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HUMAN FACTORS AND ROAD SAFETY: OVERVIEW OF RECENT RESEARCH AT THE HIGHWAY SAFETY RESEARCH INSTITUTE

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16. Abstract

This report presents a brief overview of research performed at the Human Factors Division of the Highway Safety Research Institute within the last five years. The research dealt with the following topics: vehicle headlighting, vehicle rear lighting and signaling, legibility of traffic signs, driving test development, handicapped drivers, elderly drivers, vehicle conspicuity, vehicle displays and controls, windshield damage and safety, epidemiology of accidents, and theoretical issues.

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INTRODUCTION

This article will focus on recent research at the Human Factors Division of the University of Michigan Highway Safety Research Institute in Ann Arbor, Michigan. The Human Factors Division is currently operating with a $400,000 per year research budget. The staff consists of four Ph.D. scientists, one secretary, and several part-time research assistants. The primary research staff is trained in experimental and industrial psychology, industrial and operations engineering, human factors, and statistics. Excellent support services are provided by the Highway Safety Research 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., handicapped and elderly drivers, driving-test development), vehicle-centered (e.g., vehicle lighting and signaling, instrument-panel controls and displays, vehicle conspicuity), and environment-centered (e.g., legibility of traffic signs). In examining these issues, various experimental approaches have been taken, including computer-controlled laboratory studies, actual on-the-road monitoring of drivers' eye movements and video-recording of drivers' maneuvers, 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 five years.

VEHICLE HEADLIGHTING

A 1977 report (Olson, 1977) covers 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).

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.

An ongoing headlighting project is investigating the current U.S. low-beam system and potential ways of improving its photometrics. Several interim reports have been published (the latest is Olson and Sivak, 1981a), describing the various laboratory and field studies performed thus far.

In related research Olson (1982) investigated headlighting beam-aim variance associated with replacement of burned out lamps without reaim. 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.

Much of the HSRI headlighting research utilized a computer program developed in the early 1970's (Mortimer and Becker, 1973; Becker and Mortimer, 1974). This program predicts the 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 program.

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

VEHICLE REAR LIGHTING AND SIGNALING

The literature on automobile rear lighting and signaling was reviewed by Sivak (1978). The review focused on the effects of color, intensity, position, and spacing of rear lights. The report also contains an annotated bibliography (36 publications).

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) utilized 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.

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 visual research, analysis of signaling requirements, and recommendations.

LEGIBILITY OF TRAFFIC SIGNS: RETROREFLECTIVITY AND OBSERVER AGE

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

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) young and old subjects were matched in terms of high-luminance (daytime) visual acuity. The subjects drove or were driven toward a sign. The results indicated that the legibility distances of 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 young and old subjects in terms of low-luminance (nighttime) visual acuity. Additionally, this study showed that glare sources positioned outside of the fovea might improve nighttime legibility performance under certain conditions.

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 screening of drivers, vehicles, and components. A number of driving tests were developed, together with suitable performance measures. These were administered to a group of subjects, and the data 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 a number of relevant driving-skill dimensions.

HANDICAPPED DRIVERS

An ongoing research project studies 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, those 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 will likely improve driving performance as well. This implication is experimentally tested in the current research; an interim report on this phase of the research (Sivak, Hill, Olson, and Henson, 1981) contains a

literature review on retraining of perceptual/cognitive skills of persons with brain damage, and a pilot experiment.

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

CONSPICUITY OF VEHICLES

Olson, Halstead-Nussloch, and Sivak (1981) evaluated a range of daytime and nighttime treatments for improved front conspicuity of motorcycles. Using a gap-acceptance methodology and unalerted drivers in actual traffic, several treatments were shown to significantly 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 report covers 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 their large size, tractor-semitrailers 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.

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 standards of symbols.

Automobile multifunction stalk 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 increased the time for subjects to make braking decisions. This effect was especially pronounced when a light simulating the glare of an oncoming vehicle's headlights was present.

EPIDEMIOLOGY OF ACCIDENTS

Sivak (1981a) investigated the relation of violence/aggression and other macro-level variables to traffic accidents. The analytical technique used was multiple regression, which was applied to 1977 data from each of the 50 U.S. states. Motor-vehicle-accident fatalities per registered vehicle was the dependent variable. The main finding of this analysis is that homicide rates (but not suicide rates) predict states' motor-vehicle-accident fatalities; additional significant predictors were the proportion of young drivers, and fatalities from accidents other than those connected to motor vehicles. These three variables accounted for 68% of the variance of motor-vehicle-accident fatalities.

THEORETICAL ISSUES

Olson and Sivak (1981b) dealt with problems in the detection and identification of significant roadway conditions. The paper discussed the complex, non-automatic, and different nature of these two processes; it points out problems with each, and suggests means for improvement.

In a related article, Olson, Sivak, and Henson (1981) discussed headlighting and visibility limitations, especially

from the point of view of the danger to pedestrians. This danger, it is argued, is a consequence of the limitations of low-beam headlighting systems, coupled with pedestrians' overestimations of their own nighttime visibility. It was recommended that the most effective countermeasure would involve proper education of both motorists and pedestrians regarding these issues.

Sivak (1981b) 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 which 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 (1981c) briefly summarized current knowledge of how human factors contribute to traffic accidents, and outlined preventive measures motorists can take to minimize their chances of being involved in an accident.

CONCLUDING COMMENTS

This review was intended to provide an indication of the breadth and depth of the recent research at the Human Factors Division of the Highway Safety Research Institute. The wide variety of issues 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.

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