Visual Detection of Driving While Intoxicated

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Visual cues were identified and procedures were developed to enhance on-the-road detection of driving while intoxicated (DWI) by police patrol officers. Related research was reviewed; police officers with demonstrated effectiveness in DWI detection were interviewed; DWI arrest reports were analyzed; and a study was conducted to determine the frequency of occurrence and relative discriminability of visual cues. Based on the results, a DWI detection guide was developed and verified in a field study involving a sample of 10 law enforcement agencies located throughout the United States. Use of the guide was accompanied by a statistically significant 12% overall increase in DWI arrest rate.

INTRODUCTION

On-the-road detection of driving while intoxicated (DWI) requires the observation and interpretation of visual cues by police patrol officers. The effectiveness of DWI detection, therefore, is a function of the frequency with which patrol officers see and recognize cues indicative of DWI and the extent to which observed cues discriminate between DWI and driving while sober (DWS). What cues occur frequently enough to be useful? Which cues discriminate most accurately between DWI and DWS? This research was conducted to answer these and related questions and to provide patrol officers with a practical guide for DWI detection.

The Detection Problem

Only a very small proportion of persons DWI are arrested for this offense—only about one in 2000 (Summers and Harris, 1978). Limited enforcement resources and factors inhibiting enforcement motivation (Arthur Young and Company, 1974; Oates, 1974) might explain the low arrest rates. However, even when persons DWI have been observed by patrol officers who were highly motivated to arrest, the arrest rate was found to be very low (Beital, Sharp, and Glauz, 1975).

As determined from roadside breath-testing surveys conducted throughout the United States (Lehman, Wolfe, and Kay, 1975), about 6% of people driving at night have a blood alcohol concentration (BAC) equal to or greater than 0.10% by weight, the legal definition of DWI in most cities. About 15% have a BAC level equal to or greater than 0.05. Thus, if DWI were defined at the BAC $\geq$ 0.10 level, the probability of detecting DWI from a random stop would be 0.06; at BAC $\geq$ 0.05, the probability would be 0.15. Visual cues that aid in discriminating between DWI and DWS can serve to increase detection probabilities above these chance levels. Thus, the key to enhanced DWI detection is determination of the relative discriminability of visual cues that are likely to be observed in association with DWI.

Related Research

Numerous studies have investigated the effect of alcohol on driving behavior; they have employed laboratory apparatus, driving simulators, and instrumented vehicles in the field. Reviews of many of these studies have been provided by Heimstra and Struckman (1973) and Perrine (1974 and 1975). The results, however, have been relevant to the current project only indirectly. Although substantial evidence has been developed to indicate that alcohol-induced driver impairment is exhibited mainly in four driving functions—steering control, velocity control, time-sharing of attention, and information processing—the findings have not been specific enough to permit the identification and assessment of visual detection cues. On the other hand, these findings provided a useful framework for the collection and analysis of additional data.

Lists of cues have been developed previously through interviews with police officers experienced in DWI detection (Carnahan, Holmes, Keyes, Stemler, and Dreveskracht, 1974); a listing was also developed as part of the current study. The resulting listings have been both comprehensive and logically organized; however, lists of this type can have only limited utility for DWI detection without associated information about relative frequencies of cue occurrence or relative cue discriminability.

ANALYSIS OF DWI ARREST REPORTS

Initially, an analysis was completed of a sample of 1288 DWI arrest reports from nine different police agencies throughout the United States. A total of 3658 visual detection cues was reported in the sample, an average of 2.8 cues per arrest. Frequency distributions prepared from the data, combined with the results of previous research and cue listings obtained from experienced patrol officers, provided the basis for a preliminary listing of 129 visual cues potentially useful for DWI detection.

ON-THE-ROAD DETECTION STUDY

Approach

An on-the-road study of DWI detection was conducted to determine the relative discriminability and frequency of occurrence of visual detection cues under conditions typically encountered by patrol officers. Trained observers accompanied police officers on patrol and recorded instances of driving behavior and vehicle actions that deviated from normal. In each instance, the police officer stopped the vehicle and, if possible, measured the BAC of the driver with a portable breath tester. Measures of BAC were obtained in 93% of all stops. In addition to cue descriptions and BAC level, the observer recorded driver characteristics and the circumstances and conditions under which the stop was made. Since the data-collection effort required conducting prearrest breath tests of drivers, the study was conducted in two states, Indiana and North Carolina, which permitted, by statute, prearrest breath testing.

Results

A total of 643 DWI detection events was observed and recorded. The sample of detection events was nearly identical to the national sample of arrest reports, relative to the distributions of times at which stops were made, the location of stops (urban or rural), and the percentages of male and female drivers stopped. A total of 1681 cue occurrences was recorded during the 643 detection events, an average of 2.6 cues per event, which is close to the average of 2.8 cues per arrest reported in the national sample of arrest reports. These results suggest that the stops made in the detection study were typical of those made normally by police patrols.

In the detection study, 39% of the drivers stopped had a BAC less than 0.05; 23% had a BAC greater than 0.05 but less than 0.10; and 38% had a BAC equal to or greater than 0.10. Of course, most of the national sample of DWI arrests, 96%, reported drivers with BAC equal to or greater than 0.10.

Cues were combined and redefined, ultimately, into a set of 23 visual cues that ac-counted for 92% of the 1681 cue occurrences in the detection study. The 23 resulting cues are listed in Table 1; frequency of occurrence, $P(BAC \geq 0.10)$, and $P(BAC \geq 0.05)$ are pre-sented for each cue.

A listing of the 134 cues observed in the detection study served as the starting point for the analysis. This listing included 118 cues from the preliminary listing of 129 cues, plus

TABLE 1

DWI Visual Detection Cues Derived from On-the-Road Study

Visual Cue	Occurrence (Times in 1000 Detections)	P(BAC ≥ 0.10)	P(BAC ≥ 0.05)
Stopping (without cause) in traffic lane	29	0.69	0.90
Following too closely	29	0.62	0.76
Turning with wide radius	35	0.60	0.83
Appearing to be drunk	57	0.58	0.75
Driving on other than designated roadway	42	0.57	0.79
Straddling center or lane marker	65	0.57	0.78
Almost striking object or vehicle	62	0.56	0.71
Slow response to traffic signals	20	0.50	0.55
Headlights off (at night)	27	0.48	0.67
Signaling inconsistent with driving actions	49	0.47	0.71
Weaving	145	0.47	0.69
Tires on center or lane marker	101	0.47	0.67
Drifting	108	0.46	0.70
Swerving	49	0.45	0.73
Accelerating or decelerating, rapidly	81	0.44	0.67
Slow speed—more than 10 MPH below limit	32	0.44	0.66
Fast speed—more than 10 MPH above limit	101	0.37	0.55
Failing to respond to traffic signals or signs	85	0.36	0.53
Braking erratically	23	0.35	0.74
Stopping inappropriately other than in lane	33	0.33	0.61
Turning abruptly or illegally	48	0.31	0.58
Driving into opposing or crossing traffic	37	0.30	0.54
Driving with vehicle defect(s)	42	0.29	0.43

16 new cues observed during the detection study. Since this initial listing was empirically derived, it was not logically cohesive and contained many infrequently occurring cues. Therefore, cues were redefined to maximize frequency of occurrence, maintain levels of cue discriminability, and enhance cue understandability and applicability. For example, the cue "weaving" was defined as the deviation from vehicle path alternately toward one side of the roadway and then the other, creating a zig-zag course. The original listing contained seven weaving cues that differed from each other mainly as a function of weave amplitude; i.e., weaving in lane, lane to lane, lane to shoulder, across lane, across centerline, center of roadway with no centerline, shoulder to shoulder. At little loss in cue discriminability and at substantial increase in cue frequency of occurrence and applicability, all seven were combined into the single weaving cue.

Typically a cue occurred with one or more other cues, the average number of cues per detection event being 2.6. Two or more cues were observed in 66% of the detection events. However, relatively few subsets of cues occurred together consistently. Only 9 subsets of the 134 cues occurred 10 times or more in the sample of 643 detection events, and essentially no subset of the 23 cues in the final set occurred frequently enough to warrant further consideration.

Relatively high correlations (ranging from 0.62 to 0.82) among distributions of cue frequencies were obtained under alternative detection conditions: duration of observation, distance at which the cue was observed, time of day, lighting conditions, location (urban or rural), condition of the vehicle, sex of the driver, and number of passengers in the vehicle. More modest correlations (ranging from 0.49 to 0.56) were obtained for the following conditions: number of traffic lanes, divided vs. undivided highway, traffic density, and

age of the driver. All correlations were statistically significant ($p < 0.01$).

The one variable that most influenced the frequency of cues observed was patrol emphasis. About 58% of the detection events occurred under general patrol, in which DWI was just one of many possible offenses of concern to the patrol officer. About 42% of the detection events occurred under patrols which emphasized DWI enforcement. The correlation between cue frequency distributions obtained under the two types of patrol was only 0.22.

Conclusions

(1) Although the potential number of visual detection cues is large, most detection events can be accounted for by a relatively small number of cues.
(2) There are large differences among visual detection cues in the frequency with which they occur with DWI and in their ability to distinguish between DWI and DWS.
(3) Typically, a visual detection cue is observed with one or more other cues. However, there are no subsets of specific cues that occur frequently together.
(4) Except for patrol emphasis, the conditions under which cues are observed have relatively little influence on frequency of cue occurrence.
(5) The basis exists for the development and evaluation of a DWI detection guide to facilitate the application of research findings to on-the-road detection of DWI by police patrol officers.

DWI DETECTION GUIDE

The extent of competing demands placed upon patrol officers—the variety of situations likely to be encountered, the stringent demands on available time, the need for rapid response, and the large amount of other information that must also be learned and retained—suggested that the findings of this study be presented for use simply and directly. Therefore, a DWI detection guide was developed to transform the research findings into a practical aid for DWI detection. Because the empirical results were not neces-

sarily simple or free of subtlety, extrapolation and judgment were exercised during this process. Guide development was governed by the following criteria: account for the largest number of detection events with the smallest number of detection cues; enhance the discriminability of available detection cues; employ a probabilistic output; accommodate multiple cue occurrences; accommodate alternative enforcement statutes and policies; and emphasize simplicity, practicality, and ease of use.

The resulting Drunk Driver Detection Guide is presented in Figure 1. The guide, together with a booklet of cue definitions, was designed as a simple performance aid that could be implemented by patrol officers after a brief training session.

The probability values contained in the guide were obtained by rounding the values shown in Table 1. The special adjustments for multiple cues were obtained by linear regression from average DWI probability values computed for the following conditions of cue occurrence: cue observed as one of one or more cues; cue observed as one of two or more cues; and cue observed as one of three or more cues. Values in the guide are those computed for cues when they were observed as one of one or more cues. On the average, these values were found to be increased by 5 where the cue was observed as one of two or more cues and increased by 10 when a cue was one of three or more cues. Similarly, under each condition, probability values for $P(\text{BAC} \geq 0.05)$ were found to be increased by 20 over the value for $P(\text{BAC} \geq 0.10)$.

FIELD VERIFICATION

Approach

A field test of the guide was conducted with a sample of 10 law enforcement agencies at locations throughout the United States. The 10 agencies employed different types of patrols: general patrols responsible for both criminal and traffic enforcement; general traffic patrols responsible for enforcement of traffic laws; selective traffic patrol responsible mainly for DWI enforcement. The test employed a within-subjects type of experimental design and several measures likely to reflect the impact and utility of using the guide and to verify the detection probabilities contained in the guide.

Measures related to DWI enforcement effectiveness were obtained from each agency during a 12-mo baseline period and during a 3-mo test period in which the guide was used. Three measures were obtained monthly for each agency during both baseline and test periods: number of DWI arrests per 100 person-hours of patrol, frequencies with which detection cues were reported on arrest reports, and BAC levels of persons arrested.

DRUNK DRIVER DETECTION GUIDE

Percentage of nightime drivers with BAC equal to or greater than .10

Visual Cues

STOPPING [WITHOUT CAUSE] IN TRAFFIC LANE 70
FOLLOWING TOO CLOSELY 60
TURNING WITH WIDE RADIUS 60
APPEARING TO BE DRUNK 60
DRIVING ON OTHER THAN DESIGNATED ROADWAY ... 55
STRADDLING CENTER OR LANE MARKER 55
ALMOST STRIKING OBJECT OR VEHICLE 55
SLOW RESPONSE TO TRAFFIC SIGNALS 50
HEADLIGHTS OFF [AT NIGHT] 50
SIGNALLING INCONSISTENT WITH DRIVING ACTIONS 45
WEAVING 45
TIRES ON CENTER OR LANE MARKER 45
DRIFTING 45
SWERVING 45
ACCELERATING OR DECELERATING RAPIDLY 45
SLOW SPEED [MORE THAN 10 MPH BELOW LIMIT] 45
FAST SPEED [MORE THAN 10 MPH ABOVE LIMIT] 35
FAILING TO RESPOND TO TRAFFIC SIGNALS OR SIGNS 35
BRAKING ERRATICALLY 35
STOPPING INAPPROPRIATELY [OTHER THAN IN LANE] 35
TURNING ABRUPTLY OR ILLEGALLY 30
DRIVING INTO OPPOSING OR CROSSING TRAFFIC 30
DRIVING WITH VEHICLE DEFECT[S] 30

Special Adjustments to the Percentages
• 2 cues: Add 5 to the larger percentage.
• 3 or more cues: Add 10 to the largest percentage.
• To predict BAC equal to or greater than .06: Add 20 to the percentage obtained for drivers with BAC equal to or greater than .10.
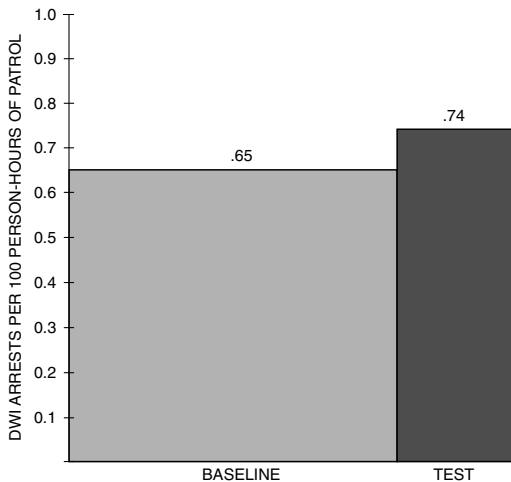
Figure 1. *DWI detection guide.*

Figure 2. *Average DWI arrest rates for all 10 participating agencies during baseline and test periods.*

During the 3-mo test period, two additional measures were obtained: ratio of drivers DWI to drivers apprehended for each cue or cue combination and opinions and suggestions of participating police officers regarding use of the guide.

Results

Collectively, for all 10 participating agencies, DWI arrest rate was 12% higher during the test period than during the baseline period. This difference was statistically significant ($p < 0.01$). Comparison of baseline and test periods is shown graphically in Figure 2. Individually, five agencies had significant increases in DWI arrest rates of up to 94%; four agencies did not change significantly; and one agency had a significant decrease. Changes within an agency were consistent among the different types of patrols employed by the agency. These results were based on a total of 5348 arrests made during the 15-mo period by 466 patrol officers during 788 200 person-hours of patrol activity.

There were no statistically significant differences between baseline and test periods on any of three measures that might have reflected changes in DWI detection practices. The number of visual detection cues recorded per arrest did not increase; a shift to the use of higher probability cues was not statistically significant; and the BAC levels of persons arrested did not decrease significantly.

Probability values contained in the guide were verified by the proportions of drivers apprehended during the field test who were found to have BAC levels equal to or greater than 0.05 and 0.10. Average guide probability values over all cues were essentially the same as the average probabilities calculated from field-test data.

Correlations between guide DWI probabilities and test probabilities for individual cues ranged from 0.48 to 0.59 and were statistically significant ($p < 0.05$) in all cases. Comparisons of guide and test values must be made in light of two important factors that would be expected to decrease the correlations. First, the probabilities contained in the guide were derived from data collected using procedures that were substantially different from those employed for collecting data in the field test. Guide probabilities were based on data obtained by stopping each driver observed to be exhibiting deviant driving behavior and administering a breath test to the driver. Observers accompanied patrol officers for purposes of recording the data. Field-test probabilities, on the other hand, were obtained from data recorded on special forms during regular patrol by the patrol officers themselves. Some detection procedures, such as the use of radar to detect fast speed, differed substantially from those used in the earlier study. Each time a driver was apprehended, the officer used normal procedures, such as field sobriety tests, to estimate the three categories of BAC. Verification, by followup chemical tests, of about two-thirds of the BAC ≥ 0.10 estimates showed them to be

99% accurate. The procedures used in the field test were dictated by the need to obtain a large, geographically representative sample.

Second, guide probability values used for the correlations were obtained directly from the guide rather than from the original data. Thus, they were rounded-off values for $P(\text{BAC} \geq 0.10)$ that were extended to multiple cue conditions and to $P(\text{BAC} \geq 0.05)$ through application of the special adjustments presented at the bottom of the guide. Correlations between field-test values and the actual values obtained from the earlier detection study were higher in all cases, ranging from 0.49 to 0.68.

Experienced police officers who used the guide were generally skeptical that use of the guide would enhance their own DWI detection ability. However, most officers considered the guide to be a valuable aid for increasing patrol awareness of useful detection cues, training inexperienced patrol officers, preparing DWI arrest reports, and supporting court testimony.

CONCLUSIONS

The utility of the Drunk Driver Detection Guide developed for on-the-road detection of DWI was demonstrated. Use of the guide resulted in an overall increase in DWI arrest rate of 12%. This increase took place in a sample that included 10 police agencies located throughout the United States. These agencies employed various types of patrols, included a wide range of geographic and traffic conditions, and reflected different levels of motivation for DWI enforcement. Although there were no statistically significant changes in detection practices, such as those revealed by greater use of the more discriminating cues or by arrests of more drivers with lower BAC levels, trends were in the expected directions.

The DWI probability values associated with cues contained in the guide were verified by field-test results, providing a basis for using guide values with confidence. Although some modifications to guide values were indicated, the overall result was one of verifying the average probability values as well as the values associated with individual cues. By combining field-test and detection study data, the guide values will be based on a total of 4662 detection events that occurred at 12 different locations throughout the United States.

Some difficulty might be expected in gaining acceptance of the guide by police officers experienced in DWI enforcement. Many feel they have little or nothing to learn from the guide or that detection is not a primary problem in DWI enforcement. On the other hand, after using it, officers stated that the guide would be of value for a variety of purposes.

ACKNOWLEDGMENTS

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