In recent years, it has become increasingly clear that low dosages of alcohol can cause significant impairment of behavior, including the skilled performance required for the successful operation of motor vehicles, locomotives, ships, etc. Consequently, many nations are reducing the blood alcohol concentration (BAC) limit for driving under the influence of alcohol (e.g., USA: from 100 mg/dl to 80 mg/dl; Sweden: from 50 mg/dl to 20 mg/dl). Two critical questions which must be addressed are: "At what BACs do statistically significant effects of alcohol on behavior become apparent in the average drinker, and which behaviors are most reliable for discriminating drinkers who may be under the influence of alcohol?" The answer to these questions depends largely upon the behavioral domain selected to assess performance and the measurement methods applied.

At the Vermont Alcohol Research Center, both traditional and nontraditional methods are being used to measure the effects of alcohol on behavior, particularly at low BACs (Perrine, in press). Through the use of innovative methods and technology, the earliest detectable onset of alcohol effects on traditional psychomotor behaviors is being investigated using extremely sensitive instrumentation. Involuntary behaviors and aspects of behavior that are normally outside of conscious awareness, such as speaking and oculomotor functioning, are also being investigated using sophisticated, innovative technologies.

The Standardized Field Sobriety Test (SFST), comprised of the horizontal gaze nystagmus (HGN), walk-and-turn (WAT), and one-leg-stand (OLS) tests, is widely used by police officers in the USA for preliminary assessment of impairment in motorists stopped for deviant driving behaviors or because of crash involvement (Perrine, Foss, Meyers, Voas, & Veléz, in press). Each of these tests are administered using a standardized protocol and specific behavioral cues, such as using the arms for balance, are counted as indications of impairment. Specific decision criteria are then applied by the officers to determine whether or not to proceed with further collection of evidence. However, these tests were developed and validated for drinkers with BACs at or above 100 mg/dl, and recently, the reliability and validity of these tests to detect even these relatively high BACs under field conditions have come into question (Perrine et al., 1992).
The psychomotor aspects of the field sobriety tests - the OLS and WAT tasks - are designed to assess locomotor co-ordination and postural stability. As part of a larger project investigating chronic and acute tolerance among drinking drivers, these tasks are included as part of a more complete test battery investigating the psychobiological effects of alcohol. These testing sessions are conducted under laboratory conditions, and the BACs achieved by the subjects are manipulated as an independent variable. Analyses of the OLS and WAT performances derived from overt observation and manual scoring, under these optimal conditions, have indicated manifest behavioral impairment at 100 mg/dl; however, manually scored performances at BACs of 50 mg/dl do not differ statistically from 0 mg/dl performances.

In addition to the manual scoring of OLS and WAT performance in accordance with the standardized criteria developed for police officers, performances are also being assessed using a three-dimensional measurement system capable of resolving the spatial location of infra-red emitting diodes to within 0.1 mm (OPTOTRAK system from Northern Digital Equipment Inc., Canada). By attaching these transmitters to the subjects, this system allows very small movements of the body and perturbations of postural control to be quantified as continuous measures, rather than the ordinal measurement method available from the manual scoring of overtly observable cues. The same laboratory performances reported above (which indicated significant performance decrements at 100 mg/dl using the manual scoring criteria) show significant changes in postural stability and locomotor co-ordination at 50 mg/dl when the data obtained from the OPTOTRAK are analyzed. Current analyses of the data are addressing the degree to which these differences are due to gross upper body adjustments or smaller balancing movements achieved primarily by arm and hand movements.

The HGN subtest of the SFST assesses disruption of oculomotor functioning. Subjects are tested for: (1) lack of smooth pursuit eye movements; (2) HGN onset at an off-angle axis of less than 45 degrees; and (3) evidence of HGN at 45 degrees. These three cues are observed for each eye, for a total of six possible cues. Data indicate that this subtest can be valid for the detection of intoxicated drivers (above 100 mg/dl) under field conditions, but the validity and reliability of the subtest is largely dependent upon the training and experience of the test administrators (Perrine et al., 1992). Under laboratory conditions, we have obtained statistically significant results from manually scored HGN tests at BACs of 50 mg/dl.

In addition to the manual administration of the HGN subtest under laboratory conditions, two electronic measurement system prototypes (the EM/2 Alcohol and Drug Screener from Oculokinetics, Inc., California, and the FIT 1000 from Pulse Medical Instruments Inc., Maryland) are being assessed for their ability to detect
oculomotor disruption due to alcohol. In addition to the ability to detect the presence or absence of specific cues (such as smooth pursuit eye movements or HGN) these instruments also provide the means for quantifying performance parameters such as maximum velocity of smooth pursuit eye movements, precise angle of HGN onset, eye movement latency, and saccadic velocity. Initial indications suggest that these systems may be able to detect the onset of alcohol effects at very low BACs. Our current research is addressing issues of variability between and within individuals under both alcohol and no-alcohol conditions.

Innovative methods and technologies are also being applied to the investigation of the effects of alcohol on speech performance. Krüger (1989) has developed a small portable device -- the Logoport -- which provides the means for analyzing the temporal characteristics of unconstrained speech. Logoport data collected during thirty-minute experimental testing sessions demonstrating the effects of alcohol on free speech are presented by Mundt, Kelleher, and Perrine (in press) in these proceedings. Inconsistent results have been reported regarding the influence of alcohol on very fine aspects of speech articulation. While Schwartz (1992) has reported voice onset time variability to be resistant to alcohol intoxication, Vollrath (1992) has found indications of lengthened articulation pauses following alcohol ingestion. The influences of alcohol on both voice onset times and articulation pauses are currently being investigated at the Vermont Alcohol Research Center using instrumentation and methodology described by Vollrath (1992) for the measurement of speech motor times. Further discussion of the effects of alcohol on speech production and the potential impact of technology for the detection of intoxication can be found in Perrine, Krüger, and Kelleher (in press).

Recent developments of sensor and microcomputer technologies have provided the means for detecting and measuring subtle effects of alcohol that were not possible only a few year ago. Interest in the detection of low BAC effects has been increasing recently, both for basic understanding of the effects of alcohol in humans and for potential law enforcement applications. With continued interest, the role and contribution of these emerging technologies will become increasingly important.

Acknowledgments: This research was supported by PHS grant P01 AA07203 from the National Institute of Alcohol Abuse and Alcoholism to M.W. Perrine, Principal Investigator.
REFERENCES


