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Vision field testing in intoxicated individuals

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Abstract

PURPOSE: Law enforcement officers regularly conduct tests of physiological responses to assess impairment in drivers. Previous studies showed that visual field decreases with alcohol intoxication. We assessed visual fields at blood alcohol concentrations (BACs) around the per se limit, 0.08 g% for most states and Canada. We also propose a new test that officers may use in addition, or as an alternative, to other tests.

METHODS: We tested 34 volunteer drinkers at baseline and at three intervals after starting drinking. All testing was done with both eyes open. Peripheral visual field was assessed with an arc perimeter, centered 30 cm from the bridge of the nose. The target was moved in from the periphery until the subject was able to identify it. Modified Confrontation Visual Field (MCVF) was assessed with the evaluator standing 60-80 cm from the subject, presenting 1, 2, or 5 fingers at 45 deg lateral angles with respect to midline. On each of three presentations on each side, the evaluator assessed the presence of head turn, incorrect count, saccade or fixation loss, and body sway. BAC was measured with a calibrated breath analysis instrument at each set of evaluations.

RESULTS: Peripheral visual field, averaged over both eyes, decreased linearly with increasing BAC. On the MCVF test, body sway, fixation loss, and the presence of two or more clues all increased linearly with increasing BAC. The overall accuracy of the MCVF test at the 0.08 g% criterion level is 68.4%.

CONCLUSIONS: We confirm the decrease in peripheral visual field with increasing BAC. We also demonstrate increasing difficulty in performing MCVF with increasing BAC. We believe these results will assist the law enforcement community to remove impaired drivers from the road.

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Signature Page

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Dustin Harlin: Dustin is a native of Northern Idaho growing up in Coeur d'Alene. He attended Ricks College in Rexburg, Idaho, for two years and earned an A.A.S. degree in Natural Sciences. Dustin transferred to Brigham Young University for one year, and eventually graduated from the University of Utah with a B.S. degree in Behavioral Science & Health. He is currently attending Pacific University College of Optometry as a fourth year student on preceptorship. Upon completion of his Doctor of Optometry degree, Dustin plans to continue clinical education in a Cornea & Contact Lens residency program and then enter private practice.

Levi Porter: Before coming to Oregon for optometry school, Levi spent his entire life in Wyoming. He graduated fi-om the University of Wyoming with a B.S. in Exercise Physiology. After becoming a certified strength and conditioning specialist through the National Strength and Conditioning Association, Levi worked as a personal trainer prior to entering optometry school. Upon completion of optometry school, Levi will pursue a residency position in ocular disease or surgical co-management. Eventually, he plans to practice primary eye care in a small group practice in Wyoming or northern Colorado. Ideally, the practice would allow Levi to combine his love of sports with a career in optometry by emphasizing sports vision.

ABSTRACT

PURPOSE: Law enforcement officers regularly conduct tests of physiological responses to assess impairment in drivers. Previous studies showed that visual field decreases with alcohol intoxication. We assessed visual fields at blood alcohol concentrations (BACs) around the per se limit, 0.08 g% for most states and Canada. We also propose a new test that officers may use in addition, or as an alternative, to other tests.

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CONCLUSIONS: We confirm the decrease in peripheral visual field with increasing BAC. We also demonstrate increasing difficulty in performing MCVF with increasing BAC. We believe these results will assist the law enforcement community to remove impaired drivers from the road.

Key Words: visual field, alcohol, intoxication, law enforcement, driving

INTRODUCTION

Many states include minimum visual field requirements, typically 110 deg or more horizontally, for drivers who hold unrestricted licenses.' However, law enforcement officers who regularly assess intoxicated drivers report that such drivers consistently complain of difficulty detecting and attending to peripheral objects. This is especially prevalent in cases when intoxicated drivers collide with pedestrians, bicyclists, or other vehicles in adjacent lanes, claiming that they "never saw the victim."

An early study by Colson intimated his excellent anecdotal account of visual field constriction with alcohol intoxication, following a "champagne binge" of a group of aviators in France during World War I:

> When we left the café and started back to our billets my peripheral fields seemed to be markedly contracted, although central visual acuity appeared to be unaffected. I felt that I was looking through a pair of nonmagnifying binoculars.[2]

However, Colson's subsequent clinical evaluation many years later failed to show changes in visual fields using a perimeter and test methods available at the time.[2]

More recent studies have since demonstrated changes, at moderate levels of alcohol intoxication, in peripheral signal detection,) peripheral visual field,' and central visual field.[5] Most changes noted in these studies, though statistically significant, were typically small in magnitude, requiring either specialized instrumentation and/or extensive testing. For example, von Wright and Mikkonen's subjects each completed nine test periods, with each test period lasting approximately 40 min and comprising 1,080 trials.) Hill and Toffolon, using a Goldmann perimeter, showed average decreases of horizontal and vertical monocular peripheral fields of about 10 deg each at an average blood alcohol concentration (BAC) of 0.134 g%.[4] Using an automated perimeter to measure central fields, Wild et al. demonstrated an average reduction in index mean deviation by 1.0 dB and an increase in pattern standard deviations at an average BAC of 0.0695 g%.[5] On the other hand, Quintyn et al., using a different automated perimeter, found no visual field changes at an average BAC of 0.057 g%.[6] It is possible that changes in visual fields at this BAC were too small to detect with this instrument.

In a study of suspected intoxicated drivers, Simpson-Crawford and Slater used a standard confrontation visual field technique as part of a clinical examination by a doctor.[7] They found significant reductions in visual fields, but did not provide any parametric data. Also, they did not suggest that law enforcement officers use this technique in the field. Likewise, none of the other previous studies employed any test of visual fields that could be used by an officer to assist in his/her decision to arrest a driver on suspicion of Driving Under the Influence (DUI). In fact, Hill and Toffolon suggested that visual field losses can only be documented with a perimeter and not with a confrontation technique.[4]

Moskowitz and Sharma concluded that changes in visual performance are due to attentional or processing deficits rather than sensory inhibition.' They observed decreases in peripheral visual fields at average BACs up to 0.09 g%, but only in the presence of a central visual task. While the physiological mechanisms of intoxication may be different than the aging process, this is functionally similar to the decrease in the useful field of view observed in older adults described by Ball and Owsley.[9]

One goal of this study is to confirm the decrease in the attentional peripheral visual field at BACs around the per se limit for alcohol intoxication, currently 0.08 g% for passenger vehicle drivers for most states and Canada. We also propose a variation of the confrontation visual field test, incorporating elements that assess coordination skills in addition to the actual subjective response. To be useful to a law enforcement officer, a test should not take an unreasonably long time to perform, it should not require the use of any special measurement apparatus, it should be within the ability of an average sober individual, and it should not place the officer, the suspect, or bystanders at risk.[10]

Using the suggested procedure and scoring criteria outlined below, we believe that this test that can be performed reliably by law enforcement officers, and that it may provide additional, or alternative, psychophysical evidence to establish whether or not a driver is impaired. This test also can be performed on seated subjects who may not be able to perform any tests that involve standing or walking.

METHODS

Alcohol Workshops

The current study was conducted at four regularly-scheduled alcohol workshops in Oregon. These workshops are commonly used to train officers on the use of standardized field sobriety tests. Workshops usually last about three to four hours, during which subjects receive measured doses of their alcoholic beverages of choice for about two hours, as well as snack foods. Each subject's BAC was carefully monitored throughout the workshop. All BAC measurements were conducted by certified breath analysis specialists using calibrated instruments (Intoxilyzer 5000, CMI, Owensboro, KY) and procedures equivalent to those required for the measurement of an actual DUI suspect in Oregon, including a 15-min waiting period prior to the breath test during which no alcohol was consumed.

Evaluations of visual fields were performed in a room or area separate from the training area in order to avoid disrupting the trainees. Each subject was evaluated four times during each workshop. Baseline evaluations were performed at the beginning of the workshop, prior to the subject's first drink; measurements confirmed that all subjects started with BACs of 0.00 g%. The first set of evaluations was conducted about one hour after the start of drinking, the second set was conducted at the end of the two-hour drinking period, and the final set was conducted at the end of the workshop, at least one hour after the last drink.

Two tests of visual fields (see below) were conducted using a double-masked procedure, as neither the researchers responsible for the measurements nor the subjects were aware of the subjects' BACs during the evaluations. Since most evaluations were conducted during the 15-min waiting period prior to a breath test, subjects did not consume any alcohol during the actual visual field evaluations. Subjects worked with the trainees as part of the regular workshop in the time between the second and final sets of visual field evaluations.

Subiects

Thirty-four volunteer drinkers, 21 female and 13 male, overall average age 28.9+/-6.9 yrs, participated in the study. Subjects were recruited from local colleges, prosecutors' and attorneys' offices, and police academy offices. All subjects were Caucasian, of legal drinking age, and acknowledged varying levels of experience with drinking alcohol. None of the subjects reported chronic alcoholism, fatigue, presence of any health conditions, or use of any medications that precluded consumption of alcohol or participation in the study. All subjects passed a health screening prior to participating in the workshop, including assessment of blood pressure, pulse rate, pupil size and reaction to light, and eye movements. Each subject signed an informed consent form, which was approved by the agency conducting the alcohol workshop (Oregon State Police, Oregon Department of Public Safety and Standards Training, or Washington County (OR) Sheriffs Office).

Subjects were recruited based solely on their availability, and not on their age, gender, weight, or ethnicity. Demographic data are summarized in Table 1. There was no significant difference in age between female and male subjects, $t(32)=0.21$, $p=0.837$. There was a significant difference in weight based on gender, $t(32)=3.03$, $p=0.005$. However, this difference is irrelevant, since each subject's BAC was determined with a precise breath analysis instrument (see above), rather than estimation based on subject characteristics and volume of alcohol consumed.

Table 1 also summarizes the types of prescription lenses, if any, used for driving. Subjects who wore spectacles were evaluated without the correction in place, since neither task required good acuity and the spectacle frame could have interfered with measurement of the visual field or observation of the eyes. Subjects who wore contact lenses retained the correction throughout the workshop, as contact lenses will not affect the results.

Table 1. Demographic data for the drinking volunteers in the study. s.d. = standard deviation.

		Female	Male
	Number	21	13
Age, yrs	Mean (s.d.)	29.1 (7.0)	28.5 (7.1)
	Minimum	21	21
	Maximum	43	44
Weight, kg	Mean (s.d.)	67.2 (15.6)	85.6 (19.6)
	Minimum	48.6	65.9
	Maximum	120.5	140.9
Prescription for Driving	Spectacles	4	1
	Contact Lenses	4	2

Test Procedures

Peripheral Visual Field (PVF)

Temporal PVFs were assessed with an arc perimeter, centered 30 cm from the bridge of the nose. All testing was conducted with both eyes open. The subject fixated a yellow circular central target that subtended 1.4 deg. A red circular target, also subtending 1.4 deg, was manually moved from beyond 90 deg (not seen) towards the center at about 2 deg/sec until the subject reported the ability to identify the color. The subject's left visual field was always tested before the right visual field. The test typically required less than 1 min to complete.

The instrument was shown to each subject at the first presentation during the baseline measure and a single practice trial was allowed, if necessary. However, multiple trials at the later evaluations were not conducted, in an effort to avoid practice effects. We have no reason to suspect that this brief test, even though it was conducted multiple times at least one hour apart, produced significant practice effects. In fact, almost all subjects consistently demonstrated visual field constrictions at the non-zero BAC evaluations throughout the test session.

Modified Confrontation Visual Field (MCVF)

MCVF differs from standard confrontation field testing in that the temporal angle of stimulus presentation is fixed, the subject keeps both eyes open, and the evaluator assesses the presence of indicators in addition to the ability of the subject to see the peripheral stimuli.

During the test, the evaluator and subject stand facing each other, about arm's-length (60-80 cm) apart. The evaluator gives the following instructions to the subject:

- o "Please look at the bridge of my nose and keep looking there during the test."
- o "I will show you either 1, 2, or 5 fingers off to either side." (While saying this, the evaluator holds up either hand directly in front of the subject, with the palm toward the subject, presenting the index finger, then the index and middle fingers in a “V” shape, and finally all five fingers spread apart with open palm, respectively.)
- o "Please tell me how many fingers you see when I present them. Do you understand?"

The evaluator then positions both hands halfway between himself and the subject, at about eye level, at 45 deg lateral angles with respect to the subject's midline; thus, the evaluator's hands will be just beyond the edge of most subjects' shoulders at this distance. The evaluator presents the finger stimuli six times, alternating between the subject's left and right visual fields, in the sequence left, right, left, right, right, left. On each of the six presentations, the evaluator can present the number of fingers in random order, but is encouraged to eventually present all three options in both visual fields.

On each presentation, the evaluator assesses the presence of each of four indicators: head turn, incorrect count, saccade or fixation loss, and body sway. "Incorrect count" includes subject responses such as "one" (a possible choice) when two fingers are presented and "four" (not a described choice) when five fingers are presented. Presence of any indicator, whether only once or during all six presentations, is counted as a single clue for the evaluation. This is consistent with the scoring of the standardized field sobriety tests commonly used by law enforcement officers."

For this study, each subject was tested only once at each test period, in an effort to avoid practice effects. The test typically required less than 1 min to complete.

We recognize that performing this test may place an officer at undue risk, as both of the officer's hands will be removed from his/her holstered sidearm, pepper spray, and/or nightstick. Likewise, this position would make it impossible to hold a flashlight properly or safely at night. Therefore, we recommend that this test **only** be conducted in the presence of, or with the assistance of, backup officers at roadside, or in the controlled environment of the stationhouse during a drug recognition evaluation.

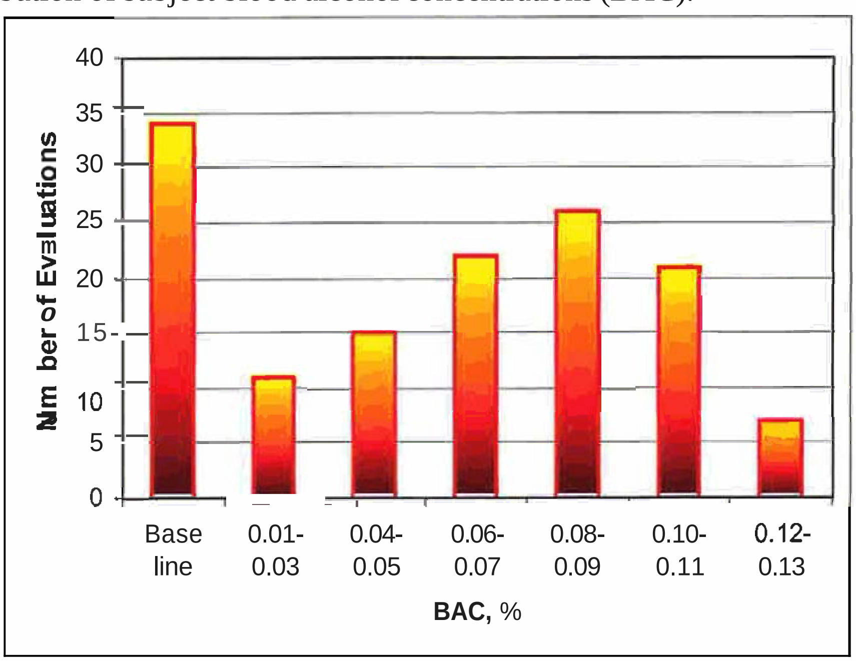
In the interest of public safety during an actual traffic stop, if the suspect were to claim not to be able see the evaluator's hand on either or both sides when the stimuli are presented, testing should be stopped, as the subject may be suffering from an actual visual field loss associated with a cerebral vascular accident or recent head injury. Medical treatment should be sought immediately. This situation never occurred during this study at any level of intoxication for any subject.

RESULTS

BAC

The BAC goal for most subjects in typical alcohol worltshops is about 0.08 g%, as that represents the per se limit for presumed intoxication defined legislatively by most states. The range of BACs for all trials in this study was 0.01-0.13 g%. The distribution of subject BACs for all evaluations, in 0.02 g% intervals, is shown in Figure 1. Note that only two evaluations were conducted with subject BAC equal to 0.01 g%. Results of all testing for these subjects are within the respective ranges of results for the 0.02-0.03 g% interval; therefore, they are included in that interval.

Figure 1. Distribution of subject blood alcohol concentrations (BAC).



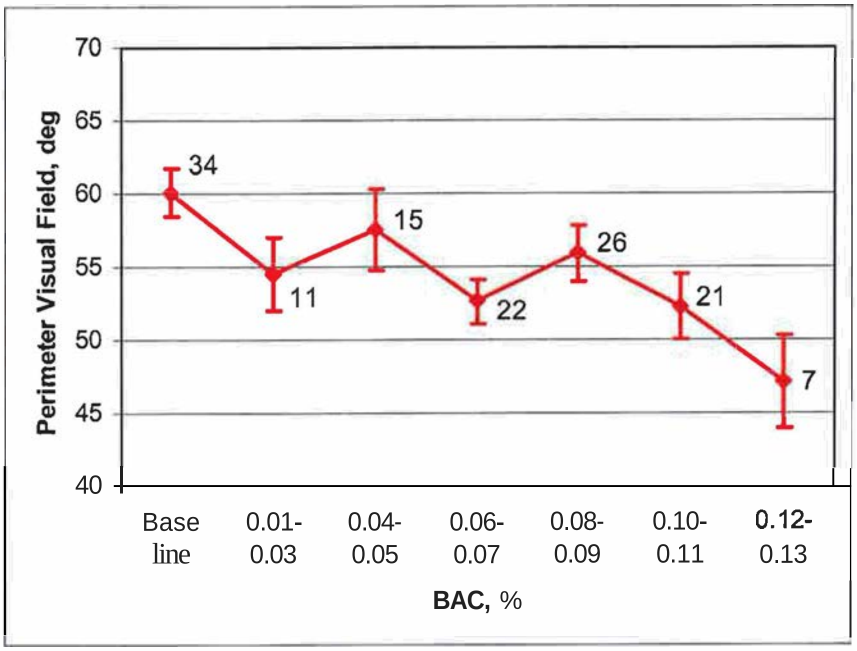
Repeated-measures analysis of variance shows that there were no significant differences in BAC between female and male subjects for the three test trials, $F(1,32)=0.11$, $p=0.742$, but that there were significant differences for the trials themselves, $F(2,64)=75.86$, $p=0$. However, the qualitative changes in BAC between the sets of evaluations were not consistent across subjects. Specifically, while BAC increased for all subjects from baseline to the first set of evaluations, it was constant for one subject and declined for a second subject, between the first and second sets of evaluations. Likewise, BAC was constant for four subjects and decreased for 23 subjects between the second and final sets of evaluations. In addition, the decreased BAC for these subjects at the final set of evaluation was almost never as low as the increasing BAC at the first set of evaluations. Consequently, the results are distributed asymmetrically with respect to peak BAC.

Peripheral Visual Field

Repeated-measures analysis of variance demonstrates that there were no significant differences in PVFs at baseline between left and right fields ($p>0.79$), nor between female and male subjects ($p>0.57$). Therefore, all visual field angles are averaged over both fields and reported without regard to gender.

Average unilateral PVF angle for all subjects was 60.0+/-9.8 deg at baseline and decreased to 47.3+/-8.3 deg for the highest BAC interval (see Figure 2). Regression analysis demonstrates that there is a linear relationship between BAC interval and PVF (see Table 2), with PVF decreasing by about 1.6 deg unilaterally, or 3.2 deg bilaterally, per 0.02 g% BAC interval. The correlation coefficient is -0.829 and is significant at $p<0.05$ (see Table 3).

Figure 2. Average peripheral visual field angle at different blood alcohol concentration (BAC) intervals. Standard error bars indicated.



<u>Modified Confrontation Visual Field</u>

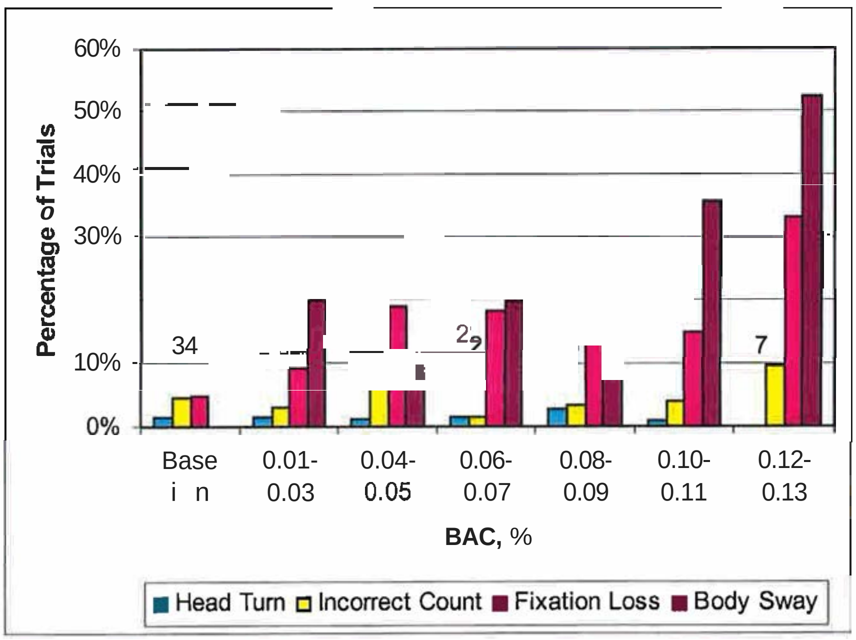
Using χ^2 analysis, there were no significant differences in observation of any component of MCVF at baseline between female and male subjects: $p>0.85$ for head turn; $p>0.55$ for incorrect count; $p>0.14$ for fixation loss; $p=1$ for body sway; $p>0.85$ for the presence of two or more indicators. Therefore, all results are reported without regard to gender.

On baseline testing, subjects showed fixation loss on 4.9%, incorrect count on 4.4%, head turn on 1.5%, and body sway on 0% of all trials. Only three of the 34 subjects (8.8%) demonstrated two or more indicators at baseline. This represents the false-alarm rate for healthy, sober, naive subjects.

Most observations increased with increasing BAC interval, with body sway on 52.4%, fixation loss on 33.3%, and incorrect count on 9.5% of trials at the highest BAC interval (see

Figure 3). Head turn did not exceed 2.6% of trials at any BAC interval and may only be an issue at BACs above those evaluated in this study, i.e., greater than 0.13 g%.

Figure 3. Percentage of observed signs with modified confrontation visual field testing different blood alcohol concentration (BAC) intervals. 2+ Clues = presence of two or more Head Turn, Incorrect Count, Fixation Loss, and Body Sway.



The presence of two or more indicators occurred in 57.1% of trials at the 0.12-0.13 g% BAC interval. Using 0.08 g% BAC as the criterion, the sensitivity of the test is 40.7% and the false-alarm rate for subjects with non-zero BAC is 16.7%. The accuracy of the test is 60.8% for non-zero BAC trials, and 68.4% for all trials including the zero BAC baseline measures. Some jurisdictions still use 0.10 g% as the per se limit for alcohol intoxication. At this level, the sensitivity of the test is 42.9%, the false-alarm rate is 24.7%, the accuracy for non-zero BAC trials is 66.7%, and the overall accuracy for all trials including zero BAC baseline measures is 72.8%.

Regression analysis demonstrates that there is a linear relationship between BAC interval and most MCVF factors (see Table 2). The corresponding correlation coefficients for all pairwise comparisons are shown in Table 3. Presence of two or more of the four possible clues on MCVF results in high correlations with both BAC and PVF.

Table 2. Intercept, slope, and square of correlation coefficient for linear regression analyses for each test component with respect to 0.02 g% BAC intervals. 2+ Clues = presence of two or more of Head Turn, Incorrect Count, Fixation Loss, and Body Sway. *p<0.05, **p<0.005.

	Intercept	Slope		R^2
Peripheral Visual Field =	59.10 deg	-1.61 deg	x BAC Interval	0.687*
Head Turn =	1.75%	-0.16%		0.187
Incorrect Count =	3.14%	+0.49%		0.158
Fixation Loss =	6.41%	+3.39%		0.668*
Body Sway =	0.90%	+7.49%		0.856**
2+ Clues =	4.97%	+7.50%		0.858**

Table 3. Correlation coefficients comparing individual and grouped factors of the study. 2+ Clues = presence of two or more of Head Turn, Incorrect Count, Fixation Loss, and Body Sway. *p<0.05, **p<0.005.

	Peripheral Visual Field	Head Turn	Incorrect Count	Fixation Loss	Body Sway	2+ Clues
BAC Interval	-0.829*	-0.433	0.397	0.817*	0.925**	0.926**
Peripheral Visual Field		0.630	-0.383	-0.803*	-0.925**	-0.813*
Head Turn			-0.736	-0.582	-0.491	-0.420
Incorrect Count				0.675	0.419	0.505
Fixation Loss					0.772*	0.767*
Body Sway						0.965**

DISCUSSION

We confirm that there is a measurable, significant decrease in PVF with increasing BAC when assessed with an arc perimeter. The task was intended to be attentional in nature, since the subject was required to report recognition of the color of the peripheral target, rather than merely its movement, while actively fixating the central target. The argument can be made that the results arise from the decreased reaction time due to intoxication, since the peripheral target was moved continuously, albeit slowly, during the test. Nonetheless, a deficiency in either perceptual mechanism will lead to difficulty while operating a motor vehicle. Also, in either case, the visual field constrictions reported here are consistent with previous research and anecdotal reports.

For the MCVF test, we find significant increases in fixation loss and body sway with increasing BAC, but no significant change in the presence of head turn or incorrect count of fingers presented for the range of BACs tested. Nevertheless, we recommend that these latter components remain part of the testing criteria, since they may be more evident at BACs above those achieved in this study (0.13 g%). In addition, the presence of two or more of the four possible clues is highly correlated with BAC, and the test offers good accuracy for determining impairment at per se BAC limits of either 0.08 or 0.10 g%.

We suggest that follow-up studies assess MCVF with subjects at BACs above 0.13 g%, with intoxicating drugs other than or in addition to alcohol, and in conjunction with other field sobriety tests. Likewise, we must determine whether law enforcement officers can conduct the test under training, arrest, and drug recognition evaluation conditions. If the test can be used under field conditions, it will provide additional information to an officer regarding driver impairment and it will help to make our streets and highways safer.

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