than those of Control subjects only at the 4-hour session. However, Alcohol subjects made significantly more dynamic tracking errors than Controls during the 1-, 2-, and 4-hour sessions. These data suggest that eye-hand coordination may show little or no impairment following alcohol ingestion in static situations, yet may be seriously degraded during motion.

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ALCOHOL AND DISORIENTATION-RELATED RESPONSES. III. EFFECTS OF ALCOHOL INGESTION ON TRACKING PERFORMANCE DURING ANGULAR ACCELERATION

I. Introduction.

Schroeder[7 8] has shown that the ingestion of alcohol depresses both nystagmus and "vertigo" sensations to rotatory or caloric vestibular stimulation when subjects are in darkness but, in illumination, similarly provoked nystagmus is considerably stronger than it is normally. This poses some obvious questions regarding the ability of men to perform visual tasks adequately during vestibular stimulation after drinking alcohol. Most studies of the effects of alcohol on human performance involve static situations, i.e., situations in which the men are not subjected to motion. It is conceivable that the addition of motion, which is involved in a variety of activities, such as piloting an aircraft or driving an automobile, might produce deleterious effects on performance not usually obtained in static situations. Therefore, the present study was designed to examine some of the effects of alcohol ingestion on visual tracking performance during angular accelerations.

II. Method.

A. *Subjects.* Twenty male college students, paid volunteers ranging in age from 21 to 30 years, served as subjects. None had previous laboratory experience involving vestibular stimulation. Each subject was assigned at random to one of two equal groups: a Control and an Alcohol group.

B. *Apparatus.* Angular acceleration was supplied by a Stille-Werner RS–3 rotator fitted with a small cockpit (see Figure 1) in which the subject was enclosed and seated upright with his horizontal semicircular canals approximately in the plane of rotation. A fitted headrest helped to maintain the desired position. A triangular waveform input from a Wavetek model 155 waveform generator was used as a command signal for the rotator. The velocity of the latter was proportional to the input voltage and a peak angular velocity of 120°/sec was attained in both the clockwise and counterclockwise directions. The waveform period was 48 sec.

A compensatory visual tracking task provided both a direct practical measure of performance and an indirect measure of acuity. The tracking apparatus has been described in detail elsewhere.[3] Briefly, a 14-sec sinusoidal "forcing function" input deflected the vertical needle of an aircraft localizer/glide-slope indicator while the subject attempted to maintain the needle in the null position by manipulation of a control stick. Deviations of the needle from this position were considered errors, and a voltage proportional to these deviations was electronically integrated over consecutive 1-sec intervals throughout a trial.

The display was illuminated by a 3vDC bulb mounted in a tube in front of the subject, but below his line of sight (see Figure 2). Light was projected through the tube to localize on the display and to minimize reflection in the otherwise darkened room. The luminance of the display was measured with the aid of a card sprayed

This study was conducted at the FAA's Civil Aeromedical Institute and was co-sponsored by the FAA, the Army (U.S. Army Medical Research and Development Command) and the Navy (USN Aerospace Medical Research Laboratory, Pensacola). Dr. Collins is Chief of the Psychology Laboratory and Dr. Schroeder is a Research Psychologist at CAMI; Lt. Gilson is a Research Psychologist and Dr. Guedry is Head of the Psychophysiology Division at USNAMRL. The expert assistance of Carl Moore in obtaining the blood samples, and of Elizabeth Gilson, Carlyn Manley, Cynthia Cochran, and Blair Fennell in the collection and scoring of data are gratefully acknowledged. Gas chromatographic analyses of the blood samples were performed under contract by Dr. Kurt Dubowski, University of Oklahoma Medical Center.

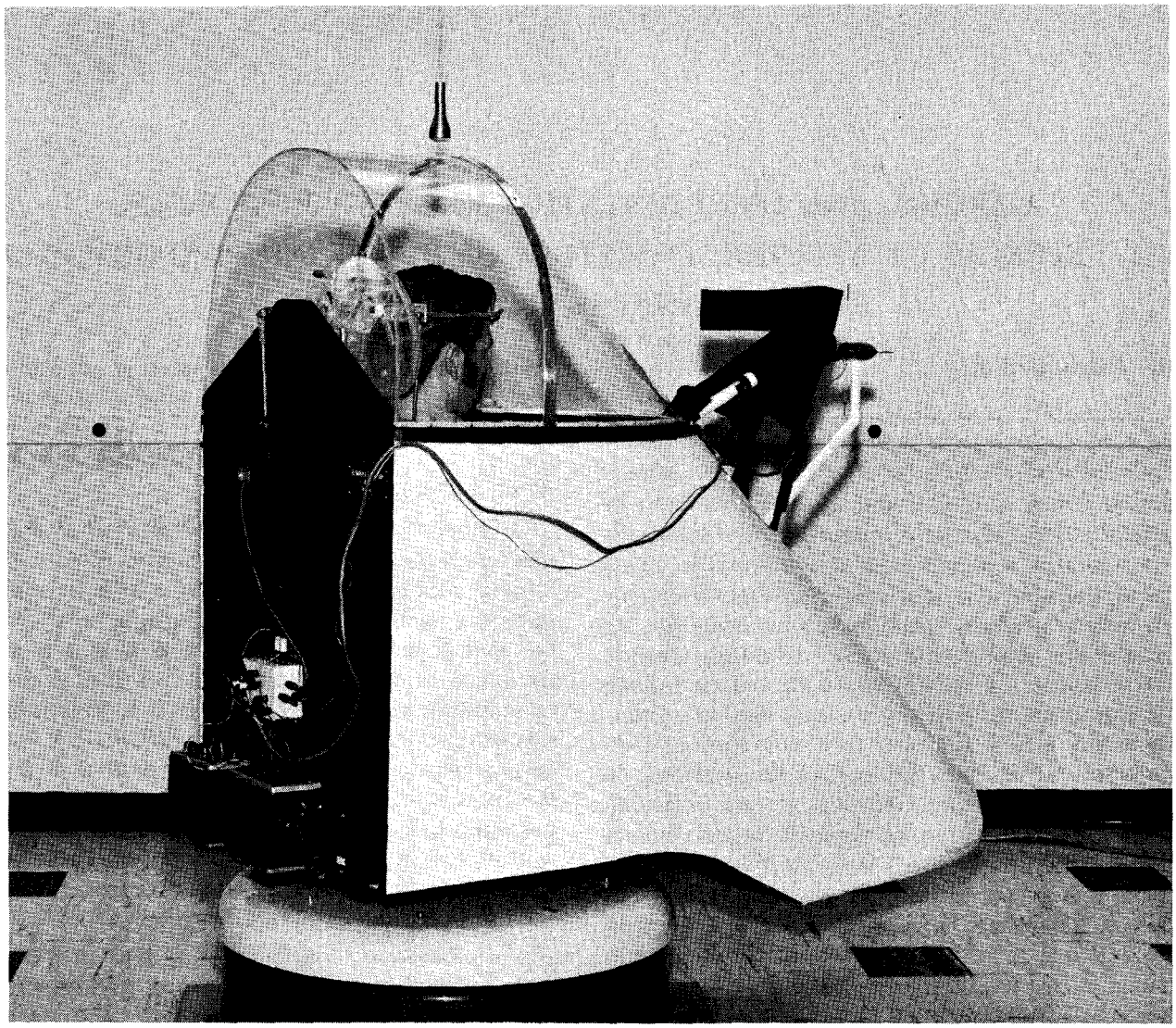

FIGURE 1. The rotation device with the visual display attached.

with the same white paint as the display needles. This card was placed in the light, just in front of the display, and measurements were made with a MacBeth illuminometer from the subject's viewing position. The voltage across the bulb was adjusted until the luminance was 1 ft.L, a level recommended for aircraft instruments.[5]

C. *Recording.* Silver disk electrodes taped to the outer canthi of the eyes and a reference electrode on the forehead were used to record eye movements by the corneoretinal potential method with a 3-sec preamplification time constant. Calibration of horizontal eye movements was accomplished with two small, alternately-flashing lights, horizontally separated to subtend a visual angle of 15 deg. Integrated tracking error, eye movements, and rotational velocity were simultaneously displayed on an Offner type T electroencephalograph.

D. *Alcohol Ingestion.* Subjects in the alcohol group consumed a mixture of 100-proof Smirnoff vodka and orange juice. The mixture (900 ml) contained 2.0 ml of vodka per kg of body weight. Control subjects received only orange juice with a few drops of rum extract added to alter the odor and taste of the beverage. (They were led to believe that they were drinking alcohol.) All subjects consumed their drinks within a 30-min period.

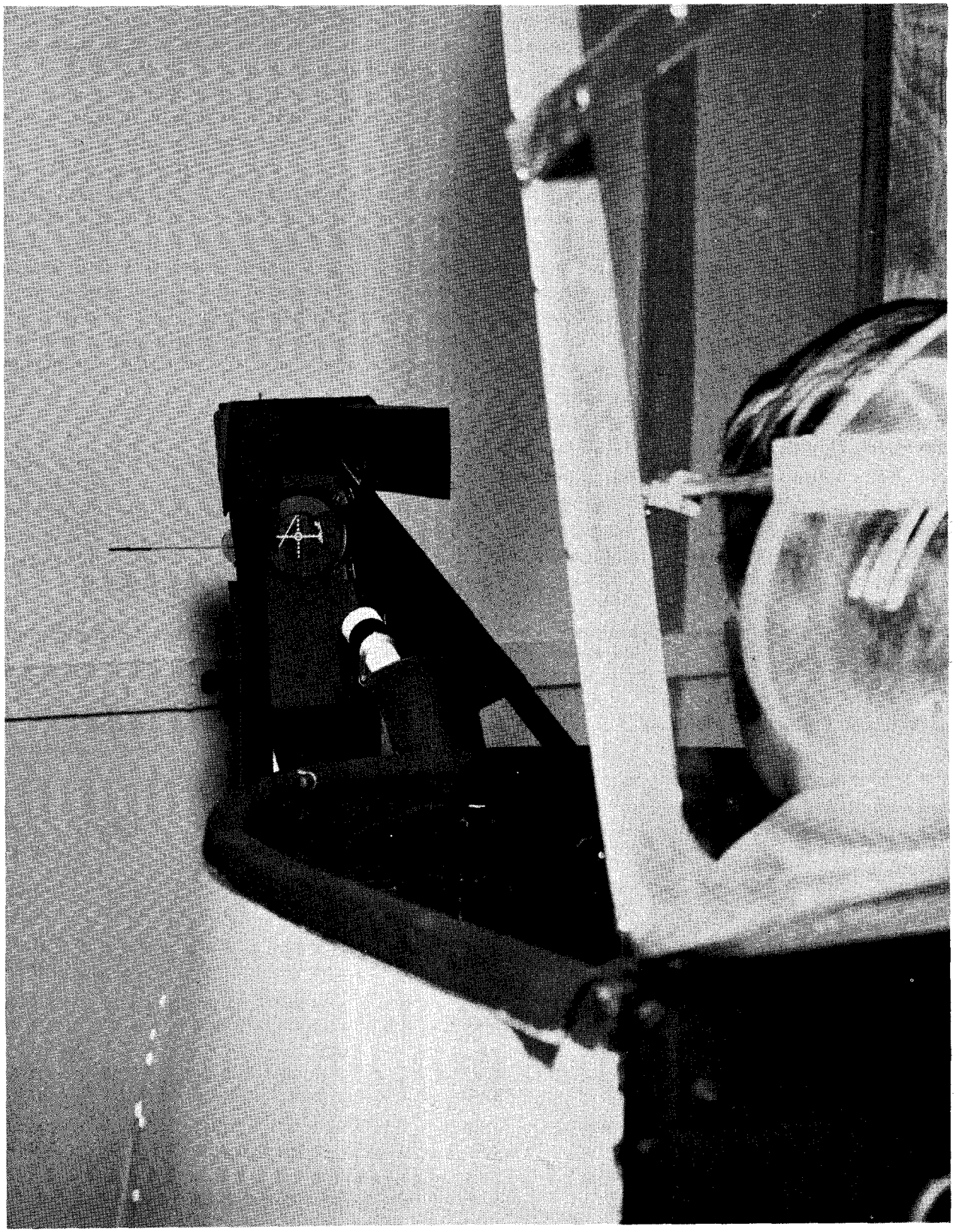

FIGURE 2. View of the visual display from inside the rotator. With room lights turned out, only the instrument dial and a dim, partial outline of the cabin interior could be seen by the subject.

E. *Procedure.* Prior to being tested, each subject was given five min of tracking practice with the cockpit stationary. The experimental sequence which followed comprised six testing sessions: a pre-drinking session and five post-drinking sessions at 1, 2, 4, 8, and 10 hours after drinking. All sessions, practice and experimental, were conducted with the room in total darkness with the exception of the visual display. Immediately before each testing session, venous blood samples of from three to five cc were drawn for analysis of blood alcohol levels by gas chromatography. (Tests of positional alcohol nystagmus were also performed; see Appendix A.)

Each session consisted of a two-min "static" tracking trial with the cockpit stationary and a four-min "dynamic" tracking trial with the cockpit rotating through five complete cycles (240 sec). The order of these trials was alternated across subjects and at least a 1-min interval was allowed between trials. Eye-movement calibrations were obtained prior to each period of dynamic tracking.

F. *Scoring.* The tracking errors for one-sec intervals were summed and an average value was obtained for each static and dynamic trial.

Measures of nystagmus included the number of nystagmic beats and the amount of slow phase eye displacement occurring in three 5-sec intervals during each dynamic tracking trial; one sampling inteval was 32–37 sec from the start, one was 131–136 sec from the start, and the other was 10–15 sec from the end of each trial. The sampling intervals were chosen to include maximum nystagmus output in a single direction near the beginning, middle, and end of each test period. Mean values in deg/sec or beats/sec were calculated and used to represent nystagmus output.

III. Results.

The following average values of ethanol were obtained for the Pre, 1-, 2-, 4-, 8-, and 10-hour samples, respectively, from the Alcohol group: 0%, .074%, .073%, .047%, .001%, and 0%. Control group subjects yielded no evidence of ethanol in their blood samples (see Appendix B).

TABLE 1.—Means and standard deviations by session for tracking error (arbitrary units), slow phase nystagmus (deg/sec) and, frequency of nystagmus (beats/sec).

Measure	Group	Condition		Session					
				Pre	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Performance:									
	Control	Static	Mean	5.43	5.21	4.74	4.51	4.77	4.73
			SD	1.71	0.86	0.52	0.59	0.41	0.53
Tracking Error									
	Control	Dynamic	Mean	6.73	5.44	5.06	4.88	4.91	4.50
			SD	1.86	0.65	0.65	0.52	0.51	0.55
	Alcohol	Static	Mean	5.29	5.92	5.86	5.78	4.74	4.84
			SD	1.46	1.15	1.01	1.28	1.74	0.62
Tracking Error									
	Alcohol	Dynamic	Mean	5.97	7.51	6.85	6.02	4.70	4.89
			SD	1.14	0.82	1.13	0.88	1.32	0.54
Nystagmus:									
Slow Phase	Control	Dynamic	Mean	5.42	3.30	3.29	3.06	2.35	3.10
			SD	2.83	2.16	1.81	2.24	1.37	1.54
Frequency	Control	Dynamic	Mean	1.40	1.54	1.57	1.42	1.16	1.24
			SD	0.91	1.05	0.86	0.94	0.75	0.73
Slow Phase	Alcohol	Dynamic	Mean	3.85	12.15	9.16	6.01	2.82	2.82
			SD	3.10	5.45	4.60	4.54	2.31	3.18
Frequency	Alcohol	Dynamic	Mean	1.53	3.70	3.31	2.51	1.29	1.19
			SD	1.10	1.06	1.09	1.16	0.83	0.72

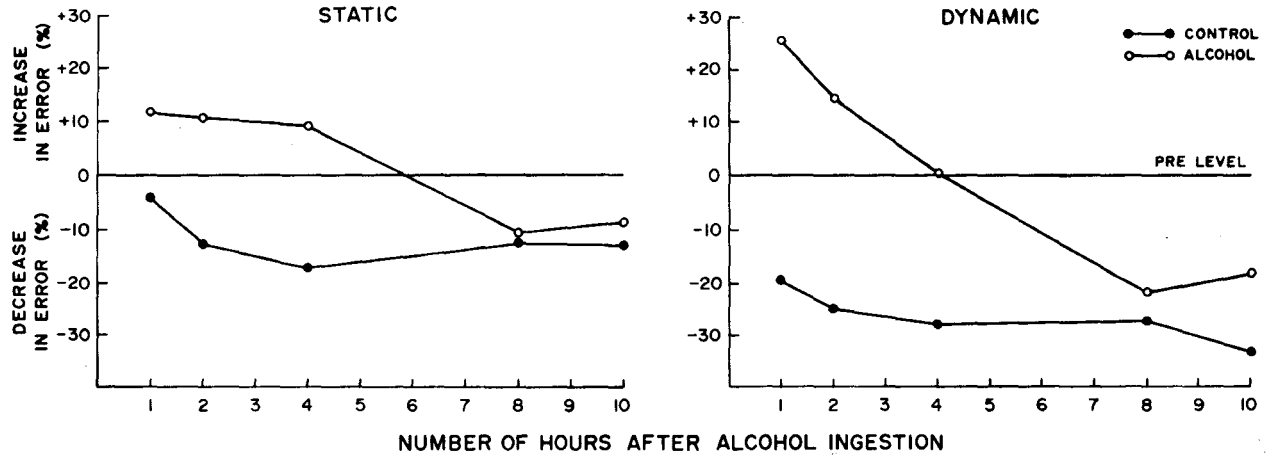

FIGURE 3. Changes in tracking error under static (stationary) and dynamic (angular acceleration) conditions. The "0" lines represent the base-levels of tracking error during the Preliminary trials. Tracking error scores for the five post-drinking sessions were converted to percentages of increase or decrease from the base levels.

Means and standard deviations for the slow phase and frequency measures of nystagmus and for the tracking error in both static and dynamic conditions appear in Table 1 (individual scores are in Appendices C through E). Changes in performance across sessions are shown in Figure 3 where they are presented as percentages of increase or decrease in tracking error based on the pre-drinking level. Representative tracings of nystagmus during dynamic tracking are depicted in Figure 4 and plots of the nystagmic measures across sessions are in Figure 5.

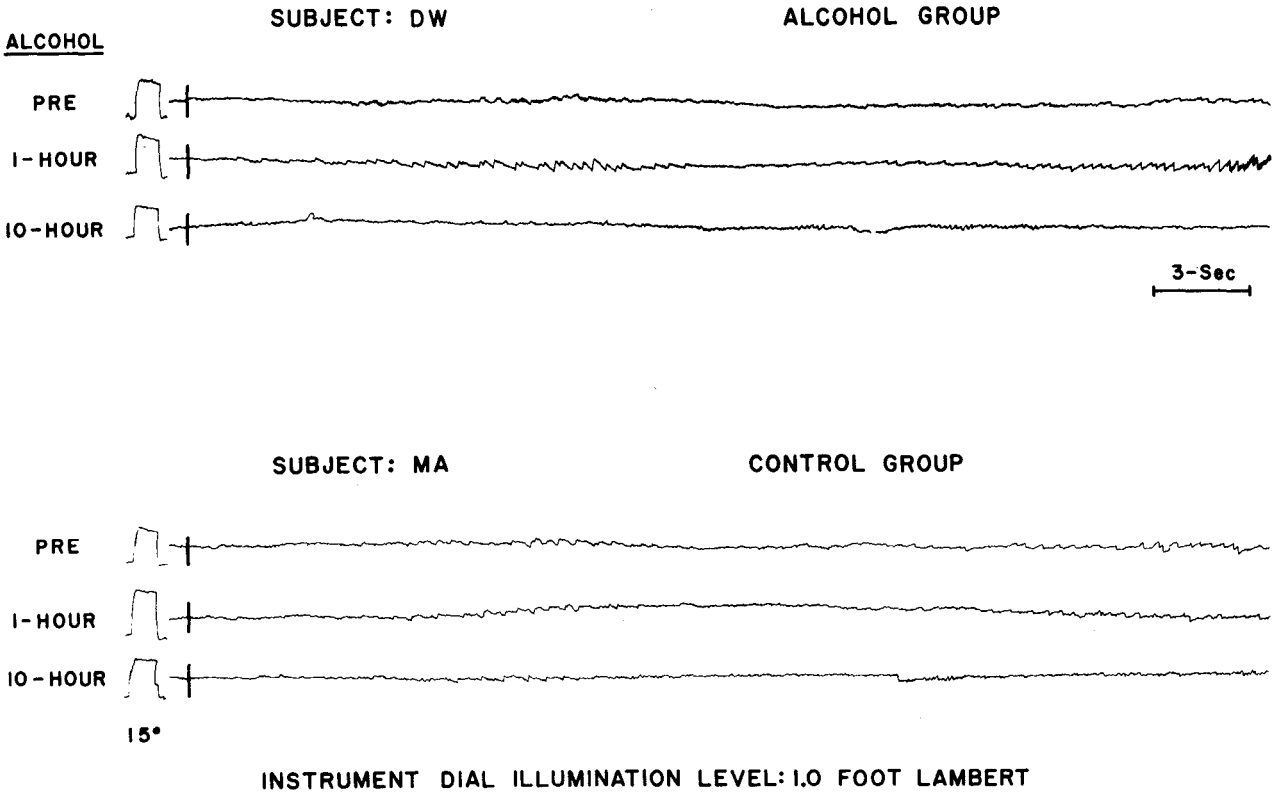

FIGURE 4. Tracings of nystagmus during angular accelerations. The eye-movement activity clearly increases following alcohol ingestion.

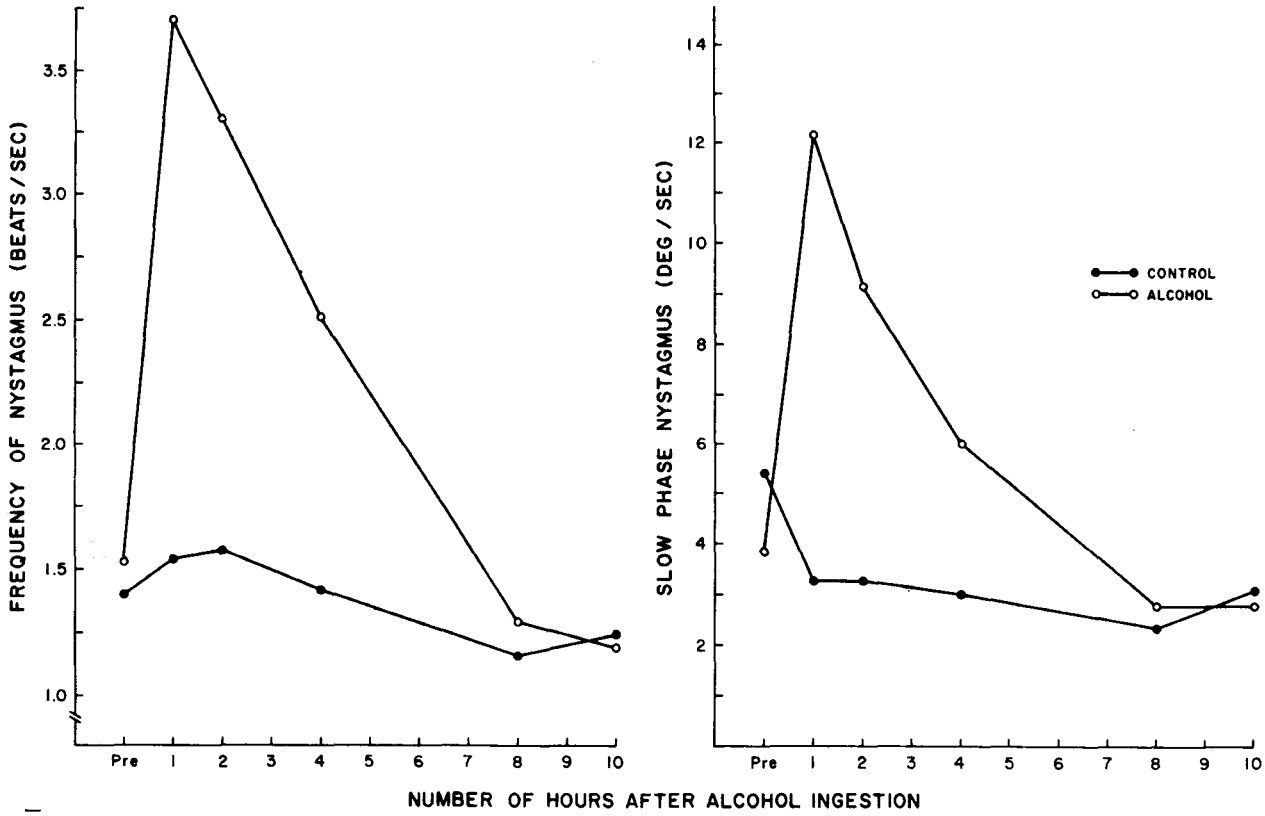

FIGURE 5. Output of sampled nystagmus during each test session for the Control and Alcohol subjects.

TABLE 2.—Results of t tests between pre-alcohol and each post-alcohol measure of the slow phase displacement and the frequency of nystagmus resulting from sinusoidal rotations, and of tracking error under static and dynamic conditions.

Measure	Group	Nystagmus Comparisons: Pre vs. 1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Slow Phase	Alcohol	−7.09***	−6.31***	−2.44*	+1.70	+1.04
	Control	+3.67**	+2.84*	+2.80*	+3.59**	+2.23
Frequency	Alcohol	−6.58***	−6.38***	−3.69**	+0.86	+1.33
	Control	−0.95	−1.02	−0.17	+1.04	+0.91

Condition	Group	Tracking Error Comparisons: Pre vs. 1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Static	Alcohol	−2.96*	−2.23	−1.88	+0.89	+1.24
	Control	+0.48	+1.19	+1.69	+1.15	+1.29
Dynamic	Alcohol	−4.00**	−3.12*	−0.32	+2.60*	+3.94**
	Control	+2.38*	+3.05*	+3.35**	+3.25**	+3.64**

*$p < .05$
**$p < .01$
***$p < .001$

A. *Control Group.* The Control group evidenced only a slight decline in static tracking error (an expected improvement with practice) from the Pre through the 10-hour session. None of the changes was statistically significant (Table 2). However, dynamic tracking error evidenced a fairly steady decline from the Pre through the 10-hour testing sessions; all 1- to 10-hour error scores were significantly ($p<.05-.01$) below the Pre scores (Table 2). Frequency measures of nystagmus for Control subjects showed no significant change (see Table 2) across the six sessions, nor was there any significant difference in slow phase ocular velocity across the last five sessions; however, all but the last session of the latter were significantly below ($p<.05-.01$) the Pre test level of slow phase activity.

B. *Alcohol Group.* In contrast to Control subjects, both the average static and dynamic tracking errors increased for the Alcohol group at the 1–, 2-, and 4-hour testing sessions; however, only the increase for the 1-hour static session ($p<.05$) and for the 1- and 2-hour dynamic sessions ($p<.05-.01$), were significantly above the respective Pre values (Table 2). Measures of nystagmus for Alcohol subjects also presented a totally different picture from that of the Control group. Both the deg/sec and the beats/sec measures increased significantly ($p<.05-.001$) from the Pre tests through the 1-, 2-, and 4-hour tests. At the 8- and 10-hour tests, nystagmus was below the Pre levels, but not significantly so (see Table 2).

C. *Comparison of the Control and Alcohol Groups.* In comparing the two groups, t tests were conducted on "change" (or difference) scores, i.e., the differences in scores between the Pre and the 1-hour sessions, the Pre and the 2-hour sessions, etc. (see Table 3).

Static tracking differences between the Control and Alcohol groups were significant ($p<.05$) only for the 4-hour session. However, in the dynamic condition, differences between the two groups were significant ($p<.01-.001$) at the 1-, 2-, and 4-hour sessions; thus, with the addition of motion, the Alcohol group performed with significantly more errors than the Control group during the first four hours following alcohol ingestion (Table 3).

With respect to nystagmus, the Control group had significantly less slow phase velocity ($p<.001$) and frequency of nystagmus ($p<.01-.001$) than did the Alcohol group for the 1-, 2-, and 4-hour sessions, and less slow phase nystagmus ($p<.05$) for the 8-hour session. Thus, the Alcohol subjects were less able than Control subjects to suppress their eye movements by fixation on the visual display during angular acceleration.

TABLE 3.—Results of t tests comparing Alcohol subjects with Control subjects on measures of nystagmus and tracking error. Comparisons were made between difference scores for each session (i.e., the difference in scores of each post-ingestion session from those of the pre-ingestion session).

	Comparisons: Alcohol vs. Control Group				
	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Nystagmus Measure					
Slow Phase	8.24***	7.55***	4.37***	2.20*	1.03
Frequency	5.44***	4.82***	3.56**	0.00	−0.56
Tracking Error					
Static	1.70	1.06	2.13*	0.12	0.38
Dynamic	4.25***	4.14***	3.31**	0.74	1.72

* $p < .05$
** $p < .01$
*** $p < .001$

IV. Discussion.

Although alcohol effected an increase in tracking errors during static performance tests, the increase was significantly above pre-drinking levels only during the 1-hour session. Moreover, differences between the Alcohol and Control groups in static tracking error were significant only during the 4-hour session when the effects of alcohol were beginning to wane.

However, during vestibular stimulation, the eye-hand coordination required by the tracking task showed marked impairment by alcohol for the 1-, 2-, and 4-hour sessions in comparison both with the Alcohol group's pre-drinking performance and with the steady improvement demonstrated by the Control group. The extent of this impairment appears to be directly correlated with the increased nystagmic activity to angular accelerations following alcohol ingestion. Thus, degradation of eye-hand coordination during stimulation of the semicircular canals appears to be closely related to the alcohol-induced loss of the ability to maintain adequate visual fixation (and visual acuity) on an object and thereby inhibit nystagmus. A similar degradation of visual acuity and tracking performance without alcohol has been reported previously.[3,4] However, the magnitude of vestibular stimuli for commensurate losses was necessarily greater in those studies since, without alcohol, the visual fixation mechanism suppressing nystagmus was functioning normally.

These data have several practical implications. Activities which show little or no impairment in static situations following alcohol ingestion may be seriously degraded during motion. Further, the task required of the subjects here was a relatively simple one, i.e., the subject could concentrate on the single stimulus display. However, in many work activities, such as piloting an aircraft, the attention of the pilot has to shift from one stimulus "display" to another. It has been shown that deleterious effects of alcohol on performance in static situations are greatest when time-sharing of attention across several tasks is required[1] or if the task requires "divided attention."[6] The addition of motion to a complex time-sharing task where performance is already degraded by alcohol might be especially hazardous.

As a final point, it should be noted that the average blood-alcohol levels obtained in this study were considerably below the legal definitions, in most state motor vehicle statutes, of when an individual is presumed to be under the influence of intoxicating liquor. (The District of Columbia and 23 state laws cite a blood alcohol level of .150% or more as a presumptive legal index; 21 states use .100%. Utah uses .080% as presumptive, and several other states are considering reducing their current levels to .080%. Five states have no defined levels.)[2] Only three subjects exceeded .090% during any of the blood-sampling periods.

V. Summary.

Following practice, two groups of 10 subjects each were given Pre (base-line) tests of tracking performance in both static (stationary) and dynamic (whole body angular acceleration) conditions. One group then received orange juice which contained 2.0 ml of 100-proof vodka per kg of subject weight; the other group drank orange juice with a few drops of rum extract added. All subjects were led to believe that they were receiving alcohol. Additional tests were conducted 1, 2, 4, 8, and 10 hours after drinking. All tests were in total darkness with the exception of the visual display which was illuminated to recommended levels for cockpit instruments. Static tracking error declined slightly for the Control group, but increased over the Pre-drinking level during the 1-, 2-, and 4-hour tests for the Alcohol group; only the 1-hour scores differed significantly from the Pre scores for the Alcohol group. In comparing the two groups, static tracking errors for Alcohol subjects were significantly higher than those of Control subjects only at the 4-hour session when the effects of alcohol were beginning to wane. However, in the dynamic tests, Alcohol subjects made significantly more tracking errors than Control subjects during the 1-, 2-, and 4-hour sessions. These data suggest that hand-eye coordination may show little or no impairment following alcohol ingestion in static situations, yet may be seriously degraded during motion.

APPENDIX A

Positional Alcohol Nystagmus

For possible supplementary information, tests of positional alcohol nystagmus were performed before each testing session and immediately after the blood samples were drawn. The subject assumed a supine position and was instructed to position his head upright, to the left, upright, to the right, and upright again, while in total darkness with his eyes open. Each position was held for 45 sec while the subject performed a mental arithmetic task. Nystagmic responses were recorded on an Offner type T electroencephalograph and calibration was accomplished prior to each positional series by instructing the subject to sweep his eyes between special ceiling markers subtending 20 deg of visual angle.

Ratings of positional nystagmus showed fairly consistent results. PAN I responses were rated as strong and as about equally vigorous during the 1-hour and 2-hour post-alcohol sessions; a reduction in output of about ⅔ occurred in the 4-hour session. All but one subject showed typical PAN I responses; the exception (subject BR) gave only weak occasional nystagmus. PAN II responses were obtained from eight subjects during the 8-hour session and were rated as being slightly more vigorous than the 4-hour PAN I nystagmus. Only five subjects yielded PAN II responses during the 10-hour session.

APPENDIX B

APPENDIX B.—Blood alcohol levels in percent determined by gas chromatography for Alcohol and Control subjects.

Control Group		Alcohol Group						
			Session					
Subject	Pre	Subject	Pre	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
MK	0	MB	0	.077	.063	.042	0	0
MA	0	BR	0	.057	.070	.053	0	0
SM	0	MC	0	.040	.055	.022	.002	0
PS	0	DW	0	.064	.066	.050	0	0
RC	0	BB	0	.103	.086	.054	0	0
BS	0	JH	0	.059	.087	.047	.006	0
JC	0	JU	0	.103	.075	.056	0	0
RM	0	BO	0	.068	.079	.054	.002	0
AA	0	GP	0	.063	.067	.034	.003	0
TT	0	DB	0	.101	.079	.054	0	0
	–		–	——	——	——	——	–
Mean	0	Mean	0	.074	.073	.047	.001	0
SD	0	SD	0	.021	.010	.010	.002	0

APPENDIX C

APPENDIX C.—Control group: Tracking error in arbitrary units under static and dynamic conditions.

Condition	Subject	Session					
		Pre	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Static	MK	2.89	3.79	3.63	3.01	4.09	3.98
	MA	5.76	5.20	4.25	4.25	4.59	4.84
	SM	4.23	5.50	5.32	5.05	5.36	4.34
	PS	4.56	5.12	5.19	5.13	5.41	5.31
	RC	5.54	5.56	4.90	5.07	4.68	5.93
	BS	3.40	4.20	4.80	4.50	4.60	4.20
	JC	6.90	6.06	4.67	4.24	4.33	4.80
	RM	4.86	5.16	5.16	4.46	4.78	4.56
	AA	7.94	6.94	5.21	4.82	5.17	4.77
	TT	8.17	4.54	4.27	4.60	4.68	4.54
	Mean	5.43	5.21	4.74	4.51	4.77	4.73
	SD	1.71	0.86	0.52	0.59	0.41	0.53
Dynamic	MK	5.53	4.64	4.23	3.96	3.94	3.77
	MA	6.96	5.68	5.60	4.74	5.46	4.26
	SM	5.90	5.35	4.69	5.01	5.07	5.15
	PS	5.69	6.23	5.15	5.26	5.50	5.46
	RC	7.34	6.33	6.45	5.76	5.36	4.94
	BS	3.71	4.08	4.06	4.24	4.39	3.84
	JC	9.19	5.89	4.95	5.29	4.85	4.62
	RM	4.95	5.42	5.13	4.82	4.42	4.39
	AA	10.04	5.56	5.43	5.25	5.35	4.70
	TT	8.01	5.21	4.88	4.44	4.72	3.88
	Mean	6.73	5.44	5.06	4.88	4.91	4.50
	SD	1.86	0.65	0.65	0.52	0.51	0.55

APPENDIX D

APPENDIX D.—Alcohol group: Tracking error in arbitrary units under static and dynamic conditions.

Condition	Subject	Session					
		Pre	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Static	MB	4.79	4.90	4.98	4.96	3.50	4.57
	BR	5.36	5.21	5.31	4.95	1.66	4.31
	MC	4.13	4.98	4.36	3.99	2.45	4.66
	DW	4.25	5.88	5.73	5.26	5.79	4.38
	BB	4.54	5.59	5.81	5.57	5.68	4.15
	JH	4.42	4.98	5.38	5.27	4.09	4.20
	JU	6.32	6.69	7.04	7.91	7.81	5.95
	BO	8.03	8.47	7.78	8.02	6.03	5.63
	GP	7.60	7.36	6.94	6.86	5.09	5.56
	DB	3.45	5.12	5.30	5.01	5.27	4.97
	Mean	5.29	5.92	5.86	5.78	4.74	4.84
	SD	1.46	1.15	1.01	1.28	1.74	0.62
Dynamic	MB	5.06	7.03	6.40	5.41	3.79	4.81
	BR	6.00	6.79	5.99	5.58	2.48	4.79
	MC	4.93	6.80	5.39	4.75	3.00	4.08
	DW	5.65	6.77	5.79	5.85	5.42	4.66
	BB	5.18	8.79	7.78	5.57	4.99	4.36
	JH	5.79	8.65	7.15	5.99	4.02	4.34
	JU	6.41	7.86	8.19	6.63	7.16	5.66
	BO	7.95	8.42	8.49	7.86	5.68	5.68
	GP	8.10	7.42	7.87	7.13	4.90	5.54
	DB	4.65	6.53	5.42	5.45	5.55	5.01
	Mean	5.97	7.51	6.85	6.02	4.70	4.89
	SD	1.14	0.82	1.13	0.88	1.32	0.54

APPENDIX E

APPENDIX E.—Control group: Nystagmus measures from the angular acceleration based on three 5-sec samples from each session for each subject.

Measure	Subject	Session					
		Pre	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Slow Phase Nystagmus (deg/sec)	MK	1.3	1.2	2.7	0.0	0.0	0.5
	MA	5.3	3.9	2.6	2.6	2.8	2.5
	SM	4.8	5.1	4.1	4.8	3.8	6.3
	PS	10.9	6.7	7.9	8.2	3.2	4.8
	RC	10.3	7.1	5.0	4.2	4.4	3.9
	BS	5.3	2.2	2.4	2.2	2.9	3.2
	JC	3.9	2.5	2.0	2.5	2.3	1.9
	RM	4.2	1.9	2.3	1.8	2.6	2.3
	AA	5.0	1.3	2.1	3.8	1.3	3.3
	TT	3.2	1.1	1.8	0.5	0.2	2.3
	Mean	5.42	3.30	3.29	3.06	2.35	3.10
	SD	2.83	2.16	1.81	2.24	1.37	1.54
Frequency of Nystagmus (beats/sec)	MK	0.2	0.2	0.6	0.0	0.0	0.3
	MA	2.4	2.7	2.2	2.0	1.7	1.9
	SM	0.9	2.5	2.5	2.5	2.2	2.1
	PS	3.0	3.0	3.1	2.9	1.9	2.4
	RC	2.3	2.7	2.4	2.2	1.7	1.7
	BS	1.7	1.4	1.5	1.3	0.9	1.4
	JC	1.6	1.4	1.1	1.6	1.5	0.8
	RM	1.1	0.9	0.8	0.9	1.3	1.0
	AA	0.3	0.3	0.6	0.6	0.3	0.5
	TT	0.5	0.3	0.9	0.2	0.1	0.3
	Mean	1.40	1.54	1.57	1.42	1.16	1.24
	SD	0.91	1.05	0.86	0.94	0.75	0.73

APPENDIX F

APPENDIX F.—Alcohol group: Nystagmus measures from the angular acceleration based on three 5-sec samples from each session for each subject.

Measure	Subject	Session					
		Pre	1-Hour	2-Hour	4-Hour	8-Hour	10-Hour
Slow Phase Nystagmus	MB	9.9	24.4	20.9	17.0	7.4	4.9
	BR	6.5	12.8	10.2	11.3	6.1	11.6
	MC	1.5	13.5	9.4	4.8	3.7	2.6
	DW	4.2	17.5	10.1	5.5	1.9	1.0
	BB	3.3	11.5	9.5	6.0	3.4	2.0
	JH	3.9	7.9	5.7	3.4	2.3	2.3
	JU	7.5	13.8	11.0	5.0	2.5	1.7
	BO	0.0	8.0	5.8	4.1	0.1	0.6
	GP	0.3	4.8	3.5	0.1	0.0	0.2
	DB	1.4	7.3	5.5	2.9	0.8	1.3
	Mean	3.85	12.15	9.16	6.01	2.82	2.82
	SD	3.10	5.45	4.60	4.54	2.31	3.18
Frequency of Nystagmus	MB	3.5	5.0	4.9	4.7	2.7	2.6
	BR	2.5	4.8	4.3	3.7	2.0	2.0
	MC	0.6	4.8	4.1	2.7	2.1	1.8
	DW	2.3	4.8	4.1	2.7	0.9	0.7
	BB	1.7	3.0	3.5	3.1	1.9	1.1
	JH	1.5	2.7	2.3	1.8	1.3	1.3
	JU	2.4	3.6	3.4	2.1	1.1	1.0
	BO	0.0	3.6	3.0	2.1	0.2	0.4
	GP	0.1	1.7	1.0	0.1	0.0	0.1
	DB	0.7	3.0	2.5	2.1	0.7	0.9
	Mean	1.53	3.70	3.31	2.51	1.29	1.19
	SD	1.10	1.06	1.09	1.16	0.83	0.72

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