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The effects of ingested alcohol on accommodative, fusional, and dark vergence

R. J. MILLER, RICHARD G. PIGION, and MASATOSHI TAKAHAMA
Washington State University, Pullman, Washington

To examine the effects of ingested alcohol on vergence, we measured vergence in 8 male emmetropes, aged 21-23 years, under two alcohol dosage conditions (placebo and 1.5 ml/kg of 95% ethanol). For each of these conditions, after consumption of the appropriate drink, dark vergence and fusional and accommodative vergence to near and far targets (viewing distance = 30 cm and 6 cm) were assessed every 30 min for a total of 6 h. Intoxication produced significant increases in convergence for far fusional and far accommodative targets. Intoxication also led to a tendency toward decreased convergence for near fusional and near accommodative targets, although the results were less clear than in the case of the far viewing conditions. Dark vergence did not change with intoxication; it also did not appear to be significantly related to other alcohol-induced vergence changes, although the size of the sample made it impossible to reach meaningful conclusions regarding this last point.

It has been reported that alcohol intoxication produces diplopia (double vision) (e.g., Brecher, Hartman, & Leonard, 1955; Charnwood, 1950; Cohen & Alpern, 1969; Colson, 1940; Levett & Karras, 1977; Powell, 1938; Wist, Hughes, & Forney, 1967). One possibility suggested by such a symptom is that alcohol may have an impact on one or more vergence mechanisms, reducing the observer's ability to converge or diverge in a manner appropriate for the elimination of retinal disparity. Such a hypothesis can be adequately tested only if it is clear what aspect(s) of vergence is (are) being affected by alcohol.

There are several types of vergence which, if impeded by alcohol, could contribute to diplopia, including fusional, accommodative, and tonic vergence (e.g., Ogle, Martens, & Dyer, 1967; Owens & Leibowitz, 1982; Toates, 1974). For a thorough description of alcohol-induced vergence changes, evaluations are needed of alcohol effects on all these aspects of vergence. Alcohol effects on proximal vergence might also be of interest, but the status of this phenomenon is debatable (e.g., Morgan, 1950, 1968; Toates, 1974); any evaluation of alcohol effects must await a clear demonstration of the existence of proximal vergence.

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Fusional Vergence

We have found no reports in the literature to date of investigations of the effects of alcohol on pure fusional vergence, in the absence of accommodative stimulation. This is probably primarily due to the fact that the clinical tradition has encouraged a much greater interest in fusion-free measures of phoria, in which the principal stimulus for vergence is an accommodative one.

Accommodative Vergence

More data are available regarding the effects of alcohol on accommodative vergence than on any other aspect of vergence. The usual observations have been that alcohol produces esophoria for far viewing (Adams, 1978; Brecher et al., 1955; Cohen & Alpern, 1969; Colson, 1940; Hogan & Linfield, 1983; McNamee, Piggins, & Tong, 1981; Moskowitz, Sharma, & Shapero, 1972; Powell, 1938; Wist et al., 1967), and exophoria for near viewing (Brecher et al., 1955; Cohen & Alpern, 1969; Hogan & Linfield, 1983; Powell, 1938). Brecher et al. (1955) suggested the presence of an alcohol-induced neutral vergence point at a viewing distance of about 60 cm, although Cohen and Alpern (1969) failed to confirm this.

Alpern (1962) speculated that alcohol might result in a decrease in AC/A, a prediction confirmed by Cohen and Alpern (1969), who found decreases in both stimulus and response AC/A following alcohol ingestion.[1] Ogle et al. (1967) recalculated data reported by Powell (1938) and concluded that the latter had shown alcohol-induced decreases in stimulus AC/A. Hogan and Linfield (1983) reported that low dosages of alcohol reduced AC/A, but the changes were not statistically significant.

Dark Vergence

Several authors have argued that there is a "resting" position for vergence, at some position between extreme convergence and divergence, that represents a tonic vergence value (e.g., Owens & Leibowitz, 1982; Schor, 1980, 1983). Vergence movements are conceived as active movements away from this tonus (toward either far or near). Thus, tonic vergence is seen as having an influence on both near and far vergence, the degree of influence depending on the value of tonic vergence for the particular observer. Various phenomena appear to be related to tonic vergence, including the effects of physiological stress and reduced sensory feedback, development of vergence in infancy, and certain anomalies of space perception (Owens & Leibowitz, 1982). The tonic position of vergence generally is inferred from the amount of vergence in force in total darkness (i.e., dark vergence).

Owens and Leibowitz (1982) speculated that alcohol-induced eso- and exophorias for accommodative vergence may occur because alcohol induces a regression of vergence toward this tonic position. To date, however, no investigation of the effects of alcohol on dark vergence has been reported.

In summary, although the literature reveals a fair amount of information regarding the effects of alcohol on accommodative vergence, it shows very little regarding alcohol-induced changes in fusional and dark vergence. The purpose of the present experiment was to examine the effects of moderate levels of alcohol intoxication on accommodative, fusional, and dark vergence, and to make a preliminary examination of the degree to which alcohol-induced changes in fusional and accommodative vergence represent a regression toward dark vergence.

METHOD

Subjects

The subjects were 8 males, aged 21-23 years (mean = 21.25 years). All subjects were moderate drinkers, as defined by the volume-variability index of the drinking habits questionnaire of Cahalan and Cisin (1968; Cahalan, Cisin, & Crossley, 1969). This measure comprises a list of questions directed toward specifying in considerable detail the kinds of beverages consumed by the subject, as well as frequency and amount of consumption. Limiting the experiment to males avoided sex differences in the absorption and metabolism of alcohol, which in women are partly mediated by the menstrual cycle (see, e.g., Jones & Jones, 1976; Simpson, Erwin, & Linnoila, 1981). All subjects' weights were within 10% of desirable weight as defined by Metropolitan Life Insurance Company tables (Burton, 1976). Each subject was paid $50 for completing all sessions. All subjects were volunteers, from whom informed consent was obtained after the nature of the procedures had been fully explained.

Subjects were screened for general visual function using a Bausch and Lomb Ortho-Rater and a Dioptron Nova diagnostic eye computer. All subjects had uncorrected acuity of at least 20/20 (6/6) far and 13/13 (0.33/0.33) near in both eyes. No subject had any lateral phoria outside of the following ranges: -0.66^{Δ} (exo) to $+1.33^{\Delta}$ (eso) for far viewing, -3.0^{Δ} (exo) to -6.0^{Δ} (exo) for near viewing. No subject had any measurable vertical phoria, and all had fine stereopsis of at least 96%. The Dioptron Nova has a relatively high false-positive rate for indicating myopia (Grosvenor, Perrigin, & Perrigin, 1985; Perrigin, Grosvenor, Reis, & Perrigin, 1984); therefore, Ortho-Rater values were used to screen out myopes. The Dioptron Nova was used to screen out hyperopia and astigmatism. If Dioptron Nova readings indicated a positive sphere value (i.e., hyperopia), a subject was not used unless his spherical equivalent was less than +0.50 D. Subjects were not excluded on the basis of myopic Dioptron Nova readings as long as their far acuity was 20/20 (6/6) or better and their cylinder readings were less than +0.75 D. All of the above criteria applied to both eyes. All subjects reported no history of visual problems.

Apparatus

Intoximeter. An Intoximeter (Model Mark IV, Intoximeter, Inc., St. Louis) was used to make all blood alcohol level (BAL) estimates. This instrument uses gas chromatography to estimate BAL from deep-lung air samples.

Nonius alignment apparatus. All vergence measurements were made with an apparatus utilizing the Nonius alignment principle and based on a design reported by Owens and Leibowitz (1976). The apparatus is shown in Figure 1. It presented two vertical lines dichoptically, one above the other. The lower (standard) line was visible only to the subject's right eye; the upper (variable) line was seen only by the left eye. Each of these lines was produced by a separate strobe lamp (Samigon Ac Master/Slave Electronic Flash units, average flash duration 0.001 sec). The bottom strobe was fixed in position and was masked and filtered so that its flash was perceived as a vertical red line, 2 × 10 mm. The top strobe was attached to a sliding carrier and was masked and filtered so that it provided a vertical line of the same dimensions as the bottom line. Because of the sliding carrier, this line could be moved laterally across the subject's field of view.

Two sheets of polarizing material were attached to the case of the apparatus, one covering the top line and the other the bottom line. The transmission axes of the two sheets were perpendicular to one another. Polarizing filters were also placed in front of the subject's eyes, the filter over the left eye being at an axis perpendicular to that of the right eye. Thus, the bottom line was visible only to the right eye, and the top line was visible only to the left eye. Because flash duration was very brief (0.001 sec), there was little likelihood that flash-induced changes in either vergence or accommodation would contaminate measurements, as the reaction time for vergence responses is 0.15-0.20 sec (Rashbass & Westheimer, 1961; Westheimer & Mitchell, 1956), and that for accommodation is 0.35-0.40 sec (Campbell & Westheimer, 1960).

The lines were presented (via a beam splitter) at a distance of 1 m from the plane of rotation of the subject's eyes; this plane was estimated to lie 13.5 mm behind the corneal apex (Burde, 1981). The lines were flashed simultaneously within the subject's field of view, with the position of the top line varied via a staircase procedure until the point of subjective alignment of the two lines was determined. Because the distance from the eyes to the lines was known, as were the subject's interpupillary distance and the actual lateral distance between the two lines when they were perceived as aligned, the angle of vergence could be readily computed.

The subject's head was fixed in position with a biteboard for all vergence measurements. Because the biteboard made oral responding difficult, the subject was given a pushbutton connected to a buzzer. With this he could indicate the perceived position of the top line relative to the bottom line (i.e., right or left).

Accommodative vergence stimulus. Stimulation for accommodative vergence was provided by the monocular (left eye) presentation of a black cross (see inset, Figure 1) on a circular white background (Miller, Pigion, & Martin, 1985). Two targets were used, one for near viewing (30 cm from the corneal apex; dioptric equivalent = 3.33) and the other for far viewing (6 m; 0.17 D). The gap in the arm of the cross had a visual angle of 2.29′, and the white background was 2.41° in diameter. The remainder of the visual field was black. The average overall luminance of each target was approximately 315 cd/m².

Each cross could be turned about its central axis so the gap could be in any of the four arm positions shown in Figure 1. The subject's task was to indicate the position of the gap. Given the small size of the gap, accurate performance required constant effort, as the cross was rotated approximately every 5 sec, and each new position of the gap was determined randomly. Both targets were aligned directly in front of the subject on the interocular midline.

Because the biteboard made oral responding difficult, the subject was provided with a video-game joystick. He indicated the position of the target gap by moving the joystick in the appropriate direction. The joystick was wired to a panel of lights, visible only to the experimenter, which showed the subject's responses. Errors were rare, and the subject was informed whenever he made an incorrect response.

Fusional vergence stimulus. To provide a stimulus for fusional vergence, in the absence of stimulation to accommodation, a pinpoint light source was used. This target was provided by a 115-μ pinhole mounted 14.5 cm in front of the filament of a Viewlex projector (Model AP-20), which used a Radiant CBC bulb (75 W, about 750 cd of luminous intensity). The entire system was surrounded by a lighttight case, so that the only light that escaped came from the pinhole. A .32-cm-thick sheet of ground glass was placed 2.0 mm directly in front of the pinhole (i.e., on the subject's side) to make the spot of light even less resolvable. The result was a very tiny, very dim spot of light that had gradually decreasing illuminance at its edges and essentially no resolvable boundaries. The target was shown in an otherwise totally dark room. Fusional vergence was stimulated by binocular viewing of this target at two distances, 30 cm and 6 m. The illuminance of the target at the two distances was kept constant through the use of neutral density filters.

This target has been shown in previous research (Miller, 1980) to provide a stimulus sufficient to maintain fusion and stimulate vergence without providing enough visual information directly to stimulate changes in accommodation. Such a target provides an open-loop condition (Fincham & Walton, 1957; Morgan, 1968) in which vergence is disparity induced, whereas accommodation is free to vary as it is driven by vergence.

Procedure

The experiment consisted of two conditions, presented during two separate sessions, differentiated only in terms of alcohol dosage. Each subject experienced both conditions. All sessions were run in the evening to minimize diurnal variation in alcohol absorption and metabolism. Prior to these two sessions, each subject participated in a screening session.

Screening session. The purpose of the screening session was to ascertain that the subject met all criteria for participation and to give practice with the apparatus and procedures. Height, weight, and general visual functioning (Ortho-Rater and Dioptron Nova readings) were assessed at this time (the drinking habits questionnaire had been administered by telephone when the subject was first contacted). Following these measurements, the subject practiced detecting and responding to the Nonius lines in total darkness and while viewing the near and far accommodative and fusional vergence targets.

At the end of the screening session, the subject was instructed to consume no alcohol or other drugs on testing days, and to avoid consumption of any food or liquid (other than water) during the 3 h preceding each experimental session.

Experimental sessions. The procedures for both experimental sessions were identical except for the dosage of alcohol. In each session, the subject was given 10 ml of total liquid per kilogram of body weight. For the placebo condition, the drink was pure unsweetened tomato juice. For the alcohol condition, the drink contained 1.5 ml/kg of 190 proof (95%) ethanol mixed with tomato juice. Each drink was served in a covered opaque cup and was consumed through a straw. To help disguise the alcohol content, two drops of ethanol and two drops of eucalyptus oil were placed on the cover so that all drinks smelled the same. The two conditions were run on separate evenings for each subject. The order of the two conditions was counterbalanced across subjects.

At the beginning of each session, baseline values of six variables were assessed, in the following order: (1) dark vergence—vergence assessed in total darkness; (2) near fusional vergence—vergence assessed while the subject binocularly viewed the near pinpoint target; (3) far fusional vergence—vergence assessed while the subject binocularly viewed the far pinpoint target; (4) blood alcohol level (BAL)—assessed with the Intoximeter; (5) near accommodative vergence—vergence assessed while the subject monocularly viewed the near accommodation cross; (6) far accommodative vergence—vergence assessed while the subject monocularly viewed the far accommodation cross.

After these measurements were made, the subject consumed a small amount of food (white bread, 0.9 g/kg of body weight). The food was given to alleviate the nausea experienced by some subjects when they drink alcohol on an empty stomach. After he had eaten the food, the subject was given the drink for that session. The drink was consumed over a 20-min period, with 25% of the total amount being given every 5 min. Then a 10-min period elapsed while alcohol remaining in the mouth and throat tissues was absorbed. At the end of this period the subject rinsed his mouth thoroughly with water.

After the 10-min absorption period, the six variables were assessed again. These measurements were repeated every 30 min for a total of 6 h.

RESULTS

Vergence was measured under five different conditions (dark vergence, near fusional vergence, far fusional vergence, near accommodative vergence, and far accommodative vergence), which will be referred to collectively as viewing condition. Each of these five viewing conditions was assessed at 13 different time periods (baseline plus the 12 postdrinking 30-min time intervals). In addition, there were two different dosage conditions (placebo and alcohol). All vergence measurements are expressed as degrees of vergence angle (see Figure 1).

Basic BAL Data

As described earlier, BAL was assessed once every 30 min. In all cases, baseline BAL = 0%. The mean peak BAL value for the alcohol condition was .078% (SD = .007, range = .07–.09). The mean consecutive number of the time period during which each subject's peak BAL value first occurred for the alcohol condition was 4.13 (SD = 1.69, range = 1–6).

Time-Related Effects

A 5 × 13 (viewing condition × time period) analysis of variance was performed on the vergence data for the placebo condition alone. Results of this analysis showed the effects of viewing condition to be statistically significant [$F(4,28) = 100.32, p < .0001$]. Neither the effect of time period nor the interaction was significant. Thus it would appear that time-related effects such as fatigue, practice, and so forth did not have a significant effect on vergence.

Alcohol-Related Changes in Vergence

The principal question addressed by the present experiment was whether or not vergence would be affected by

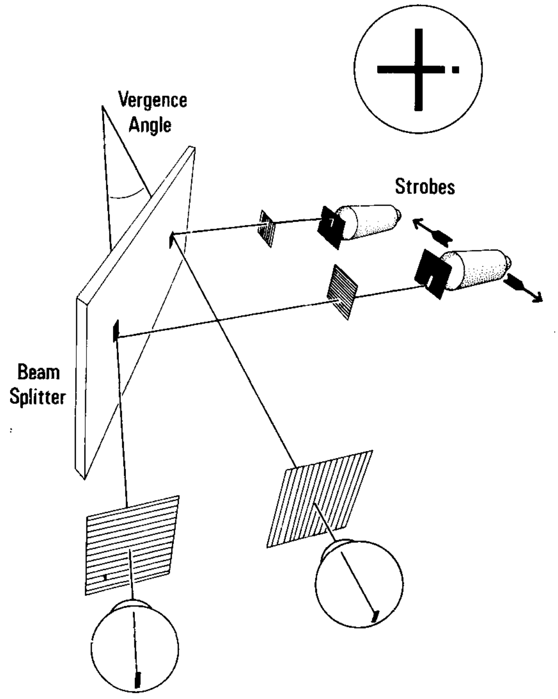

Figure 1. Apparatus for assessing vergence and inducing accommodation. Insert is accommodative vergence stimulus.

intoxication. To answer this question, it was not sufficient merely to examine group changes over time, as there were considerable intersubject differences in when the peak of the BAL curve occurred. Because the subjects did not all peak at the same time, vergence changes induced by higher levels of intoxication were distributed across numerous time intervals when the sample was considered as a whole, diluting their effects in any analysis based on time-related changes.

To solve this problem, each subject's vergence data were divided into three intoxication levels. The first level (BAL 1) consisted of baseline data. The second level (BAL 2) consisted of the means of all postdrinking data obtained for a given subject when his BAL was less than .06%. The third level (BAL 3) consisted of the means of data obtained for the subject when his BAL was .06% or greater. Vergence data from each of the five stimulus conditions were analyzed using 2 × 3 (dosage condition × intoxication level) analyses of variance.

Dark vergence. The effect of intoxication level on dark vergence is shown in Figure 2. Analysis of variance demonstrated that neither of the main effects nor the interaction was statistically significant.

Near fusional vergence. The effect of intoxication level on near fusional vergence is shown in Figure 3. Neither of the main effects nor the interaction was statistically significant, although the probabilities of all three F values were less than .10.

Far fusional vergence. The effect of intoxication level on far fusional vergence is also shown in Figure 3. Analysis of variance showed that the effects of dosage condition were significant [$F(1,7) = 7.50, p < .03$], as were the effects of intoxication level [$F(2,14) = 11.82, p = .001$] and the interaction [$F(2,14) = 6.79, p < .01$]. Because of the significant interaction, a Newman-Keuls analysis was performed comparing all six means. The three means for the placebo condition were not significantly different from one another. For the alcohol condition, BAL 3 was significantly different from BAL 1 and BAL 2 ($p < .01$), and BAL 2 was significantly different from BAL 1 ($p < .05$). In addition, at BAL 3, the alcohol con-

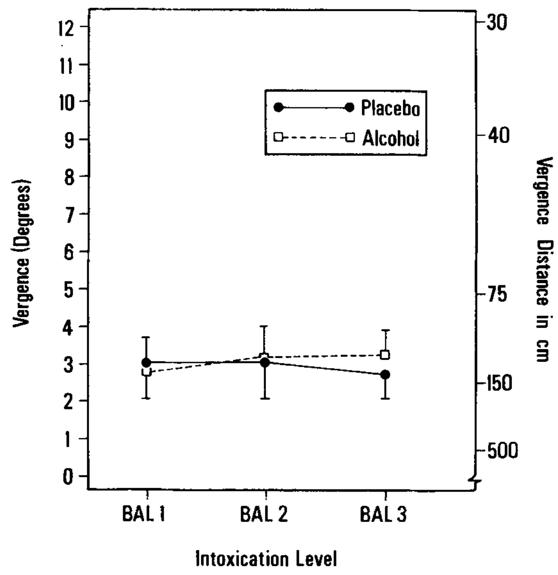

Figure 2. Dark vergence values for all conditions. Variability expressed as standard deviation. Vergence distance scale assumes interpupillary distance of 6.4 cm.

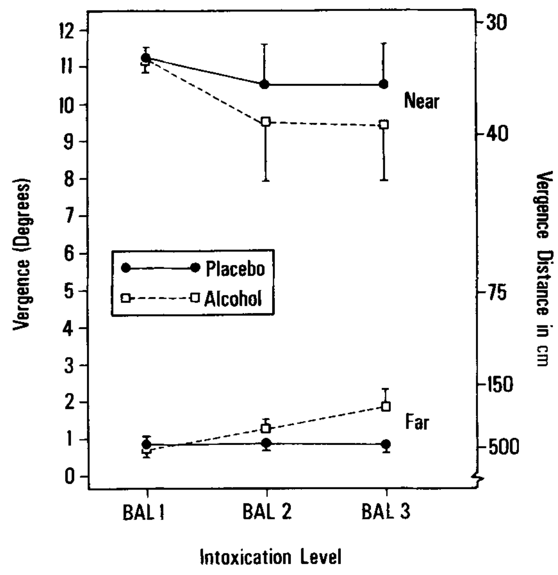

Figure 3. Near and far fusional vergence values for all conditions.

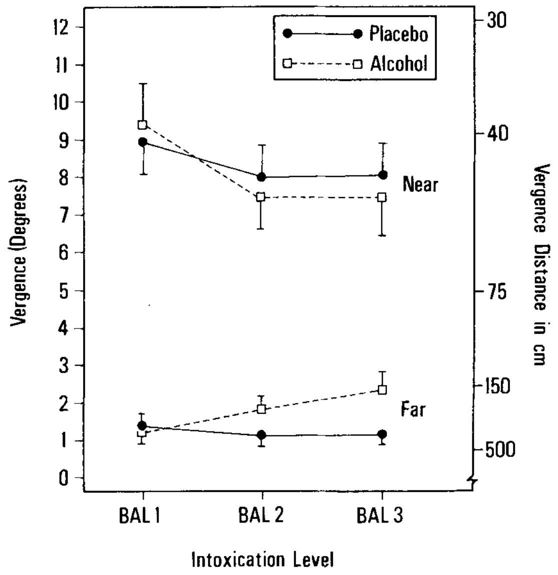

Figure 4. Near and far accommodative vergence values for all conditions.

dition was significantly different from the placebo condition ($p < .01$).

Near accommodative vergence. The effect of intoxication level on near accommodative vergence is shown in Figure 4. Analysis of variance showed that the effect of dosage condition was not significant. The effect of intoxication level was significant [$F(2,14) = 25.03$, $p < .0001$], as was the interaction [$F(2,14) = 5.15$, $p < .03$]. Newman-Keuls analysis showed that BAL 1 was significantly different from BAL 2 and BAL 3 for both the alcohol condition ($p < .01$) and the placebo condition ($p < .05$). None of the other differences between means was significant.

Far accommodative vergence. The effect of intoxication level on far accommodative vergence is also shown in Figure 4. Analysis of variance showed the effect of dosage condition to be significant [$F(1,7) = 13.15$, $p < .01$], as were the effect of intoxication level [$F(2,14) = 8.19, p < .01$] and the interaction [$F(2,14) = 16.81$, $p < .001$]. Newman-Keuls analysis showed that for the alcohol condition, BAL 3 was significantly different from BAL 1 and BAL 2, and BAL 2 was significantly different from BAL 1 ($p < .01$). In addition, the placebo condition was significantly different from the alcohol condition at both BAL 3 ($p < .01$) and BAL 2 ($p < .05$).

Relations Between Vergence Change and Dark Vergence

As we stated in the introduction, Owens and Leibowitz (1982) have suggested that alcohol-induced changes in vergence may represent a regression of vergence to the tonic position, represented by dark vergence. If such is the case, one would expect that near and far fusional and accommodative vergence would get closer to dark vergence as intoxication level increased. Such an occurrence certainly is implied by the results shown in Figures 2–4. However, is this tendency for vergence to approach the tonic position due to some direct influence of a tonus tendency, or is it just an artifact of the fact that alcohol is decreasing the vergence range, and the tonic position happens to be somewhere within this range?

Table 1 presents vergence measurements for all subjects for near and far fusional and accommodative vergence in the alcohol condition. Included for each subject are BAL 1 (baseline) and BAL 3 (highest level of intoxication) values for each type of vergence. Also included for each subject are change (difference) scores for each type of vergence. These represent the amount by which vergence changed as the subject's intoxication level increased from BAL 1 to BAL 3. The last column in Table 1 contains the baseline (BAL 1) dark vergence readings for all subjects.

If alcohol-induced changes in vergence are in fact regressions to dark vergence (and not just decreases in vergence range), these changes should be related to dark

Table 1
Alcohol Condition Vergence Data for All Subjects for BAL 1 and BAL 3

	Type of Vergence												
	Near Fusional			Far Fusional			Near Accommodative			Far Accommodative			
Subject	BAL 1	BAL 3	BAL 1 minus BAL 3	BAL 1	BAL 3	BAL 3 minus BAL 1	BAL 1	BAL 3	BAL 1 minus BAL 3	BAL 1	BAL 3	BAL 3 minus BAL 1	Dark Vergence
1	10.91	10.39	0.52	0.87	1.20	0.33	10.24	8.30	1.94	0.98	1.28	0.30	2.74
2	9.47	2.31	7.16	0.37	0.94	0.57	6.19	4.35	1.84	0.68	1.70	1.02	2.06
3	11.68	11.42	0.26	0.66	1.17	0.51	7.95	7.45	0.50	0.85	1.39	0.54	2.32
4	11.80	8.32	3.48	0.53	2.61	2.08	6.22	5.00	1.22	0.79	3.64	2.85	1.02
5	11.93	11.23	0.70	0.79	2.27	1.48	10.98	8.63	2.35	1.10	2.01	0.91	1.39
6	11.03	10.01	1.02	0.76	3.56	2.80	9.78	7.66	2.12	2.50	3.77	1.27	5.22
7	10.73	9.94	0.79	1.18	1.41	0.23	10.83	7.15	3.68	0.99	2.29	1.30	4.21
8	11.77	11.55	0.22	1.17	1.58	0.41	12.36	10.71	1.65	1.61	2.14	0.53	3.13
Mean	11.17	9.40	1.77	0.79	1.84	1.05	9.32	7.41	1.91	1.19	2.28	1.09	2.76
SD	0.83	3.05	2.42	0.28	0.90	0.96	2.29	2.02	0.92	0.60	0.95	0.80	1.41
r*	.	.	−.35	.	.	+.12	.	.	+.47	.	.	−.25	.

Note—*BAL = blood alcohol level. All vergence data are expressed in degrees of vergence angle.* **Correlations between dark vergence and change scores.*

vergence. That is, in the case of near fusional or accommodative vergence, subjects with far (low) dark vergence values should change vergence relatively more when intoxicated than subjects with near (high) dark vergence values. On the other hand, in the case of far fusional or accommodative vergence, subjects with far dark vergence values should change less than subjects with near dark vergence values.

These predictions were examined in two ways. First, looking at BAL 1, it is clear that for all subjects dark vergence was closer to far than to near values for both accommodative and fusional vergence. Thus, one would expect that if alcohol is driving vergence toward dark vergence, the change scores for near fusional and accommodative vergence should be greater than those for far vergence. That is, since dark vergence is closer to far values at the outset, far vergence has to change less than near vergence to approach dark vergence. For fusional vergence, the mean difference between near and far change scores was in the expected direction, but was not statistically significant. For accommodative vergence, the difference barely achieved significance [$t(7) = 1.92$, $p < .05$, by one-tailed test].

Second, we calculated Pearson product-moment correlations comparing dark vergence with each of the four sets of change scores. The resulting correlation coefficients are shown in Table 1. None of the coefficients is statistically significant.

DISCUSSION

Fusional Vergence

In general, intoxication produced a tendency toward increasing fusional convergence for far viewing and increasing fusional divergence for near viewing (Figure 3). This tendency was most pronounced for far viewing, where there not only was significantly greater convergence under the effects of alcohol than was the case at baseline, but the degree of convergence increase was significantly related to degree of intoxication (i.e., BAL 3 produced greater convergence than BAL 2). The effect for near viewing was analogous, but not statistically significant. This lack of significance can be attributed, at least in part, to the fact that near fusional vergence measurements were characterized by greater variability than other vergence measurements. The reason for this greater variability is not clear, but it does suggest that future experiments with this variable should feature larger numbers of subjects.

Accommodative Vergence

The results of accommodative vergence measurements were consistent with several previous findings, as cited in the introduction. That is, intoxication produced a tendency toward increased esophoria for far viewing and increased exophoria for near viewing. Again, the effect was clearer for far viewing, where the degree of esophoria was directly related to degree of intoxication. For the near viewing alcohol condition, both BAL 2 and BAL 3 produced greater exophoria than baseline (BAL 1), although BAL 2 and BAL 3 did not differ significantly from each other. The direct role of alcohol in this effect is rendered somewhat unclear by the fact that parallel changes in vergence also were found for the placebo condition, although the presence of a significant interaction between intoxication level and dosage condition suggests that alcohol produced greater vergence changes than did the placebo.

Dark Vergence

It is clear that intoxication had no systematic effect on dark vergence. Apparently, tonic vergence is relatively resistant to alcohol, at least at the moderate intoxication levels induced in the present experiment. Furthermore, there was no very clear support for the position that alcohol-induced changes in accommodative and fusional vergence represent regression of vergence toward tonic vergence, although some aspects of the findings were consistent with such an interpretation. A definitive statement on this issue will require research with larger numbers of subjects, so that meaningful correlational relationships can be explored.

Conclusions

The general effect of alcohol was to produce a decrease in vergence range, manifested by changes in both fusional and accommodative vergence. The intoxication levels obtained in the present experiment were moderate, and future research should include higher levels of intoxication. Furthermore, the effects were clearer at far viewing than at near. Perhaps closer near targets should be utilized in future research to determine if greater divergence effects occur. However, intoxication levels and viewing distances of the present experiment are reasonable analogs of many common social drinking settings; the fact that reliable vergence changes were found under these conditions suggests that similar changes occur in a variety of everyday drinking contexts.

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NOTE

1. The AC/A ratio is one expression of the synkinesis between convergence and accommodation. It is the number of prism diopters of accommodative convergence per diopter of accommodation for a given observer at a given moment. For the stimulus AC/A, the amount of accommodation in the ratio is defined by the distance of the target (i.e., the amount of accommodation demand provided by a given target at a given distance). For the response AC/A, accommodation is the amount of accommodation actually in force for a given eye. Stimulus and response AC/A ratios are often not identical, as observers frequently do not accommodate to a degree that exactly matches the demands of the target (see Burde, 1981).

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