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DELINEATION OF HAZARDS FOR OLDER DRIVERS VOLUME 2. APPENDIXES

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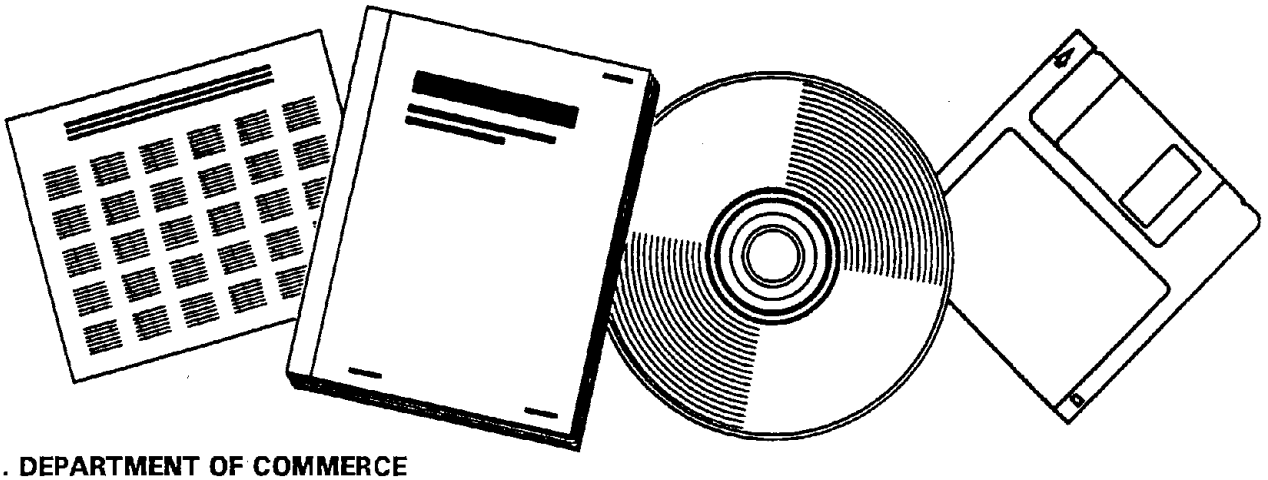

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Delineation of Hazards for Older Drivers

Volume II: Appendixes

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U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

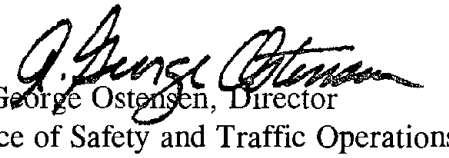
FOREWORD

The proportion of the driving population over age 65 is growing significantly. Older motorists can be expected to have problems in detecting and comprehending hazardous situations, given the known changes in their sensory, perceptual, cognitive, and psychomotor performances.

Object markers serve an important function and are intended to delineate obstructions within or adjacent to the roadway. They are applied to numerous situations where an object cannot be removed or protected, but could cause injury or damage to a vehicle if hit. Unfortunately, the exact meaning of object markers has become unclear over the years.

The research documented in this report identified drivers' problems with the conspicuity, recognizability, and comprehensibility of object markers. Through laboratory and field studies, a number of different static and dynamic markers were evaluated for their effectiveness and a cost-benefit analysis was conducted.

The information contained in this report should be of interest to highway designers, traffic engineers, and highway safety specialists involved in the design and operation of highway facilities.



A. George Ostensen, Director
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16. Abstract

The objective of this research project was to identify conspicuity, recognizability, and comprehensibility problems with object markers, particularly as they relate to the needs and capabilities of the older driver. This was accomplished through a series of tasks and three sets of experiments (problem identification, laboratory and field studies) which determined through empirical research the effect of selected enhancements on the design and implementation of current object markers. Specifically, emphasis was placed on optimizing the design and implementation of Type 1, Type 2, and Type 3 object markers in order to increase conspicuity, recognizability, and comprehension, while eliminating confusion with other devices. Changes including size, color, shape, placement, and symbology were investigated under daytime and nighttime conditions for various roadway geometries. Additionally, object markers employing active technology (e.g., flashing beacons) were evaluated for comprehension and conspicuity in a field setting. While the specific meanings of current markers were not necessarily well understood by subjects, the general message of caution, general hazard, or general warning was typically conveyed in a field setting. Findings from the studies of static markers did not produce results that strongly support the adoption of new markers over existing object markers. While novel markings generally led to higher conspicuity, the magnitude of this improvement was small and generally not statistically significant. Using the findings from the lab and field studies, a cost-benefit analysis found that for the passive markers, two of the new, novel markers (Double Modified Chevron and cone symbol) demonstrated good results when a high weight was placed on conspicuity. The device with the lowest benefit-cost payoff was the painted pavement hash marks. None of the additional costs of the active device applications were justified on the basis of the cost-benefit analysis. Recommendations for changes to the MUTCD were discussed and suggestions were made for future research.

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Hazard perception,TOD, signing, object markers, safety, research program, human factors, older drivers.	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
	ILLUMINATION			
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE and PRESSURE or STRESS			
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
	TEMPERATURE (exact)			
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE and PRESSURE or STRESS			
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

TABLE OF CONTENTS
Volume I

TABLE OF CONTENTS
Volume I (Continued)

LIST OF FIGURES
Volume I

LIST OF TABLES
Volume I

LIST OF TABLES
Volume I (Continued)

TABLE OF CONTENTS
Volume II

LIST OF TABLES
Volume II

INTRODUCTION

This volume of appendixes is a companion report to Volume I: *Delineation of Hazards for Older Drivers*. Volume I describes the entire project, presents the primary experimental findings, discusses the findings, and makes recommendations for revisions to the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD).[1] This volume provides supporting information and additional detail for the problem identification, laboratory and field experiments in the form of procedures.

Appendix A provides a list of interview questions submitted to the industry during the literature review.

Appendix B provides a table of traffic control device studies from the literature review.

Appendix C provides procedures for the problem identification, laboratory and field experiments.

APPENDIX A
LIST OF INTERVIEW QUESTIONS FROM LITERATURE REVIEW

1.a. What types of roadside conditions qualify as hazards? Why?

1.b. Which of these hazards warrant the use of object markers?

2.a. What are the current uses for hazardous object markers in your agency?

2.b. What types of markers are used for the roadside conditions previously described?

2.c. Does your agency use hazardous object markers in conjunction with other traffic control devices? If so, which ones?

3. How effective have the hazardous object markers employed by your agency been in improving the driving conditions of the roadways?

4. In your opinion, do you think that the average drivers understand the meaning of these signs?

5. Do you have any suggestions for alternative designs of the object markers currently in use?

6. Is there anything else you care to add or additional issues that our research should consider?

APPENDIX B
TABLE OF TRAFFIC CONTROL DEVICE STUDIES FROM LITERATURE REVIEW

Table 1. Traffic control device studies from literature review.

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Lerner, N (1991) (38) COMSIS report to AIGA	"Testing Protocols for ANSI Safety Symbols"	Laboratory	100 total (subgroup of general population, 18+ yrs, at least 1/3 55+ yrs); 25 view "old" symbols, 75 view "new" symbols	Booklets containing symbols, each page containing color image of one symbol	Safety symbols (42 "old" designs in one booklet, 42 "new" designs in another booklet) with two questions under each sign (meaning of?, response to?)	Measured percent of correct interpretations (completely correct, partially correct, incorrect, no answer given) and percent of critical confusions	Summary of types and frequency of wrong answers occurring for each symbol; Chi-square test to compare old and new designs
		Laboratory	30 total (subgroup of general population, all 18+ yrs, at least 1/3 55+ yrs); each subject views all 84 symbols	Scaled-down versions of signs (2-20 in) to simulate 12 in target at various distances; non-glossy surface	Safety symbols (42 "old" designs and 42 "new" designs)	Screen for 20/33 visual acuity; primary datum of interest was point at which subject identified all key graphic elements of the symbol (subject remained seated at distance of 25 ft from easel); subject viewed all 84 symbols (42 in each of two sessions)	Cumulative frequency plot for size/distance of full identification of all symbol elements; table of median and 85th percentile size/distance of full identification (expressed as function of age category and in terms of visual angle subtended by target); median and 85th percentile distance of identification of each key graphic feature; discuss elements poorly detected, kinds of errors, confusions

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Zwahlen, HT, Hu, X, Sunkara, M, and Duffus, M (1991) (39)	"Recognition of Traffic Sign Symbols in the Field During Daytime and Nighttime"	Track	20 total; 10 daytime (4 female, 6 male), 10 nighttime (3 female, 7 male); average ages 25.5 and 29.8 yrs., respectively	Unused airport runway; 1980 Plymouth Horizon, 1985 Dodge Aries; 12 regulation traffic signs	Warning sign symbols	Subject drove along runway (with low beams on at night); measured recognition distance; for nighttime, subject verbally notified experimenter in car when symbol on sign was recognized and then would switch off headlights; for daytime, experimenter in car would drop small sand bag out of car window when notified of symbol recognition (distance between bag and post was recognition distance)	Daytime distances were 1.2 times larger than nighttime distances; ANOVA based on time of day, symbol type, side of roadway; Spearman rank correlation test show daytime rankings matched significantly with nighttime rankings
Lee, RL Jr., Hostetter, RS, and Leibowitz, HW (1991) (40)	"Driver Visibility Under Wet Pavement Conditions: Size, Shape, and Spacing of Object Markers/ Delineators"	Laboratory	90 total (30 for each condition tested)	Computer simulation; Amtron color monitor with mouse	Rectangular delineators, circular delineators, +2.25 diopter lenses	Dark-adapted subjects were seated 17 in from monitor; viewed digitized image for 2 s and required to identify 1 of 6 roadway geometrics; viewed 60 variations of 2 left curves; separate groups were involved in testing effects of delineator size, delineator shape, delineator spacing, and combined systems; measured correctness of response	Only spacing variable provided consistent, statistically significant results across the two curve groups; ANOVA's based on subject age, levels of rainfall, effect of size, shape, spacing, luminance level

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Staplin, L, Lococo, K, and Sim, J (1990) (41) FHWA-RD-90-055	"Traffic Control Design Elements for Accommodating Drivers with Diminished Capacity"	EXP 1 Phase 1 Laboratory	58 total (28 young/middle-aged, 30 older self-selected); older subjects were 65+ years	Slides, Lafayette tachistoscopic shutter and control unit, neutral density filters mounted on sliding glass frames, Minolta illuminance meter, 12-volt bulb	Regulatory, warning, and guide signs (18 signs each) with four-word messages	Subjects were dark adapted for 10-15 minutes; image of sign initially presented so small that subject could not read; sign size and letter size increased with each successive presentation (0.5 s duration); subject gave verbal response when any word could be detected and another response when message could be read; experimenter recorded letter size at which first word was detected and at which entire message could be read up to equivalence of 20/125; repeated for average glare of 1.26 lux imposed by 12-volt bulb	Data blocked at two levels of glare (no glare and 1.26 lux glare); ANOVA for effects of test group sign type, level of glare; letter size required for complete message legibility was consistently larger than that required to discern individual words, for both young and old groups; older subjects required larger mean letter sizes and showed larger standard deviations; glare effect not conclusive possibly due to location of glare source
		EXP 1 Phase 2 Laboratory	58 total (28 young/middle-aged, 30 older self-selected); older subjects were 65+ years	DETECT seeing distance computer model, Minolta illuminance meter, Pritchard photometer	Regulatory, warning, and guide signs	Visibility level at various lateral offsets and glare vehicle locations measured as the minimum distance that the sign is legible downstream; subjects were initially divided into 6 age categories (25-, 35-, 45-, 55-, 65-, 75- year old)	Youngest driver group showed best performance and least variability; separation of performance distributions of 25- and 75-year-olds for guide sign characters increases significantly when glare source is introduced

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Staplin, L, Lococo, K, and Sim, J (1990) (41) **FHWA-RD-90-055**	"Traffic Control Design Elements for Accommodating Drivers with Diminishing Capacity"	EXP 2 Laboratory	58 total (27 young/middle-aged, 31 older self-selected); mean ages 36.6 and 70.5 years, respectively	Slides, Pritchard photometer, part-task driving simulator, PC-driven CRT tracking display, slide projectors coupled to multivision slide composer/micro-processor unit	Equivalent verbal and symbol formats for 6 sign messages; additional distractor stimuli similar to given targets (visual features of sign type, message format, message length)	Subjects performed tracking task as signs were presented (each test set had either symbol or verbal stimuli only); each sign presented for duration of 2 s; after 3rd member of set, "spelled out" message was presented; subject asked if corresponding sign was presented in test set by pressing 1 of 2 yes/no buttons; measured response time and response accuracy on primary task, and tracking performance on secondary task	Randomized block design differing in two levels of tracking difficulty; older drivers consistently had fewer correct responses; higher percent correct for verbal vs. symbol signs for both groups; percent correct dropped as tracking task difficulty increased for both groups; 3-way repeated measures ANOVA blocked according to message content; performance differences between groups for latency of response were not significant

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 3 Laboratory	54 total (24 young/middle-aged, 30 older, self-selected); mean ages 36.5 and 70.6 yrs, respectively	Slides, multivision slide composer/ microprocessor in conjunction with Lafayette shutter control mechanism	Traffic control elements of varying shapes and colors	Subjects responded to stimulus matrix containing 9 equal-sized elements (3x3); each matrix contained 1 traffic control element with 8 distractors (2 with similar color, 2 with similar shape, 4 dissimilar); subjects waited 50, 250, and 450 ms before attempting to recall briefly-presented target (1 s) stimulus; measured accuracy of subjects' recall of targets	2-way repeated measures ANOVA's to test effects of test group and probe delay plus interaction; blocked according to target stimulus category (color/shape); white/rectangle, yellow/diamond, yellow/pentagon have less "attention-getting" value; once noticed, regulatory signs are accorded more priority over distractors

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Staplin, L, Lococo, K, and Sim, J (1990) (41) FHWA-RD-90-055	"Traffic Control Design Elements for Accommodating Drivers with Diminishing Capacity"	EXP 4 Laboratory	48 total (24 young/middle-aged, 24 older, self-selected); mean ages 36.3 and 71.8 yrs, respectively	Slides, driving simulator, slide projectors, Multivision 301 composer/microprocessor, PC-driven variable instability tracking device	Images photographed from 1/24-scale model of 500 ft segment of divided limited access roadway; orange diamond and yellow diamond warning signs, yellow rectangle advisory signs (targets); other guide signs, regulatory signs, and warning signs (distractors)	Varied sign location (roadside, overhead), level of competition, with other signing (target isolated or with 1 or 2 distractors), relative size of sign (target equal or smaller than distractors, target larger than distractors), color/shape of targets (yellow/diamond, orange/diamond, yellow/rectangle); measured response latency and correctness of response; RT were times required for subject to move foot from floor to accelerator or from floor to brake pedal; measured percent correct, incorrect, no response	Descriptive statistics showed older drivers often demonstrated largest deficits with higher numbers of adjacent, competing stimuli; GLM 3-way analysis (test group, target sign type, presentation format); Scheffe post hoc test showed orange/diamond yielded fewer correct responses by older drivers; yellow/diamond revealed exaggerated response times for both groups, as did critical messages presented on smaller (or equal-sized) sign as distractor
Jensen, CR Anderson, LA and Mullen, J Jr. (1988) (42)	"Determining Perceived Traffic Sign Dimensions with Multidimensional Scaling"	Laboratory	57 total, (12 in study 1 were from general population, 45 in study 2 were undergraduate and graduate students)	Color reproductions of traffic signs attached to 3x5 index cards	8 regulatory signs, 8 warning signs	Subject shown pair of signs and asked extent to which signs were similar to each other by rating on scale of 1 (very similar) to 9 (not at all similar); sign pair presented for 2 s with 3 s response time; study 1 subjects viewed sign pairs twice; study 2 subjects viewed sign pairs once	Similarity judgements submitted to multidimensional scaling routine Alscal; 3- dimensional solution yielded best fit for each study: color/sign contents, message form (symbol, word), shape

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Paniati, JF (1988) (43)	"Legibility and Comprehension of Traffic Sign Symbols"	Laboratory	32 total: 16 "young" group (8 female, 8 male), 16 "old" group (8 female, 8 male); average ages 33 and 61 yrs, respectively; paid $30	Zoom lens mounted on Mast random access slide projector; rear-projected computer graphics slides; Textronics development system for randomizing slides; computer controlled servos to control zoom ratio	22 symbol warning signs; 8 alphabetic warning signs	Legibility distance (sign images simulated as moving toward subject; subject depressed hand-held button when symbol could be identified; if incorrect response, trial resumed from point of interruption); comprehension (sign images displayed at large size); self-paced; subject asked meaning; response classified as correct, substantially correct, incorrect; measured percent correct	ANOVA with repeated measures for effects of age and sign type on legibility distance - young group distances were significantly greater than old group, signs with color cues or simple symbols yield longer distances; Spearman rank correlation showed association between legibility distance and comprehension; ANOVA for legibility distances of symbolic vs. alphabetic signs showed significant differences between age groups, types of signs, word vs. symbol, and interactions

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Sedney, CA, Walker, J, Alicandri, E, and King, RE (1987) (26) FHWA/ RD-87/091	"Legibility and Driver Response to Selected Lane and Road Closure Barricades"	Laboratory	36 total (18 females, 18 males); mean age 41.5 years; equally divided into 3 age groups (17-32, 33-48, 49-75 years)	Scale models of lane and road closure barricades (1 in=1.52 ft); wheelchair; 40-ft aluminum box beam (2"W X 6"H); 13 pieces of aluminum angle screw-mounted on top of beam; magnets attached to angles; two vertical members attached to wheelchair with lights mounted to simulate headlights	Diagonal stripe, small and large diamond patterns for Type I/II (lane closure) barricades; 9 designs	Subject seated in wheelchair in dark hallway 265 ft from furthest sign (to simulate up to 1 mi distance); viewed signs with left eye only; experimenter pushed wheelchair toward sign; measured detection distance (distance array first detected) and recognition distances (distances color of sheeting and specific pattern detected); subjects asked what they would do if specific array was encountered	Descriptive statistics: mean detection distances showed high-intensity grade sheeting slightly better than engineering grade; diagonal stripes slightly better than diamond patterns (although all patterns had adequate detection distances); pattern recognition distances were significantly shorter for diagonal stripes than for either diamond patterns; no significant difference between high-intensity and engineering grade sheeting for recognition distances; diagonal stripes conveyed meaning better than diamonds

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Sedney, CA, Walker, J, Alicandri, E, and King, RE (1987) (26) FHWA/ RD-87/091	"Legibility and Driver Response to Selected Lane and Road Closure Barricades"	Survey	N/A	Survey questionnaire	Single sign and merge array barricade patterns	Four questions total: intrinsic meaning, directional response (single sign); action to be taken, directional response (merge array)	Barricade interpreted as general nondirectional warning; split chevron communicated direction more effectively than standard striped pattern for barricades and merge arrays

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Alicandri, E, Colon, M, Walker, J, and Roberts, K (1986) (44)	"The Legibility of Features on Interstate Guide Signs"	Laboratory	18 total (9 females, 9 males); average age 40 yrs; range 18-64 yrs; equally divided into 3 age groups (16-29, 30-49, 50+ yrs)	Color pictures, tripod, Lite-Mate photometer with SpotMate to measure illumination	10 overhead highway guide signs (route shields, place names, cardinal direction words)	Subject seated 20 ft from stimulus sign; subject asked to read each feature of sign as soon as possible; sign moved toward subject at 1-ft increments until all features were identified; measured recognition distances for individual features and overall identification distance	Approximated missing data using regression formulas and correlation matrix of features for each sign; ANOVA (feature, picture, age group); Ryan-Einot-Gabriel-Welsh multiple F test post hoc comparisons; younger group distance were significantly greater than 2 older groups, but 2 older group distances not significantly different from each other; similar analysis for distances converted to visual angle produced similar results; in general route shields most difficult to read

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Alicandri, E, Roberts, K, and Walker, J (1986) (45) FHWA/ RD-86/067	"A Validation Study of the DOT/FHWA Highway Simulator (HYSIM)"	Laboratory and Field experiment	32 total (16 female, 16 male); half of each gender < 30 yrs, half > 30 yrs; average age 32.4 yrs; paid $30	Laboratory: HYSIM Field: test vehicle instrumented to collect data on speed, steering wheel reversals, accelerator position changes, recognition and detection distances, physiological measures	Four traffic signs (three symbolic, one verbal)	Vehicular measures (speed, steering wheel reversals > 20 deg, accelerator position changes > 10 percent of total travel distance); performance measures (sign detection distance was point subject first saw sign of specifically stated background color; sign recognition distance was point subject could read/understand sign); distances in laboratory based on verbal response; distances in field study based on push button response	5-way ANOVA based on place (field vs. HYSIM), sign, zone within sign, sex, age group; proc GLM used to analyze detection, and recognition distances and accelerator position changes due to missing data; field detection distances greater than HYSIM; recognition distances varied between field and HYSIM possibly as a result of differences in background luminance
Leonard, SD and Matthew, D (1986) (46)	"How Does the Population Interpret Warning Signals?"	Laboratory	368 university psychology students (198 females, 170 males)	Questionnaires with images of color signs	12 warning signs with brief description of hazard and recommended action	Size, color, presence or absence of statement of consequences, and signal word (caution, warning, danger) were varied; given specific situations, subjects were asked to rate, on 7-point scale, whether they would obey or disregard sign	T-tests to determine gender differences yielded no significant differences; ANOVA with groups as between subject factor and signal order as within subjects factor showed no effect; ANOVA's based on effect of signal words, color of sign; size of letters showed no effects

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Wunderlich, RC (1985) (47) TRR 1027	"Evaluation of Freeway Crash Cushion Delineation Treatments"	Field observation	N/A	Delineators at freeway gore areas reflectorized nose panels, yellow painted barrels with reflectorized stripe, raised reflective pavement markers	Four levels of freeway gore area delineators	Accident-reduction rate, repair rate of damaged cushions	Treatments with flashing lights and static elements reduced repair rate, treatments with static elements did not reduce repair rates overall, but those with back panels did reduce repair rates
McNees, RW (1985) (48) TRR 1027	"Route Designators to the Centers of Large Urban Areas and Suburbs within Urban Areas"	Laboratory	100 total	Slides of miniature signs	Freeway guide sign messages (6 one-word messages, 6 two-word combination messages)	Miniature guide signs presented at each of four scenario locations under investigation; subjects denoted which sign they expected to see and which they prefer to see at each location along route by pressing button on control panel corresponding to sign; measured time to locate, preference, and expectancy	Significant differences among locations and message types

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Brewer, KA, Thieman, AA, Woodman, WF, and Avant, LL (1985) (49) TRR 1027	"Highway Sign Meaning as an Indicator of Perceptual Response"	EXP 1 Laboratory	30 total	Tachistoscope, slides	16 warning signs with word legends and/or symbol legends and 16 blank presentations	Subject presented with 32 pre- and post-masked tachistoscopic inputs; asked whether input was a road sign or a blank flash; initially 110 ms presentations with exposure durations reduced over succeeding series until subject performed no better than chance level; three additional series of 32 inputs were presented at this level; measured number of times sign correctly detected at chance-level exposure; afterward, subjects responded to semantic differential test (twelve 7-point scales) about 8 of the signs	Mean chance-level exposure duration was 24 ms; semantic differential measures of meanings of signs are not symmetrically related to laboratory tests of abilities to detect signs
Brewer, KA, Thieman, AA, Woodman, WF, and Avant, LL (1985) (49) TRR 1027	"Highway Sign Meaning as an Indicator of Perceptual Response"	EXP 2 Laboratory	36 total	Tachistoscope, slides	16 warning signs with word legends and/or symbol legends	Subject presented sign tachistoscopically; asked which one of two other signs shown outside tachistoscope was just presented (forced choice identification); subjects divided into 3 groups for different exposure durations (32, 41, 49 ms); measured number of errors to determine probability of correct recognition; afterwards, subjects responded to semantic differential test (twelve 7-point scales) about 8 of the signs	Semantic differential measures of meanings of signs are not symmetrically related to laboratory tests of abilities to recognize signs

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 3 Laboratory	48 total	Response box with 4 buttons; slides	16 warning signs with word legends and/or symbol legends	Subjects were asked which of 4 responses they would make to given sign (stop, slow, left, right) and pressed button corresponding to response; measured mean reaction time for each sign over 10 randomly ordered presentations; afterwards, subjects responded to semantic differential test (twelve 7-point scales) about 8 of the signs	Semantic differential measures of meanings of signs are not symmetrically related to laboratory tests of decision reaction time
Walker, J, Alicandri, E, and Roberts, K (1985) (50) FHWA/ RD-85/064	"Symbolic Sign for Oversized-Truck Route Signs"	EXP 1 Laboratory	60 total (38 females, 22 males) from general public; age range 16-64 yrs; average age 37 years	Slides photographed from computer graphics, rear projected; color photographs of permissive signs	6 candidate symbolic regulatory signs; permissive versions (green circle, no slash) and prohibitory versions (red circle, slash); 6 other standard signs used as distractors	Subjects walked toward each sign in vision tunnel; measured recognition distances (distances from sign where each of 2 or 3 features were recognized); subjects then shown photos of the 6 permissive signs and asked meaning and then to rank signs on how well they conveyed meaning	2x6 factorial design (message by type of sign) with repeated measures; permissive sign recognition distances significantly greater than prohibitory signs
		EXP 2 Laboratory	121 total (6 female, 115 male) truck drivers	FHWA step van, slides, rear projected	Same as EXP 1 except only 1 oversized truck route sign and 2 small, obscure signs	Subjects seated in front of screen, asked to push button as soon as they decided what message was; measured recognition time (time from onset of stimulus slide until button pushed); subjects then told meaning of signs and asked to rank signs on how well they conveyed meaning	Prohibitor signs recognized or guessed more quickly than permissive signs NOTE: Effective size of signs was much larger than in EXP 1.

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Walker, J, Alicandri, E, and Roberts, K (1985) (50) FHWA/ RD-85/081	"An Evaluation of Candidate Symbolic Routing Signs for Trucks Carrying Hazardous Cargo"	EXP 1 Laboratory	107 total: 26 truck drivers (4 female, 22 male). 81 general public (43 female, 38 male); average ages 36.3 and 22.4 years, respectively; paid	Color computer graphics Xerox copies; booklets	6 symbolic routing signs for trucks (permissive and prohibitory versions); 12 distractor signs	Self-paced; subjects wrote meaning of each sign and effect it would have on their driving; after reading intended meanings, subjects recorded preferences and ranked signs by writing numbers next to pictures; answers coded as completely wrong, partially correct, completely correct	Chi-square analysis by message type (permissive, prohibitor) and symbol type - more prohibitory signs were fully correct, more permissive signs were completely wrong; Friedman Chi-square tests performed on rankings-diamond was worst symbol and cab of truck with "HC" included was best

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 2 Laboratory	30 total (15 female, 15 male); average age 31 years	Color computer graphics prints; rear-projected slides	6 symbolic routing signs for trucks (permissive and prohibitory versions); 12 distractor signs most likely to be confused with candidate signs	Subjects viewed prints of 6 candidate signs and were told meaning; subject shown slide in 120 ft tunnel, asked to walk toward sign until any feature could be identified; continued procedure until all major features were identified (half of subjects saw permissive, half prohibitory); then subjects were shown slides of symbolic and distractor signs and asked to identify signs; next subjects were asked to arrange prints on stand from best to worst	Average distance of feature identification directly correlated with sign size; diamond was most visible, flatbed truck symbol was least visible; 2X6 ANOVA (message type by symbol type) black background "HC" recognized at farthest distance, symbolic trucks recognized at least distance; Friedman Chi-square tests performed on rankings-diamond was worst, white background and black background "HC" were best
Mace, DJ, King, RB, and Dauber, GW (1985) (51) FHWA/ RD-85/056	"Sign Luminance Requirements for Various Background Complexities"	Phase I Laboratory with Field validation	12 total for laboratory study (age range 22-55 yrs); 15 total for field validation study (age range 23-62 yrs)	Transparencies of photographs of roadway sites; projector; rating forms	None - 24 roadway sites of varying visual complexity	For laboratory, transparencies shown for 2 min duration; van carrying subjects remained in roadway lane 30 s then moved to shoulder until all questionnaires were completed for each site; subjects rated site complexity on 6-point scales for distractions, driving demand, number of bright sources, number of signs, etc.	Spearman-Brown reliability coefficients showed rating scales in field had greater reliability than those in laboratory

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Mace, DJ, King, RB, and Dauber, GW (1985) (51) FHWA/ RD-85/056	"Sign Luminance Requirements for Various Background Complexities"	Phase 2 Field experiment	15 total (age range 22-64 yrs; mean age 38 yrs	Standard warning signs with new Type II sheeting (engineering grade); silk-screened dot pattern used to degrade luminance to 72% and 36% of Type II specifications; Digital Measuring Instrument (DMI)	Yellow diamond warning signs with 6 single-word legends	Warning signs placed at 22 sites used in Phase I; each site observed by 5 subjects under each level of sign brightness; subject drove vehicle with experimenter; subject said "detect" when yellow diamond detected and would say specific word when legible; experimenter noted distances from sign using DMI	Spearman-Brown reliability coefficients showed highly significant correlations for recognition distances for each subject; regression analysis showed brightness of sign improved both recognition and legibility distances; visual complexity ratings and ANOVA showed visual complexity has negative effect on recognition, but no effect on legibility; sign brightness has positive effect on both recognition and legibility

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Freedman, M, Staplin, LK, and Decina, LE (1985) (52) FHWA/ RD-85/046	"Limited Sight Distance Warning for Vertical Curves"	EXP 1 Laboratory	256 total (equal number of females and males); age range: 16-75 yrs	Slides of signs projected onto real-world background of hilly, two-lane rural road	6 sight distance warning signs (3 alphabetic, 3 symbolic), similarly shaped, unrelated distractor signs	Subject viewed each candidate sign with 3 distractor signs and asked meaning and what action should be taken if sign encountered; measured speed of recognition; next, subject studied 1 candidate and 3 distractor signs and identified each sign when exposed to brief (50 ms) projection; next asked to rank alphabetic signs and rank symbolic signs	Determined which alphabetic sign and which symbolic sign scored highest in comprehensibility and recognizibility and which of each was preferred; symbol signs were correctly identified 50% more often than alphabetical signs
		EXP 2 Field experiment	64 total (36 females, 28 males)	Standard roadway signs; photographs of signs	2 alphabetic signs; symbol and alphabetic sign combination	Subject drove route, experimenter in vehicle recorded actions on checklist of driver as candidate sign was encountered (slowing, braking, turning head, etc.); after driving route, subject named as many signs seen along route as possible in free recall test and asked to explain meaning; then shown photographs of signs and asked if encountered or not; measured frequency of recall, percent correct interpretations	Determined which signs were most frequently recalled and recognized; showed drivers most often responded to symbol sign by slowing or braking
Freedman, M, Staplin, LK, and Decina, LE (1985) (52) FHWA/ RD-85/046	"Limited Sight Distance Warning for Vertical Curves"	EXP 3 Field obser-vation	N/A	Standard roadway signs	2 alphabetic signs, symbol and alphabetic sign combination	Conducted concurrently with field experiment; recorded vehicle velocity, lateral position, etc.	No statistical significance between effects of signs on velocity; some marginally significant findings for sign effects on behavioral measures, but no sign emerged superior

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Lerner, N and Collins, BL (1983) (53)	"Symbol Sign Understandability When Visibility is Poor"	Laboratory	42 total	Slides, neutral density filters, veiling source	18 building exit symbols, 108 foil symbols	Subjects viewed signs at each of 3 levels of visibility; measured comprehension (subjects indicated whether symbol meant "exit" or not); measured percent error	ANOVA based on level of visibility, symbol type; significant differences among signs under all viewing conditions, especially most difficult condition
Gordon, DA (1981) (54)	"The Assessment of Guide Sign Informational Load"	EXP 1 Laboratory	50 total, with almost equal number of males and females; paid $15	Question booklets of 4- by 5- in cards with destination names; color slides on image of black and white four-lane highway, rear projected	13 familiar freeway guide signs (5 signs repeated with nonguidance information removed), 5 unfamiliar guide signs	Subjects read required destination on card; based on sign information projected on screen, indicated lane they would take to reach destination by pressing button corresponding to lane number; informational load measured in terms of response times and errors	Descriptive statistics showed familiar signs elicited somewhat longer responses than unfamiliar signs (most likely result of complexity of signs used in study) and that subjects were not appreciably slowed by nonguidance clutter
		EXP 2 Laboratory	Same subjects as in EXP 1	Question booklets of 4- by 5- in cards with destination names; color slides, rear projected	8 destination signs with place names and/or route numbers	Slides showed either 3, 5, or 8 signs; subjects read required destination card; pressed button corresponding to number under destination sign	Descriptive statistics showed that increasing number of signs increased response times

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 3 Laboratory	Same subjects as in EXP 1	Question booklets of 4- by 5- in cards with destination names; color slides on image of black and white four-lane highway, rear projected; area map	10 freeway guide signs	Subject used destination card to plan route before observing slide; subject selected appropriate lane of travel to reach destination; measured response times and errors	Descriptive statistics showed much longer response times than those found in EXP 1
Dewar, RE and Ells, JG (1980) (55)	"Techniques for Evaluation of Traffic Signs"	EXP 1 Laboratory	N/A	70 color slides	Symbolic traffic signs	Open-ended response indicating meaning and appropriate action to be taken in response to each symbol; multiple-choice questions to indicate which of three symbols represent specific message (matching technique); multiple-choice questions to indicate which of four possible meanings is correct for specific symbol	No need to determine whether subjects understand the action to be taken in response to a symbol since this index correlates highly w/comprehension of the meaning; general agreement across the three methods
		EXP 2 Laboratory	N/A	16 color slides	Symbolic traffic signs	Preference method rank ordering; rate 'clarity of meaning' on a 5-point scale	General agreement between methods
Ells, JG, Dewar, RE and Milloy, DG (in press, 1980) (56) [from Dewar & Ells (1980)]	" An Evaluation of Six Configurations of Railway Crossbuck Sign"	Laboratory	N/A	Small photographs of crossbuck signs; wheelchair	Six versions of railway crossbuck signs	Subjects moved in wheelchair toward sign and called out "stop" when sign could be read; distance to sign was legibility distance	Differences in legibility distance measurements were similar to laboratory measures of reaction time and glance legibility

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Ells, JG and Dewar, RE (in press 1980) (57) [from Dewar & Ells (1980)]	"Legibility and Comprehension of Six Traffic Sign Alphabets"	Laboratory	N/A	Small photographs of traffic signs; wheelchair	Traffic signs with various alphabets (letter and digit forms)	Subjects moved in wheelchair toward sign and called out "stop" when sign could be read; distance to sign was legibility distance	Measures in laboratory comparable to roadway measures
Mackett, J and Dewar, RE (in press, 1980) (58) [from Dewar and Ells (1980)]	"Evaluation of Symbolic Public Information Signs"	Laboratory	N/A	Small photographs of signs; internally illuminated box with small opening at one end and clamp, holding photograph	Traffic signs	Photograph moved along track in box toward subject; subject indicated at what point the sign could be read	Amount of time required to test subject is relatively brief
Allen, RW, Parseghian, Z, and Van Valkenburgh, PG (1980) (23) FHWA/ RD-80/126	"Age Effects on Symbol Sign Recognition"	Laboratory	60 total divided into 4 age groups with 3 training subgroups each (age range 20-79 yrs); paid $5/h plus $2 completion bonus, penalized for speeding, accidents, and recognition errors	Interactive driving simulator with complete steering and speed control; computer stored performance measures	72 symbols signs divided into 6 color-coded categories	Recognition distance - subject pressed foot switch to indicate when sign recognized, then verbalized meaning; experimenter recorded correctness (substantially correct, partially correct, essentially incorrect) and confidence level (certain, not sure, don't know); also measured speed and steering control	Regression analysis and ANOVA; no age effects on learning or retention; older drivers have longer response times; signs with bold, simple, unique symbols recognized at further distances

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Lerner, ND and Collins, BL (1980) (59)	"The Assessment of Safety Symbol Understandability by Different Testing Methods"	Laboratory	91 total (58 female, 33 male); median ages 41 and 25 yrs, respectively	Color placards, slides, and photographs of each symbol; booklets for photographs; black felt tip markers and blank paper	25 fire safety signs	Subjects were tested in groups of 7 to 18 people; slides and placards presented initially at a rate of 1 every 2 min and increased to 1 every 30 s; half of group responded to multiple choice questions to select definition, half wrote their own definition of sign meaning; subjects then answered in similar manner to booklet photographs of symbols (self-paced); measured correctness of response (correct, partially correct, incorrect); subjects rated confidence in correctness of each answer on 5-point scale; subjects then given booklet with definitions and asked to draw symbol that conveyed meaning of definition (supplementary information)	2-factor ANOVA's showed no significant effect of mode of symbol presentation, nor interaction of mode with type of response; lenient scoring (correct and partially correct grouped together) showed no significant effect for type of response; strict scoring (partially correct considered incorrect) showed significantly lower number of correct responses for definition group than multiple-cho ce group; rank ordering was similar between groups
Roberts, KM, Lareau, EW, and Welch, D (1977) (60) [from Dewar & Ells (1980)]	"Perceptual Factors and Meanings of Symbolic Information Elements, Vol. II"	Laboratory	N/A	19 traffic sign messages	Symbolic and verbal versions of each sign	Understanding time (time required for verbal indication of meaning), accuracy (correctness of interpretation), certainty (5-pt scale rating certainty of understanding), preference (rank ordering), identification time (time required to accurately identify all elements of sign); "efficiency index" calculated based on sign's overall effectiveness	Only meaningful correlation was between mean latency (time to formulate response) and certainty of accuracy

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Dewar, RE, Ells, JG, and Cooper, P (1977) (61) [from Dewar & Ells (1980)]	"Evaluation of Roadway Guide Signs at an International Airport"	Phase 1 Field observation	N/A	Videotape recordings	Roadway guide signs	Traffic flow: total traffic volume, number of vehicles stopping, number of vehicles reversing direction, number of vehicles which changed destinations	N/A
		Phase 2 Laboratory	2 sets for subjects (1 for original signs, 1 for modified signs)	42 black and white slides (21 original roadway signs, 21 modified roadway signs); 7 additional slides further modified	Drawings of roadways and their associated signs; each roadway lane numbered consecutively from left to right	Lane choice technique: subject indicated, as rapidly as possible, the number of the lane he should be in to reach specific destination; measured reaction time and percentage of correct responses (reaction time and glance legibility)	N/A
Dewar, RE, Ells, JG, and Cooper, P (1977) (61) [from Dewar & Ells (1980)]	"Evaluation of Roadway Guide Signs at an International Airport"	Phase 3 Field observation	N/A	8 modified signs; videotape recordings	Guide signs modified based on phase 2 study	Traffic flow: total traffic volume, number of vehicles stopping, number of vehicles reversing direction, number of vehicles which changed destinations	Generally, traffic flow at locations where sign messages were modified was smoother (fewer stops, reversals, erratic maneuvers); findings show that lab measures of reaction time and glance legibility can be used for traffic sign design

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Roberts, KM and Klipple, AG (1976) (62)	"Driver Expectations at Freeway Lane Drops"	EXP 1 Laboratory	20 total (no specifics)	35-mm slides; response buttons	Stimulus slide: photographed roadway with fictitious signs superimposed Response slide: graphics of 5 different roadway exit geometrics	Variables: lane drop panel message, sign position, exit route number, exit destination name Expectations regarding exit lane drop geometrics, routes, and destinations: choice correctness (measured with response buttons keyed to each choice) and response latency (time between presentation of response slide and subject's response); subjective certainty of the accuracy of each choice (verbally indicated relative certainty of response 1=very uncertain, 5=very certain)	MUST EXIT and EXIT ONLY messages most helpful in forming correct expectations
		EXP 2 Laboratory	30 total	35-mm slides; response buttons	Stimulus slide: photographed roadway with fictitious signs superimposed Response slide: graphics of 5 different roadway exit geometrics	Variables: interchange geometrics (lane drop, major split), sign type (conventional, diagrammatic), sign position, lane drop panel message; MOE's same as EXP 1	MUST EXIT and EXIT ONLY messages most helpful in forming correct expectations
Jacobs, RJ, Johnston, AW, and Cole, BL (1975) (63)	"The Visibility of Alphabetic and Symbolic Traffic Signs"	EXP 1 Laboratory	10 total	Black and white slides representing 27 sizes of signs, projector, +2.00 diopter lens	16 familiar regulatory and warning road signs with both alphabetic and symbolic messages	Self-paced; subject looked at fixation target and pressed "ready" button to present slide; measured legibility distances based on correct responses for given size sign images	Employed probit analysis to determine legibility distances for which 50% and 95% correct responses occurred; for most signs, alphabetic symbols yield significantly greater legibility distances than symbolic counterparts

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Jacobs, RJ, Johnston, AW, and Cole, BL (1975) (63)	"The Visibility of Alphabetic and Symbolic Traffic Signs"	EXP 2 Laboratory	5 total	Black and white slides representing 27 sizes of signs, projector, +2.00 diopter lens, spherical biconvex lenses for defocusing	16 familiar regulatory and warning road signs with both alphabetic and symbolic messages	Self-paced; subject looked at fixation target and pressed "ready" button to present slide; subject held biconvex lens up to eye to obtain various levels of defocusing; measured legibility distances based on correct responses for given size sign images	Employed probit analysis to determine legibility distances for which 50% and 95% correct responses occurred; for most signs, alphabetic symbols yield significantly greater legibility distances than symbolic counterparts; decrease in visual acuity by a factor of 2 halves legibility distance
Dewar, RE and Ells, JG (1974) (64)	"Comparison of Three Methods for Evaluating Traffic Signs"	EXP 1 Track	16 total (8 male, 8 female); Age range: 20-36 yrs (mean 25.8); paid $10.00	16 regulation-size traffic signs	24- by 36- in white rectangular regulatory sign and 30- by 30- in yellow diamond warning sign; half verbal, half symbolic messages	Each sign viewed once at each of two different speeds (30 mi/h and 50 mi/h); classification distance (distance from sign when subject verbally classified sign as warning or regulatory); identification distance (distance from sign when subject verbally indicated meaning of sign); both measured to nearest foot by Numetric Distance Measuring Instrument (DMI); variables included speed (30 mi/h, 50 mi/h), direction (north, south), sign type (reg.,warn.), message type (symbol,verbal), task (classify,identify)	5-way ANOVA; better performance on warning signs than regulatory signs; symbols were identified better than verbal signs; classification measure was better than identification measure

1 mi/h = 1.61 km/h

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 2 Track	16 total (3 male, 8 female); Age range: 19-35 yrs (mean 25.8); paid $2.00	16 "miniature" traffic signs (1/3 size of regulation); same materials and production methods as regulatory signs	8- by 10- in white rectangular regulatory sign and 10- by 10- in yellow diamond warning sign; half verbal, half symbolic messages	Same as EXP 1 except each sign viewed twice at speed of 17 mi/h (1/3 of 50 mi/h speed of EXP 1); classification distance and identification distance measured	4-way ANOVA; better performance on warning signs than regulatory signs; symbols were identified better than verbal signs; classification measure was better than identification measure
Dewar, RE and Ells, JG (1974) (64)	"Comparison of Three Methods for Evaluating Traffic Signs"	EXP 3 Laboratory	30 total (15 male, 15 female); Age range: 19-62 yrs (mean 26.8); at least 5 yrs driving experience; paid $2	26 slides of traffic signs rear-projected onto screen; dark vision tunnel	6 information (3 symbolic, 3 verbal) green or blue in color; 20 warning or regulatory with symbolic or verbal message (5 of each combination); 15 were same as in EXP 1 and EXP 2; 2 groups: 1) small signs corresponding to regulation traffic sign at distance of 193 ft (stop dist. at 50 mi/h), 2) larger stimulus corresponding to reg. traffic sign at distance of 83 ft (stop dist at 30 mi/h)	Classification task (as quickly as possible after stimulus, verbally indicated "yes" if warning or regulatory sign, no response if information sign); identification task (replied with verbal meaning of sign as rapidly as possible); verbal reaction times measured to nearest millisecond (using Hunter timer) from onset of stimulus to activation of a voice key; each sign presented 5 times total (once in each of 5 blocks - first block was practice trial); if data error rate > 5%, not used	4-way ANOVA; better performance on warning signs than regulatory signs; unlike EXP 1 and EXP 2, verbal signs were identified better than symbols; classification measure was better than identification measure
Dewar, RE and Ells, JG (1974) (65)	"Methods for the Evaluation of Traffic Signs"	EXP 3 Field observation	N/A	Time-lapse photography	Dual turn signs	Driver behavior: traffic volume in each lane which passed through intersection, turned left, turned right, combinations of lane changes	Effect of signs inconclusive; recommend collecting larger sample (several days of photography) for adequate analysis

1 ft = 0.305 m
1 mi/h = 1.61 km/h

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 4&5 Laboratory	15 university students (11 male, 4 female); subjects tested individually or in pairs; paid $1.50	70 colored slides	Foreign traffic sign symbols divided into warning, regulatory, and information types	Each sign viewed once at distance of 10 ft from screen; self-paced; subject wrote down meaning of sign and action to be taken; indicated on paper when answer was a guess; scored as correct, partially correct, incorrect: percentages of each score determined for each sign	Very few partially correct; subject usually either was sure of meaning or did not know it all; action to be taken corresponded highly with meaning (comprehension); small proportion of guesses were correct
		EXP 6&7 Laboratory	68 university students (19 males, 15 females); tested in large group in classroom; 17 males, 17 females tested individually or in groups of 2 or 3; paid $1.50	75 colored slides	Foreign traffic sign symbols	Each sign viewed once at distance of 10 ft from screen; group or self-paced; subject wrote down meaning of sign and action to be taken; indicated on paper when answer was a guess; scored as correct (includes entirely or partially) or incorrect; percentages of each score determined for each sign for large group and small group	Results from testing sign meaning in large group do not vary from results of individuals or small groups
		EXP 8 Laboratory	73 university students	Blank white paper, drawing pencils including colors	12 traffic sign messages	Subjects asked to draw symbol to represent each traffic sign message; determined common elements in symbols for each message [sign shape, pictograph, colors used, prohibition sign (cross or slash)]	Population stereotype data is a good place to begin in search for new symbolic traffic sign messages

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Dewar, RE and Ells, JG (1974) (65)	"Methods for the Evaluation of Traffic Signs"	EXP 9 Laboratory	31 university students	20 colored slides of traffic signs	Symbolic traffic signs	1) Semantic differential using bi-polar adjectives (e.g. good-bad, slow-fast, rugged-delicate), each symbol was rated using three adjective pairs; 2) Recognition (subjects wrote out what symbol meant)	Semantic differential factors (evaluative, potency, activity, understandability) were significantly correlated with degree of understandability
		EXP 10 Laboratory	87 university students in classroom situations	15 slides	7 regulatory traffic signs, 4 guide signs, 1 warning sign, 3 information signs	Subjects viewed each sign for 30 s and answered specific questions about each (most multiple-choice) regarding meaning or response action; measured percentage of correct responses	Method is useful for measuring adequacy with which signs convey intended meaning
		EXP 11&12 Laboratory	40 university students tested individually (20 male, 20 female); paid $1.50	18 color slides	Foreign traffic sign symbols found to have little intrinsic meaning	Subjects required to write down meaning of sign when first seen; then subject given meaning and instructed to learn it; subject then asked to identify sign meanings again; repeated until all responses were corrected on 3 consecutive trials; 20 subjects tested 3 weeks later - asked for meaning, learning, cue or element of symbol used to aid memory, or whether just memorized	Comprehension errors in first part of experiment highly correlated to errors during memory testing in second part

1 ft = 0.305 m

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 13&14 Laboratory	14 years of age and older Method 1: 220 subjects Method 2: 224 subjects Method 3: 15 subjects	Questionnaires, color slides	Traffic sign symbols	Method 1: Subjects completed multiple choice questionnaire on sign meaning (chose which of 3 signs, drawn on questionnaire, best represented meaning); Method 2: Multiple choice questionnaire (chose which of four meanings for sign drawn on questionnaire was correct); Method 3: Subjects shown color slides, 15 s each, and wrote meaning; measured percentage of correct responses	Meaning of traffic sign symbols can be adequately measured using multiple-choice mode where symbol is presented along with 4 possible meanings
		EXP 15 Laboratory	926 total	Color photographs	Traffic sign symbols and messages	Subject given traffic sign message with 2, 3, or 4 symbols; subjects asked to rank order symbols according to their adequacy to convey message; measured mean rankings of symbols	Found some symbols more adequate than others
		EXP 16 Laboratory	2350 total (49% male; 51% female); divided into four groups	4 different questionnaires	4 Sets of 10 different traffic sign symbols with intended meanings	Rating (5-point scale) how well each symbol covered intended meaning	Some degree of consistency within this rating technique for clarity
Dewar, RE and Ells, JG (1974) (65)	"Methods for the Evaluation of Traffic Signs"	EXP 17 Laboratory	40 university students (20 male, 20 female); paid $1.50	Color slides, projection tachistoscope, cardboard poster with colored replicas of all signs tested	20 traffic sign messages (10 warning, 10 regulation); half of each type were verbal, half symbolic	Stimuli presented for 40 ms; subject required to match stimulus sign to colored replicas on cardboard in front of him (each was numbered) and write number of corresponding sign; half of subjects also rated each sign on semantic differential	Correlations between glance legibility and semantic differential are greatest for evaluation and understandability of symbolic signs

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
		EXP 18 Laboratory	30 university students (15 male, 15 female); paid $2.00	26 slides rear projected onto screen	6 information signs (3 symbolic, 3 verbal), 20 remaining were warning or regulatory, verbal or symbolic (5 each combination); one set small signs (corresponding to viewing distance of 193 ft), one set larger signs corresponding to viewing distance of 83 ft)	Subject sat 30 ft from screen in dark tunnel; reaction times measured for classification (replied "yes" as quickly as possible for either warning or regulatory, no response if information) and identification (verbal response of meaning as quickly as possible); verbal reaction times measured with Hunter Timer (to nearest msec) from onset of stimulus to activation of voice key	4-way ANOVA (sign size x sign type x message type x task); RT smaller for classification than identification, smaller for large signs than small signs, smaller for warning signs than regulatory signs, smaller for verbal than symbolic
		EXP 19 Laboratory	16 university students (8 male, 8 female) with at least 5 years driving experience; paid $3.00	26 slides rear projected onto screen	Same as EXP 18, except only larger signs used	Same as EXP 18, except loading task added; subjects required to respond to subset of randomly presented numbers 1-99 and depress response key when number was between 50 and 59 inclusive	3-way ANOVA (task x message type x sign type); RT smaller for classification than identification, smaller for warning than regulatory, smaller for verbal than symbolic
		EXP 20 Laboratory	16 university students (8 male, 8 female) with at least 5 years driving experience; paid $3.00	26 slides, colored motion picture scene	Same as EXP 18, except only smaller signs used	Same as EXP 18, except slides front projected onto colored motion picture scene; divided attention task added; subjects required to maintain speed of 50 mi/h registered on automobile speedometer on desk in front of him by manipulating a knob with fingers (experimenter could alter speed)	4-way ANOVA; (sex x task x message type x sign type); RT smaller for classification than for identification, smaller for warning than regulatory

1 mi/h = 1.61 km/h

Table 1. Traffic control device studies from literature review (Continued).

AUTHOR	TITLE	TYPE OF STUDY	SUBJECTS	MATERIALS USED	TCD's USED	MOE DEFINITION	RESULTS
Case, HW, Hulbert, SF, and Wojeik, CK (1965) (66) [from Dewar & Ells, (1980)]	"Development of an Expeditious Method for Off-Site Testing of Freeway Sign Formats (Sign-Tester)"	Laboratory	N/A	Full-scale highway lanes and signs drawn on roll of paper; paper rolled through machine to simulate movement; steering wheel to move paper-transport mechanism to simulate lane of travel	Sequence of highway interchange signs	N/A	N/A
Desrosiers, RD (1965) (67) [from Dewar & Ells (1980)]	"Moving Picture Technique for Highway Signing Studies - An Investigation of its Applicability"	Laboratory and Track	N/A	Film presentation of signs for laboratory; miniature traffic signs (1/3 scale of normal size) for track test	Traffic guide signs	Legibility distance (indicated which line of sign target name located on by pressing button); for track, subjects drove 20 mi/h (simulating approach of 60 mi/h)	Same trends for both methods, but mean legibility distances were 5 to 6 times greater in field test
Burg, A and Hulbert, SF (1962) (68) [from Dewar & Ells, (1980)]	"Predicting the Effectiveness of Highway Signs"	Laboratory	N/A	16 mm motion picture taken from position normally occupied by driver's head	Traffic signs to indicate lane-drop	After each film sequence subject indicated initial impressions of signs; after all signs viewed, expressed personal preference among signs	N/A

1 mi/h = 1.61 km/h

APPENDIX C
INSTRUCTIONS FOR THE PROBLEM IDENTIFICATION, LABORATORY, AND FIELD STUDIES

INSTRUCTIONS
PROBLEM IDENTIFICATION EXPERIMENT 1
ROADWAY PERCEPTION

Thank you for participating in our study of roadway scenes. When we start you will see a roadway scene presented for **two** seconds on the screen, and then you will be given time to answer a series of questions about the scene. After each scene is presented, you will see a slide with a big number on it. It should be the same as the answer sheet you're working on. It is important to make sure your answers are being written on the page that corresponds with the correct slide. The number slide will stay on the screen until everyone has had plenty of time to answer all the questions. We have arranged the questions in order of their importance, so please answer them in order. Although you will be given enough time to complete all the questions, not all the details mentioned in each question will be present in every slide. If you are not sure of an answer, please give your best guess. Blank answers will cause us a lot of problems when we review the data. Although the questions are written on every page, we will go over them now in some detail and show you some examples on the screen.

Q1. What type of surroundings were in the scene?

A. Country

(Slide 1.1) This is a country area. You will see few houses, possibly some farms and woods. The roads will be usually two-laned with narrow shoulders.

B. City

(Slide 1.2) This is an city scene. The scenes you will see in this category will have few if any houses, but many stores and businesses. The streets may have two or four lanes, and parking may or may not be allowed.

C. Freeway

(Slide 1.3) Here you are on a freeway. The freeways you will see will have a minimum of four lanes, and interchanges with ramps rather than traffic lights at intersections with other roads. I-66, 70, 95 and 495 are examples in this area.

D. Arterial

(Slide 1.4) Here you are on an arterial street. An arterial is a large, busy road that is not quite a freeway. It is different than an city area because any businesses are not right next to the road, and it is too large and too busy to be called country surroundings. The arterials you will see in this study will have four or more lanes, traffic lights, only a limited number of

junctions and few driveways.

E. Residential

(Slide 1.5) Here you are in a residential neighborhood. The scenes you will see in this category will have many houses and side streets. There may or may not be parked cars along the streets.

Q2. How many vehicles were in the lane in front of you?

Each slide is taken from the driver's point of view. In this question we are only interested in the lane that the car is in and the possible cars or trucks in front of your car.

A. 0 (none)

(Slide 2.6) The car you see is coming toward you, so it doesn't count. Only count cars, trucks, or vans in your lane.

B. 1 (one)

(Slide 2.7) This is another example of a residential street and there is one car in front of you.

C. 2+ (two or more)

(Slide 2.8) Here you are on the freeway and there are two cars in front of you. One is much further ahead and harder to see. If you notice this, then we would like you to answer "C" two or more cars.

(Slide 2.9) Here is another example of an city street. There are many cars in you lane, but for our purposes we are only interested in whether or not you notice zero, one or two + cars in your lane.

Q3. Were there any intersecting streets, roads or ramps?

YES

NO

(Slide 3.10) Here you would mark "Yes" because this freeway has an on ramp in the far part of the slide from the right. For this study we will consider freeway on/off ramps as intersections; however, driveways WILL NOT count as intersections.

Q4. Were there any vehicles at the intersection?

YES

NO
NOT APPLICABLE (There were no intersections)

(Slide 4.11) Here you would mark "YES," the van on the left is leaving the intersection. Note on this question that you do not have to worry about how many vehicles or what direction they are going, just as long as they are on the intersecting road, street, exit or entrance ramp.

(Slide 4.12) Here you would mark "NO." Notice that there are no cars in the intersection; however, there is a car ahead on the left in a driveway. Again, remember to ignore driveways, they will not be considered intersections.

Q5. Were there any immovable objects that should not be hit?

YES What were they: _____

NO

I will give you some examples of immovable objects that would cause damage to your car or personal injury if hit. By immovable we mean permanent things such as trees, telephone poles, bridges, etc. We are not referring to something that is standing still but can be move out of the way, for example parked cars and pedestrians.

(Note to experimenter: Take care to direct the subject's attention to the hazard, not the marker.)

(Slide 5.13) In this country scene, the tree on the right which is very close to the road, is a potential hazard. You can see it looks like it's been hit several times.

(Slide 5.14) Here the concrete bridge piers are certainly something to avoid.

(Slide 5.15) This hazard is very difficult to see. There is a culvert running under the roadway and the foundation on either side of the road may damage your tires if it were hit. (Point to section on screen so all will be aware of area)

(Slide 5.16) You would answer "Yes" here as well. Notice that the house is almost <u>in</u> the road.

(Slide 5.17) This is another example of an arterial. The island is a hazard, although not as dangerous as a telephone pole, a tree or a wall, you still wouldn't want to hit it.

Q6. Were there any pedestrians anywhere in the scene?

YES

NO

(Slide 6.18) Yes, this is a pretty self-explanatory question.

(Slide 6.19) No, You might be tempted to assume that a child is going to come running out after the ball. However, only mark "Yes" if you actually see the pedestrian.

(Slide 6.20) Lastly, notice the pedestrians in the distance here.

We don't expect you to see everything in every slide. We have deliberately made the exposures brief to simulate the limited amount of time you have as you are driving down the road.

Any questions?

INSTRUCTIONS
PROBLEM IDENTIFICATION EXPERIMENT 2
SIGN AND MARKER COMPREHENSION

Thank you for participating in our study on sign meaning. Please open the booklet to the first photograph. As you read in the consent form, you will be looking at photographed scenes with signs or markers in them and answering questions or giving us opinions about them.

On each right-hand page is an enlargement of the particular marker we want you to focus on. On each left-hand page is a colored photo of a roadway scene with the sign or marker in it. If at any time during the session you don't see the sign or marker in the photograph, raise your hand and I'll point it out to you. The type of roadway situation in which the sign is placed may be very helpful in determining your answer, especially if you are not sure of the answer. Please do not mark 'I don't know'. If you haven't seen the sign before, we want your best and most complete guess as to what it means and what it would require you to do.

We would first like you to answer the two questions on each right-hand page about the sign shown:

1. **Exactly** what does this sign mean to me as a driver?

2. **Specifically** what action would I take when I saw this sign?

Please write your complete response directly on the right page and do not mark on the colored photographs! You may use other signs in the scene to help you guess the meaning of the sign indicated; however, please be very careful to only explain the sign shown on the answer page. We do not want you to explain any additional signs in the scene.

We cannot overemphasize the importance of detail in your answers. We need you to be as complete as you can, so that we will have an accurate understanding of your knowledge and opinions on each sign. Do not assume that any information is general knowledge. When writing the details to each question, you may want to pretend that you are explaining the sign to a new driver, a child or someone from another country, in which case you would have to be very specific.

Please work independently. We want to get as many separate opinions as possible. Also, some other groups of volunteers will be looking at different types of signs, and we want to keep those differences separate in our findings. Each person has a different order of scenes, so it is important that you don't look at what your neighbor is doing. Speaking of order, we found in a preliminary study that some people's interpretations of later signs in the booklet were influenced by signs earlier in the booklet. Although this is difficult to guard against, we would like you to try to keep your later answers independent from your earlier ones.

I would like to mention one last thing about writing your answers. Some signs or markers are used in more than one scene. When giving your response be sure that you are referring to the current scene only. Some signs and/or situations are experimental so a particular sign may have different meanings in different scenes.

To give you some idea as to the level of detail we would like, I would like to read some examples of answers that are too sketchy and some that are at the level of detail we need to be able to determine how well the signs are understood. I will read you examples of answers that are too sketchy, as well as answers that have enough detail. Please don't write any answers on the three practice pages, but you might be thinking about what answer you would put down.

Example	Sketchy answer	Appropriate answer
#1 - Yield (R2-1)	Yield	Yield sign. This sign is used at an intersection where other traffic has the right of way. I should look, merge with traffic, and stop only if the lane is not clear.
#2 - Hill (W7-1b)	Hill	Up ahead is a steep and/or long grade. Anyone hauling a heavy load should slow down, test their brakes, and shift into a lower gear if necessary.
#3 - Amphitheater (RL-010)	Don't Know	I guess, since this is a brown and white sign, that it has something to do with a recreation area. Perhaps it's that an assembly area or stage is near.

Now, just a few more instructions before you get started. The volunteer number I gave you earlier should be written on the top left side of each answer sheet. This is simply so we can code each answer into the appropriate age group and can therefore tell if older and younger volunteers think the signs and markers mean different things or require different kinds of action. These numbers will be used by the people coding the data for analysis so that your name and organization will never ever have to be used.

You will also notice that each photo has a number on the little paste-on tab. Please put this number on the top right side of each answer sheet. Since everyone will have the same photographs, but in a different order, this number will allow us to identify each scene and determine the range of answers for each.

Remember, your volunteer number goes on the top left, and the photograph number on the top right of each answer sheet. Does anyone have a question? ... If not, you may begin. Please raise your hand when you are finished with the answers and you will be given several more tasks which will be explained on the written material we give you.

Now that you have completed the 'meaning' and 'action' questions, please read over the two sets of statements below. One set is about the familiarity of the sign and the other set is about the danger of the scene. Then turn to the notebook you just finished and rate each **sign** for familiarity (choose <u>one</u> number only), and rate each **scene** for danger (choose <u>one</u> letter only) from the sets of statements below. <u>Don't</u> rate the three example scenes at the front of the book; start with scene #4.

Once again, there are no right or wrong answers. We are interested in your opinions.

<u>Sign Familiarity Rating</u>:

1. I have never seen this sign.

2. I have seen this sign only a few times in my life.

3. I have seen this sign several times but it is not a common sign.

4. I see this sign almost every time I drive.

5. I see this sign every time I drive.

<u>Scene Danger Rating</u>:

A. This is a safe situation. An accident here is highly unlikely. I would not change my actions if I were driving through this scene.

B. This is a fairly safe situation. An accident here is possible but unlikely. I would make myself more alert but would not otherwise change my actions.

C. This is a slightly dangerous situation. An accident could happen here if I was careless. I would become more alert and make sure I was in full control of the car if I were driving through this scene.

D. This is a fairly dangerous situation. An accident could happen here unless I was very careful. I would probably slow down and be especially alert if I were driving through this scene.

E. This is a very dangerous situation. An accident is highly likely here unless I braked heavily and prepared for further emergency action.

INSTRUCTIONS
PROBLEM IDENTIFICATION EXPERIMENT 3
OBJECT MARKER DESIGN AND IMPLEMENTATION

To begin the design half of the session, the experimenter then read the following script:

Good Morning! We've asked you here to help us get the average drivers opinion on items along a roadway that present a potential hazard to motorists. We will be talking about the types of items that get hit by cars and how we can decrease these accidents.

The first thing traffic engineers try to do is to clear away as many of these hazardous objects as possible. The idea is to create a "clear zone" on both sides of the roadway. This is helpful to drivers because if they happen to go off the road, they can usually maneuver back into their lane without hitting anything.

If we could clear away all hazardous objects on the sides of roadways, the accidents would significantly decrease. Unfortunately it is very expensive and some items can not be removed. Some examples of the objects I am referring to are: bridge rails and columns, the ends of guard rails, ditches, telephone poles, trees and mailboxes.

These are all items that are relatively close to the side of the road. Since they can not be removed, we would like to determine the BEST possible way to mark them. For instance, should we put a sign on the item to draw attention to it. This would be helpful to drivers who started to drift slightly out of their lane. If a driver can see an object in time, he or she will have a chance to maneuver around it and avoid an accident.

Today we are going to split our session into two different parts. During the first half, we will show you scenes of various objects and we'd like you to design a new or improved way of marking each one. During the second half, we will hold an informal discussion about your opinions on this topic.

Let me go into a little more detail about what I want you to do first. In your notebooks are 12 scenes containing hazardous objects which we have chosen and also a line drawing for practice. For each scene we'd like you to do several things.

1. Locate the object we have chosen for the scene. It will be described on the top of the right page.

2. Looking at the content of the scene, decide how you would mark this object to best warn motorists of the potential danger.

3. Draw your design on the right page, as large as you can. This is so we can see all of the details clearly. You may use any colors, shapes, or patterns you choose. However, you can not use letters or words.

4. After you have drawn your marker, we would like to know where you would position it in relation to your object. We are only interested in placing the markings close to the objects themselves. For example, we are not interested in a warning sign that would be placed "AHEAD" of the object on the road. We want you to place your marker either directly on the object or on a pole very close to the object. It is your decision as to the height and actual positioning.

   We know that a lot of you will want advance warning, however that is not in the scope of this project. You will have a chance to voice your opinions later.

   (Show examples of signs placed "AT" an object: large arrow, t-intersection arrow, chevron alignment sign.)

   You do not have to squeeze in an exact replica of your design. Just the outline of your markers shape and include the pole if it is not going to be placed directly on the object.

5. Last we'd like you to rate the level of danger this object poses in this scene. Circle your choice underneath your drawing on the right hand page. Choose slight, moderate, or extreme danger.

Now please open to your practice scene, it is the first line drawing in your book. Also, please remove the single sheet of instructions in the inside cover. This is to aid you in following our numerous instructions. I will read through them and show you an example on this board, before you begin any writing of your own.

(Note to experimenter: Draw shape on object and also draw pole and shape on pole.)
You will need to use these blue pencils to write on the scenes.

Before I let you get started, I would like to briefly describe the hazards we would like you to design for. Each of your books is in a different order, so you'll have to look up here while I describe each object. Again, please call me to clarify the objects when you get to a scene that is not clear.

(Note to experimenter: Pick up one book and flip through all 12 scenes, reading the hazard and pointing to it in the scene. Describe its location to the group.)

Please bear in mind that these 12 situations are just a sample of the many actual situations on our roads and highways.

I need to point out that although these pictures are all daylight scenes, you need to consider what the situation would be like at night. A large tree would be hard to miss during the day, but at night, it doesn't stand out from its background, especially in the narrow headlight

beams. At least at night you can be sure that the object marker will be reflective. All signs nowadays are made of a material that reflects your headlights directly back at you, which makes them really stand out. So it will be a given that your signs, no matter what color, will be reflective.

We want everyone to work independently on designing these new and improved hazard markers. Please do not talk to each other during this portion of the experiment and do not look to other people for ideas. We will not be discussing or showing your particular designs unless you want to.

If you want to draw a second or alternate design for a situation, feel free. Get a blank sheet of paper from the middle of the table and go ahead, then write the description of the scene on the sheet, and slip it into the booklet at that page. You also might want to do this if you finish early. However, we do want to leave enough time for the discussion period. Take about 5 minutes for each scene.

Remember, there are no right or wrong answers. So, let yourself relax and have fun. We don't expect anyone to be a trained artist. The main point is to get your idea down on paper. The only time we want you to be **precise** is when you place your marker in the scene on the left page. You will have plenty of opportunity to get across any ideas that you were unable to express during the drawings, when me move into our discussion.

Any questions? Call me over at any time to answer specific questions.

Please feel free to use the restrooms at any time and when you have finished your 12 drawings, help yourself to refreshments that I will be setting out on the table in the back.

This is very important! In order to get full credit for this half of the experiment, you must complete at least one drawing for each scene. If you do not feel that a warning is necessary in this situation, you will have plenty of opportunity to express your thoughts during our discussion. So please make sure that you design a drawing for each scene and remember, they can be as simple or as complex as you would like.

[End of verbatim instructions for part 1]

The moderator's question path used during the focus group in part 2 was as follows:

Hello and welcome! Thank you all for joining us today. My name is _____, and I will be moderating the discussion. This is _____, who will be helping and taking some notes. As you can see, we are also taping this discussion just so we have a full record of it and don't miss anyone's ideas. Please make yourselves comfortable and feel free to help yourselves to the refreshments or to use the restrooms at any time during our discussion. This should be a relaxed and informal discussion and everyone should have plenty of opportunities to join in.

We have invited you all to discuss your ideas about objects on or near a roadway that may be hazardous to drivers. We are also interested in your opinions on how these hazardous objects could be marked in order to forewarn motorists. We want to learn about your experiences, hear your opinions, and get your ideas on how things are done and how they can be improved.

First, let me tell you a little about what you can expect today and what we expect from you. We have asked you all here because you are all current drivers over the age of _____. We will hold an informal discussion about our topic and would like to learn ALL of your ideas. Your conversation can be free flowing, I don't think there is any need to go systematically around the table with the exception of our introductions. Our object today is to get as many ideas and opinions as possible, so please don't hesitate to bring up a point that may differ with someone else. We are not looking for a consensus and there is no need to try to persuade the other members of the group. We do want to make sure that everyone has ample time to express their ideas and get your points heard. We are particularly fond of a group setting because it helps to stimulate discussion and prompt ideas. I have several questions to ask about the topic of hazardous objects and the various ways to mark them that I will throw out for discussion through out our session and during that time I will sit back and listen to your thoughts.

Before we start let me point out that as you can see we will be video taping your discussion. This is so my boss can review your ideas and comments at a later date. Also, we don't want to miss anyone's opinions by relying solely on notes. Please, try to be aware of sneezes and coughs, they tend to dominate the microphone and drown out who ever is speaking at the time. Remember, this is going to be a very relaxed conversation and feel free to get up at any time to get refreshments or to use the restrooms.

<u>Question path</u>

I. Introductions / Where have you lived?

Let's start by going around the table and each of you can briefly introduce yourself and tell each other where you've lived during the years that you've been driving. The setting that you have done most of your driving in will be very helpful to us when we review your opinions. For example, someone who lived mostly in Arizona may have a very different outlook on driving than someone from Boston. Let's start on my left and go around the table.

II. Accident Experience

Think about the many car accidents you have seen on roadways, heard about from friends and relatives, or any you have actually been involved in. We are interested in those involving hazardous objects. By this we mean accidents where an object was struck either in the

middle or on the side of the road. Think back also to any close calls you may have had and were able to successfully prevent an accident. What hazardous objects could have been involved if you had not avoided them. Everybody's at least come close to hitting something at some point. We would like to find out what these objects were.

(Note to experimenter: Another helpful technique is the probe. Use after a topic has been explored to prompt subjects with vague ideas to stimulate further conversation. The probes are only offered after subjects appeared to exhaust their opinions and suggestions.)

PROBES: Do you think they could have been prevented if they were better marked?
Weather: clear, rain, snow, fog
Night versus Day
Distractions: passengers, radio, other cars, etc?

III. Hazardous Objects

GM conducted a study where they learned that if what they call a "clear zone" can be maintained on a roadway that accidents would be reduced close to zero. By this they meant clearing away any item that a car could possibly come in contact with near the side of roadways. This is most beneficial to drivers who have gone off the side of the road. If nothing is in the way to be hit, most of the time drivers can recover and get safely back on the roadway. However, not all items can be completely cleared from the side of all roads. It's just too expensive. We are then left with the dilemma of how to make them more noticeable, especially at night, so that drivers have a chance to navigate around them if necessary.

We've mentioned several specific hazardous objects, for example _____ and _____. Now let's try to generate a larger list of objects that would possibly be likely to be hit. What other types of items along a roadway would you consider dangerous.

PROBES: Size (How big to be a hazard?)
Nearness (How close to road to be a hazard?)
Material of object (Are some things more hazardous than others?)
night versus day
type of road
speed of travel
natural versus manmade object
put there by whom (highway officials, other businesses, individuals)

IV. Markers

Now that we've mentioned a large variety of potentially hazardous markers, I'd like to get your ideas and opinions on ways in which they can be marked.

These object markers are necessary to alert drivers to the potential danger. We are interested in ways to catch the attention of drivers so they will notice the hazard and be able to avoid it if necessary. You may want to draw upon some of the ideas you used in your drawings.

What are some ways of alerting a driver of a potential hazard? What do you think would be most effective?

PROBES: size
shape
color
pattern
height
position
how often (number of signs?)
night versus day
"AT" versus "AHEAD"
"Hazard ahead" sign?
match type of object to specific markers?

(Note to experimenter: summary and conclusion of session)

Well, I think that's about it. Can anyone think of anything we've missed? We've sure covered a lot and have gotten many terrific ideas. Thank you all very much for joining us today.

[End of Question Path]

INSTRUCTIONS
LABORATORY EXPERIMENT 1

You are about to participate in a study sponsored by the Federal Highway Administration to determine how well drivers understand traffic signs and situations. To begin, please open your booklet to the first photograph. As you read in the consent form, you will be looking at photographed scenes with signs or markers in them and answering questions or giving us opinions about them.

On each right-hand page is an enlargement of the particular sign we want you to focus on. At times you may see that the right hand page has been colored to represent the **exact** color of the sign. Please keep these colors in mind when viewing the signs, as the color in the photo may not always be accurate. On the left-hand page is a photo of a roadway scene with the sign or marker in it. If at any time during the session you don't see the sign or marker in the photograph, raise your hand and I'll point it out to you. The type of roadway situation in which the sign is placed may be very helpful in determining your answer, especially if you are not sure of the answer. If you haven't seen the sign before, we want your best and most complete guess as to what it means and how you would drive if you saw it.

Underneath the large sign on the right page are two questions: 'What does this sign mean' and how would it affect your driving?' Please fill in your best and most complete answer. Please be very specific with your answers and do not assume that we know any information.

You may use other signs in the picture to help you **guess** the meaning of the sign indicated; however, please be very careful to only answer about the sign shown on the right page.

We cannot overemphasize the importance of details in your answers. We need you to be as complete as you can, so that we will have an accurate understanding of your knowledge and opinions on each sign. Do not assume that any information is general knowledge. When writing the details to each question, you may want to pretend that you are explaining the sign to a new driver, a child or someone from another country, in which case you would have to be very specific.

Please work independently. We want to get separate opinions. Also, other subjects will be looking at different types of signs, and we want to keep those differences separate in our findings. Although everyone has the same general booklet, the people beside you may have a different order within their booklet. Therefore, it is important that you don't look at what your neighbor is doing.

I would like to mention one last thing about selecting your answers. Some signs or markers are used in more than one scene. When giving your response be sure that you are referring to the scene on the left page only. Some signs and/or situations are experimental so a particular sign may have different meanings in different scenes.

Now, just a few more instructions before you get started. The subject number I gave you earlier should be written on the top left side of your answer pages. Please do that on each page as you get to it. These numbers will be used by the people coding the data for analysis so that your name and organization will never have to be used.

Are there any questions? If not, you may begin. Please raise your hand when you are finished with the answers.

INSTRUCTIONS
LABORATORY EXPERIMENT 2

1. Explain that the signs or pavement markings will be on the right side of the road at the end of the white edge line.

2. Starting at 305m (1,000 ft) ask the subjects if they can see a sign or pavement marking. If they can, ask them to describe it. If a sign, ask, "CAN YOU MAKE OUT THE COLOR, SIGN SHAPE, OR ANY SYMBOL OR TEXT?" If a marking, ask, "CAN YOU MAKE OUT THE COLOR, SHAPE?"

3. If they cannot see any stimulus at 305 m (1,000 ft), drive 16.1 km/h (10 mi/h) until they can.

4. After detection, proceed in 15.25-m (50-ft) increments asking the subject at each step, "IS THERE ANY CHANGE IN THE COLOR, SHAPE, SYMBOL OR TEXT."

5. If they are having trouble describing the shape or symbol, ask them to draw it.

6. If the sign is blank, ask the subject if they think that it is blank or if they think it has a word or symbol on it that they cannot see because it is so far away.

INSTRUCTIONS
LABORATORY EXPERIMENT 3

The purpose of this study is to find out how the driving environment affects driver attention. Your participation will provide us with information on how different roadway and traffic conditions affect attention.

You will see two different 30 minute video tapes of roadway scenes, each taken from the driver's point of view. We would like you to pretend you are the driver, and tell us whenever something attracts your attention. Be sure to report anything which attracts your attention, no matter how inconsequential it may seem. Keep in mind, this is not a test of your driving ability, and we have no standards by which we can compare you to other drivers taking part in this study.

By the end of the first 30 minutes, your attention may be changing. At this point, we will give you a 10 minute break to stretch your legs and use the restroom. When you return from your break, you will view a second 30 minute tape. Your task will again be to verbally report everything that catches your attention.

Throughout this study, your job will be to view the tape and simply call out items that catch your eye. At some times you may find you have little to report, while at other times you might be quite busy. For this reason, you do not need to be very detailed when identifying objects, rather a brief description is all we need. For example, if a car parked on the right side of the road grabs your attention, you need only to say "car on right." If however a common item catches your eye, please provide a description such as "RED sign" or "driveway on LEFT," to distinguish it from the others. We will show you a few practice scenes so you are comfortable with the task when the study begins.

These tapes are a collection of short drives from around the area. In between drives you may see a brief black screen or even some fuzz or snow, please disregard these items and continue to look at the screen and report the items that attract your attention. Also you will find that some of the scenes on the tapes may end abruptly without much prior warning. For instance, a drive may end in the middle of the street before reaching the corner. We would like you to just continue along no matter how the scenes change.

Do you have any questions?

I will start the practice videotape now, please look at the TV monitor. Call out all objects or things that attract your attention during the tape, as you see them. Please do not engage in any other conversation until the video ends. This short tape will be

used for practice so you can become familiar with our procedure. However, on the real tapes we must ask that you do not talk about any other things while the study is in progress.

INSTRUCTIONS
FIELD STUDIES 1 AND 2

First drive:
Read the following instructions to the subject:

> You will be driving a predetermined route, twice. During each drive we will be collecting different types of information. I will give you instructions before we begin driving each time, about the type of information we are interested in.
>
> During this first drive we are interested in what captures a driver's attention. As you drive along the route, I would like you to tell me all the items that attract your attention, as they occur. A driver notices many different things when she or he is driving, some which have to do with driving, and some which don't. This is not a test of driving ability, we simply want to see what drivers notice. We will drive along several different types of roadways that will have varying amounts of traffic. This will provide us with a good variety of situations and traffic levels.
>
> Because there will be numerous potential items that may attract your attention during this drive, we ask that you do not engage in any other conversation until the drive has ended. You will simply be driving in your normal manner and calling out all things that attract your attention as you notice them. It may be helpful to stay in the right lane as much as possible, unless I tell you otherwise.
>
> We would like you to call out the things you look at while you are driving. For instance, as you drive you might say, 'on-coming traffic'; 'big tree on right'; 'car in side street'; 'speed limit sign'; 'gas station on left'; etc. We want you to call out all the things you look at. Each time you change your attention please call out the next item. We are interested in all the items you notice even if they don't relate directly to driving or if you see them frequently and they seem trivial. Basically, what are the things you look at? I will be sure to give you advanced warning of all turns. Also, please be sure to leave plenty of space between your car and the one in front of you.
>
> As you drive, your eyes are constantly shifting from one thing to another. This shifting happens many times per second. It is impossible to talk as fast as your eyes are shifting, but we would like you to come as close as possible to that speed by quickly saying **EVERYTHING** that your eyes shift toward as you drive. You will need to speak very concisely to catch the largest number of glances, so single words or very short phrases are fine. This can be fairly tiring, so I will ask you to do this talking procedure for a short time and then

give you a break before asking you to do it again. **It is important, however, to try to say everything that your eyes notice during the procedure.** I will give you feedback about how you are doing early in our drive so that we can perfect the process and get the most out of the drive.

After the first two miles (3.22 km) of the route, have the subject stop in an appropriate location. At this time, provide the subject with feedback or clarification of the intended procedure and answer any questions. This period is used as practice for the procedure to ensure that the subject has an understanding about the type and quantity of information expected during the drive. To focus the drivers' feedback somewhat, indications of signs or road markings should be reinforced by the experimenter as needed and spurious information regarding activity or objects not related to the driving exercise are to be discouraged. The purpose of this feedback is to keep the subject somewhat focused without biasing them toward simply looking for signs or roadway markings.

(This stop point will also provide you with the opportunity to terminate the experiment, if the subject exhibits unsafe driving tendencies or is unable to comprehend the requirements of the experimental procedure. If all aspects of the practice run are acceptable, continued.

Second drive:
Once back at the initial meeting place, provide the subject with a short break. Before beginning the second navigation of the route, read the following instructions:

During this second drive we are interested in how people interpret certain signs and roadway markers. Along this route, there will be 10 roadway signs/line markings that I will point out to you. It is important to remain in the right lane, stay at or below the speed limit for safety and to allow plenty of time to view the designated sign or pavement marking.

After we pass an intended sign or marker, I will ask you to pull over in a safe place to answer two questions about the item's meaning. Then we will go on to the next site. The questions will always be the same: *"Exactly what do you think this sign/marking means?"* and *"What action, if any, should you as a driver take in response to it?"* Please answer them as completely and exactly as possible to avoid any confusion on the part of the experimenter. Remember though, this is a test of the effectiveness of highway markings, not of your capability to use them. Just do your best.

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