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VISUAL DETECTION OF DRIVING WHILE INTOXICATED Project Interim Report: Identification of Visual Cues and Development of Detection Methods

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The first phase of a two-phase study is reported. The second phase will involve the field test of the DWI detection guide.

16. Abstract

The report describes the initial phase of a two-phase project on the visual, on-the-road detection of driving while intoxicated (DWI). The purpose of the overall project is to develop and test procedures for enhancing on-the-road detection of DWI. The emphasis of the first phase was on the identification of visual cues and the development of procedures that effectively discriminate between DWI and driving while sober (DWS).

The literature was reviewed, expert opinion was surveyed, 1288 DWI arrest reports were analyzed, and an on-the-road detection study was conducted. In the detection study, trained observers accompanied police officers on patrol and recorded 643 instances of driving behavior and vehicle actions that deviated from normal. In each instance, the patrol officer stopped the vehicle and measured the blood alcohol concentration (BAC) of the driver with a portable breath tester.

A DWI detection guide was developed to facilitate the application of research findings to the on-the-road detection of DWI by police patrol officers. The guide consists of 23 visual cues, a value for each cue reflecting the ability of the cue to discriminate between DWI and DWS, and a set of three rules for estimating the probability of DWI for any set of observed cues. The 23 cues accounted for 92 percent of the cues observed during the detection study.

Eight specific conclusions about the visual detection of DWI were also developed and presented.

Prior to making the guide generally available or implementing its use on a wide-scale, a field test is required to evaluate its effectiveness.

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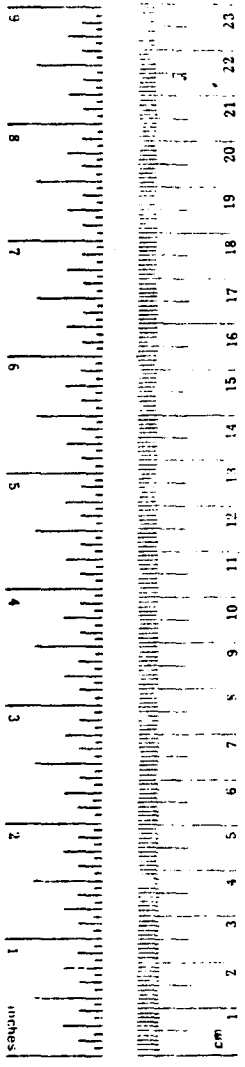
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	*kilometers*	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	*liters*	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
F	Fahrenheit temperature	5 9 (after subtracting 32)	*Celsius* temperature	C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	*miles*	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	*cubic* feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
C	Celsius temperature	9 5 (then add 32)	Fahrenheit temperature	F

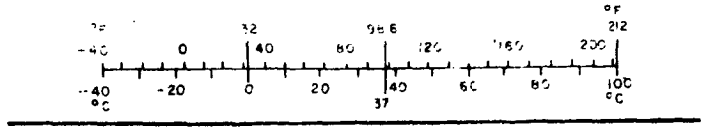


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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

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

This report describes the initial phase of a two-phase project on the visual detection of DWI. The overall purpose of the project is to develop and test procedures for enhancing on-the-road detection of DWI. The emphasis of the first phase was on the identification of visual cues and on the development of detection procedures that effectively discriminate between DWI and DWS. The second phase will consist of a field-test of these procedures.

THE DWI DETECTION PROBLEM

Only a very small proportion of persons DWI are arrested for this offense--only about one in 2000. Reasons for a low arrest rate might include limitations on enforcement resources, lack of enforcement motivation, inability to detect DWI, and others. However, research has shown that even when persons DWI have been observed by police officers who were highly motivated to arrest for DWI, the arrest rate was relatively low.

As determined from roadside breathtesting surveys conducted throughout the United States, about six percent of drivers at night have a blood alcohol concentration (BAC) equal to or greater than 0.10. About 15 percent have a BAC 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 ≥ 0.05, the probability would be 0.15. Visual cues which are capable of 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 which are likely to be observed in association with DWI.

RELATED RESEARCH

Many studies have investigated the effect of alcohol on driving behavior; they have employed laboratory apparatus, driving simulators, and instrumented vehicles in the field. However, the results are only indirectly relevant to the objectives of the present project. 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.

Lists of cues have been developed through interviews with police officers experienced in DWI detection. The resulting listings have been both comprehensive and logically organized; however, they have been of only limited use for DWI detection. Without the availability of information about the relative frequencies of cue occurrence or relative cue discriminability, there has been no basis for the development of practical guidelines for employment of the visual cues for DWI detection.

ANALYSIS OF DWI ARREST REPORTS

An analysis was completed of a sample of 1288 DWI arrest reports from nine different police agencies throughout the United States. A total of 3,658 visual detection cues were reported in the sample, an average of about three 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 visual cues potentially useful for DWI detection. This listing is presented on pages 29 through 33.

ON-THE-ROAD DETECTION STUDY

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 measured the BAC of the driver with a portable breath tester. In addition to cue descriptions and BAC level, the observer recorded the circumstances and conditions under which the stop was made, and other driver characteristics. Since the data collection effort required conducting pre-arrest breath tests of drivers, the study was conducted in two states, Indiana and North Carolina, that permitted, by statute, pre-arrest breath testing.

A total of 643 DWI detection events were observed and recorded, 378 in Charlotte, North Carolina, and 265 in Fort Wayne, Indiana. The sample was comparable to the national sample of 1288 DWI arrests in several basic respects: time of day of stops, location (urban vs. rural) of the stops, and sex of the driver. The main way in which the detection study sample differed from the arrest report sample was in the distribution of the BAC levels of the drivers. In the detection study it was necessary to obtain a sufficiently broad range of BAC levels among drivers stopped to permit a meaningful analysis of cue discriminability. Thirty-nine percent of the drivers had a BAC < 0.05; 23 percent had a BAC in the range from 0.05 to 0.10; and 38 percent had a BAC ≥ 0.10. In contrast, 96 percent of the sample of DWI arrests reported drivers with BAC ≥ 0.10.

Analyses of the 1681 cue occurrences recorded during the 643 detection events included: computation of cue frequencies, calculation of cue discriminability values, study of cue co-occurrence, assessment of cue order of appearance, and correlational analyses to determine the impact on cue occurrence of alternative detection strategies, characteristics, and conditions. As part of the analytical effort, cues were recombined and redefined, ultimately, into a set of 23 visual cues that accounted for 93

percent of the cue occurrences in the detection study. The 23 cues are listed in the DWI detection guide presented on page 5.

DWI DETECTION GUIDE

A DWI detection guide was developed to facilitate the application of research findings to the on-the-road detection of DWI by police patrol officers. 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--suggest that the findings of this study be presented for use simply and directly. Therefore, the DWI detection guide was developed to transform the research findings into a practical aid for DWI detection. Because the empirical results were not necessarily 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.
- Emphasize simplicity, practicality, and ease of use.

The detection guide is presented on the next page. The guide, together with cue definitions, can be put into the form of a simple performance aid for use by patrol officers. It is anticipated that use of the aid can be implemented through one or a series of brief training sessions conducted during roll-call at the start of patrol shifts.

CONCLUSIONS

1. Alcohol-induced driver impairment is exhibited mainly in four driving functions--steering control, velocity control, time-sharing of attention, and information processing.

DWI DETECTION GUIDE

1. *The number to the right of each cue listed below is the percentage of nighttime drivers expected to have a BAC equal to or greater than (≥) 0.10, if that cue is observed.*

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**

2. *If one additional cue is observed, add 5 to the larger of the two percentage values to obtain the expected percentage of drivers with BAC ≥ 0.10. If two or more additional are observed, add 10 to the largest percentage to obtain the expected percentage of drivers with BAC ≥ 0.10.*

3. *To obtain the expected percentage of drivers with BAC ≥ 0.05, add 20 to the percentage obtained for drivers with BAC ≥ 0.10.*

Figure 3. DWI detection guide.

2. Although the potential number of visual detection cues is very large, most detection events can be accounted for by a relatively small number of cues.

3. Typically a detection cue is observed with one or more other cues. However, there are few subsets of specific cues that occur frequently together.

4. There are large differences among visual detection cues in the frequency with which they occur with DWI, and in their ability to discriminate between DWI and DWS.

5. In general, the conditions under which cues are observed have relatively little influence on cue occurrence.

6. Patrol strategy (general patrol vs. patrol with DWI emphasis) greatly affects the relative frequencies with which cues are observed.

7. The DWI detection guide, developed from study results, will facilitate the application of research findings to on-the-road detection of DWI by police patrol officers.

8. A field test is required to evaluate the impact of the detection guide, prior to any widespread implementation or use of the guide.

INTRODUCTION

Only a very small percentage of persons driving while intoxicated (DWI) are arrested for this offense--about one in 2000 (Summers and Harris, 1978; Borkenstein, 1975). Reasons for this low arrest rate might include limited enforcement resources, lack of enforcement motivation, inability to detect DWI, and others. Previous studies (Arthur Young and Company, 1974; Oates, 1974) identified numerous factors, primarily motivational in nature, that inhibit arrests for DWI. However, additional evidence (Beital, Sharp, and Glauz, 1975) suggested that the percentage of persons DWI who are arrested is small--about one in 200--even when observed by police officers who are highly motivated to arrest for DWI. Thus, the inability of police officers to detect DWI is likely to be a significant contributor to low DWI arrest rates.

PROJECT OBJECTIVES

This report describes the initial phase of a two-phase project on the visual detection of DWI. The project purpose is to develop and test procedures for enhancing on-the-road detection of DWI. The emphasis of the first phase was on the identification of visual cues and on the development of detection procedures that effectively discriminate between DWI and driving while sober (DWS). Specific objectives were:

- Determination of the relative frequencies of occurrence of visual cues indicative of DWI.
- Estimation of the relative extent to which visual cues discriminate DWI from DWS.
- Development of a DWI detection guide--selected visual cues and procedures for their use in DWI detection.

THE DWI DETECTION PROBLEM

As determined from roadside breathtesting surveys conducted throughout the United States (Lehman, Wolfe, and Kay, 1975), about six percent of

drivers at night have a blood alcohol concentration (BAC) equal to or greater than 0.10. About 15 percent have a BAC equal to or greater than 0.05. Thus if DWI were defined at the BAC ≥ 0.10 level, the probability of apprehending a person DWI by means of a random stop would be 0.06; at BAC ≥ 0.05, the probability would be 0.15. Visual cues which are capable of 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 which are likely to be observed in association with DWI.

What is an ideal visual detection cue? A cue that occurs for every DWI under all possible conditions; a cue that discriminates perfectly between DWI and DWS, always occurring with DWI and never occurring with DWS; and a cue that is so highly visible it can be seen for miles. Perhaps such a cue would be a bright blue glow emanating from the vehicle driven by a person beyond the legal BAC limit. Should such a cue be available, the problem of visual detection of DWI would virtually disappear.

In contrast to the fantasized ideal, the real-world detection of DWI is a problem of subtlety and complexity. As a consequence of observing and interpreting one or more visual cues, the patrol officer assesses the likelihood that the person is DWI. This assessment is then combined with other information to reach an enforcement decision--to apprehend or to not apprehend. Either choice might be incorrect. A driver apprehended might be DWS (false detection), or a driver not apprehended might be DWI. The ideal cue would not lead to an incorrect choice because, when the cue is present, the probability of DWI is one; when the cue is not present, the probability of DWI is zero. At the other extreme, when a driver is apprehended by a random stop, the probability of DWI (BAC ≥ 0.10) is only 0.06, and the probability of DWS (false detection) is 0.94. In the world that exists between these two extremes, the decision to apprehend involves the observation and interpretation of visual cues, and the subsequent trade-off between the value of a correct detection and the cost of a false detection. Although the factors involved in the trade-off, and the post-detection apprehension process,

are outside the scope of this study, they establish requirements for DWI detection. The detection process should employ visual cues that occur frequently with DWI, are most capable of discriminating between DWI and DWS, and are simple to understand and easy to use by police patrol officers.

For purposes of this discussion and the research reported here, a visual cue for on-the-road detection of DWI is defined in terms of the following characteristics:

- A visual indication that occurs prior to the police officer's decision to take any overt action to stop the vehicle.
- A deviation from normal driver or driving behavior--driver behavior within the vehicle as well as vehicle response to driving actions.
- An indication that is not associated with an accident or with any extra-vehicular activity of the driver.

The number of different visual detection cues is likely to be great as a function of individual differences among drivers and of the many driving conditions and situations that can be encountered. As shown in Figure 1, DWI detection cues are indirect products of the intake of alcohol into the body of the driver. Although substantial individual differences might exist in the nature and degree of reaction to alcohol, alcohol generally impairs the functions required for driving--sensory-motor, perception, attention, and information processing. Changes in these functions lead to abnormal execution of driving tasks and abnormal driver behavior which, in turn, provide visual cues for on-the-road detection of DWI.

Visual detection cues might vary as a consequence of interactions among impaired functions, driving circumstances, and conditions of observation. Examples of circumstances and conditions that might influence the occurrence, nature, degree, and discriminability of visual cues include the following:

- Time of detection
- Distance of observation
- Weather
- Lighting

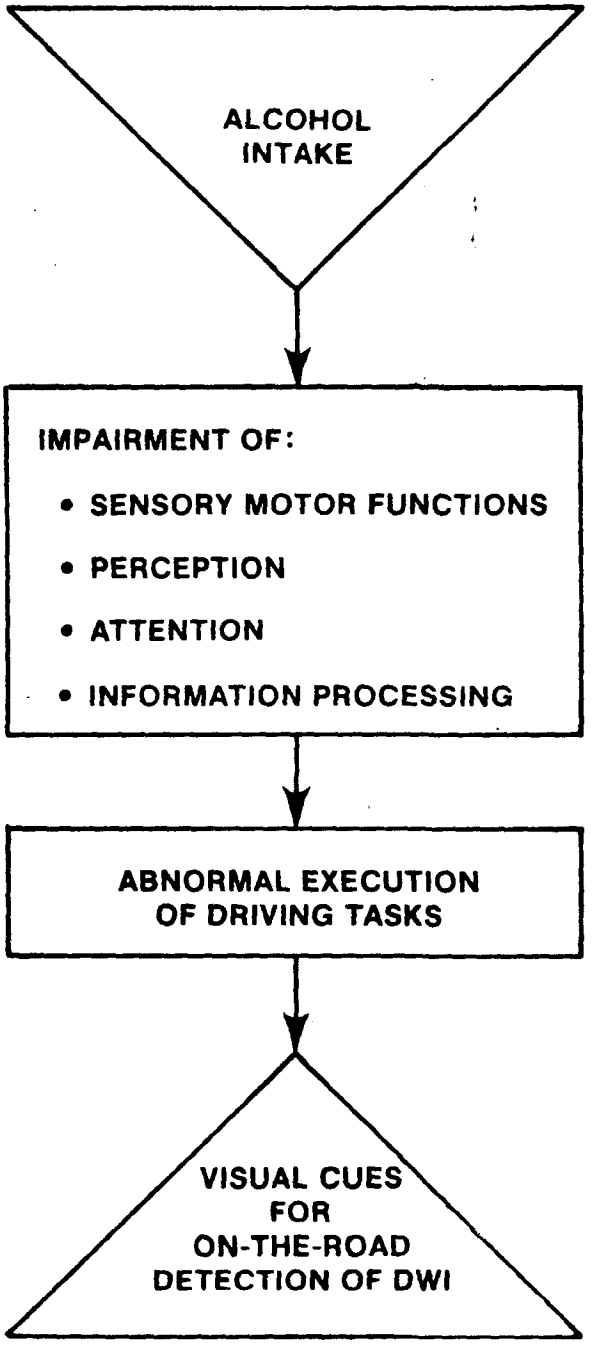


Figure 1. The indirect relationship between alcohol intake and visual cues for on-the-road detection of DWI.

- Location (rural or urban)
- Roadway geometry
- Number of lanes in the roadway
- Roadway divided or undivided
- Nature of roadway surface
- Traffic density
- Condition of vehicle
- Age of driver
- Sex of driver
- Race of driver
- Number of passengers
- Use of medication or drug

The potential complexity of DWI detection was examined previously during the DWI Law Enforcement Training Project (Carnahan, Holmes, Keyes, Stemler, and Dreveskracht, 1974). Police officers, traffic research personnel, and others attempted to list and classify useful cues for DWI detection. The effort produced listings of 45 cue classes, 113 cue elements, and 235 specific behaviors. In presenting these listings in a manual for DWI law enforcement training, interactions among cues and related conditions were emphasized. The manual stated that there were 15,216 individual, traffic-related, environmental, situational, and sequential factors that could be associated with each single cue or behavior; and, as a consequence, there were nearly 30 billion combinations of factors for each single cue or behavior. Although this analysis appears to be stretching the point a bit, it does suggest the potential complexity of the visual detection of DWI. The cited study did not address the frequency of occurrence of cues or the extent to which any of the cues discriminated between DWI and DWS.

Finally, although it is possible to estimate from existing data the proportion of drivers on the road who are DWI, it is not now possible to estimate the fraction of these drivers who contribute one or more visual cues to their detection. More effective on-the-road detection has the potential of contributing to DWI enforcement to the extent that observable

cues emanate from drivers DWI. Although it would appear reasonable to assume that the more hazardous drivers are those who are most likely to contribute cues to their detection, there is no evidence at present to support this premise.

RELATED RESEARCH

No research had been completed previously to determine, specifically, the frequencies of occurrence or the discriminability of visual cues for DWI detection. On the other hand, extensive study had been made of the influence of alcohol on driving behavior. Although the results of this previous work do not relate directly to the objectives of the present project, they provide a potentially useful backdrop for the project. When combined with the findings of this project, they might broaden and deepen the foundation for the resulting DWI detection guide.

A systematic review of the literature revealed many studies that investigated the effect of alcohol on driving behavior. The studies employed laboratory apparatus, driving simulators, and instrumented vehicles in the field. Findings related directly or indirectly to project objectives were reviewed and classified according to the type of driving function affected. There was substantial support that alcohol-induced driver impairment is exhibited mainly in four driving functions--steering control, velocity control, time-sharing of attention, and information processing. Findings on a fifth aspect of driving, risk-taking, were mixed.

Steering Control

Alcohol impairs vehicle steering control. Vehicle heading deviations were found to be both greater and more frequent for DWI than for DWS. Using a closed-loop driving simulator in the laboratory, Mortimer and Sturgis (1975) found that lateral position error was significantly greater for intoxicated subjects (0.10 BAC). Jex and his associates (1974) concluded that alcohol significantly impaired steering control. From a driving

simulation experiment conducted in the laboratory, heading deviations and deviations from lane were both found to increase with the driver's BAC level. In a review of 14 driving simulator studies that investigated the effects of alcohol on driving behavior, Heimstra and Struckman (1973) concluded that one general effect of alcohol was the impairment of heading control.

Results of several laboratory studies provided additional evidence that alcohol impairs vehicle steering control. Using a compensatory tracking task, Reid and his associates (1973) found that intoxicated subjects had significantly greater tracking error than control subjects. Sugarman, Cozad and Zavala (1973) correlated BAC level with performance on different aspects of driving performance. The highest correlation was between BAC level and steering performance. In a study to determine the effects of alcohol on vehicle-passing performance, Light and Keiper (1971) found that subjects at a 0.09 BAC level exhibited significantly more steering deviations than subjects of a control group.

These findings suggest that visual cues related to deviations in vehicle heading and vehicle displacement might serve to discriminate between DWI and DWS. Specifically, they suggest that cues such as the following might be useful:

- Weaving--the sinusoidal path made by a vehicle as the driver executes a series of path deviations and corrections.
- Drifting--a gradual straight line deviation from the designated vehicle path.
- Swerving--an abrupt change of vehicle heading executed to return to the designated path.
- Straddling a lane marker or a roadway centerline.
- Driving with tires on center or lane marker.

Velocity Control

Alcohol impairs the control of vehicle velocity, leading to deviations in motion of the vehicle along its path--more frequent accelerator

reversals and abnormalities in starting and stopping. In their review of the effects of alcohol on driving behavior, Heimstra and Struckman (1973) concluded that alcohol effects the control of vehicle velocity, including vehicle starting and stopping. Sugarman and his associates (1973) found a significant correlation between BAC level and vehicle velocity control during laboratory experimentation employing a driving simulator. In an earlier study using a laboratory driving simulator, Loomis and West (1958) found that subjects at a 0.15 BAC level exhibited increased reaction times for velocity control and committed more starting and stopping errors than did a control group. Perrine and Huntley (1971) studied the effects of alcohol on driving performance using a car instrumented to record driver control movements. A treatment group (0.10 BAC) made more accelerator reversals and errors in stopping than a control group. A later replication of the experiment produced similar results. Impairment of vehicle velocity control, in the manner indicated by the results of these studies, suggests the following possible visual detection cues:

- Stopping abruptly
- Stopping in an inappropriate location
- Accelerating or decelerating rapidly
- Braking erratically
- Almost striking an object or vehicle

Time-Sharing of Attention

Alcohol impairs the ability of the driver to time-share attention among competing stimuli in the driving environment. Concentrating primarily on the main driving tasks, the intoxicated driver is less aware of surrounding events, has greater reaction time to extra-foveal stimuli, and makes more inappropriate responses to stimuli. Moskowitz, Ziedman, and Sharma (1976) found that alcohol degraded the ability of drivers to shift attention from one stimulus or event to another. Eye-point-of-regard measures were taken of drivers at 0, 0.075, and 0.15 BAC levels in a simulated driving situation. Alcohol increased both the dwell and pursuit

durations of eye movements, including a corresponding decrease in dwell frequency. Jex, Allen, and DiMarco (1974) had previously found similar results. Also using a simulated driving situation and eye-point-of-regard measures, they found that the ability to time-share between a continuous steering task and an intermittent discrete response task was significantly and systematically degraded at 0.11 and 0.16 BAC levels. Kobayashi (1975) used an eye-point-of-regard system to investigate selective attention of drivers controlling a vehicle on a close driving course. Intoxicated drivers (0.05 BAC) were found to fixate on stimuli in the driving environment for longer periods of time than control drivers, and spent significantly more time looking at the road straight ahead.

Additional evidence of the impairment of selective attention was provided by Perrine (1974) in his review of the literature on the behavioral effects of alcohol on driving. He summarized studies of information processing, selective attention, pattern recognition, short-term memory, and reaction time, where alcohol was a treatment condition. A primary conclusion was that alcohol interferes with the allocation (time-sharing) of attention; performance on central visual tasks conflicts with performance on peripheral visual tasks.

Impairment of the driver's ability to time-share attention among central and peripheral tasks suggests several visual detection cues for DWI. These include those that might emanate from inappropriate responses (including no response) to peripheral visual stimuli as well as the inappropriate performance (including non-performance) of peripheral vehicle operation tasks. Thus, visual detection cues might include:

- Driving without headlights on
- Failing to respond to traffic signals or signs
- Signalling inconsistent with driving actions
- Almost striking stationary objects

Information Processing

Alcohol impairs the information processing ability of the driver. Under the influence of alcohol, drivers respond more slowly, provide inappropriate responses more frequently, select less effectively among alternatives, respond less appropriately to unanticipated driving tasks, comprehend unexpected situations more slowly, and detect and perceive events less effectively. In his reviews of alcohol experiments on driving-related behavior, Perrine (1975, 1974) concluded that alcohol affects the driver's information processing capacity, as evidenced by degraded stimulus-response coordination. Although results of the studies reviewed suggested relatively little impairment of stimulus perception, they consistently showed a significant decrement in the ability to provide correct responses to the stimuli perceived. Heimstra and Struckman (1973) reached a similar conclusion from their review of driving simulator studies: alcohol significantly affects the information processing rate, increasing the time required by the driver to react to complex driving situations. However, somewhat contradictory conclusions were reached by Levine, Greenbaum, and Notken (1973) in their attempt to classify and integrate research findings on the effect of alcohol on human performance. They classified studies relative to findings on behavioral components of cognition, sensory-perceptual processes, and psychomotor processes. They concluded that the sensroy-perceptual tasks were most impaired, that the psychomotor tasks were least impaired, and that the cognition tasks fell in between. Definitional differences might have accounted for some of the apparent contradictions.

Laboratory studies involving tasks indirectly related to driving provided additional evidence that alcohol impairs information processing ability. Moskowitz and Murray (1975) found, from a tightly controlled study, that alcohol decreased the information transfer rate from sensory storage to short-term memory. The implication of this finding is that intoxicated drivers require more time to comprehend unexpected situations. In a laboratory experiment conducted by Robinson and Peebles (1974), interactions between alcohol and task complexity were studied. Significant interactions

suggested that DWI will lead to more errors than DWS in complex driving situations. Related results were obtained by Huntley (1974) in an experimental study conducted to determine the effects of stimulus-response familiarity on choice reaction time. He found that when associations were novel, choice reaction times were increased by alcohol, and that the magnitude of the increase was related logarithmically to the number of equally likely stimulus response pairs. Again, the implication is that alcohol impairment of information processing is likely to be more pronounced in novel rather than routine driving situations.

Impaired information processing capability is likely to be reflected by driving behavior that is inappropriate for the circumstances. In contrast to visual cues which emanate from impaired steering and velocity control, the visual cues are likely to be indicative of the driver's confused state. Thus, cues for the visual detection of DWI might include:

- Driving into opposing/crossing traffic
- Slow speed
- Driving on other than the designated roadway
- Slow response to traffic signals
- Turning inappropriately or illegally
- Stopping (without cause) in the lane of traffic
- Almost striking another moving vehicle
- Almost striking a stationary object

Risk-Taking

At this time there is no definitive assessment of the effects of alcohol on driver risk-taking. Although some evidence seems to support an increase in risk-taking, as a result of intoxication, the driving behavior in question might also be explained in terms of driver impairment.

Two studies are presented here to illustrate the conflicting evidence that exists and some of the problems in assessing the influence of alcohol on risk-taking. A laboratory experimental study was performed by

Light and Keiper (1971) to determine the effects of moderate blood alcohol on automobile passing behavior. The apparatus used was a fixed-base simulator using a moving-belt visual display system along with a subsidiary passing-aid display. Subjects with a 0.09 BAC appeared to exhibit greater risk taking behavior than those in a control group. A greater number of passes were attempted and more accidents resulted. The authors concluded that alcohol degraded sensory-motor skills and increased risk-taking. However, it was not really possible to partial out these two effects. For example, the apparent difference between the alcohol and control group in risk-taking might be attributed to a lack of awareness, by the intoxicated driver, of the degree of impairment of sensory-motor skills. It might also be accounted for by an impaired perception of the actual risk itself. In either case, the resulting driving behavior might be explained as well by impairment as by risk-taking.

The effect of alcohol on perceived risk was studied by Browning and Wilde (1975). Drivers rated their perceived risk of the driving situations they encountered under both simulated and actual traffic conditions. Three treatment conditions were employed--sober, placebo, and 0.08 BAC level. No significant differences in risk perception were found among the three treatment conditions. These results suggest that apparent risk-taking behavior of intoxicated drivers cannot be explained by impaired risk perception.

Assessment of the risk-taking characteristics of DWI is further complicated by the possible biphasic effects of alcohol, as discussed by Perrine (1974). Alcohol is frequently found to have different effects at different BAC levels: low concentrations appear to be excitatory or stimulating where as higher concentrations appear to be inhibitory or depressive. These effects have been found to be mitigated by age, being more extreme among younger drivers. The implication is that consciously committed unsafe driving behaviors might be more characteristic of lower rather than higher BAC levels.

If alcohol does, at some levels, increase driver risk-taking, consciously committed unsafe driving acts might be expected to provide some visual cues of DWI. These cues might include:

- Passing inappropriately or illegally
- Turning rapidly, abruptly, or illegally
- Speeding
- Failing to respond to traffic signals or signs
- Accelerating or decelerating rapidly
- Following too closely

OBSERVATIONS FROM OPERATIONAL EXPERIENCE

The operational experience of police officers has been tapped to produce lists of potential visual cues for DWI detection. As part of the DWI law enforcement training project, Carnahan and his associates (1974) compiled a listing of DWI detection cues from the following sources:

- Review of existing medical and police literature
- A panel of Michigan Police Officers from state, county, and local agencies
- Alcohol enforcement specialists in the following police agencies: San Diego Police Department, California Highway Patrol, Reno Police Department, Phoenix Police Department, and Denver Police Department
- Staff members and patients in an alcoholism ward
- Former police officers who were members of the Highway Traffic Safety Center, Michigan State University and assigned to the DWI Law Enforcement Training Project

The resulting list was organized in terms of cue classes, cue elements, and specific vehicle maneuver and human indicator cues. A total of 45 cue classes, 113 cue elements, and 235 specific behaviors were included. Examples of these are provided in Table 1 to illustrate the nature and form of the listing; the complete listing is contained in the referenced document.

Although the listing of detection cues produced by this effort was both comprehensive and logically organized, it was of limited use for DWI detection because two critical questions remained unanswered: What is the expected frequency of occurrence of each cue? To what extent does each cue discriminate between DWI and DWS? As discussed earlier, the most useful cues are those that occur relatively frequently and that discriminate between

TABLE 1

Sample Identification Detection (Pre-Apprehension) Cues from Carnahan et al (1974)

CUE CLASS	*CUE ELEMENTS AND BEHAVIORS*
I-A-1 Vehicle speeds	A. Posted speed: 1. Faster than posted 2. Slow speed (impede) B. Safe speed: (basic speed law) 1. Faster than safe 2. Slow (impede)
I-A-6 Weaving on roadway	A. Changes lanes--passing: 1. Enters passing lane frequently 2. Passes in different lanes B. Changes lanes--not passing 1. Changes lanes frequently 2. Weaves in lane
I-A-20 Unnecessary stop	A. Stops in traffic lane for no apparent reason B. Vehicle moves and stops again
I-A-25 Excessive use of horn	A. Vehicle in motion: 1. Use in passing 2. Use when weaving 3. Use on pedestrian 4. Use for non-traffic situation B. Stationary vehicle: 1. Excessive use of horn
I-B-7 Directing attention straight ahead	A. Leans into steering wheel B. Face close to windshield C. Clutching steering wheel D. Fixed gaze straight ahead

DWI and DWS. Without this information, a listing of cues is of marginal value to the police officer.

An initial step of the present study also involved the solicitation of information about detection cues from individuals with operational experience in DWI detection. Nine police agencies located throughout the United States participated in the study. These agencies were:

- California Highway Patrol
- Santa Ana (California) Police Department
- Los Angeles (California) Police Department
- Tacoma (Washington) Police Department
- Kansas City (Missouri) Police Department
- Hennepin County (Minnesota) Sheriff's Department
- Stockton (California) Police Department
- Denver (Colorado) Police Department
- New Jersey State Police

Within each agency an "expert" in DWI detection was selected and interviewed. The primary selection criteria were:

- Demonstrated proficiency and motivation relative to DWI detection, as determined from DWI arrest rates
- A minimum of three years of concurrent DWI detection experience (average number of years experience of those interviewed was 8.6)
- The completion of one or more specialized DWI Law Enforcement courses (average number of course hours completed by those interviewed was 68)

Each selected police officer was asked to describe the visual DWI detection cues he used most frequently and to indicate which of these cues he favored. The results are summarized in Table 2.

These results are of interest in two ways. First, they indicate which, of the lengthy list of possible cues, are being used regularly and which, through operational experience, have become most favored. Second, they suggest the extent of differences that exist among officers who are both trained and experienced in DWI enforcement. Of the 30 cues identified,

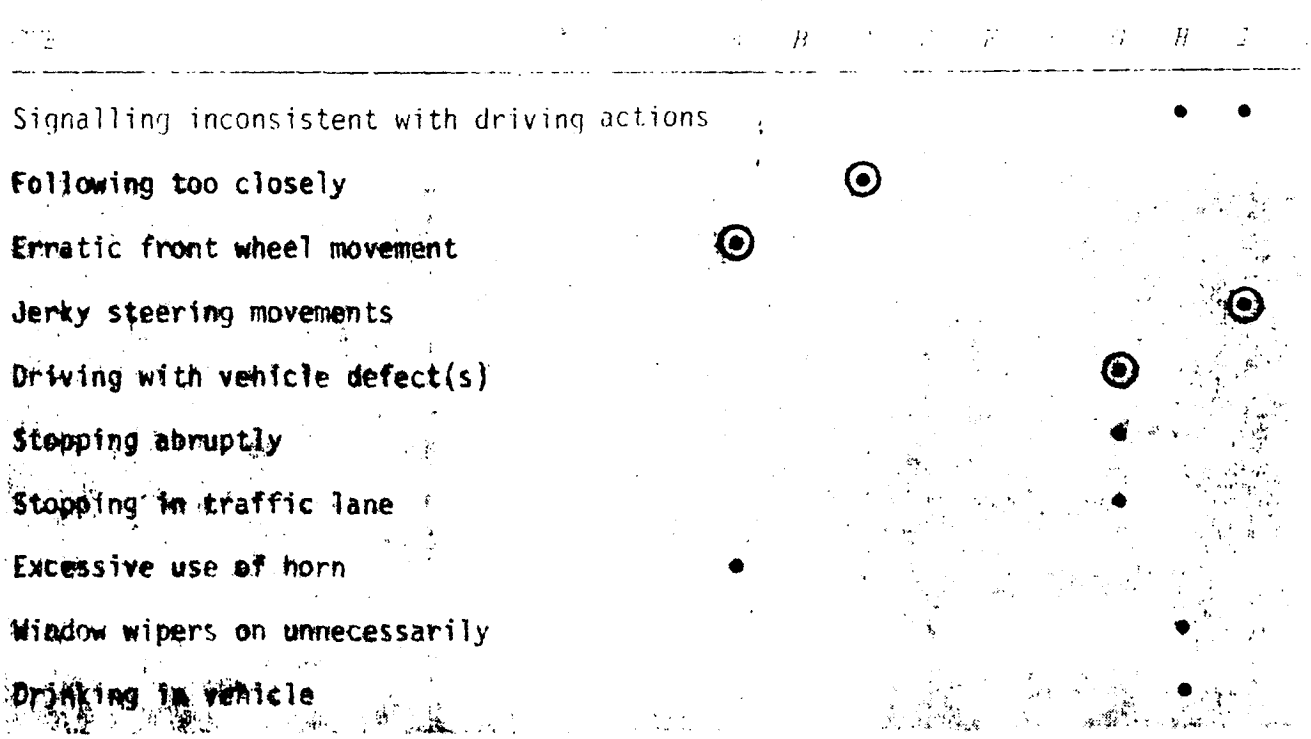
TABLE 2

Cues Employed (•) and Favored (◯) by DWI Detection "Experts" from Nine Different Agencies

CUE	AGENCY								
	A	B	C	D	E	F	G	H	I
Weaving	◯	◯	•	◯	◯	◯	•	◯	◯
Speed under limit	•	◯	•				◯	◯	◯
Speed over limit	•	•	•			◯	◯	◯	
Speed fluctuation	◯			◯		•			◯
Failing to dim high beams	•	◯				•			◯
Straddling lane marker		•			◯		•	•	
Slow to respond at traffic signal or sign	•			◯				•	•
Driver directing attention only ahead	•	◯						•	•
Turning with wide radius				◯			◯	•	
Driver clutching steering wheel		•	◯					•	
Straddling centerline		•	•			•			
Window(s) open	•				•			•	
Drifting beyond lane	•								◯
Driving with left tires on centerline			◯			•			
Driving with tires on lane marker			◯			•			
Driver appears drunk			◯	•					
Turning rapidly/abruptly				◯					•
Driving into opposing traffic						◯		•	
Braking erratically								•	•
Driving without headlights on								•	•

TABLE 2 (Continued)

Cues Employed (•) and Favored (◯) by DWI Detection "Experts" from Nine Different Agencies



only three were mentioned by six or more officers and only eight were mentioned by four or more officers. The remaining 22 cues were mentioned by three or fewer officers. These results suggest that, in current practice, there is relatively little consistency among the detection cues employed and favored by police officers engaged in DWI enforcement.

RESEARCH APPROACH

Previous research and operational experience provided listings of potentially useful cues for DWI detection. The next step was to determine the relative frequencies of expected cue occurrence and the relative potential of cues for discriminating between DWI and DWS. Therefore, the remainder of this initial phase of the research project was devoted to the following:

- Analysis of DWI arrest reports to determine the manner and relative frequencies with which visual cues have occurred.
- Completion of a field study in which potential visual detection cues were observed, BAC levels of the drivers measured by portable breath testers, and conditional probabilities of DWI computed for cues and cue combinations.
- Development of a DWI detection guide consisting of selected cues and the procedures for their use in DWI detection.

The methods employed and results obtained are described in the next three sections of the report.

ANALYSIS OF DWI ARREST REPORTS

An analysis was completed of a sample of 1288 DWI arrest reports from nine different police agencies. Results of the analysis, combined with the results of previous research and the observations from operational experience, provided the basis for a preliminary listing of visual cues potentially useful for DWI detection.

LIMITATIONS OF THE ANALYSIS

Although DWI arrest reports provided a readily available source of information about the circumstances of DWI detection and the visual cues reported by police officers, the results made only a limited contribution to project objectives. The main limitations of the analysis were:

- *Potential reporting biases.* Descriptions provided on arrest reports of detection and arrest events might emphasize those pre-arrest cues and events found to be supportive of departmental policy or adjudication. Other potentially useful cues might not have been noted or included in the report narrative. Thus, the frequency distribution of cue occurrence obtained from the analysis of arrest reports might actually differ from the actual distribution.
- *No basis for cue discriminability estimates.* Cues obtained from DWI arrest reports are, in almost all cases, those exhibited by a driver with BAC of 0.10 or greater. Thus, without a complete distribution of BAC levels, there is no basis for estimating the extent to which a given cue discriminates between DWI and DWS.
- *Problems of semantic interpretation.* Words and phrases employed to describe driver behavior and vehicle actions might not be consistent from one agency to another, or from one police officer to another. Thus, in collecting data only from written arrest reports, inaccuracies might result from interpretations of the words and phrases used.

In spite of these limitations, the analysis of DWI arrest reports was useful. From this readily available source of information, empirical data were obtained to aid in the development of a preliminary list of

DWI detection cues. Preliminary distributions of cue occurrence and cue co-occurrence were also developed. Furthermore, since a relatively large sample of DWI arrest reports were obtained from a number of different police agencies over a relatively lengthy period of time, certain reporting biases might have been minimized.

METHOD

A sample of 1288 DWI arrest reports was obtained, 144 from each of nine participating police agencies. In obtaining the sample of reports, staff members traveled to the agency, supervised the selection of reports, and recorded arrest report data on a special form. An example of the form is provided in Figure A1 of the Appendix. At each agency, 12 reports were randomly selected from the total number of reports filed during each of the previous 12 months (July 1976 through June 1977). From the total of 1296 data collection forms completed, 8 were eliminated when later found to be not complete or not useable for one reason or another, leaving a total sample of 1288 for the analysis.

The sample of police agencies were selected for participation on the basis of several criteria: a reporting and record system adequate to provide the required information on DWI arrests, geographical dispersion across the United States, and willingness to participate in accordance with the requirements of the study. The following police agencies participated:

- California Highway Patrol
- Santa Ana (California) Police Department
- Los Angeles (California) Police Department
- Stockton (California) Police Department
- Tacoma (Washington) Police Department
- Hennepin County (Minnesota) Sheriff's Department
- Denver (Colorado) Police Department
- Kansas City (Missouri) Police Department
- New Jersey State Police

As shown in the data collection form, both primary and secondary cues were recorded. Primary cues were those which were indicated in the report narrative as the primary reasons why the motorist came to the attention of the patrol officer who ultimately made the arrest. Secondary cues were those that, through further observation, provided additional support for the decision to stop the motorist for DWI. A preliminary analysis showed that listings of primary and secondary cues were essentially the same and that the frequency of occurrence of primary cues had a relatively high correlation (0.67) with the frequency of occurrence of secondary cues. As a consequence, the distinction between primary and secondary cues was not maintained for the remainder of the analysis.

Frequency distributions were generated by means of computer-based algorithms. Data from the data collection forms was put on punch-cards, entered into an IBM 370-155 computer, and subjected to a set of computer-based routines adapted from standard statistical programs--Statistical Analysis System (Barr, Goodnight, Sall, and Helwig, 1976).

RESULTS

Three types of frequency distributions were prepared. The first defined the characteristics of the DWI arrest report sample: sex, age, and race of the driver; month, day, and time of arrest; location of the arrest; BAC of the driver; and whether or not the driver was using medicine or drugs. This series of frequency distributions is provided in Table A1 of the Appendix.

The second provided frequency distributions of the cues obtained from the DWI arrest reports. These distributions are presented in the Appendix: Table A2 lists the cues in alphabetical order; Table A3 lists the cues by frequency of occurrence; and Table A4 lists the cues in order of the assigned cue number. Please note that although cue numbers extend from 1 to 376, some originally recorded cues were eliminated or combined; thus, cue numbers are not necessarily consecutive.

The third type of frequency distribution presented the co-occurrence of cues. For each cue that occurred in the sample of 1,288 arrest reports, a frequency distribution was constructed of those cues that occurred with that cue. In general, the extent of co-occurrence among any specific subset of cues was found to be quite low. Table A5 of the Appendix lists the cues that co-occurred 10 times or more and that also had a percentage of co-occurrence (frequency of co-occurrence divided by frequency of cue occurrence) of 20 or more. There were only 25 such co-occurrences. On the other hand the multiple occurrence of cues was common. Since a total of 3,658 visual detection cues were listed in the sample of 1,288 DWI arrest reports, about three visual detection cues were reported, on the average, for each arrest. Therefore, although multiple cue occurrences were the rule rather than the exception, the repeated co-occurrence of particular cues was minimal.

PRELIMINARY LISTING OF DWI VISUAL DETECTION CUES

Results of the DWI arrest report analyses, along with the results of previous research and experience, provided the basis for constructing a preliminary listing of DWI visual detection cues. Three staff members, two of whom were former police officers with DWI detection experience, jointly constructed a preliminary list of cues. Cues which deviated only slightly in form or meaning were combined into a single cue category. However, this was done conservatively so as to not lose any meaningful distinctions. The resulting listing is provided in the following pages on Table 3.

TABLE 3

Preliminary Listing of DWI Visual Detection Cues

Cues are described by action-object descriptors and are grouped by actions. Each cue is listed with its assigned numerical code.

WEAVING

1 In lane
2 Lane to lane
3 Lane to shoulder
4 Across lane(s)
5 Across centerline
6 In center of roadway with no centerline
7 Shoulder to shoulder (curb to curb)

SWERVING

8 In lane
9 Lane to lane
10 Back to lane
11 Across lane(s)
12 Toward edge of roadway
13 Onto shoulder
14 On and off roadway
15 Onto centerline
16 Onto median
17 Across centerline
18 Back and forth
19 To avoid collision
20 Across lane(s)
21 Lane to lane
22 In lane
23 Toward edge of roadway
24 Across centerline
25 Onto shoulder
26 On and off roadway

DRIVING

27 In opposing lane
28 In center of roadway
29 In parking lane
30 On shoulder
31 On other than designated roadway
32 On median
33 On edge of roadway
34 Off roadway
35 Over curb

TABLE 3 (Continued)

Preliminary Listing of DWI Visual Detection Cues

36 With left tires on centerline
37 With tires on lane marker
38 With vehicle defect(s)
39 Without headlights on
40 With jerky steering motions
41 With interior lights on
42 With 4-way flashers on
43 Wrong way on one way street
44 Straight from turn-only lane

STRADDLING

45 Lane marker
46 Centerline

TURNING

47 With wide radius
48 With excessive speed
49 From wrong lane
50 Illegally on red light
51 Left illegally
52 U illegally
53 U abruptly
54 Across corner
55 Over curb
56 Abruptly/sharply
57 Slowly
58 Into oncoming traffic

STOPPING

59 Abruptly
60 Abruptly for police signals
61 In traffic lane
62 In intersection
63 In prohibited zone
64 In cross walk
65 Short of intersection
66 On shoulder
67 Across lane(s)
68 12-24" from curb
69 25-48" from curb
70 More than 48" from curb
71 For green signal
72 For flashing yellow signal

TABLE 3 (Continued)

Preliminary Listing of DWI Visual Detection Cues

FAILING

73 To respond to police signals
74 To respond to change in traffic signal
75 To stop for red traffic signal
76 To stop for stop sign
77 To slow for caution signal
78 To yield during lane change
79 To yield to oncoming traffic
80 To yield ROW at intersection
81 To yield to pedestrians
82 To signal turn or lane change
83 To dim high-beams
84 To heed police directions

SPEEDING

85 0-10 MPH over limit
86 11-20 MPH over limit
87 21-30 MPH over limit
88 More than 30 MPH over limit
89 (Excess for conditions)
90 Through intersection

SLOW SPEED

91 0-10 MPH under limit
92 11-20 MPH under limit
93 21-30 MPH under limit
94 More than 30 MPH under limit

SLOW TO RESPOND

95 To police signals
96 To change in traffic signals

ACCELERATING

97 Rapidly forward
98 Rapidly backward
99 And decelerating
100 Then stalling
101 And breaking traction

TABLE 3 (Continued)

Preliminary Listing of DWI Visual Detection Cues

ALMOST STRIKING

102 Police vehicle
103 Parked vehicle
104 Another moving vehicle
105 Bicyclist
106 Police officer
107 Curb
108 Median
109 Sign/object/wall/building

STRIKING

110 Curb
111 Median
112 Sign/object/wall/building

APPEARING

113 To be drunk

ATTEMPTING

114 To elude police

BACKING

115 Into traffic
116 On roadway

DECELERATING

117 Rapidly
118 Slowly

DRINKING

119 In vehicle

EXITING

120 Improperly from driveway

TABLE 3 (Continued)

Preliminary Listing of DWI Visual Detection Cues

FOLLOWING

121 Too closely

FORCING

122 Other vehicles off roadway
123 Police vehicle off roadway
124 Other vehicles to swerve

GESTURING

125 Obscenely to police

IMPEDING

126 Traffic

PASSING

127 Improperly/illegally

SIGNALLING

128 Constantly
129 Inconsistent with driving actions

ON-THE-ROAD DETECTION STUDY

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 measured the BAC of the driver with a portable breath tester. In addition to cue descriptions and BAC level, the observer recorded the circumstances and conditions under which the stop was made, and other driver characteristics. Since the data collection effort required conducting pre-arrest breath tests of drivers, the study was conducted in two states, Indiana and North Carolina, that permitted, by statute, pre-arrest breath testing.

METHOD

Selection of Participating Agencies

From the 12 states which, at the time of the study, had statutes permitting the use of pre-arrest breath-testing procedures, 2 agencies were selected for participation in the study. Selection criteria were:

- Demonstrated experience, performance, and motivation relative to DWI detection
- Representation of potentially different environmental and geographic conditions
- High expected level of cooperation in light of the demands of the study.

A telephone survey was conducted of potential participants; follow-up letters were sent to those which expressed interest and which, according to the above criteria, appeared most promising. Final selection and arrangements were made through personal visits to the following agencies:

- Charlotte (North Carolina) Police Department
- Fort Wayne (Indiana) Police Department
- Indiana State Police
- Madison (Wisconsin) Police Department
- Nebraska State Patrol
- St. Louis Park (Minnesota) Police Department
- South Dakota Highway Patrol
- Suffolk County (New York) Police Department

The Charlotte and Fort Wayne Police Departments were those finally selected for study participation. The critical criterion was the level of expected cooperation. Although these two agencies met the other criteria, they were most willing to participate in strict accordance with the procedures developed for the study.

Selection and Training of Data-Collection Observers

Ten observers, five in each city, were recruited, selected, and trained for the study. The observers were recruited through universities located near the participating agencies; they were selected through the use of personal history questionnaires and personal interviews.

Prior to the initiation of data collection, a training session was conducted for selected observers by project field supervisors. The training program consisted of the following components:

- Instruction on data collection procedures, measures, equipment, materials, and scheduling
- Verbal definitions and visual demonstrations (motion pictures and diagrams) of potential visual detection cues emphasizing differences among cue descriptions.
- Detailed instructions and about five hours of supervised field practice in recording cue descriptions and associated information.
- Assessment of observer proficiency from reviews of completed data collection forms and from on-the-road performance tests in which observers in one vehicle independently recorded detection cues as a second vehicle executed 18 different driver-behavior and vehicle action deviations.

- A follow-up session after the practice observation and assessment period to discuss and rectify any observational problems encountered.

The observers were supervised during the data-collection effort by two project staff members; one was assigned to Charlotte and the other to Fort Wayne. The two supervisors had the following qualifications: police patrol experience involving DWI detection and arrest; analysis of 1,288 DWI arrest reports from nine different police agencies; interviews with experts on DWI detection from the nine police agencies; and participation in the design of the data collection effort.

Police Training

In parallel to observer training, participating police officers were instructed in research objectives and study procedures. A total of 42 police officers from the two agencies participated in the study. The training was conducted by the project field supervisors. Training emphasized the special requirements of the study and the coordination required with observers. The police training program included the following:

- Instruction on data collection procedures, including descriptions of the responsibilities of both police officers and the accompanying observer, and instruction on the use of breath-testing equipment.
- Verbal and visual definitions of terms likely to be employed in cue descriptions (however this training was more limited than that provided to observers; the purpose here was to enhance communication by standardizing the terminology employed).
- Practice during one regular shift (about five hours) in applying the procedures with an assigned observer.
- A follow-up session after the practice period to discuss and rectify any observational problems encountered.

Data Collection

Data collection was implemented through assignment of trained observers to police vehicles during the periods of the day and week previously found to have higher rates of DWI--at night, Thursday through Sunday. Observers recorded information on data collection forms specifically designed for the

study. For each DWI detection event, the observer recorded data of several different types: detection cues, patrol strategies employed, driver characteristics, geographical and environmental conditions, conditions of observation, and whether or not the police officer would normally have stopped the vehicle. The data collection form is presented as Figure A2 of the Appendix.

In recording visual detection cues, the observer described each cue in the space provided on the data collection form, in the order in which the cue was observed. Each cue was described using the action-object format developed earlier and presented in Table 3 of the previous section. The code spaces were used later to classify cues for purposes of computer data entry.

The field data collection sequence employed for each DWI detection event is illustrated in the flow chart of Figure 2 and described in the paragraphs that follow.

1. *The patrol officer detected aberrant driving behavior.* The data collection effort was initiated when the patrol officer detected any deviation by a motorist from normal acceptable driving behavior. This aberrant behavior need not have related directly to DWI, in the judgment of the officer, nor been that which would normally cause the officer to stop the motorist as a suspected DWI. However, the aberrant behavior was adequate to establish probable-cause justification for stopping the motorist.

2. *The observer recorded detection event data.* The form specified the data to be collected for each event and provided the spaces for recording the data as it became available. The observer also had the availability of a tape recorder to record any oral notes or to record any verbatim comments of the patrol officer. Sources of the various types of data collected were:

Types of Data	*Source*
Detection cues	Observation and officer oral reports
Detection strategies	Observation and officer oral reports

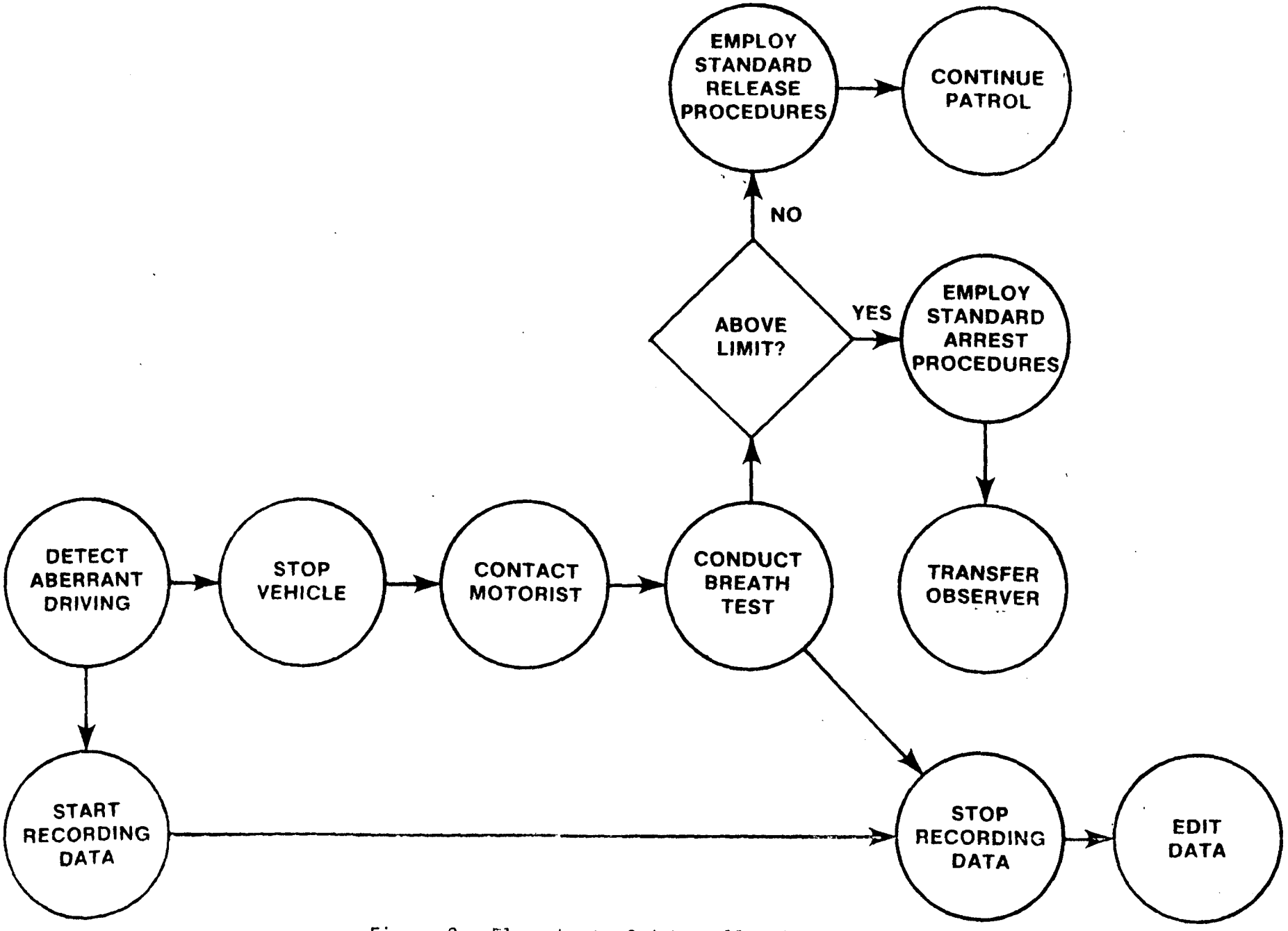


Figure 2. Flow chart of data collection procedures.

Types of Data (Cont.)	*Source (Cont.)*
Would have stopped motorist?	Officer oral report
Geographical conditions	Observation
Environmental conditions	Observation
Vehicle condition	Observation
Driver sex, race, appearance	Observation
Driver age	License
Driver BAC	Chemical test or test report
Driver medication	Question of motorist or arrest report
Passengers	Observation

3. *The patrol officer stopped the vehicle and contacted the motorist.* Standard police procedures were employed.

4. *The patrol officer administered a breath test.* Using standard procedures and the DOT-TSC Alcohol Screening Device the officer conducted a breath test of each motorist.

5. *The patrol officer determined the action to be taken with the driver.* If the BAC of the driver was above the legal limit, the officer employed standard arrest procedures in accordance with agency policy. If the BAC of the driver was below the legal limit, the officer released the driver or took whatever other action was warranted by agency policy.

6. *The observer was transferred.* After an arrest, the observer was transferred to another patrol car.

7. *Data were edited.* After completion of the observational shift in the patrol vehicle, the observer edited and assured the completeness of the recorded data.

Equipment and Materials

The following items of equipment and materials were employed during the data collection effort:

- Portable breath tester (DOT-TSC Alcohol Screening Device) with associated calibration and recharging equipment
- Cassette tape recorder and cassettes
- Battery operated lighted clipboard
- Preprinted data collection forms
- Reference listing of previously identified DWI visual detection cues

Data Analysis

A total of 643 DWI detection events were observed and recorded, 378 from Charlotte and 265 from Fort Wayne. The analysis of the 643 sets of data was conducted in the following sequence:

1. *Data were prepared.* Collected data were edited, coded, keypunched, and entered into the computer for tabulation and computation.

2. *Sample characteristics were defined.* Frequency distributions were constructed for each of the following characteristics and conditions associated with the 643 DWI detection events:

- Blood alcohol concentration of the driver
- Duration of observation
- Distance vehicle first observed
- Time of day of the stop
- Officer's statement of whether or not he would have normally stopped the vehicle
- Weather conditions
- Lighting conditions
- Location
- Roadway geometry
- Number of traffic lanes (total)
- Whether or not the roadway was divided
- Roadway surface condition
- Traffic conditions
- Vehicle condition

- Age of the driver
- Sex of the driver
- Race of the driver
- General appearance of the driver
- Number of passengers in the vehicle
- Whether or not the driver had taken medication or drugs
- Detection strategies or circumstances under which the detection took place

3. *Cue frequencies were computed.* A frequency distribution was constructed for the 134 different detection cues that occurred in the 643 detection events. The total number of cue occurrences was 1681, an average of 2.6 cues per DWI detection event.

4. *Cue discriminability values were calculated.* Discriminability values were calculated for each cue at BAC $\geq$ 0.10 and BAC $\geq$ 0.05. The discriminability value was defined as the conditional probability that the driver's BAC was equal to or greater than the specified BAC level, given the occurrence of the cue. The value was calculated by dividing the number of times the cue occurred at or above the BAC level by the total number of times the cue occurred. For example, if the driver's BAC was equal to or greater than 0.10, 43 times out of the 89 times weaving in lane was observed, the discriminability value, obtained by dividing 89 into 43, would be 0.48 at BAC $\geq$ 0.10. The discriminability value is interpreted as follows: the probability is 0.48 that the driver's BAC $\geq$ 0.10 when the cue, weaving in lane, is observed.

5. *Cues were redefined.* Cues were redefined to: simplify the understanding and use of cues, maintain cue discriminability, broaden cue categories to be more encompassing, and eliminate cues that did not fully fit the concept of DWI detection. As a result of this step, a redefined list of 30 DWI visual detection cues was developed; each cue on the list occurred 20 times or more in the sample of DWI detection events. The list of 30 cues encompassed 92% of all cue occurrences in the sample.

6. *Cues were related to detection conditions.* Distributions of cue frequencies and discriminability values of the 30 redefined cues were constructed under alternative characteristics and conditions of the sample of DWI detection events. In addition, multiple cue occurrences were analyzed.

7. *Correlational analyses were completed.* Correlational analyses were completed to determine the impact on cue occurrence of alternative detection strategies, characteristics, and conditions.

RESULTS

The findings of paramount importance were the frequencies of occurrence and relative discriminability values of detection cues; they provided the foundation for development of a DWI detection guide. The most useful cues for the guide were those which occurred most frequently and which discriminated most accurately between DWI and DWS. As a consequence, the thrust of the analysis was to identify a relatively small number of cues that could be found in most DWI detection events, and to determine which of those had the greatest power of discrimination between DWI and DWS. Since the analytical approach was outlined previously, the purposes of this section are to present the results and to discuss their implications. The detailed analytical results are presented in Tables 4 through 8 in this section and in Tables A6 through A14 of the Appendix.

Characteristics of the Sample of DWI Detection Events

Of prime concern was obtaining a sufficiently broad range of BAC levels among the drivers stopped to permit a meaningful analysis of cue discriminability. Success in this regard is illustrated by the initial entry in Table A6 of the Appendix. Thirty-nine percent had a BAC of less than 0.05; 23 percent had a BAC in the range from 0.05 to 0.10; and 38 percent had a BAC $\geq$ 0.10. In contrast, nearly all (96 percent) of the sample of DWI arrests analyzed earlier reported drivers with BAC $\geq$ 0.10. Of course, the distribution of BAC levels obtained in the on-the-road study reflected that vehicles were stopped for exhibiting any driver or

driving abnormality observed by the police officer, whether or not it might be considered indicative of DWI.

On other key characteristics, the detection study sample was comparable to the DWI arrest report sample. The significance of this is that comparability provides the basis for generalization of the detection study findings. For example, as shown in Table A6 of the Appendix, the two samples were nearly identical relative to the distribution of times at which the stops were made, the location of stop (urban or rural), and the percentages of male and female drivers stopped. On the other hand, the detection study sample included a larger percentage of drivers under age 25 and a smaller percentage of drivers 35 and older, as compared to the DWI arrest-report sample. Also, as a function of the parts of the country sampled in the detection study, relatively more Black drivers were included in the detection study sample whereas more Spanish-American drivers were included in the DWI arrest-report sample.

The detection events were generated by police officers engaged in both general patrol and patrol with DWI emphasis. About 58% of the detection stops were made by officers on general patrol; about 42% of the stops were made by officers on patrol with DWI emphasis. A detailed distribution of the strategies and circumstances under which the 643 stops were made is presented in Table A7 of the Appendix.

Relative Frequency of Observed Detection Cues

A total of 1581 cue occurrences were recorded during the 643 detection events; the frequency distribution of observed cues is provided in Table A8 of the Appendix. Cues are listed in decreasing order of frequency of occurrence. Observed cues included 118 of the 129 cues contained in the preliminary listing (Table 3) and 16 new cues observed during the detection study. Thus, the listing of Table A8 contains a total of 134 cues.

These data served mainly as the starting point for developing a more useful and meaningful set of cues. A major problem of this empirically

derived list of 134 cues was that the information it contained was fragmented and not logically cohesive. The potential existed for cue redefinition so that more cue occurrences could be accounted for by a smaller set of cues. As can be seen from Table A8, 108 of the 134 cues occurred in fewer than 20 of the 643 detection events; 56 cues occurred in fewer than 5 of the 643 detection events. Also, certain observed behaviors, such as "slow to respond to police signals," did not fit the pre-apprehension criterion established for a detection cue.

Cue Co-occurrence

Typically a cue occurred with one or more other cues. Since 1681 cue occurrences were observed in the 643 detection events, the average number of cues observed per detection event was 2.6. However, relatively few cues occurred together consistently. As shown in Table A9 of the Appendix, only nine of the 134 cues had even a modest level of co-occurrence. These cues co-occurred with another cue 10 times or more and had a percentage of co-occurrence of 20 or more. The nine cues co-occurred to this degree in only 11 instances.

Redefined Detection Cues

As a result of eliminating 34 of the observed cues, and redefining the remaining 100, a set of 30 cues was developed. Each of the 30 occurred 20 or more times in the sample of 643 detection events; the 30 redefined cues accounted for 92% of all detection cue occurrences. The set of 30 cues that emerged from this part of the effort is presented in Table 4; cues are listed in decreasing order of their frequency of occurrence.

Observed cues were eliminated from the list for one of five different reasons. First, some cues were not really detection cues at all, but only served to reinforce the detection after the patrol officer had initiated apprehension procedures. Second, the cue would be impractical for DWI detection because it presented an inadequate detection threshold. Third,

TABLE 4

Redefined Visual Detection Cues

CUE NUMBER AND NAME	FREQUENCY
R23 Speeding more than 10 MPH over limit	101
R 1 Weaving in lane	89
R 5 Drifting beyond lane	87
R21 Failing to respond to traffic signals or signs	85
R11 Driving with tires on lane marker	68
R25 Accelerating/decelerating rapidly	57
R28 Appearing to be drunk	57
R 2 Weaving beyond lane	56
R 3 Swerving beyond lane	49
R22 Signalling inconsistent with driving actions	49
R 7 Driving on other than designated roadway	42
R 8 Driving with vehicle defect(s)	42
R 6 Driving into opposing/crossing traffic	37
R13 Straddling centerline	37
R14 Turning with wide radius	35
R26 Almost striking moving vehicle	35
R10 Driving with left tires on centerline	33
R19 Stopping inappropriately other than in traffic lane	33
R24 Slow speed more than 10 MPH under limit	32
R18 Stopping in traffic lane	29
R29 Following too closely	29
R12 Straddling lane marker	28
R16 Turning illegally	28
R 9 Driving without headlights on	27
R27 Almost striking stationary object	27
R17 Stopping abruptly	24
R30 Braking erratically	23
R 4 Drifting in lane	21
R15 Turning rapidly/abruptly	20
R20 Slow to respond to change in traffic signals	20

the cue was related in a minor or major way to an accident; that is, the cue involved the vehicle striking another vehicle or object. Fourth, the cue was only incidental to the DWI detection process and would not serve a useful function in detection. Finally, the cue occurred less frequently than in 20 of the 643 detection events and could not be logically combined into a redefined cue that occurred 20 times or more. Cues eliminated from further analysis are listed in Table A11 of the Appendix. The eliminated cues accounted for a total of 329 of the 1681 cue occurrences; 220 were eliminated for the first four reasons and 109 were eliminated because they did not meet the frequency-of-occurrence criterion.

In redefining the remaining 100 cues into the list of Table 4, the three main guidelines employed:

- Maximize the frequency with which each redefined cue occurred in the sample of 643 detection events; conversely, define the smallest number of detection cues to account for the largest number of cue occurrences.
- Maintain levels of cue discriminability.
- Enhance cue understandability and applicability.

The redefinition process is illustrated by development of the redefined cue, *weaving beyond lane*. Six different observed cues had, in common, weaving with a weave-amplitude greater than that contained within the traffic lane (*weaving: lane to lane, lane to shoulder, across lane, across centerline, center of roadway with no centerline, shoulder to shoulder*). At essentially no loss in discriminability and at an increase in cue occurrence, the six were incorporated into the redefined cue named *weaving beyond lane*. The result was two weaving cues--*weaving in lane* and *weaving beyond lane*--that between them accounted for weaving at all possible amplitudes. Each redefined cue is also presented in Table A10 of the Appendix along with the observed cues of which it is constituted.

Influence of Detection Conditions on Frequency of Cue Occurrence

To what extent is the observation of a visual DWI detection cue a function of the conditions under which the observation is made? If the influence is great, one would expect relatively low correlations between distributions of cue frequencies obtained under alternative detection conditions. In general, the relatively high correlation coefficients actually obtained, suggested that many of the conditions studied had relatively little influence on the particular detection cues observed. As shown in Table A12 of the Appendix, the intercorrelations obtained were relatively high, especially considering the potential number of chance factors at work to diminish the reliability of the frequency distributions. Thus, the correlations obtained (ranging from 0.62 to 0.82) suggest that the following conditions have relatively little influence on the particular cues observed:

- Duration of observation
- Distance at which the cue was observed
- Time of day of the stop
- Lighting conditions
- Locations (urban vs. rural)
- Condition of the vehicle
- Sex of the driver
- Number of passengers in the vehicle

The more modest correlations (0.49 to 0.56) obtained for the following conditions suggest that they are more likely to have some influence on the particular cues observed:

- Number of traffic lanes
- Divided vs. undivided roadway
- Traffic density
- Age of the driver

The one variable that seemed to impact significantly on the frequency of cues observed was patrol emphasis. As discussed earlier, 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; and about 42% of the detection events occurred under patrol which emphasized DWI enforcement. The correlation between cue frequency distributions obtained under these alternatives was only 0.22, a coefficient not statistically significant from zero. An examination of the two distributions revealed that cues associated with the general infraction of traffic rules (speeding, failing to respond to traffic signals) were observed more frequently under general patrol, and that cues less directly associated with these more obvious infractions (drifting beyond lane, driving with tires on lane marker) were observed more frequently under DWI-emphasis patrols.

Order of Cue Appearance

Most cues were observed with one or more other cues. In 66% of the 643 detection events, two or more cues were observed. Since cues were recorded in the order in which observed, frequency distributions were constructed to show the number of times each cue was observed first, second, third, fourth, fifth, and sixth. Relatively few detection events (14%) had more than three observed cues.

As one might expect, cues were most frequently first-observed, next most frequently second-observed, and third most frequently third-observed. However, there were some notable differences in this regard among the 30 different cues. For example, *failing to respond to traffic signals or signs* was the first-observed cue 84% of the time that it was observed. In contrast, *drifting beyond lane* was the first-observed cue in only 31% of the time it was observed, occurring most frequently (44% of the time) as the second-observed cue. The frequencies of occurrence of all 30 redefined cues are presented in Table A13 of the Appendix, by the order in which observed.

Detection Study Results vs. Arrest Report Results

Because of the procedural differences in apprehending drivers, the frequency distribution of visual cues obtained from detection study data differed from the frequency distribution obtained from arrest reports. In the detection study, the vehicle was stopped whenever abnormal driver or driving behavior was observed; this was not likely to be the case in the reported arrests.

Although a modest correlation (0.52) existed between the two distributions, there were some notable and relevant differences between them. The two distributions are shown in Table A14 of the Appendix. Because the total numbers of detection events differed, the detection-study frequencies were increased by a constant to be comparable to those obtained from the arrest reports. The italics and arrows of Table A14 indicate the existence and direction of differences between the two distributions; notably larger frequencies (differences exceeding 30) are indicated by the arrows. Certain cues were overly represented in the arrest-report sample, in comparison to the detection-study sample. As will be presented later, these cues (listed below) are not necessarily the most discriminating.

- Driving on other than designated roadway
- Straddling lane marker
- Almost striking moving vehicle
- Weaving in lane
- Weaving beyond lane
- Swerving beyond lane
- Driving into opposing/crossing traffic

Cue Discriminability Values

Detection probabilities expected in the absence of any visual cues provide a benchmark for the interpretation of cue discriminability values.

From data collected in 78 roadside breath testing surveys involving a total of 41,847 motorists stopped at night (Lehman, et al., 1975), the probability that a randomly stopped motorist would have a BAC ≥ 0.10 was determined to be 0.06. The probability that a randomly stopped motorist would have a BAC ≥ 0.05 was determined to be 0.15. In comparison, the 30 redefined visual cues provided DWI detection probabilities ranging from 0.19 to 0.81 for BAC ≥ 0.10, and detection probabilities ranging from 0.22 to 0.94 for BAC ≥ 0.05. Discriminability values (conditional probabilities of DWI) are presented for the 30 redefined cues, under different conditions, in Tables 5, 6, 7, and 8. In most cases of DWI detection, more than a single cue is present. In 83% of the arrest reports analyzed and in 66% of the detection events, two or more cues were observed. Therefore, the analysis of cue discriminability must be made within the context of multiple-cue occurrence. That is, discriminability values associated with the observation of a single cue alone would represent an atypical situation within the context of practical DWI enforcement. Consequently, discriminability values were calculated for each cue within the context of one or more cues, two or more cues, and three or more cues.

Cue discriminability values based upon the conditional probability that the drivers' BAC level is equal to or greater than 0.10 are presented in Tables 5 and 6. In Table 5, values are presented for each cue when the cue was observed as one of one, one of two, or one of three or more cues; regardless of the order in which the cues were observed. In contrast, Table 6 presents discriminability values for each cue when the cue was the first observed of one, two, or three or more cues. In reviewing these tables, one must keep in mind that the amount of data upon which the values are based decreases from the left column to the right: that is, the amount of data available for calculating the discriminability values involving three or more cues was substantially less than that for calculating discriminability values involving one

TABLE 5

Cue Discriminability Values: Probability that the Driver's BAC ≥ 0.10

CUE NUMBER AND NAME	P(BAC ≥ 0.10) WHEN CUE WAS OBSERVED AS: ONE OF 1 OR MORE CUES	ONE OF 2 OR MORE CUES	ONE OF 3 OR MORE CUES
R18 Stopping in traffic lane	.69	.70	.79
R27 Almost striking stationary object	.63	.67	.67
R29 Following too closely	.62	.50	.50
R14 Turning with wide radius	.60	.60	.58
R28 Appearing to be drunk	.58	.67	.77
R 7 Driving on other than designated roadway	.57	.61	.63
R12 Straddling lane marker	.57	.57	.61
R13 Straddling centerline	.57	.60	.68
R26 Almost striking moving vehicle	.51	.56	.61
R20 Slow to respond to change in traffic signals	.50	.59	.63
R11 Driving with tires on lane marker	.49	.51	.55
R 1 Weaving in lane	.48	.50	.55
R 9 Driving without headlights on	.48	.56	.75
R 5 Drifting beyond lane	.47	.48	.51
R22 Signalling inconsistent with driving actions	.47	.51	.67
R25 Accelerating/decelerating rapidly	.46	.49	.56
R 2 Weaving beyond lane	.45	.51	.67
R24 Slow speed more than 10 MPH under limit	.44	.43	.47
R 3 Swerving beyond lane	.43	.42	.47

TABLE 5 (Continued)

Cue Discriminability Values: Probability that the Driver's BAC ≥ 0.10

CUE NUMBER AND NAME	P(BAC ≥ 0.10) WHEN CUE WAS OBSERVED AS: ONE OF 1 OR MORE CUES	ONE OF 2 OR MORE CUES	ONE OF 3 OR MORE CUES
R 4 Drifting in lane	.43	.45	.50
R10 Driving with left tires on centerline	.42	.48	.43
R17 Stopping abruptly	.42	.38	.50
R23 Speeding more than 10 MPH over limit	.37	.45	.65
R21 Failing to respond to traffic signals or signs	.36	.49	.74
R30 Braking erratically	.35	.38	.58
R19 Stopping inappropriately other than in traffic lane	.33	.44	.56
R16 Turning illegally	.32	.39	.50
R15 Turning rapidly/abruptly	.30	.28	.48
R 6 Driving into opposing/crossing traffic	.30	.42	.55
R 8 Driving with vehicle defect(s)	.29	.36	.38

TABLE 6

Discriminability Values for First-Observed Cues: Probability that the Driver's BAC ≥ 0.10

CUE NUMBER AND NAME	P(BAC ≥ 0.10) WHEN CUE WAS OBSERVED: FIRST OF 1 OR MORE CUES	FIRST OF 2 OR MORE CUES	FIRST OF 3 OR MORE CUES
R29 Following too closely	.81	.67	.67
R18 Stopping in traffic lane	.75	.83	.75
R13 Straddling centerline	.56	.64	.63
R28 Appearing to be drunk	.56	.90	.86
R27 Almost striking stationary object	.56	.67	.75
R 3 Swerving beyond lane	.53	.56	.67
R30 Braking erratically	.50	1.00	1.00
R 1 Weaving in lane	.49	.53	.58
R11 Driving with tires on lane marker	.48	.55	.55
R25 Accelerating/decelerating rapidly	.45	.52	.44
R26 Almost striking moving vehicle	.44	.67	.60
R24 Slow speed more than 10 MPH under limit	.43	.40	.75
R 7 Driving on other than designated roadway	.42	.46	.56
R 9 Driving without headlights on	.40	.44	.75
R12 Straddling lane marker	.40	.40	.50
R17 Stopping abruptly	.38	.20	.00
R14 Turning with wide radius	.36	.36	.29
R23 Speeding more than 10 MPH over limit	.34	.48	.71
R 5 Drifting beyond lane	.33	.33	.33

TABLE 6 (Continued)

Discriminability Values for First-Observed Cues: Probability that the Driver's BAC $\geq$ 0.10

CUE NUMBER AND NAME	P(BAC $\geq$ 0.10) WHEN CUE WAS OBSERVED: FIRST OF 1 OR MORE CUES	FIRST OF 2 OR MORE CUES	FIRST OF 3 OR MORE CUES
R15 Turning rapidly/abruptly	.33	.29	.33
R10 Driving with left tires on center line	.31	.42	.29
R21 Failing to respond to traffic signals or signs	.31	.44	.75
R22 Signalling inconsistent with driving actions	.29	.31	.20
R 6 Driving into opposing/crossing traffic	.28	.44	.50
R19 Stopping inappropriately other than in traffic lane	.27	.57	.67
R16 Turning illegally	.23	.33	1.00
R 8 Driving with vehicle defect(s)	.22	.31	.50
R20 Slow to respond to change in traffic signals	.22	.33	.00
R 4 Drifting in lane	.20	.25	.00
R 2 Weaving beyond lane	.19	.25	.43

TABLE 7

Cue Discriminability Values: Probability that the Driver's BAC ≥ 0.05

CUE NUMBER AND NAME	P(BAC ≥ 0.05) WHEN OBSERVED CUE IS: ONE OF 1 OR MORE CUES	ONE OF 2 OR MORE CUES	ONE OF 3 OR MORE CUES
R18 Stopping in traffic lane	.90	.93	.95
R14 Turning with wide radius	.83	.83	.77
R13 Straddling centerline	.81	.83	.82
R 7 Driving on other than designated roadway	.79	.81	.74
R29 Following too closely	.76	.68	.67
R28 Appearing to be drunk	.75	.86	.85
R12 Straddling lane marker	.75	.75	.72
R26 Almost striking moving vehicle	.74	.78	.78
R30 Braking erratically	.74	.81	.75
R 5 Drifting beyond lane	.71	.71	.65
R22 Signalling inconsistent with driving actions	.71	.76	.81
R17 Stopping abruptly	.71	.71	.75
R 2 Weaving beyond lane	.70	.76	.92
R10 Driving with left tires on centerline	.70	.76	.76
R 1 Weaving in lane	.69	.68	.73
R 3 Swerving beyond lane	.69	.70	.62
R27 Almost striking stationary object	.67	.67	.67
R 9 Driving without headlights on	.67	.75	.88
R 4 Drifting in lane	.67	.70	.71
R11 Driving with tires on lane marker	.66	.66	.65

TABLE 7 (Continued)

Cue Discriminability Values: Probability that the Driver's BAC $\geq$ 0.05

CUE NUMBER AND NAME	P(BAC $\geq$ 0.05) WHEN OBSERVED CUE IS: ONE OF 1 OR MORE CUES	ONE OF 2 OR MORE CUES	ONE OF 3 OR MORE CUES
R24 Slow speed more than 10 MPH under limit	.66	.68	.65
R15 Turning rapidly/abruptly	.65	.61	.60
R25 Accelerating/decelerating rapidly	.65	.65	.67
R19 Stopping inappropriately other than in traffic lane	.61	.72	.69
R20 Slow to respond to change in traffic signals	.55	.65	.75
R16 Turning illegally	.54	.61	.67
R 6 Driving into opposing/crossing traffic	.54	.63	.73
R23 Speeding more than 10 MPH over limit	.55	.62	.74
R21 Failing to respond to traffic signals or signs	.53	.67	.74
R 8 Driving with vehicle defect(s)	.43	.54	.50

TABLE 8

Discriminability Values for First-Observed Cues: Probability that the Driver's BAC $\geq$ 0.05

CUE NUMBER AND NAME	P(BAC $\geq$ 0.05) WHEN CUE IS OBSERVED: FIRST OF 1 OR MORE CUES	FIRST OF 2 OR MORE CUES	FIRST OF 3 OR MORE CUES
R29 Following too closely	.94	.89	.67
R 3 Swerving beyond lane	.80	.89	.83
R26 Almost striking moving vehicle	.78	1.00	1.00
R15 Turning rapidly/abruptly	.78	.71	.67
R 1 Weaving in lane	.76	.75	.84
R18 Stopping in traffic lane	.75	.83	.75
R13 Straddling centerline	.75	.79	.75
R 7 Driving on other than designated roadway	.74	.77	.67
R25 Accelerating/decelerating rapidly	.72	.74	.78
R24 Slow speed more than 10 MPH under limit	.71	.80	1.00
R28 Appearing to be drunk	.68	1.00	1.00
R27 Almost striking stationary object	.67	.67	.75
R11 Driving with tires on lane marker	.64	.64	.55
R14 Turning with wide radius	.64	.64	.43
R 5 Drifting beyond lane	.63	.63	.33
R22 Signalling inconsistent with driving actions	.62	.69	.60
R 9 Driving without headlights on	.60	.67	.75
R12 Straddling lane marker	.60	.60	.60
R 4 Drifting in lane	.60	.75	.00

TABLE 8 (Continued)

Discriminability Values for First-Observed Cues: Probability that the Driver's BAC $\geq$ 0.05

CUE NUMBER AND NAME	P(BAC $\geq$ 0.05) WHEN CUE IS OBSERVED: FIRST OF 1 OR MORE CUES	FIRST OF 2 OR MORE CUES	FIRST OF 3 OR MORE CUES
R 2 Weaving beyond lane	.59	.70	.86
R23 Speeding more than 10 MPH over limit	.56	.70	.86
R10 Driving with left tires on centerline	.56	.67	.57
R 6 Driving into opposing/crossing traffic	.55	.69	.67
R19 Stopping inappropriately other than in traffic lane	.53	.86	1.00
R30 Braking erratically	.50	1.00	1.00
R17 Stopping abruptly	.50	.40	.00
R21 Failing to respond to traffic signals or signs	.49	.65	.75
R16 Turning illegally	.46	.67	1.00
R 8 Driving with vehicle defect(s)	.37	.54	.50
R20 Slow to respond to change in traffic signals	.22	.33	.00

or more cues. Therefore, the values are progressively less stable from the first column through the third column. Also, because the values in Table 5 are based upon larger sample sizes than the values in Table 6, the most stable discriminability values are those presented in the first column of Table 5.

Tables 5 and 6 show two primary findings. The first is that substantial differences exist in the discriminability of cues. In Table 5, the largest values are more than twice the size of the smaller values; in Table 6, the larger values are more than four times the size of the smaller values. The second main finding is that cue discriminability values increase somewhat as the number of co-occurring cues increases; however, as shown in the average discriminability values presented in Table 9, the increases are relatively modest.

Cue discriminability values based upon conditional probabilities that the driver's BAC level is equal to or greater than 0.05 are presented in Tables 7 and 8. These tables are directly comparable to Tables 5 and 6, and the same qualifications discussed earlier apply. The cue discriminability values for BAC $\geq$ 0.05 are relatively large, indicating that the occurrence of any one of these cues provides a relatively high probability that the driver's BAC is equal to or greater than 0.05. Few discriminability values are less than 0.50 and more than half are greater than 0.70. As shown in Table 9, the trend of increasing values with increasing co-occurrence is not as pronounced or consistent for BAC $\geq$ 0.05 as it is for BAC $\geq$ 0.10.

The correlations between cue discriminability values for the BAC $\geq$ 0.10 level and for the BAC $\geq$ 0.05 level is relatively high, 0.77 on the average.

TABLE 9

Average Discriminability Values of the 30 Redefined Cues

	$P(BAC \geq 0.10)$	$P(BAC \geq 0.05)$
When the cue is one of:		
• One or more cues	.46	.68
• Two or more cues	.50	.72
• Three or more cues	.55	.73
When the cue is the first-observed of:		
• One or more cues	.40	.62
• Two or more cues	.49	.72
• Three or more cues	.54	.67

DWI DETECTION GUIDE

A DWI detection guide was developed to facilitate the application of research findings to the on-the-road detection of DWI by police patrol officers. 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--suggest that the findings of this study be presented simply and directly. Therefore, the DWI detection guide was developed to transform the research findings into a practical aid for DWI detection. Because the empirical results were not necessarily simple or free of subtlety, extrapolation and judgment were exercised during the guide development process. The process was governed by the following criteria:

- *Account for the Largest Number of Detection Events with the Smallest Number of Detection Cues.* Early in the project 376 detection cues were identified. Through a process of combining and redefining on the basis of study results, this number was reduced to 30 cues that accounted for 92% of the cue occurrences in the on-the-road detection study. Could this number be further reduced?
- *Enhance the Discriminability of Available Detection Cues.* Any visual cue is useful to the extent that it discriminates between DWI and DWS. Consequently, in defining the final set of cues, care was taken to maintain the level discriminability values.
- *Employ a Probabilistic Output.* The detection of DWI is probabilistic in nature. Through the observation of one or more visual cues, the patrol officer determines the likelihood (probability) that the motorist is DWI. The most precise statement of this output is a numerical probability value--decimal fraction, chances in one hundred, or expected percentage.
- *Accommodate Multiple Cue Occurrences.* DWI detection cues seldom occur alone. Consequently, the guide must accommodate and reflect the influence on DWI assessments of multiple cue occurrences. For example, if Cue A, Cue F, and Cue P are all three observed, what is the probability of DWI?

- *Accommodate Alternative Enforcement Statutes and Policies.* The most common legal limit is now defined as a BAC equal to or greater than 0.10. However, some states have an additional impaired category, starting at a legal limit of BAC equal to 0.05. The detection model was designed to accommodate both limits. Also, the department should be able to establish its own criterion (probability of DWI) for the decision to apprehend or to not apprehend.
- *Emphasize Simplicity, Practicality, and Ease of Use.* Assuming that complexity and subtlety will inhibit the use of DWI detection procedures, the guide was designed to be simple and practical. Certain liberties were taken with the research results, and extrapolations were made from the results to this end. The objective was to provide the patrol officer with a relatively short list of cues and a relatively simple set of procedures for their use.

VISUAL DETECTION CUES

A final set of cues was developed from a review of the information obtained from all sources--published literature, arrest reports, experienced patrol officers, and the on-the-road detection study. The set of 30 cues which emerged from the detection study was further reduced to a total of 23 cues which accounted for 92% of the cue occurrences in that study. The resulting set of cues is shown in Table 10. The correlation between the P(BAC $\geq$ 0.10) values and the P(BAC $\geq$ 0.05) values was 0.83, indicating that although the P(BAC $\geq$ 0.05) values averaged 20 points more, their distribution was very similar to the P(BAC $\geq$ 0.10) values.

In addition to probability values for each cue, Table 10 presents frequency-of-occurrence values. These values were derived from the detection study data; each value is the number of drivers in 100 who exhibited that cue and also were found to have a BAC $\geq$ 0.10. (Because of multiple occurrences, the values add to greater than 100.) As can be determined from an examination of these values in Table 10, no single cue can be expected to be observed in more than a relatively small percentage of DWI events.

The following descriptions and definitions are provided to distinguish one cue from another, and to illustrate the essential characteristics of each cue.

TABLE 10

Final Set of Visual DWI Detection Cues

VISUAL CUE	OCCURRENCE (TIMES IN 100)	P(BAC ≥ .10)	P(BAC ≥ .05)
Stopping (without cause) in traffic lane	3	.69	.90
Following too closely	3	.62	.76
Turning with wide radius	3	.60	.83
Appearing to be drunk	5	.58	.75
Driving on other than designated roadway	4	.57	.79
Straddling center or lane marker	6	.57	.78
Almost striking object or vehicle	5	.56	.71
Slow response to traffic signals	2	.50	.55
Headlights off (at night)	2	.48	.67
Signalling inconsistent with driving actions	4	.47	.71
Weaving	11	.47	.69
Tires on center or lane marker	7	.47	.67
Drifting	8	.46	.70
Swerving	4	.45	.73
Accelerating or decelerating rapidly	6	.44	.67
Slow speed--more than 10 MPH below limit	2	.44	.66
Fast speed--more than 10 MPH above limit	6	.37	.55
Failing to respond to traffic signals or signs	5	.36	.53
Braking erratically	1	.35	.74

TABLE 10 (Continued)

Final Set of Visual DWI Detection Cues

VISUAL CUE	*OCCURRENCE (TIMES IN 100)*	*P(BAC ≥ .10)*	*P(BAC ≥ .05)*
Stopping inappropriately other than in lane	2	.33	.61
Turning abruptly or illegally	2	.31	.58
Driving into opposing or crossing traffic	2	.30	.54
Driving with vehicle defect(s)	2	.29	.43

Stopping (Without Cause) in Traffic Lane

The critical element in this cue is that there is no observable justification for the vehicle to stop in the traffic lane; the stop is not caused by traffic conditions, traffic signals, an emergency situation, or related circumstances. Intoxicated drivers might stop in lane when their impaired information processing capability is inadequate to the driving decisions required. As a consequence, stopping (without cause) in the traffic lane is likely to occur at intersections or other decision points.

Following Too Closely

The vehicle is observed following another vehicle while not maintaining the legal minimum separation.

Turning With Wide Radius

The vehicle path during a turn is outside the normal turn path; or, more precisely, the radius defined by the distance between the turning vehicle and the center of the turn is longer than normal.

Appearing to be Drunk

This cue is actually one or more of a set of indicators related to the personal behavior or appearance of the driver. Examples of specific indicators might include:

- Tightly gripping the steering wheel
- Face close to the windshield
- Eye fixation
- Slouching in the seat
- Gesturing erratically or obscenely
- Drinking in the vehicle
- Driver's head protruding from vehicle

Driving on Other Than Designated Roadway

The vehicle is observed being driven on other than the roadway designated for traffic movement. Examples include driving: at the edge of the roadway, on the shoulder, off the roadway entirely, and straight through turn-only lanes or areas.

Straddling Center or Lane Marker

The vehicle is moving straight ahead with the center or lane marker between the left-hand and right-hand wheels.

Almost Striking Object or Vehicle

The observed vehicle almost strikes a stationary object or another moving vehicle. Indicators include: passing abnormally close to a sign, wall, building, or other object; passing abnormally close to another moving vehicle; and causing another vehicle to maneuver to avoid collision.

Slow Response to Traffic Signals

The observed vehicle exhibits a longer than normal response to a change in traffic signal. For example, the driver remains stopped at the intersection for an abnormally long period of time after the traffic signal has turned green.

Headlights Off (at Night)

The observed vehicle is being driven with both headlights off during a period of the day when the use of headlights are required.

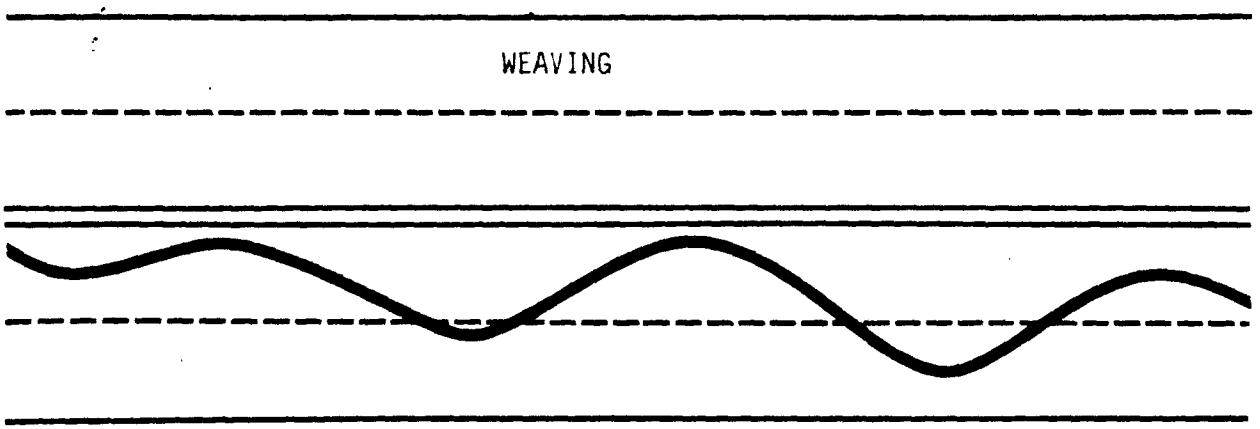
Signalling Inconsistent with Driving Actions

A number of possibilities exist for the driver's signalling to be inconsistent with the associated driving actions. This cue occurs when inconsistencies such as the following are observed: failing to signal a turn or lane change, signalling opposite to the turn or lane change

executed, signalling constantly with no accompanying driving action, and driving with four-way flashers on.

Weaving

Weaving occurs when the vehicle alternately moves toward one side of the roadway and then the other, creating a zig-zag course. The pattern of lateral movement is relatively regular as one steering correction is closely followed by another. Weaving is illustrated by the diagram below. The perspective of this diagram is looking from above down on the roadway. A four-lane roadway is represented, marked with a solid double center line and dashed lane markers. At the left, the weave is shown initially as being contained totally within lane, going beyond the lane boundary as the driver continues.



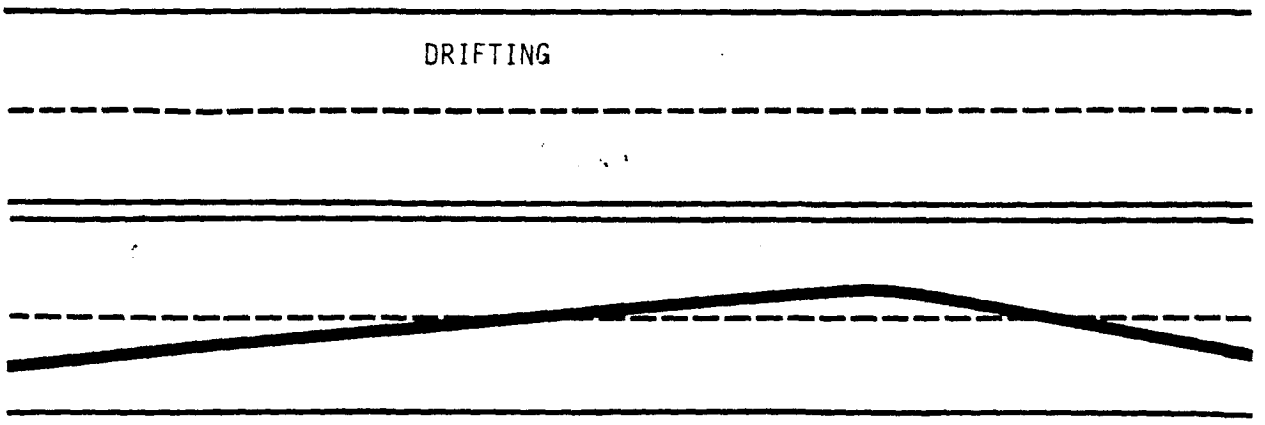
Tire on Center or Lane Marker

The left-hand set of tires of the observed vehicle is consistently on the center line, or either set of tires is consistently on the lane marker.

Drifting

Drifting is a straight-line movement of the vehicle at a slight angle to the roadway. As the driver approaches a marker or boundary

(lane marker, center line, edge of the roadway), the direction of drift might change. As shown in the illustration below, the vehicle drifts across the lane marker toward the center line, then the driver makes a correction and the vehicle drifts across the lane marker toward the edge of the roadway. Drifting might be observed within a single lane, across lanes, across the center line, onto the shoulder, and from lane to lane.

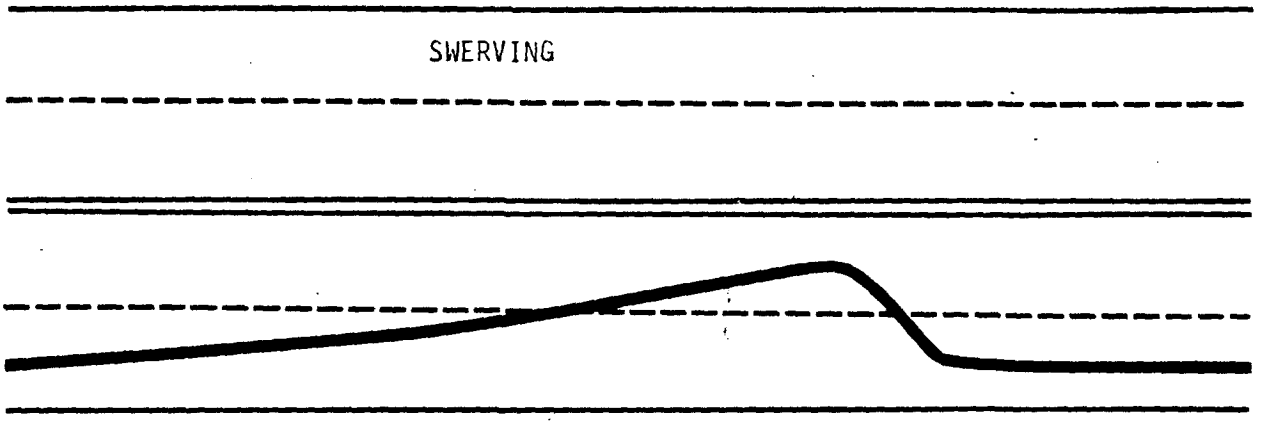


Swerving

A swerve is an abrupt turn away from a generally straight course. Swerving might occur directly after a period of drifting when the driver discovers the approach of traffic in an on-coming lane or discovers that the vehicle is going off the road; swerving might also occur as an abrupt turn is executed to return the vehicle to the traffic lane. In the illustration at the top of the next page, a swerve was executed to return to lane after a period of drifting toward the opposing traffic lane.

Accelerating or Decelerating Rapidly

This cue encompasses any acceleration or deceleration that is significantly more rapid than that required by the traffic conditions. Rapid acceleration might be accompanied by breaking traction; rapid deceleration might be accompanied by an abrupt stop. Also a vehicle might alternately accelerate and decelerate rapidly.



Slow Speed (More than 10 MPH Below Limit)

The observed vehicle is being driven at a speed that is more than 10 MPH below the speed limit.

Fast Speed (More than 10 MPH Above Limit)

The observed vehicle is being driven at a speed that is more than 10 MPH above the speed limit.

Failing to Respond to Traffic Signals or Signs

The observed vehicle fails to respond to a traffic signal or sign. For example, the vehicle fails to stop for a red traffic signal, fails to stop for a stop sign, or fails to slow for caution signals.

Braking Erratically

The driver of the observed vehicle is braking unnecessarily frequently, maintaining pressure on the brake pedal ("riding the brakes"), or braking in an uneven or jerky manner.

Stopping Inappropriately (Other than in Traffic Lane)

The observed vehicle stops at an inappropriate location or under inappropriate conditions, other than in the traffic lane. Examples

include stopping: in a prohibited zone, at a cross walk, far short of an intersection, on a walkway, across lanes, for a green traffic signal, or for a flashing yellow traffic signal.

Turning Abruptly or Illegally

The driver executes any turn that is abnormally abrupt or illegal. Specific examples include turning: with excessive speed, sharply from the wrong lane, a U illegally, and outside the designated turn lane.

Driving into Opposing or Crossing Traffic

The vehicle is observed heading into opposing or crossing traffic under one or more of the following circumstances: driving in the opposing lane, driving the wrong way on a one-way street, backing into traffic, failing to yield to on-coming traffic, failing to yield the right-of-way at an intersection.

Driving with Vehicle Defect(s)

The observed vehicle is being driven with one or more defects, such as: faulty headlights, faulty taillights, flat tire, or one of many other observable mechanical or electrical defects.

DETECTION GUIDE

The detection guide, developed in accordance with the previously-described criteria, is presented in Figure 3. In preparing the guide, discriminability values for BAC $\geq$ 0.10 were changed from probabilities to percentages and rounded to the nearest number divisible by five. Values for multiple cue occurrences and BAC $\geq$ 0.05 are obtainable from simple rules.

The guide, together with cue definitions, can be put into the form of a simple performance aid for use by patrol officers. It is anticipated

DWI DETECTION GUIDE

1. *The number to the right of each cue listed below is the percentage of nighttime drivers expected to have a BAC equal to or greater than (≥) 0.10. if that cue is observed.*

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

2. *If one additional cue is observed, add 5 to the larger of the two percentage values to obtain the expected percentage of drivers with BAC ≥0.10. If two or more additional are observed, add 10 to the largest percentage to obtain the expected percentage of drivers with BAC ≥0.10.*

3. *To obtain the expected percentage of drivers with BAC ≥0.05, add 20 to the percentage obtained for drivers with BAC ≥0.10.*

Figure 3. DWI detection guide.

that use of the aid can be implemented through one or a series of brief training sessions conducted during roll-call at the start of regular police patrol shifts.

CONCLUSIONS

1. Alcohol-induced driver impairment is exhibited mainly in four driving functions--steering control, velocity control, time-sharing of attention, and information processing. Deviations from normal performance of these functions lead to specific visual cues that are useful for on-the-road detection of DWI.

2. Although the potential number of detection cues is very large, most detection events can be accounted for by a relatively small number of detection cues. Twenty-three cues were defined to account for 92% of the detection events recorded in the on-the-road detection study.

3. Typically, a detection cue is observed with one or more other cues. In the sample of 1288 arrests analyzed, two or more cues were reported in 83% of the arrests; about three cues were reported per arrest. In the sample of 643 detection events, two or more cues were observed in 66% of the events; 2.6 cues, on the average, were observed per event. However, there are few subsets of specific cues that occur frequently together.

4. There are large differences among detection cues in the frequency with which they occur with DWI, and in their ability to discriminate between DWI and DWS. Among the final list of 23 cues, the most frequently occurring cue occurred over 10 times as often with DWI as the least frequently occurring cue. The discriminability value of the most discriminating cue was more than twice that of the least discriminating.

5. In general, the conditions under which cues are observed have relatively little influence on cue occurrence. Conditions having the least influence were: duration of observation, distance of observation, time of day, lighting, location (urban vs. rural), vehicle condition, sex of the driver, and number of passengers in the vehicle. Conditions

having somewhat more influence were: number of traffic lanes, divided vs. undivided highway, traffic density, and age of the driver.

6. Patrol strategy greatly affects the relative frequencies with which cues are observed. The correlation was essentially zero between cue frequency distributions obtained under general patrol and under patrol with DWI emphasis. The more obvious infractions of traffic rules (speeding, failing to respond to traffic signals) were observed more frequently under general patrol, whereas the more subtle cues (drifting, driving with tires on lane marker) were observed more frequently under DWI-emphasis patrol.

7. The DWI detection guide developed from study results will facilitate the application of the research findings to on-the-road detection of DWI by police patrol officers. Development of the guide 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 cues.
- Employ a probabilistic output.
- Accommodate multiple-cue occurrences.
- Accommodate alternative enforcement statutes, policies, and strategies.
- Emphasize simplicity, practicality, and ease of use.

8. Prior to the general availability or implementation of the DWI detection guide, a field test will be required to evaluate its impact on DWI enforcement. A field test plan was prepared and presented in a separate document.

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APPENDIX

ON-THE-ROAD DETECTION OF DWI

ARREST REPORT DATA

1-6
DATE OF COLLECTION . . . . ☐☐☐☐☐☐

7
AGENCY . . . . . ☐

8-17
REPORT NO. . . . . ☐☐☐☐☐☐☐☐☐☐

18-28
OCCURRENCE:

- Time . . . . . ☐☐☐☐
- Date . . . . . ☐☐☐☐☐☐
- Day of Week . . . . . ☐

29
LOCATION:

- Urban . . . . . 0 ☐
- Rural . . . . . 1 ☐
- _____

_____

30
LANES:

- 1 . . . . . 0 ☐
- 2 . . . . . 1 ☐
- 3 . . . . . 2 ☐
- 4 . . . . . 3 ☐
- Other_____ 4 ☐

31
WEATHER

- Clear . . . . . 0 ☐
- Rain . . . . . 1 ☐
- Snow . . . . . 2 ☐
- Fog . . . . . 3 ☐
- N/A . . . . . 4 ☐

DRIVER

32
SEX

- Male . . . . . 0 ☐
- Female . . . . . 1 ☐

33-34
AGE . . . . . ☐☐

35
RACE:

- C . . . . . 0 ☐
- N . . . . . 1 ☐
- SA . . . . . 2 ☐
- O . . . . . 3 ☐
- Other_____ 4 ☐

36
MEDICATION:

- No . . . . . 0 ☐
- Yes . . . . . 1 ☐
  - Type_____

37-38
BAC . . . . . ☐☐

39
HOW DETERMINED:

- Blood . . . . . 0 ☐
- Breath . . . . . 1 ☐
- Urine . . . . . 2 ☐

Figure A1. DWI arrest data collection form, page 1.

PRELIMINARY CUES

Figure A1 (Continued). DWI arrest data collection form, page 2.

SECONDARY CUES

Figure A1 (Continued). DWI arrest data collection form, page 3.

TABLE A1

Characteristics of the DWI Arrest Report Sample

CHARACTERISTIC	FREQUENCY	PERCENT
Sex of Driver		
Male	1141	89
Female	147	11
Age of Driver		
Under 25	349	27
25 to 35	385	30
35 to 45	266	21
45 and older	286	22
Race of Driver		
Black	166	14
Caucasian	710	62
Spanish-American	255	22
Other	20	2
Using Medicine/Drugs?		
Yes	177	14
No	911	71
Unknown	200	15
Location of Arrest		
Rural	177	14
Urban	1062	86
Day of the Arrest		
Monday through Wednesday	491	38
Thursday through Sunday	797	62
Time of Arrest		
0001-0600	684	53
0601-1200	11	1
1201-1800	62	5
1801-2400	531	41
Month of Arrest		
July - September 1976	308	24
October - December 1976	310	24
January - March 1977	345	27
April - June 1977	325	25

TABLE A1 (Continued)

Characteristics of the DWI Arrest Report Sample

CHARACTERISTIC	*FREQUENCY*	*PERCENT*
Blood Alcohol Concentration of the Driver		
Less than 0.05	6	-
0.05 to 0.10	55	*4*
0.10 to 0.16	522	*41*
0.16 to 0.21	422	*33*
0.21 or greater	283	*22*

TABLE A2

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
52 Accelerating for no apparent reason	3
43 Accelerating rapidly backward	3
41 Accelerating rapidly forward	73
286 Almost falling from vehicle	3
212 Almost stopping in lane	2
162 Almost striking another moving vehicle	18
168 Almost striking bicyclist	1
165 Almost striking curb	19
167 Almost striking median	11
164 Almost striking oncoming vehicle	8
163 Almost striking parked vehicle	28
160 Almost striking police officer	2
161 Almost striking police vehicle	113
166 Almost striking sign/object/wall/building	8
331 Appearing to be drunk	10
328 Attempting to elude police	20
253 Backing improperly (unspecified)	5
366 Backing into traffic	5
252 Backing on roadway	5
342 Blowing horn at police	2
343 Blowing horn for no reason	2
258 Braking erratically	5
259 Braking for no apparent reason	2
55 Breaking traction	25
266 Changing lanes abruptly	6
268 Changing lanes within intersection	3
350 Changing places w/passenger	5
60 Crossing centerline	208
63 Crossing lane marker	33
64 Crossing lanes improperly	10
44 Decelerating rapidly	4

TABLE A2 (Continued)

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
49 Decelerating slowly	3
56 Drag racing	6
85 Drifting (Unspecified)	3
92 Drifting across centerline	18
82 Drifting across lane(s)	25
83 Drifting in lane	8
84 Drifting lane to lane	16
91 Drifting onto centerline	6
86 Drifting onto shoulder	16
88 Drifting to left	5
89 Drifting to right	11
334 Drinking in vehicle	3
117 Driving in circles	1
103 Driving in middle of roadway	3
100 Driving in opposing lane	70
116 Driving in parking lane	5
106 Driving off roadway	50
105 Driving on edge of roadway	4
96 Driving on lane marker	17
97 Driving on median	13
119 Driving on other than designated roadway	17
107 Driving on shoulder	44
111 Driving over curb	17
140 Driving straight from turn only lane	10
276 Driving vehicle erratically	13
278 Driving with excess caution	3
78 Driving with interior light	1
94 Driving with left tires on centerline	18
170 Driving with vehicle defect	70
77 Driving with 4-way flashers	1
75 Driving without headlights	54

TABLE A2 (Continued)

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
69 Driving wrong way on one way street	34
72 Exiting improperly from driveway	10
80 Failing to dim high-beams	12
327 Failing to heed police directions	8
313 Failing to respond to change in traffic signals	4
320 Failing to respond to police signals	91
264 Failing to signal turn or lane change	21
66 Failing to slow for caution light	6
65 Failing to stop for red light	81
67 Failing to stop for stop sign	39
265 Failing to yield during lane change	29
322 Failing to yield row (unspecified)	3
323 Failing to yield row at intersection	5
324 Failing to yield row to oncoming traffic	4
325 Failing to yield to pedestrians	1
335 Falling from vehicle	5
53 Fishtailing	7
79 Flashing headlights	2
68 Following too closely	16
362 Forcing oncoming traffic to swerve	6
280 Forcing other vehicles off road	10
279 Forcing police vehicle off road	7
341 Gesturing obscenely to police	3
58 Impeding traffic	16
338 Leaving vehicle with lights/engine on	2
283 Losing Control	5
255 Parking for no apparent reason	5
272 Passing improperly	15
373 Pushing disabled vehicle	1
282 Pushing stopped vehicle into intersection	1
348 Racing engine	2

TABLE A2 (Continued)

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
290 Rocking vehicle back and forth	2
340 Shooting at police	1
263 Signalling constantly	3
260 Signalling inconsistent with driving act	5
34 Slow speed (more than 40 under limit)	3
46 Slow speed (unspecified)	40
26 Slow speed (0-5 under limit)	6
28 Slow speed (11-15 under limit)	15
29 Slow speed (16-20 under limit)	19
30 Slow speed (21-25 under limit)	6
31 Slow speed (26-39 under limit)	7
32 Slow speed (31-35 under limit)	4
33 Slow speed (36-40 under limit)	2
27 Slow speed (6-10 under limit)	16
307 Slow to respond to change in traffic signals	16
305 Slow to respond to police signals	73
36 Speeding (approaching signal)	5
25 Speeding (more than 40 over limit)	8
35 Speeding (unspecified)	94
17 Speeding (0-5 over limit)	6
19 Speeding (11-15 over limit)	60
20 Speeding (16-20 over limit)	48
21 Speeding (21-25 over limit)	26
22 Speeding (26-30 over limit)	14
23 Speeding (31-35 over limit)	8
18 Speeding (6-10 over limit)	45
70 Speeding for conditions	1
57 Speeding past police vehicle	7
37 Speeding through intersection	7
240 Stalling while accelerating	7
141 Starting turn then going straight	4

TABLE A2 (Continued)

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
233 Steering motions jerky	30
201 Stopping across lane(s)	5
206 Stopping and continuing to roll	9
205 Stopping and starting again	3
208 Stopping for flashing yellow traffic signal	2
207 Stopping for green lights	10
218 Stopping for no apparent reason	8
202 Stopping in crosswalk	3
203 Stopping in intersection	18
376 Stopping in prohibited zone	3
200 Stopping in traffic lane	29
371 Stopping on shoulder	3
224 Stopping short of intersection	2
210 Stopping suddenly	31
222 Stopping suddenly for police signals	7
257 Stopping vehicle with difficulty	2
213 Stopping 12-24" from curb	7
214 Stopping 25-48" from curb	5
215 Stopping 49-72" from curb	3
216 Stopping 73-96" from curb	1
14 Straddling centerline	84
16 Straddling lanes	156
297 Striking another moving vehicle	5
300 Striking curb	33
148 Striking curb after turning	3
302 Striking median	2
298 Striking parked vehicle	2
296 Striking police vehicle	3
301 Striking signal/wall/building/object	5
194 Swerving to avoid collision	3
197 Swerving (unspecified)	4

TABLE A2 (Continued)

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
363 Swerving across centerline	32
186 Swerving across lanes	28
187 Swerving back and forth	21
189 Swerving back to lane	61
365 Swerving lane to lane	20
188 Swerving on and off roadway	4
190 Swerving onto shoulder	15
191 Swerving toward curb	23
192 Swerving toward parked vehicles	3
120 Turning (wide turn)	46
145 Turning abruptly/sharply	8
147 Turning across corner	9
143 Turning erratically	3
130 Turning from wrong lane	16
127 Turning illegally on red light	10
129 Turning improperly (unspecified)	30
138 Turning into oncoming traffic	7
125 Turning left illegally	8
157 Turning over curb	6
146 Turning slowly	8
126 Turning U illegally	8
152 Turning U suddenly	6
142 Turning with excessive speed	10
51 Varying speed	27
333 Waving at police	1
10 Weaving across centerline	43
13 Weaving and speeding (unspecified)	4
3 Weaving from lane to shoulder	38
8 Weaving from shoulder to shoulder	18
1 Weaving in lane	293
2 Weaving in middle of roadway	5

TABLE A2 (Continued)

Cues from DWI Arrest Reports, Listed in Alphabetical Order

CUE NUMBER AND NAME	FREQUENCY
4 Weaving lane to lane	170
7 Weaving with erratic vehicle movement	16

TABLE A3

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	*FREQUENCY*
1 Weaving in lane	293
60 Crossing centerline	208
4 Weaving lane to lane	170
16 Straddling lanes	156
161 Almost striking police vehicle	113
35 Speeding (unspecified)	94
320 Failing to respond to police signals	91
14 Straddling centerline	84
65 Failing to stop for red light	81
41 Accelerating rapidly forward	73
305 Slow to respond to police signals	73
100 Driving in opposing lane	70
170 Driving with vehicle defect	70
189 Swerving back to lane	61
19 Speeding (11-15 over limit)	60
75 Driving without headlights	54
106 Driving off roadway	50
20 Speeding (16-20 over limit)	48
120 Turning (wide turn)	46
18 Speeding (6-10 over limit)	45
107 Driving on shoulder	44
10 Weaving across centerline	43
46 Slow speed (unspecified)	40
67 Failing to stop for stop sign	39
3 Weaving from lane to shoulder	38
69 Driving wrong way on one way street	34
63 Crossing lane marker	33
300 Striking curb	33
363 Swerving across centerline	32
210 Stopping suddenly	31
233 Steering motions jerky	30

TABLE A3 (Continued)

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	*FREQUENCY*
129 Turning improperly (unspecified)	30
265 Failing to yield during lane change	29
200 Stopping in traffic lane	29
163 Almost striking parked vehicle	28
186 Swerving across lanes	28
51 Varying speed	27
21 Speeding (21-25 over limit)	26
55 Breaking traction	25
82 Drifting across lane(s)	25
191 Swerving toward curb	23
264 Failing to signal turn or lane change	21
187 Swerving back and forth	21
328 Attempting to elude police	20
365 Swerving lane to lane	20
165 Almost striking curb	19
29 Slow speed (16-20 under limit)	19
162 Almost striking another moving vehicle	18
92 Drifting across centerline	18
94 Driving with left tires on centerline	18
203 Stopping in intersection	18
8 Weaving from shoulder to shoulder	18
96 Driving on lane marker	17
119 Driving on other than designated roadway	17
111 Driving over curb	17
84 Drifting lane to lane	16
86 Drifting onto shoulder	16
68 Following too closely	16
58 Impeding traffic	16
27 Slow speed (6-10 under limit)	16
307 Slow to respond to change in traffic signal	16
130 Turning from wrong lane	16

TABLE A3 (Continued)

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	*FREQUENCY*
7 Weaving with erratic vehicle movement	16
272 Passing Improperly	15
28 Slow speed (11-15 under limit)	15
190 Swerving onto shoulder	15
22 Speeding (26-30 over limit)	14
97 Driving on median	13
276 Driving vehicle erratically	13
80 Failing to dim high-beams	12
167 Almost striking median	11
89 Drifting to right	11
331 Appearing to be drunk	10
64 Crossing lanes improperly	10
140 Driving straight from turn only lane	10
72 Exiting improperly from driveway	10
280 Forcing other vehicles off road	10
207 Stopping for green light	10
127 Turning illegally on red light	10
142 Turning with excessive speed	10
206 Stopping and continuing to roll	9
147 Turning across corner	9
164 Almost striking oncoming vehicle	8
166 Almost striking sign/object/wall/building	8
83 Drifting in lane	8
327 Failing to heed police directions	8
25 Speeding (more than 40 over limit)	8
23 Speeding (31-35 over limit)	8
218 Stopping for no apparent reason	8
145 Turning abruptly/sharply	8
125 Turning left illegally	8
146 Turning slowly	8
126 Turning U illegally	8

TABLE A3 (Continued)

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	*FREQUENCY*
53 Fishtailing	7
279 Forcing police vehicle off road	7
31 Slow speed (26-30 Under limit)	7
57 Speeding past police vehicle	7
37 Speeding through intersection	7
240 Stalling while accelerating	7
222 Stopping suddenly for police signals	7
213 Stopping 12-24" from curb	7
138 Turning into oncoming traffic	7
266 Changing lanes abruptly	6
56 Drag Racing	6
91 Drifting onto centerline	6
66 Failing to slow for caution light	6
362 Forcing oncoming traffic to swerve	6
26 Slow speed (0-5 under limit)	6
30 Slow speed (21-25 under limit)	6
17 Speeding (0-5 over limit)	6
157 Turning over curb	6
152 Turning U suddenly	6
253 Backing improperly (unspecified)	5
366 Backing into traffic	5
252 Backing on roadway	5
258 Braking erratically	5
350 Changing places w/passenger	5
88 Drifting to left	5
116 Driving in parking lane	5
323 Failing to yield row at intersection	5
335 Falling from vehicle	5
283 Losing control	5
255 Parking for no apparent reason	5
260 Signalling inconsistant with driving act	5

TABLE A3 (Continued)

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	*FREQUENCY*
36 Speeding (approaching signal)	5
201 Stopping across lane(s)	5
214 Stopping 25-48" from curb	5
297 Striking another moving vehicle	5
301 Striking signal/wall/building/object	5
2 Weaving in middle of roadway	5
44 Decelerating rapidly	4
105 Driving on edge of roadway	4
313 Failing to respond to change in traffic signal	4
324 Failing to yield row to oncoming traffic	4
32 Slow speed (31-35 under limit)	4
141 Starting turn then going straight	4
197 Swerving (unspecified)	4
188 Swerving on and off roadway	4
13 Weaving and speeding (unspecified)	4
52 Accelerating for no apparent reason	3
43 Accelerating rapidly backward	3
286 Almost falling from vehicle	3
268 Changing lanes within intersection	3
49 Decelerating slowly	3
85 Drifting (unspecified)	3
334 Drinking in vehicle	3
103 Driving in middle of roadway	3
278 Driving with excess caution	3
322 Failing to yield right of way (unspecified)	3
341 Gesturing obscenely to police	3
263 Signaling constantly	3
34 Slow speed (more than 40 under limit)	3
205 Stopping and starting again	3
202 Stopping in crosswalk	3
376 Stopping in prohibited zone	3

TABLE A3 (Continued)

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	FREQUENCY
371 Stopping on shoulder	3
215 Stopping 49-72" from curb	3
148 Striking curb after turning	3
296 Striking police vehicle	3
194 Swerving to avoid collision	3
192 Swerving toward parked vehicles	3
143 Turning erratically	3
212 Almost stopping in lane	2
160 Almost striking police officer	2
342 Blowing horn at police	2
343 Blowing horn for no reason	2
259 Braking for no apparent reason	2
79 Flashing headlights	2
338 Leaving vehicle with lights/engine on	2
348 Racing engine	2
290 Rocking vehicle back and forth	2
33 Slow speed (36-40 under limit)	2
208 Stopping for flashing yellow traffic signal	2
224 Stopping short of intersection	2
257 Stopping vehicle with difficulty	2
302 Striking median	2
298 Striking parked vehicle	2
168 Almost striking bicyclist	1
117 Driving in circles	1
78 Driving with interior light	1
77 Driving with 4-way flashers	1
325 Failing to yield to pedestrians	1
373 Pushing disabled vehicle	1
282 Pushing stopped vehicle into intersection	1
340 Shooting at police	1
70 Speeding for conditions	1

TABLE A3 (Continued)

Cues from DWI Arrest Reports, Listed by Frequency of Occurrence

CUE NUMBER AND NAME	*FREQUENCY*
216 Stopping 73-96" from curb	1
333 Waving at police	1

TABLE A4

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	FREQUENCY
1 Weaving in lane	293
2 Weaving in middle of roadway	5
3 Weaving from lane to shoulder	38
4 Weaving lane to lane	170
7 Weaving with erratic vehicle	16
8 Weaving from shoulder to shoulder	18
10 Weaving across centerline	43
13 Weaving and speeding (unspecified)	4
14 Straddling centerline	84
16 Straddling lanes	156
17 Speeding (0-5 over limit)	6
18 Speeding (6-10 over limit)	45
19 Speeding (11-15 over limit)	60
20 Speeding (16-20 over limit)	48
21 Speeding (21-25 over limit)	26
22 Speeding (26-30) over limit)	14
23 Speeding (31-35 over limit)	8
25 Speeding (more than 40 over limit)	8
26 Slow speed (0-5 under limit)	6
27 Slow speed (6-10 under limit)	16
28 Slow speed (11-15 under limit)	15
29 Slow speed (16-20 under limit)	19
30 Slow speed (21-25 under limit)	6
31 Slow speed (26-30 under limit)	7
32 Slow speed (31-35 under limit)	4
33 Slow speed (36-40 under limit)	2
34 Slow speed (more than 40 under limit)	3
35 Speeding (unspecified)	94
36 Speeding (approaching signal)	5
37 Speeding through intersection	7

TABLE A4 (Continued)

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	*FREQUENCY*
41 Accelerating rapidly forward	73
43 Accelerating rapidly backward	3
44 Decelerating rapidly	4
46 Slow speed (unspecified)	40
49 Decelerating slowly	3
51 Varying speed	27
52 Accelerating for no apparent reason	3
53 Fishtailing	7
55 Breaking traction	25
56 Drag racing	6
57 Speeding past police vehicle	7
58 Impeding traffic	16
60 Crossing centerline	208
63 Crossing lane marker	33
64 Crossing lanes improperly	10
65 Failing to stop for red light	81
66 Failing to slow for caution light	6
67 Failing to stop for stop sign	39
68 Following too closely	16
69 Driving wrong way on one way street	34
70 Speeding for conditions	1
72 Exiting improperly from driveway	10
75 Driving without headlights	54
77 Driving with 4-way flashes	1
78 Driving with interior light	1
79 Flashing headlights	2
80 Failing to dim high-beams	12
82 Drifting across lane(s)	25
83 Drifting in lane	8
84 Drifting lane to lane	16

TABLE A4 (Continued)

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	FREQUENCY
85 Drifting (unspecified)	3
86 Drifting onto shoulder	16
88 Drifting to left	5
89 Drifting to right	11
91 Drifting onto centerline	6
92 Drifting across centerline	18
94 Driving with left tires on centerline	18
96 Driving on lane markers	17
97 Driving on median	13
100 Driving in opposing lane	70
103 Driving in middle of roadway	3
105 Driving on edge of roadway	4
106 Driving off roadway	50
107 Driving on shoulder	44
111 Driving over curb	17
116 Driving in parking lane	5
117 Driving in circles	1
119 Driving on other than designated roadway	17
120 Turning (wide turn)	46
125 Turning left illegally	8
126 Turning U illegally	8
127 Turning illegally on red light	10
129 Turning improperly &unspecified)	30
130 Turning from wrong lane	16
138 Turning into oncoming traffic	7
140 Driving straight from turn only lane	10
141 Starting turn then going straight	4
142 Turning with excessive speed	10
143 Turning erratically	3
145 Turning abruptly/sharply	8

TABLE A4 (Continued)

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	*FREQUENCY*
146 Turning slowly	8
147 Turning across corner	9
148 Striking curb after turning	3
152 Turning U suddenly	6
157 Turning over curb	6
160 Almost striking police officer	2
161 Almost striking police vehicle	113
162 Almost striking another moving vehicle	18
163 Almost striking parked vehicle	28
164 Almost striking oncoming vehicle	8
165 Almost striking curb	19
166 Almost striking sign/object/wall/building	8
167 Almost striking median	11
168 Almost striking bicyclist	1
170 Driving with vehicle defect	70
186 Swerving across lanes	28
187 Swerving back and forth	21
188 Swerving on and off roadway	4
189 Swerving back to lane	61
190 Swerving onto shoulder	15
191 Swerving toward curb	23
192 Swerving toward parked vehicles	3
194 Swerving to avoid collision	3
197 Swerving (unspecified)	4
200 Stopping in traffic lane	29
201 Stopping across lane(s)	5
202 Stopping in crosswalk	3
203 Stopping in intersection	18
205 Stopping and starting again	3
206 Stopping and continuing to roll	9

TABLE A4 (Continued)

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	FREQUENCY
207 Stopping for green light	10
208 Stopping for flashing yellow traffic signal	2
210 Stopping suddenly	31
212 Almost stopping lane	2
213 Stopping 12-24" from curb	7
214 Stopping 25-48" from curb	5
215 Stopping 49-72" from curb	3
216 Stopping 73-96" from curb	1
218 Stopping for no apparent reason	8
222 Stopping suddenly for police signals	7
224 Stopping short of intersection	2
233 Steering motions jerky	30
240 Stalling while accelerating	7
252 Backing on roadway	5
253 Backing improperly (unspecified)	5
255 Parking for no apparent reason	5
257 Stopping vehicle with difficulty	2
258 Braking erratically	5
259 Braking for no apparent reason	2
260 Signalling inconsistent with driving act	5
263 Signalling constantly	3
264 Failing to signal turn of lane change	21
265 Failing to yield during lane change	29
266 Changing lanes abruptly	6
268 Changing lanes within intersection	3
272 Passing improperly	15
276 Driving vehicle erratically	13
278 Driving with excessive caution	3
279 Forcing police vehicle off road	7
280 Forcing other vehicles off road	10

TABLE A4 (Continued)

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	FREQUENCY
282 Pushing stopped vehicle into intersection	1
283 Losing control	5
286 Almost falling from vehicle	3
290 Rocking vehicle back and forth	2
296 Striking police vehicle	3
297 Striking another moving vehicle	5
298 Striking parked vehicle	2
300 Striking curb	33
301 Striking signal/wall/bldg/object	5
302 Striking median	2
305 Slow to respond to police signals	73
307 Slow to respond to change in traffic signal	16
313 Failing to respond to change in traffic signal	4
320 Failing to respond to police signals	91
322 Failing to yield row (unspecified)	3
323 Failing to yield row at intersection	5
324 Failing to yield row to oncoming traffic	4
325 Failing to yield to pedestrians	1
327 Failing to heed police directions	8
328 Attempting to elude police	20
331 Appearing to be drunk	10
333 Waving at police	1
334 Drinking in vehicle	3
335 Falling from vehicle	5
338 Leaving vehicle with lights/engine on	2
340 Shooting at police	1
341 Gesturing obscenely to police	3
342 Blowing horn at police	2
343 Blowing horn for no reason	2
348 Racing engine	2

TABLE A4 (Continued)

Cues from DWI Arrest Reports, Listed in Order of Cue Number

CUE NUMBER AND NAME	*FREQUENCY*
350 Changing places w/passenger	5
362 Forcing oncoming traffic to swerve	6
363 Swerving across centerline	32
365 Swerving lane to lane	20
366 Backing into traffic	5
371 Stopping on shoulder	3
373 Pushing disabled vehicle	1
376 Stopping in prohibited zone	3

TABLE A5

Co-Occurrence of Cues from DWI Arrest Reports

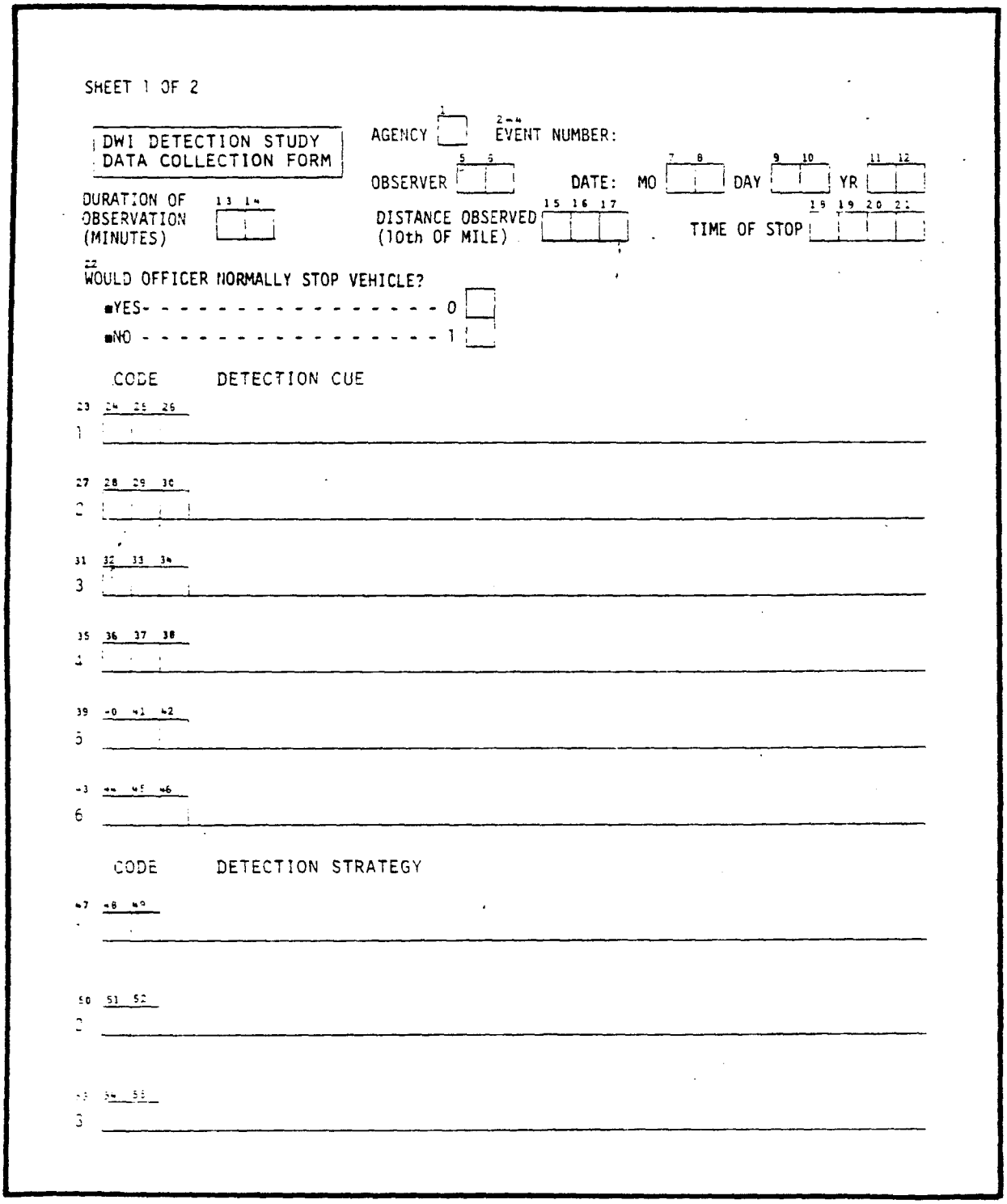
Cues listed co-occurred 10 times or more and had a percentage of co-occurrence of 20 or more. The number in parentheses after the first-listed cue is the total frequency of occurrence of that cue.

CUE NUMBER AND NAME	*FREQUENCY OF CO-OCCURRENCE*	*PERCENTAGE OF CO-OCCURRENCE*
86 Drifting onto shoulder (22)		
189 Swerving back to lane	13	*59*
106 Driving off roadway (56)		
60 Crossing centerline	29	*52*
1 Weaving in lane	12	*21*
16 Straddling lanes (164)		
1 Weaving in lane	79	*48*
51 Varying speed (31)		
1 Weaving in lane	13	*42*
107 Driving on shoulder (46)		
60 Crossing centerline	18	*39*
1 Weaving in lane	11	*24*
129 Turning improperly - unspecified (34)		
16 Straddling lanes	13	*38*
1 Weaving in lane	12	*35*
63 Crossing lane marker (33)		
1 Weaving in lane	10	*30*
320 Failing to respond to police signals (109)		
60 Crossing centerline	29	*27*
1 Weaving in lane	23	*21*

TABLE A5 (Continued)

Co-Occurrence of Cues from DWI Arrest Reports

CUE NUMBER AND NAME	FREQUENCY OF CO-OCCURRENCE	PERCENTAGE OF CO-OCCURRENCE
120 Turning - wide turn (48)		
60 Crossing centerline	13	27
1 Weaving in lane (309)		
16 Straddling lanes	79	26
14 Straddling centerline (86)		
1 Weaving in lane	22	26
305 Slow to respond to police signals (73)		
60 Crossing centerline	19	26
4 Weaving lane-to-lane	17	23
1 Weaving in lane	16	22
19 Speeding 11-15 MPH over limit (60)		
1 Weaving in lane	15	25
60 Crossing centerline (240)		
1 Weaving in lane	60	25
46 Slow speed - unspecified (42)		
60 Crossing centerline	10	24
100 Driving in opposing lane (70)		
1 Weaving in lane	16	23
60 Crossing centerline	15	21
67 Failing to stop for stop sign (47)		
41 Accelerating rapidly forward	10	21
189 Swerving back to lane (81)		
4 Weaving lane-to-lane	16	20



SHEET 1 OF 2

DWI DETECTION STUDY
DATA COLLECTION FORM

AGENCY [1] EVENT NUMBER: [2-4]

OBSERVER [5 6] DATE: MO [7 8] DAY [9 10] YR [11 12]

DURATION OF OBSERVATION (MINUTES) [13 14]

DISTANCE OBSERVED (10th OF MILE) [15 16 17]

TIME OF STOP [18 19 20 21]

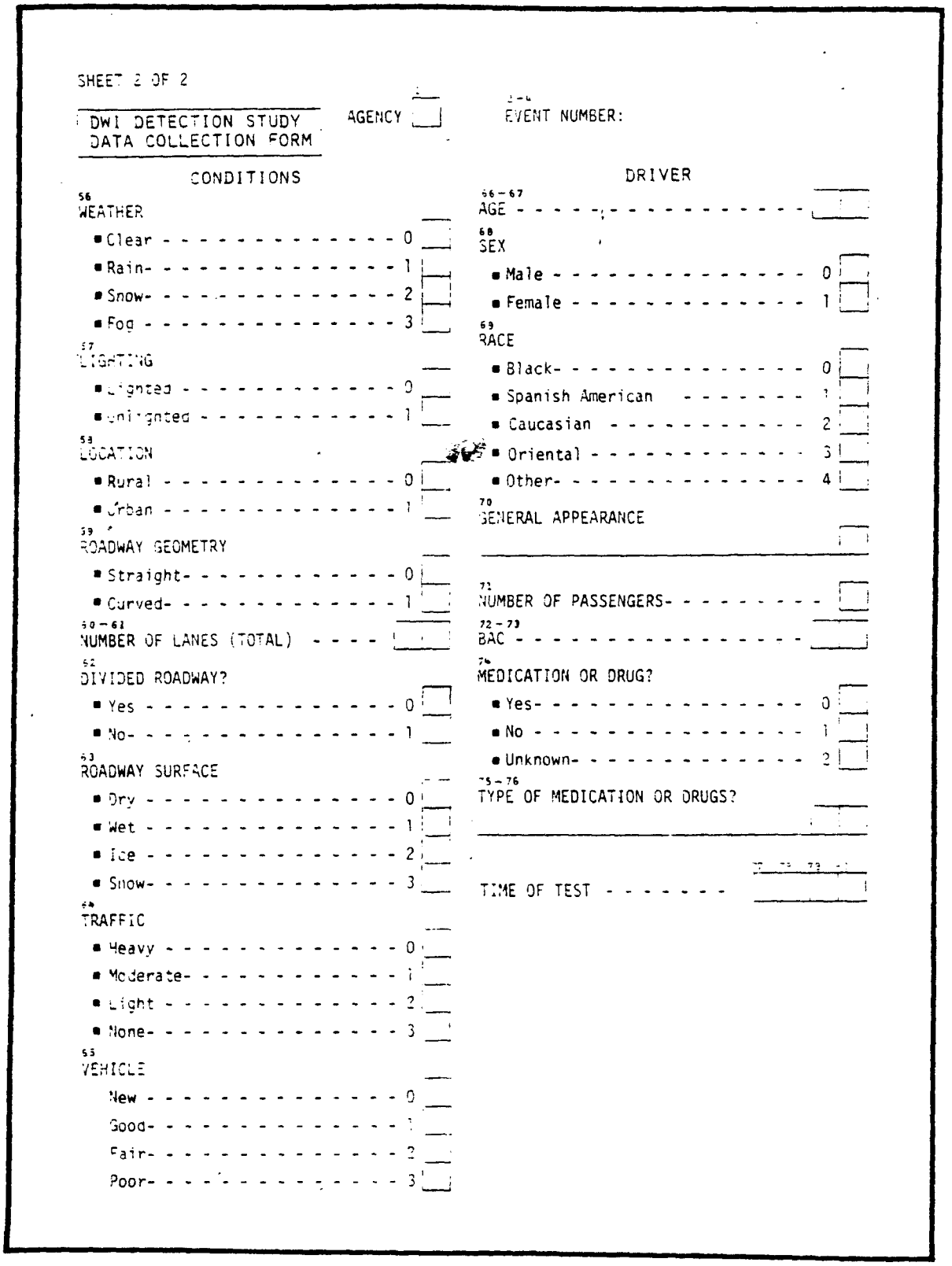
[22] WOULD OFFICER NORMALLY STOP VEHICLE?

- YES - - - - - - - - - - - - - - - - - 0 [ ]
- NO - - - - - - - - - - - - - - - - - - 1 [ ]

	CODE	DETECTION CUE
23 [24 25 26]		
1		
27 [28 29 30]		
2		
31 [32 33 34]		
3		
35 [36 37 38]		
4		
39 [40 41 42]		
5		
43 [44 45 46]		
6		

	CODE	DETECTION STRATEGY
47 [48 49]		
50 [51 52]		
7		
53 [54 55]		
8		

Figure A2. Data collection form for the on-the-road detection study.



SHEET 2 OF 2

DWI DETECTION STUDY
DATA COLLECTION FORM

AGENCY

EVENT NUMBER:

CONDITIONS

56 WEATHER
- Clear - 0
- Rain - 1
- Snow - 2
- Fog - 3

57 LIGHTING
- Lighted - 0
- Unlighted - 1

58 LOCATION
- Rural - 0
- Urban - 1

59 ROADWAY GEOMETRY
- Straight - 0
- Curved - 1

60-61 NUMBER OF LANES (TOTAL)

62 DIVIDED ROADWAY?
- Yes - 0
- No - 1

63 ROADWAY SURFACE
- Dry - 0
- Wet - 1
- Ice - 2
- Snow - 3

64 TRAFFIC
- Heavy - 0
- Moderate - 1
- Light - 2
- None - 3

65 VEHICLE
- New - 0
- Good - 1
- Fair - 2
- Poor - 3

DRIVER

66-67 AGE

68 SEX
- Male - 0
- Female - 1

69 RACE
- Black - 0
- Spanish American - 1
- Caucasian - 2
- Oriental - 3
- Other - 4

70 GENERAL APPEARANCE

71 NUMBER OF PASSENGERS

72-73 BAC

74 MEDICATION OR DRUG?
- Yes - 0
- No - 1
- Unknown - 2

75-76 TYPE OF MEDICATION OR DRUGS?

TIME OF TEST

Figure A2 (Continued). Data collection form for the on-the-road detection study.

TABLE A6

Characteristics of the On-the-Road Detection Study Sample

Characteristics of the detection-study sample (N=643) are provided below and, where data were available, compared with the DWI-arrest sample (N=1268).

CHARACTERISTIC	DETECTION STUDY N	%	ARREST REPORTS N	%
Blood Alcohol Concentration				
Less than 0.05	252	39	6	*
From 0.05 to 0.10	148	23	55	4
0.10 or greater	243	38	1227	96
Time of Stop/Arrest				
0001-0600	350	56	684	55
0601-1200	5	1	11	1
1201-1800	2	*	62	5
1801-2400	285	44	531	41
Distance Observed				
Less than 0.5 miles	269	42		
0.5 to 1.0 miles	202	31		
1.0 to 1.5 miles	107	17		
1.5 miles or greater	64	10		
Duration of Observation				
One minute or less	407	63		
Two minutes	132	21		
Three/four minutes	47	7		
Five minutes or more	55	9		
Would Officer Normally Stop Vehicle?				
Yes	499	78		
No	144	22		
Weather Conditions				
Clear	604	94		
Rain	38	6		
Fog	1	*		

TABLE A6 (Continued)

Characteristics of the On-the-Road Detection Study Sample.

CHARACTERISTIC	DETECTION STUDY N	%	ARREST REPORTS N	%
Lighting Conditions				
Lighted	500	78		
Unlighted	143	22		
Location				
Urban	568	89	1062	86
Rural	71	11	117	14
Roadway Geometry				
Straight	519	81		
Curved	122	19		
Number of Lanes				
One	6	1		
Two	228	36		
Three	7	1		
Four	290	45		
More than four	110	17		
Divided Roadway?				
Yes	238	37		
No	403	63		
Roadway Surface Condition				
Dry	581	90		
Wet/ice	62	10		
Traffic Condition				
Heavy	51	8		
Moderate	269	42		
Light	270	42		
None	52	8		

TABLE A6 (Continued)

Characteristics of the On-the-Road Detection Study Sample

CHARACTERISTIC	DETECTION STUDY N	DETECTION STUDY %	ARREST REPORTS N	ARREST REPORTS %
Vehicle Condition				
New	90	14		
Good	258	40		
Fair	199	31		
Poor	95	15		
Age of the Driver				
Under 25	333	52	349	27
25 to 35	180	28	385	30
35 to 45	76	12	266	21
45 and older	52	8	286	22
Sex of the Driver				
Male	567	88	1141	89
Female	76	12	147	11
Race of the Driver				
Caucasian	447	70	710	62
Black	168	26	166	14
Spanish American	19	3	255	22
Other	9	1	20	2
General Appearance of the Driver				
Neat	225	35		
Disheveled/sloppy	192	30		
Casual/relaxed	46	7		
Nervous/scared	32	5		
Disoriented	17	3		
Not described	131	20		
Number of Passengers				
None	167	27		
One	242	38		
Two	133	21		
More than two	87	14		

TABLE A6 (Continued)

Characteristics of the On-the-Road Detection Study Sample

CHARACTERISTIC	DETECTION STUDY N	%	ARREST REPORTS N	%
Medication or Drugs?				
Yes	25	4	177	14
No	188	29	911	71
No response	429	67	200	15

TABLE A7

Strategies/Circumstances Associated with DWI On-the-Road Detection

STRATEGY/CIRCUMSTANCE	*N*	*%*
General Patrol	334	*52*
DWI Patrol	154	*24*
General Patrol with DWI Emphasis	77	*12*
Traffic Patrol	20	*3*
Moving Surveillance in High Concentration Areas	14	*2*
Stationary Surveillance in High Concentration Areas	11	*2*
Returning to Patrol	10	*2*
Enroute to Station	9	*1*
Stationary Surveillance for Speed	8	*1*
Stopped at Traffic Signal/Sign	7	*1*
Enroute to Assist	6	*1*
Stationary Surveillance at Intersection	5	*1*
Alerted by Prior Knowledge/Contact	5	*1*
Moving Surveillance with Extended Observation of Vehicle	3	*
Alerted by Other Officer(s)	3	*
Moving Surveillance of Taverns/Clubs/Liquor Stores	2	*
Enroute to Call	2	*
Alerted by Citizen	1	*
Alerted by Police Dispatch	1	*
Stopped at Prior DWI Stop	1	*
Parked Completing Reports	1	*
Stationary Surveillance of Tavern/Club/Liquor Store	1	*
Enroute to Meal/Break	1	*

TABLE A8

Distribution of DWI Detection Cues from On-the-Road Detection Study

Cues are listed as they were observed in the sample of 643 detection events, in order of frequency of occurrence.

CUE NUMBER AND NAME	*FREQUENCY*
1 Weaving in lane	89
37 Driving with tires on lane marker	68
86 Speeding 11-20 MPH over limit	68
75 Failing to stop for red traffic signal	64
85 Speeding 0-10 MPH over limit	49
95 Slow to respond to police signals	45
38 Driving with vehicle defect(s)	42
20 Drifting across lane(s)	41
91 Slow speed 0-10 MPH under limit	41
82 Failing to signal turn or lane change	37
47 Turning with wide radius	35
97 Accelerating rapidly forward	34
36 Driving with left tires on centerline	33
113 Appearing to be drunk	30
121 Following too closely	29
45 Straddling lane marker	28
92 Slow speed 11-20 MPH under limit	28
2 Weaving lane to lane	27
10 Swerving back to lane	27
39 Driving without headlights on	27
59 Stopping abruptly	24
46 Straddling centerline	23
23 Drifting toward edge of roadway	22
22 Drifting in lane	21
87 Speeding 21-30 MPH over limit	21
104 Almost striking another moving vehicle	21
24 Drifting across centerline	19
27 Driving in opposing lane	19
76 Failing to stop for stop sign	19

TABLE A8 (Continued)

Distribution of DWI Detection Cues from On-the-Road Detection Study

CUE NUMBER AND NAME	*FREQUENCY*
119 Drinking in vehicle	18
127 Passing improperly/illegally	18
101 Accelerating and breaking traction	17
5 Weaving across centerline	16
28 Driving in center of roadway	16
83 Failure to dim high-beams	16
114 Attempting to elude police	16
133 Braking - riding brakes	16
61 Stopping in traffic lane	15
33 Driving on edge of roadway	15
21 Drifting lane to lane	14
110 Striking curb	14
48 Turning with excessive speed	12
88 Speeding more than 30 MPH over limit	12
107 Almost striking curb	12
73 Failing to respond to police signals	11
90 Speeding through intersection	11
96 Slow to respond to change in traffic signals	11
120 Exiting improperly from driveway	11
19 Swerving to avoid collision	10
40 Driving with jerky steering motions	10
62 Stopping in intersection	10
112 Striking sign/object/wall/building	10
9 Swerving lane to lane	9
31 Driving on other than designated roadway	9
55 Turning over curb	9
57 Turning slowly	9
65 Stopping short of intersection	9
74 Failing to respond to change in traffic signal	9
117 Decelerating rapidly	9
129 Signalling inconsistent with driving actions	9

TABLE A8 (Continued)

Distribution of DWI Detection Cues from On-the-Road Detection Study

CUE NUMBER AND NAME	FREQUENCY
130 Improper registration/inspection sticker	9
12 Swerving toward edge of roadway	8
44 Driving straight from turn-only lane	8
60 Stopping abruptly for police signals	8
79 Failing to yield to oncoming traffic	8
99 Accelerating and decelerating	8
134 Creating disturbance	8
8 Swerving in lane	7
49 Turning from wrong lane	7
102 Almost striking police vehicle	7
132 Braking unnecessarily	7
4 Weaving across lane(s)	6
25 Drifting onto shoulder	6
43 Driving wrong way on one-way street	6
56 Turning abruptly/sharply	6
66 Stopping on shoulder	6
124 Forcing other vehicles to swerve	6
125 Gesturing obscenely to police	6
3 Weaving lane to shoulder	5
52 Turning U illegally	5
58 Turning into oncoming traffic	5
63 Stopping in prohibited zone	5
71 Stopping for green signal	5
89 Speeding (excess for conditions)	5
122 Forcing other vehicles off roadway	5
7 Weaving shoulder to shoulder (curb to curb)	4
11 Swerving across lane(s)	4
34 Driving off roadway	4
35 Driving over curb	4
41 Driving with interior lights on	4
69 Stopping 25-48" from curb	4
93 Slow speed 21-30 MPH under limit	4

TABLE A8 (Continued)

Distribution of DWI Detection Cues from On-the-Road Detection Study

CUE NUMBER AND NAME	*FREQUENCY*
108 Almost striking median	4
111 Striking median	4
137 Striking vehicle	4
126 Impeding traffic	4
18 Swerving back and forth	3
42 Driving with 4-way flashers on	3
139 Driving overly cautious	3
50 Turning illegally on red light	3
131 Appearing to be lost	3
6 Weaving in center of roadway with no centerline	2
32 Driving on median	2
53 Turning U abruptly	2
68 Stopping 12-24" from curb	2
77 Failing to slow for caution signal	2
80 Failing to yield ROW at intersection	2
84 Failing to heed police directions	2
103 Almost striking parked vehicle/bicycle	2
109 Almost striking sign/object/wall/building	2
115 Backing into traffic	2
143 Exiting abruptly from highway	2
136 Racing contest	2
140 Waving at police officer	2
13 Swerving onto shoulder	1
14 Swerving on and off roadway	1
16 Swerving onto median	1
17 Swerving across centerline	1
30 Driving on shoulder	1
142 Driving w/top down in rain	1
145 Driving w/windshield wipers on clear day	1
64 Stopping in crosswalk	1
67 Stopping across lane(s)	1

TABLE A8 (Continued)

Distribution of DWI Detection Cues from On-the-Road Detection Study

CUE NUMBER AND NAME	FREQUENCY
72 Stopping for flashing yellow signal	1
141 Stopping on walkway	1
78 Failing to yeild during lane change	1
81 Failing to yield to pedestrians	1
138 Failing to wear cycle helmet	1
135 Almost striking pedestrian	1
116 Backing on roadway	1
118 Decelerating slowly	1
123 Forcing police vehicle off roadway	1
128 Signalling constantly	1
144 Driving wanted vehicle	1

TABLE A9

Co-Occurrence of Cues from On-the-Road Detection Study

Cues listed co-occurred 10 times or more and had a percentage of co-occurrence of 20 or more. The number in parentheses after the first listed cue is the total frequency of occurrence of that cue.

CUE NUMBER AND NAME	*FREQUENCY OF CO-OCCURRENCE*	*PERCENTAGE OF CO-OCCURRENCE*
R12 Straddling lane marker (28)		
R5 Drifting beyond lane	13	*46*
R11 Driving with tires on lane marker	12	*43*
R11 Driving with tires on lane marker (68)		
R5 Drifting beyond lane	28	*41*
R1 Weaving in lane	25	*37*
R3 Swerving beyond lane (49)		
R5 Drifting beyond lane	16	*33*
R5 Drifting beyond lane (87)		
R11 Driving with tires on lane marker	28	*32*
R1 Weaving in lane	22	*25*
R1 Weaving in lane (89)		
R11 Driving with tires on lane marker	25	*28*
R5 Drifting beyond lane	22	*25*
R7 Driving on other than designated roadway (42)		
R28 Appearing to be drunk	10	*24*
R21 Failing to respond to traffic signals or signs (85)		
R23 Speeding more than 10 MPH over limit	18	*21*

TABLE A10

Redefined DWI Detection Cues

Frequencies of occurrence in the sample of 641 detection events are shown in the parentheses. The frequency of occurrence of a redefined cue does not necessarily equal the sum of the frequencies of occurrence of the observed cues of which it is made up, because two or more old cues might have occurred in the same detection event.

REDEFINED CUE NUMBER & NAME	*OBSERVED CUE NUMBER & NAME*
R1 Weaving in lane (89)	1 Weaving in lane (89)
R2 Weaving beyond lane (56)	2 Weaving lane to lane (27) 3 Weaving lane to shoulder (5) 4 Weaving across lane(s) (6) 5 Weaving across centerline (16) 6 Weaving in center of roadway with no centerline (2) 7 Weaving shoulder to shoulder (curb to curb) (4)
R3 Swerving beyond lane (49)	9 Swerving lane to lane (9) 10 Swerving back to lane (27) 11 Swerving across lane(s) (4) 12 Swerving toward edge of roadway (8) 13 Swerving onto shoulder (1) 14 Swerving on and off roadway (1) 16 Swerving onto median (1) 17 Swerving across centerline (1)
R4 Drifting in lane (21)	22 Drifting in lane (21)
R5 Drifting beyond lane (87)	20 Drifting across lane(s) (41) 21 Drifting lane to lane (14) 23 Drifting toward edge of roadway (22) 24 Drifting across centerline (19) 25 Drifting onto shoulder (6)
R6 Driving into opposing/crossing traffic (37)	27 Driving in opposing lane (19) 43 Driving wrong way on one-way street (6) 79 Failing to yield to oncoming traffic (8) 80 Failing to yield ROW at intersection (2) 115 Backing into traffic (2)
R7 Driving on other than designated roadway (42)	30 Driving on shoulder (1) 31 Driving on other than designated roadway (9) 32 Driving on median (2)

TABLE A10 (Continued)

Redefined DWI Detection Cues

REDEFINED CUE NUMBER AND NAME	*OBSERVED CUE NUMBER AND NAME*
R7 (Continued)	33 Driving on edge of roadway (15)
	34 Driving off roadway (4)
	35 Driving over curb (4)
	44 Driving straight from turn-only lane (8)
R8 Driving with vehicle defect(s) (42)	38 Driving with vehicle defect(s) (42)
R9 Driving without headlights on (27)	39 Driving without headlights on (27)
R10 Driving with left tires on centerline (33)	36 Driving with left tires on center-line (33)
R11 Driving with tires on lane marker (68)	37 Driving with tires on lane marker (68)
R12 Straddling lane marker (28)	45 Straddling lane marker (28)
R13 Straddling centerline (37)	28 Driving in center of roadway (16)
	46 Straddling centerline (23)
R14 Turning with wide radius (35)	47 Turning with wide radius (35)
R15 Turning rapidly/abruptly (20)	48 Turning with excessive speed (12)
	53 Turning U abruptly (2)
	56 Turning abruptly/sharply (6)
R16 Turning illegally (28)	49 Turning from wrong lane (7)
	50 Turning illegally on red light (3)
	52 Turning U illegally (5)
	55 Turning over curb (9)
	58 Turning into oncoming traffic (5)
R17 Stopping abruptly (24)	59 Stopping abruptly (24)
R18 Stopping in traffic lane (29)	61 Stopping in traffic lane (15)
	62 Stopping in intersection (10)
	126 Impeding traffic (4)
R19 Stopping inappropriately other than in traffic lane (33)	63 Stopping in prohibited zone (5)
	64 Stopping in cross walk (1)
	65 Stopping short of intersection (9)
	66 Stopping on shoulder (6)
	67 Stopping across lane(s) (1)

TABLE A10 (Continued)

Redefined DWI Detection Cues

REDEFINED CUE NUMBER AND NAME	*OBSERVED CUE NUMBER AND NAME*
R19 (Continued)	68 Stopping 12-24" from curb (2)
	69 Stopping 25-48" from curb (4)
	71 Stopping for green signal (5)
	72 Stopping for flashing yellow signal (1)
	141 Stopping on walkway (1)
R20 Slow to respond to change in traffic signals (20)	74 Failing to respond to change in traffic signal (9)
	96 Slow to respond to change in traffic signals (11)
R21 Failing to respond to traffic signals or signs (85)	75 Failing to stop for red traffic signal (64)
	76 Failing to stop for stop sign (19)
	77 Failing to slow for caution signal (2)
R22 Signalling inconsistent with driving actions (49)	42 Driving with four-way flashers on (3)
	82 Failing to signal turn or lane change (37)
	128 Signalling constantly (1)
	129 Signalling inconsistent with driving actions (9)
R23 Speeding more than 10 MPH over limit (101)	86 Speeding 11-20 MPH over limit (68)
	87 Speeding 21-30 MPH over limit (21)
	88 Speeding more than 30 MPH over limit (12)
R24 Slow speed more than 10 MPH under limit (32)	92 Slow speed 11-20 MPH under limit (28)
	93 Slow speed 21-30 MPH under limit (4)
R25 Accelerating/decelerating rapidly (57)	97 Accelerating rapidly forward (34)
	99 Accelerating and decelerating (8)
	101 Accelerating and breaking traction (17)
	117 Decelerating rapidly (9)
R26 Almost striking moving vehicle (35)	19 Swerving to avoid collision (10)
	104 Almost striking another moving vehicle (21)
	122 Forcing other vehicles off roadway (5)
	123 Forcing police vehicle off roadway (1)
	124 Forcing other vehicles to swerve (6)
R27 Almost striking stationary object (27)	102 Almost striking police vehicle (7)
	103 Almost striking parked vehicle/ bicycle (2)

TABLE A10 (Continued)

Redefined DWI Detection Cues

REDEFINED CUE NUMBER AND NAME	*OBSERVED CUE NUMBER AND NAME*
R27 (Continued)	107 Almost striking curb (12) 108 Almost striking median (4) 109 Almost striking sign/object/wall/ building (2)
R28 Driver appearing to be drunk (57)	113 Appearing to be drunk (30) 119 Drinking in vehicle (18) 125 Gesturing obscenely to police (6) 134 Creating disturbance (8) 140 Waving at police officer (2)
R29 Following too closely (29)	121 Following too closely (29)
R30 Braking erratically (23)	132 Braking unnecessarily (7) 133 Braking - riding brakes (16)