UMTRI-84-16

HUMAN FACTORS AND ROAD SAFETY: OVERVIEW OF RECENT RESEARCH AT THE UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE

Michael Sivak

APRIL 1984

UMTRI The University of Michigan Transportation Research Institute

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-84-16		

4. Title and Subtitle	5. Report Date
HUMAN FACTORS AND ROAD SAFETY: OVERVIEW OF RECENT RESEARCH AT THE UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE	April 1984
	6. Performing Organization Code
7. Author(s) Michael Sivak	8. Performing Organization Report No. UMTRI-84-16
9. Performing Organization Name and Address The University of Michigan Transportation Research Institute Ann Arbor, Michigan 48109 U.S.A.	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents a brief overview of the research performed at the Human Factors Division of The University of Michigan Transportation Research Institute within the last seven years. The research has dealt with the following topics: vehicle headlighting, vehicle rear lighting and signaling, legibility of traffic signs and license plates, driving-test development, stopping sight distance, drivers with disabilities, elderly drivers, driver seated position, vehicle displays and controls, windshield damage and safety, conspicuity of vehicles, epidemiology of accidents, and theoretical issues.

17. Key Words	18. Distribution Statement
Human factors, traffic accidents, headlighting, rear lighting, controls, displays, handicapped, elderly, traffic signs, epidemiology, review	Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	19	

TABLE OF CONTENTS

INTRODUCTION

This report summarizes recent research at the Human Factors Division of the University of Michigan Transportation Research Institute (UMTRI)[1] in Ann Arbor, Michigan. It is an updated version of an earlier report (Sivak, 1982) that also appeared in German translation (Sivak, 1983a).

The Human Factors Division is currently operating with a $400,000 per year research budget. The staff consists of three Ph.D. scientists, several full- and part-time research assistants, and a secretary. The primary researchers--all human factors specialists--are trained in experimental and industrial psychology, industrial and operations engineering, and statistics. Excellent support is provided by the Institute, including electronics shop, laboratory space and equipment, library, and computer services.

The research activities of the Human Factors Division have concentrated on the safety aspects of operating vehicles. The wide range of problems investigated have included those that are driver-centered (e.g., drivers with disabilities and elderly drivers, driving-test development), vehicle-centered (e.g., vehicle lighting and signaling, instrument-panel controls and displays), and environment-centered (e.g., legibility of traffic signs). In examining these issues, various experimental approaches have been taken, including computer-controlled laboratory studies, on-the-road monitoring of drivers' maneuvers and eye movements, computer simulations, and analyses of relevant accident statistics.

The following is a brief overview of research performed at the Human Factors Division within the last seven years.

---

[1]Formerly named Highway Safety Research Institute (HSRI).

VEHICLE HEADLIGHTING

A 1977 report (Olson, 1977) discusses the historical development of automobile headlighting and describes the differences between European and American concepts in terms of construction and light output/distribution. The advantages and disadvantages of each system are described. The report also contains an extensive annotated bibliography (65 publications). A more recent review, published in 1983 (Perel, Olson, Sivak, and Medlin, 1983), describes major research findings and major issues in contemporary headlighting.

In the late 1970's a research project dealt with the feasibility of a single-beam headlighting system (Halstead-Nussloch et al., 1979). As part of this project, field evaluations and computer simulations of alternate systems were performed. The results indicated that the experimental single beams provided only marginal and situation-specific improvements over the standard U.S. low beams.

A recently completed project (Olson and Sivak, 1983c) dealt with possible improvements to the U.S. low-beam system. This research consisted of laboratory and field experiments, and computer modeling. Based on the results of this research, recommendations were made for changes to the low-beam specifications. This extensive research formed the basis for several journal and SAE publications. These publications concentrated on the effects of foreground illumination (Olson and Sivak, 1983a), comparison of headlamp visibility distances with stopping distances (Olson and Sivak, 1983b), discomfort glare from on-coming vehicles (Olson and Sivak, 1984a), discomfort and disability glare from automobile rear-view mirrors (Olson and Sivak, 1984c), and reanalysis of some past glare and illumination findings (Olson and Sivak, 1984b).

In a related research project, Olson (1982) studied headlighting beam-aim variance associated with replacement of burned out lamps without re-aim. Both U.S.-type sealed beams and replaceable-bulb units of the type used in Europe were tested. The results indicated that the European-type units were less variable in their vertical aim, while the U.S.-type units were less variable in their horizontal aim.

Motorcycle/moped headlighting was the topic of another research project (Olson and Abrams, 1982). Following several field experiments and computer simulations, an improved motorcycle/moped low-beam headlighting system was recommended.

Much of the UMTRI headlighting research used a computer program developed in the early 1970's (Mortimer and Becker, 1973; Becker and Mortimer, 1974). This program predicts seeing distance to various targets as a function of the headlamps selected, their location and aim, target position, and several other variables. Recently, Green (1980) prepared supplemental information on how to run an updated version of this program.

VEHICLE REAR LIGHTING AND SIGNALING

The literature on automobile rear lighting and signaling was reviewed in two reports. Sivak (1978) focused on the effects of color, intensity, position, and spacing of rear lights. This report also contains an annotated bibliography (36 publications). A more recent and comprehensive review (Henderson, Sivak, Olson, and Elliott, 1983) dealt with both the findings and issues in rear lighting and signaling.

The potential benefits of supplemental high-mounted brake lights were investigated in three studies. In the first study, Sivak, Post, Olson, and Donohue (1981a) measured reaction times of following drivers to brake signals presented by one of 22 configurations of brake

lights. The next two studies evaluated in-traffic responses of unalerted drivers to supplemental high-mounted brake lights: Sivak, Post, Olson, and Donohue (1981b) used a photographic technique to measure frequency and delay of brake responses, while Sivak, Olson, and Farmer (1981) used a radar to measure frequency and delay of speed-change responses. The evidence from these three studies is inconclusive as to the benefit of the high-mounted brake lights.

An important by-product of the high-mounted-brake-light studies was the accumulation of extensive data on in-traffic reaction times of unalerted drivers to brake signals from a vehicle immediately ahead. Some of these data are summarized in Sivak, Olson, and Farmer (1982).

Post (1978) reviewed the special considerations regarding lighting and signaling for emergency, school bus, and service vehicles. The report contains a review of available hardware, review of basic and applied vision research, analysis of signaling requirements, and recommendations.

LEGIBILITY OF TRAFFIC SIGNS AND LICENSE PLATES

Nighttime legibility of traffic signs was the subject of several research projects. Olson and Bernstein (1979) found that highly reflective sign backgrounds permit somewhat greater legibility distances, and that reflective backgrounds reduce the effects of changes in viewing conditions.

The results of a follow-up study by Olson, Sivak, and Egan (1983) indicate that (1) legend luminance contrast is the most important variable in nighttime sign legibility; (2) there is a relatively narrow range of optimal contrast; and (3) as background luminance increases, legibility improves and legend contrast requirements decrease.

Sivak, Olson, and Pastalan (1981) and Sivak and Olson (1982) investigated the effects of driver's age on nighttime sign legibility. In the study by Sivak, Olson, and Pastalan (1981) younger and older subjects were matched in terms of their high-luminance (daytime) visual acuity. The subjects drove or were driven toward a sign. The results indicated that the legibility distances for the older subjects were 65-77% of those for the younger subjects. In a follow-up study (Sivak and Olson, 1982) the age differences in legibility distance were eliminated by equating younger and older subjects in terms of their low-luminance (nighttime) visual acuity. Additionally, this study showed that glare sources positioned outside of the fovea might, under certain conditions, improve nighttime legibility.

Nighttime legibility of license plates was investigated by Olson and Sivak (1983d). The results of this field study indicate a general superiority for fully reflectorized license plates, especially under conditions of glare. The older subjects, in particular, seemed to benefit from the highly reflective plates.

DRIVING-TEST DEVELOPMENT

The purpose of a study by Olson, Butler, Burgess, and Sivak (1982) was to develop a battery of low-speed driving tests that could be used for preliminary systems screening of drivers, vehicles, and components. Several driving tests were developed, together with suitable performance measures. These tests were administered to a group of subjects, and the data were subjected to a factor analysis. Six factors emerged, with one or more tests under each. These results indicate that a test battery can be created using a small number of tests, in a relatively confined space and without elaborate instrumentation, and still sample several relevant driving-skill dimensions.

STOPPING SIGHT DISTANCE

A recent multidisciplinary project (Olson, Cleveland, Fancher, and Schneider, 1984) dealt with desirable sight distance as related to parameters such as driver reaction time and vehicle stopping distance. As part of this study, literature reviews and original research were conducted on driver eye height, roadway obstacle height, driver perception-response time, vehicle braking distance, accident analyses, and mathematical relationships between stopping sight distance and geometric design elements. Based on these investigations, recommendations were made for changes in design driver eye height, design obstacle height, and design braking distance.

INDIVIDUAL DIFFERENCES: DRIVERS WITH DISABILITIES

A multi-year project investigated the interrelations of brain damage, perceptual/cognitive skills, and driving. The results of the first study (Sivak, Olson, Kewman, Won, and Henson, 1981) indicate that persons with brain damage, as a group, exhibited impaired perceptual/cognitive skills and also impaired driving. However, persons with brain damage who scored well on certain perceptual/cognitive tests tended to show good driving performance as well. An implication of these results is that therapeutic techniques capable of improving the impaired perceptual/cognitive skills may improve driving performance as well.

This implication was experimentally evaluated in two studies (Sivak, Hill, Olson, and Henson, 1981; Sivak, Hill, Henson, Butler, Silber, and Olson, 1984). In these studies, simple paper-and-pencil activities were used as training techniques for perceptual/cognitive deficits. The results suggest that perceptual/cognitive skills of persons with brain damage may be amenable to relatively short-term training, with a transfer of the benefits to driving performance as well.

A pilot study (Sivak, Hill, and Olson, 1983) investigated the modifiability of perceptual/cognitive deficits by training which consisted of performing microcomputer-generated video tasks. Based on generally positive results, this study recommended comprehensive evaluation of the potential benefits of this type of training on both perceptual/cognitive skills and driving performance.

In a related area, Olson, Post, and Huber (1978) performed a safety evaluation of converted vans for transportation of the disabled and elderly. The report describes a review of the specifications, based upon analysis of crash data as well as upon consultations with manufacturers and organizations using such equipment.

INDIVIDUAL DIFFERENCES: OLDER DRIVERS

Driver age was a parameter in several studies that concentrated on other aspects of the vehicle-driver-environment system. For example, effects of driver age were investigated in the context of vehicle headlighting (Olson and Sivak, 1983c), legibility of traffic signs (Olson, Sivak, and Egan, 1983; Sivak, Olson, and Pastalan, 1981; Sivak and Olson, 1982), legibility of license plates (Olson and Sivak, 1983d), and perception-reaction time (Sivak, Post, Olson, and Donohue, 1981a; Olson, Cleveland, Fancher, and Schneider, 1984).

CONSPICUITY OF VEHICLES

Olson (1984) reviewed accident data and experimental studies related to the conspicuity of motorcycles. In an experimental study, Olson, Halstead-Nussloch, and Sivak (1981) evaluated a range of daytime and nighttime treatments for improved front conspicuity of motorcycles. Using as subjects unalerted drivers in actual traffic, several treatments were shown to increase motorcycle conspicuity.

Specifically, daytime conspicuity was improved when the low-beam headlamp was turned on, when the high-beam headlamp was turned on and modulated in intensity three times per second, or when the motorcyclist wore a fluorescent vest and helmet cover. Nighttime conspicuity was improved when the motorcycle used additional running lights, or when the motorcyclist wore a retroreflective vest and helmet cover.

In a related study, Green, Kubacki, Olson, and Sivak (1979) investigated the nighttime conspicuity of tractor-semitrailers. The study included accident analyses, a literature review, and a small-scale eye-movement evaluation of treatments for increased side and rear conspicuity. Two main findings emerged. First, despite the large size of tractor-semitrailers, they are difficult to see at night, as evidenced by the high frequency of accidents where they are struck in the side or rear. Second, the addition of even a small strip of retroreflective material can significantly increase their nighttime conspicuity.

DRIVER SEATED POSITION

Schneider, Olson, Anderson, and Post (1979) investigated effects of several anthropometric and vehicular factors on driver seated position. The subjects in this study were tested in six different vehicles for preferred seat position under non-driving and driving conditions. The results indicated that on a total sample basis there was little difference between seat positions selected under non-driving and driving conditions, but that individuals may show significant differences between the two conditions. Additional analyses indicated that stature is the most significant anthropometric variable in determining preferred seat position. Depending on the vehicle, it explained approximately 30 to 60 percent of the seat-position variance.

VEHICLE DISPLAYS AND CONTROLS

Green and Burgess (1980) and Gingold, Shteingart, and Green (1981) reported on two experiments dealing with the development and evaluation of candidate pictographic symbols for motor-vehicle displays and controls. In Green and Burgess (1980) college students served as subjects, while truck drivers were used in the Gingold et al. (1981) study. In the first parts of both experiments subjects drew pictures intended to identify vehicle controls and displays. These suggestions, along with others generated by experts, were subsequently rated by subjects in terms of their meaningfulness. Based on these ratings, recommendations were made for future international symbols.

Speedometers and tachometers were the topic of research by Green (1983). The subjects in this computer-controlled survey answered questions on the frequency and conditions affecting the usage of these displays.

Green (1984) studied driver understanding of fuel and engine gauges. The method involved asking about specifications for their own vehicles, and responding to slides of instrument clusters. The data showed that (1) many drivers knew little about their vehicles; (2) for engine functions, drivers were more likely to understand moving pointers than numeric displays; (3) pointer alignment, color-coding, and labeling the normal zone all greatly improved understanding of engine displays; and (4) drivers understood all of the existing labeling schemes for analog fuel displays but had varying levels of difficulty with digital fuel displays.

A study by Miller, Peterson, and Green (1984) investigated the effects of various screen filters on (1) specular reflection from CRT displays, and (2) user performance. The results indicated that micromesh filter reduces specular reflection, and may improve the speed and accuracy of CRT users. (Although this study was performed

in the context of indoor usage of CRTs, it is of interest here because of the planned installation of CRTs in future models of automobiles.)

Automobile multifunction stalk-mounted controls were the topic of research by Green (1979). The report contains a comprehensive literature and hardware review, as well as human factors analyses and recommendations.

WINDSHIELD DAMAGE AND SAFETY

Effects of windshield damage on driving safety were studied by Green and Burgess (1981). The report summarizes a literature review, accident-data analysis, and a laboratory experiment. The results of the computer-controlled laboratory experiment indicate that interposing a severely damaged windshield between a driver and a simulated night driving scene significantly increases the time for subjects to make braking decisions. This effect was especially pronounced in presence of a light simulating the glare of an oncoming vehicle's headlights.

EPIDEMIOLOGY OF ACCIDENTS

Sivak (1983b) investigated the relation of violence/aggression and other macro-level variables to traffic accidents. In the first of two analyses, multiple regression was applied to 1977 data from each of the 50 U.S. states. Traffic fatalities per registered vehicle was the dependent variable. The main finding of this analysis is that homicide rates (but not suicide rates) predict states' traffic fatality rates; additional significant predictors were the proportion of young drivers and the fatality rate from accidents other than those connected to motor vehicles. These three variables accounted for 68% of the variance of traffic fatalities. The second analysis successfully validated the predictive power of the two primary predictors (homicides and young drivers). The validation was performed

by using 1977 regression coefficients to estimate 1978 traffic fatalities.

THEORETICAL ISSUES

Olson and Sivak (1981) dealt with problems in the detection and identification of significant roadway conditions. The paper discusses the complex, non-automatic, and different nature of these two processes; it points out problems with each, and suggests means for improvement. An expanded discussion of these issues is contained in Olson and Sivak (1984d).

In a related article, Olson, Sivak, and Henson (1981) discussed headlighting and visibility limitations, especially from the point of view of the danger for pedestrians. This danger, it is argued, is a consequence of the limitations of low-beam headlighting systems, coupled with pedestrians' overestimation of their own visibility.

Sivak (1981a) argued that traditional correlational analyses of human skills and road accidents have not been very productive. Some of the likely reasons for this were discussed. Furthermore, an alternative approach to accident-causation was outlined. In this approach the importance of a skill with good face validity to driving is assessed in terms of its sensitivity to frequently occurring transient human states such as fatigue, stress, and alcohol intoxication.

Finally, Sivak (1981b) briefly summarized current knowledge of how human factors contribute to traffic accidents, and summarized preventive measures motorists can take to minimize their chances of accident involvement.

CONCLUDING COMMENTS

This review was intended to provide an indication of the breadth and depth of recent road-safety research at the

Human Factors Division of The University of Michigan Transportation Research Institute. The wide variety of topics investigated reflects the diversity and complexity of issues in road safety. The research described in this review has led to a greater understanding of contemporary road-safety problems, and has offered engineering, educational, and legislative solutions to many of these problems.

REFERENCES

Becker, J.M. and Mortimer, R.G. (1974). Further development of a computer simulation to predict the visibility distance provided by headlamp beams. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. HF-74-26.

Gingold, M., Shteingart, S., and Green, P. (1981). Truck driver preferences and suggestions for instrument panel symbols. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-81-30.

Green, P. (1979). Automobile multifunction stalk controls: literature, hardware and human factors review. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-79-78.

Green, P. (1980). A computer simulation of headlamp variables and drivers' sight distances: operating instructions. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-80-44.

Green, P. (1983). What do drivers say they use speedometers and tachometers for? Ann Arbor, Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-83-49.

Green, P. (1984). Driver understanding of fuel and engine gauges. Society of Automotive Engineers, Paper No. SAE-840314.

Green, P. and Burgess, W.T. (1980). Debugging a symbol set for identifying displays: production and screening studies. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. HSRI-80-64.

Green, P. and Burgess, W.T. (1981). Windshield damage and driving safety. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-81-35.

Green, P., Kubacki, M., Olson, P.L., and Sivak, M. (1979). Accidents and the nighttime conspicuity of trucks. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-79-92.

Halstead-Nussloch, R., Olson, P.L., Burgess, W.T., Flannagan, M., and Sivak, M. (1979). Evaluation of the feasibility of a single-beam headlighting system. Ann

Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-79-91.

Henderson, R.L., Sivak, M., Olson, P.L., and Elliott, W.M. (1983). Motor vehicle rear lighting and signaling. Society of Automotive Engineers, Paper No. SAE-830565.

Miller, D.E., Peterson, E.A., and Green, P. (1984). Comparison of CRT antireflection filters. Ann Arbor, Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-84-8.

Mortimer, R.G. and Becker, J.M. (1973). Development of a computer simulation to project the visibility distance provided by headlamp beams. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. HF-73-15.

Olson, P.L. (1977). The relative merits of different low beam headlighting systems: a review of the literature. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-77-55.

Olson, P.L. (1982). The effect of headlamp bulb replacement on unit aim: a comparison of SAE and ECE systems. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-82-3.

Olson, P.L. (1984). Motorcycle conspicuity. In, G.A. Peters and B.J. Peters (Eds.), Automotive Engineering and Litigation, Vol. 1. New York: Garland.

Olson, P.L. and Abrams, R.A. (1982). Improved motorcycle and moped headlamps. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-82-18.

Olson, P.L. and Bernstein, A. (1979). The nighttime legibility of highway signs as a function of their luminance characteristics. Human Factors, 21, 145-160.

Olson, P.L., Butler, B.P., Burgess, W.T., and Sivak, M. (1982). Toward the development of a comprehensive driving test: low-speed maneuvering. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-82-4.

Olson, P.L., Cleveland, D.E., Fancher, P.S., and Schneider, L.W. (1984). Parameters affecting stopping sight distance. Ann Arbor, Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-84-15.

Olson, P.L., Halstead-Nussloch, R., and Sivak, M. (1981). The effect of improvements in motorcycle/motorcyclist conspicuity on driver behavior. Human Factors, 23, 237-248.

Olson, P.L. Post, D.V., and Huber, M. (1978). Safety evaluation of vehicles used to transport the handicapped and elderly. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-78-25.

Olson, P.L. and Sivak, M. (1981). Problems in the detection and identification of significant roadway conditions. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-81-46.

Olson, P.L. and Sivak, M. (1983a). Automotive headlighting: effect of foreground illumination. Perceptual and Motor Skills, 57, 1036-1038.

Olson, P.L. and Sivak, M. (1983b). Comparison of headlamp visibility distance and stopping distance. Perceptual and Motor Skills, 57, 1177-1178.

Olson, P.L. and Sivak, M. (1983c). Improved low-beam photometrics. Ann Arbor, Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-83-9.

Olson, P.L. and Sivak, M. (1983d). Nighttime legibility of license plates. Ann Arbor, Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-83-35.

Olson, P.L. and Sivak, M. (1984a). Discomfort glare from automobile headlights. Journal of the Illuminating Engineering Society, (in press).

Olson, P.L. and Sivak, M. (1984b). Glare and headlighting design. Society of Automotive Engineers, Paper No. SAE-840047.

Olson, P.L. and Sivak, M. (1984c). Glare from automobile rear vision mirrors. Human Factors, (in press).

Olson, P.L. and Sivak, M. (1984d). Visibility problems in nighttime driving. In, G.A. Peters and B.J. Peters (Eds.), Automotive Engineering and Litigation, Vol. 1. New York: Garland.

Olson, P.L., Sivak, M., and Egan, J.C. (1983). Nighttime legibility of license plates. Ann Arbor, Michigan: The

University of Michigan Transportation Research Institute, Report No. UMTRI-83-35.

Olson, P.L., Sivak, M., and Henson, D.L. (1981). Headlamps and visibility limitations in nighttime traffic. Journal of Traffic Safety Education, 28(4), 20-22.

Perel, M., Olson, P.L., Sivak, M., and Medlin, J.W. Jr. (1983). Motor vehicle forward lighting. Society of Automotive Engineers, Paper No. SAE-830567.

Post, D.V. (1978). Signal lighting system requirements for emergency, school bus, and service vehicles. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-78-55.

Schneider, L.W., Olson, P.L., Anderson, C.K., and Post, D.V. (1979). Identification of variables affecting driver seated position. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-79-47.

Sivak, M. (1978). Motor vehicle rear lighting and signaling: effects of spacing, position, intensity, and color. An applied-literature review. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-78-8.

Sivak, M. (1981a). Human factors and highway-accident causation: some theoretical considerations. Accident Analysis and Prevention, 13, 61-64.

Sivak, M. (1981b). What a motorist can do to minimize the chances of being involved in an accident. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-81-37.

Sivak, M. (1982). Human factors and road safety: overview of recent research at the Highway Safety Research Institute. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-82-21.

Sivak, M. (1983a). Menschliche Faktoren und Verkehrssicherheit: Überblick über neuere Forschungsarbeiten am Forschungsinstitut für Verkehrsfragen an der Universitat von Michigan. Zeitschrift für Verkehrssicherheit, 29, 77-81.

Sivak, M. (1983b). Society's aggression level as a predictor of traffic fatality rate. Journal of Safety Research, 14, 93-99.

Sivak, M., Hill, C.S., Henson, D.L., Butler, B.P., Silber, S.M., and Olson, P.L. (1984). Improved driving performance following perceptual training of persons with brain damage. Archives of Physical Medicine and Rehabilitation, 65, 163-167.

Sivak, M., Hill, C.S., and Olson, P.L. (1983). Computerized video tasks as training techniques for driving-related perceptual deficits of persons with brain damage: a pilot evaluation. Ann Arbor, Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-83-48.

Sivak, M., Hill, C.S., Olson, P.L., and Henson, D.L. (1981). Preliminary testing of techniques to improve driving performance of persons with brain damage via perceptual/cognitive training. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Interim Report No. UM-HSRI-81-12.

Sivak, M. and Olson, P.L. (1982). Nighttime legibility of traffic signs: conditions eliminating the effects of driver age and disability glare. Accident Analysis and Prevention, 14, 87-93.

Sivak, M., Olson, P.L., and Farmer, K.M. (1981). High-mounted brake lights and the behavior of following drivers. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, Report No. UM-HSRI-81-31.

Sivak, M., Olson, P.L., and Farmer, K.M. (1982). Radar-measured reaction times of unalerted drivers to brake signals. Perceptual and Motor Skills, 55, 594.

Sivak, M., Olson, P.L., Kewman, D.G., Won, H., and Henson, D.L. (1981). Driving and perceptual/cognitive skills: behavioral consequences of brain damage. Archives of Physical Medicine and Rehabilitation, 62, 476-483.

Sivak, M., Olson, P.L., and Pastalan, L.A. (1981). Effect of driver's age on nighttime legibility of highway signs. Human Factors, 23, 59-64.

Sivak, M., Post, D.V., Olson, P.L., and Donohue, R.J. (1981a). Automobile rear lights: effects of the number, mounting height, and lateral position on reaction times of following drivers. Perceptual and Motor Skills, 52, 795-802.

Sivak, M., Post, D.V., Olson, P.L., and Donohue, R.J. (1981b). Driver responses to high-mounted brake lights in actual traffic. Human Factors, 23, 231-235.