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Individuals with disabilities are encouraged to attend all University of Iowa-sponsored events. If you are a person with a disability who requires an accommodation in order to participate in this program, please contact Kathy Holeton, Driving Assessment 2003 in advance at (319) 335-6804.

# 2nd International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design
# July 21-24, 2003

## Monday July 21, 2003

**1:00 PM – 6:30 PM** **Early Registration**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**6:00 PM – 9:00 PM** **WELCOME RECEPTION**
Outdoor Pavilion, Grand Summit Resort Hotel

**7:15 PM** **OPENING REMARKS**

General Chairs, Driving Assessment 2003
University of Iowa

## Tuesday July 22, 2003

**7:30 AM – 4:30 PM** **Registration Open**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**7:30 AM – 8:30 AM** **Continental Breakfast**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**8:45 AM – 10:00 AM** **KEYNOTE SPEAKER**
Grand Ballroom, Grand Summit Resort Hotel

**On the Assessment of Criteria for Driver Impairment: In Search of the Golden Yardstick for Driving Performance (01)**
Karel Brookhuis, Ph.D.
(University of Groningen – *The Netherlands*)

**10:00 AM – 10:15 AM** **BREAK-Refreshments**
Grand Ballroom Lobby, Grand Summit Resort Hotel

## Tuesday July 22, 2003

**SESSION 1 – LECTURES**
**Distraction and Workload**
**10:15 AM – 12:00 PM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Nicholas Ward (University of Minnesota)

**10:20 AM** **Multiple Resource Modeling of Task Interference in Vehicle Control, Hazard Awareness and In-vehicle Task Performance (02)**
William J. Horrey, Christopher D. Wickens
(University of Illinois at Urbana-Champaign)
Honda Outstanding Student Paper Award Winner

**10:45 AM** **Loading Drivers to Their Limit: The Effect of Increasing Secondary Task on Driving (03)**
Natasha Merat (University of Leeds — *UK*)

**11:10 AM** **Mental Workload as a Function of Traffic Density: Comparison of Physiological, Behavioral, and Subjective Indices (04)**
Carryl L. Baldwin, Joseph T. Coyne
(Old Dominion University)

**11:35 AM** **Fatal Distraction? A Comparison of the Cell-phone Driver and the Drunk Driver (05)**
David L. Strayer, Frank A. Drews, Dennis J. Crouch
(University of Utah)

**12:00 PM – 1:30 PM** **HONDA LUNCHEON & OUTSTANDING STUDENT PAPER AWARDS**
**Sponsored by Honda R&D Americas, Inc.**
Outdoor Pavilion, Grand Summit Resort Hotel

Awards presented by:
**Mr. Charles Allen** *(invited)*
Senior Vice President and General Manager
Honda R&D Americas, Inc.

Honda Outstanding Student Paper Award Winners:

- **Multiple Resource Modeling of Task Interference in Vehicle Control, Hazard Awareness and In-vehicle Task Performance (02)** William J. Horrey, Christopher D. Wickens (University of Illinois at Urbana-Champaign)
- **Time-Sharing of a Visual In-Vehicle Task While Driving: The Effects of Four Key Constructs (26)** Omer Tsimhoni, Paul Green (University of Michigan)
- **Traffic Scene Related Change Blindness in Older Drivers (40)** Sarah Batchelder, Matthew Rizzo (University of Iowa), Rick Vanderleest (Digital Artefacts, LLC), Shaun Vecera (University of Iowa)

## Tuesday July 22, 2003

**SESSION 2 – LECTURES**
**Aging and Cognition**
**1:45 PM – 3:25 PM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Craig Sauer (University of California, Riverside)

**1:45 PM** **Driver Navigation and Safety Errors in Alzheimer's Disease and Stroke (06)**
Ergun Y. Uc, Jennifer L. Smothers, Qian Shi, Matthew Rizzo
(University of Iowa)

**2:10 PM** **Older and Younger Driver Performance at Complex Intersections: Implications for Using Perception-Response Time and Driving Simulation (07)**
Christopher J. Edwards, Janet I. Creaser, Jeffrey K. Caird, Allison M. Lamsdale, Susan L. Chisholm
(University of Calgary — *Canada*)

**2:35 PM** **Can High-Risk Older Drivers Be Identified in a DMV Setting with a Brief Battery of Functional Tests? (08)**
Karlene Ball (University of Alabama at Birmingham)
Daniel Roenker (Western Kentucky University)
Gerald McGwin, Jr., Virginia Wadley, Jeff Edwards
(University of Alabama at Birmingham)
Robert Raleigh (Maryland Motor Vehicle Administration)

**3:00 PM** **An Abstract Virtual Environment Tool to Assess Decision-Making Impaired Drivers (09)**
Matthew Rizzo (University of Iowa)
Joan Severson, James Cremer, Kerri Price (Digital Artefacts, LLC)

**3:30 PM** **BREAK-Refreshments**
White Pine Room, Grand Summit Resort Hotel

**SESSION 3 – POSTERS**
**3:30 PM – 5:00 PM**
White Pine Room, Grand Summit Resort Hotel

**Visual Attention in Stroke Patients Returning to Driving (10)** Matthew I. Tofield, John P. Wann (University of Reading — *UK*)

**Effects of Cell Phone Conversation Difficulty on Driving Performance (11)** Mick Rakauskas (University of Minnesota), Leo Gugerty (Clemson University)

**Commuter Behavioral Model for the Pilot Program of an Electronic Toll System on Korean Express Highways (12)** Kyungwoo Kang (Hanyang University — *Korea*)

## Tuesday July 22, 2003

**SESSION 3 – POSTERS (cont.)**
**3:30 PM – 5:00 PM**
White Pine Room, Grand Summit Resort Hotel

**In-Vehicle Navigation Systems: Interface Characteristics and Industry Trends (13)** Robert E. Llaneras, Jeremiah P. Singer (Westat)

**Truck Driver Training Using Simulation in England (14)** Andrew M. Parkes (TRL Limited (Transport Research Laboratory) — *UK*)

**Effects of Cognitive Tasks on Drivers' Eye Behavior and Performance (15)** Xianjun Sam Zheng, Yu-chi Tai, George W. McConkie (University of Illinois at Urbana-Champaign)

**Reliability of a Road Test After Stroke (16)** Abiodun Emmanuel Akinwuntan, Willy De Weerdt, Hilde Feys (Katholieke Universiteit Leuven — *Belgium*), Guido Baten, Patricia Arno (CARA, Belgian Road Safety Institute — *Belgium*), Carlotte Kiekens (Katholieke Universiteit Leuven — *Belgium*)

**Evaluating Workload Associated with Telematic Devices Via a Secondary Task Protocol (17)** Mustapha Mouloua, Edward Rinalducci, Peter A. Hancock, J. Christopher Brill (University of Central Florida)

**Driver Preference of Collision Warning Strategy and Modality (18)** Josh Hoffman, John D. Lee, Elizabeth M. Hayes (University of Iowa)

**Naturalistic Driving/User and Task Analysis (19)** H.C. Neil Ganey, Paul Ward, Peter A. Hancock, James L. Szalma (University of Central Florida)

**Impact of Passengers on Crashes of Older Drivers (20)** Jason Yaw, Nikiforos Stamatiadis (University of Kentucky), Lisa Aultman-Hall (University of Connecticut)

**Role of a Driver Cognition Model in the Design of an Anti-Collision Warning System (21)** P. C. Cacciabue, M. Martinetto (European Commission, Joint Research Centre — *Italy*), L. Andreone, F. Tango (Centro Ricerche Fiat — *Italy*), A. Amditis, A. Polychronopoulos (Institute of Communications and Computer Systems — *Greece*), D. Kempf, H. Widlroither (Fraunhofer IAO — *Germany*)

**Steering a Driving Simulator Using the Queueing Network-Model Human Processor (QN-MHP) (22)** Omer Tsimhoni, Yili Liu (University of Michigan)

**A Systemic Model for Driver-in-Control (23)** Erik Hollnagel (University of Linköping — *Sweden*), Arne Nåbo (Saab Automobile AB — *Sweden*), Ian V. Lau (General Motors Corporation)

**Traffic Entry Judgments by Aging Drivers (24)** Nicole Skaar, Matthew Rizzo, Laura Stierman (University of Iowa)

## Wednesday July 23, 2003

**7:30 AM – 4:30 PM** **Registration Open**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**7:30 AM – 8:15 AM** **Continental Breakfast**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**SESSION 4 – LECTURES**
**Driver Performance Assessment**
**8:15 AM – 10:00 AM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Paul Green (University of Michigan Transportation Research Institute)

**8:20 AM** **The Dimensions of Driver Performance During Secondary Manual Tasks (25)**
Richard A. Young, Linda S. Angell
(General Motors Corporation)

**8:45 AM** **Time-Sharing of a Visual In-Vehicle Task While Driving: The Effects of Four Key Constructs (26)**
Omer Tsimhoni, Paul Green
(University of Michigan)
Honda Outstanding Student Paper Award Winner

**9:10 AM** **Event-Based Driver Performance Assessment (27)**
Erwin R. Boer (Erwin R. Boer Consulting)
Nicholas J. Ward (University of Minnesota)

**9:35 AM** **The Evolution of Autonomic Space as a Method of Mental Workload Assessment for Driving (28)**
John K. Lenneman (General Motors Corporation)
Richard W. Backs (Central Michigan University)

**10:00 AM – 10:15 AM** **BREAK-Refreshments**
Grand Ballroom Lobby, Grand Summit Resort Hotel

## Wednesday July 23, 2003

**SESSION 5 – LECTURES**
**Driver Fatigue and Impairment**
**10:15 AM – 12:00 PM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Maria Rimini-Doering (Robert Bosch GmbH — *Germany*)

**10:20 AM** **Microsleep Episodes, Attention Lapses and Circadian Variation in Psychomotor Performance in a Driving Simulation Paradigm (29)**
Henry J. Moller, Leonid Kayumov, Colin M. Shapiro
(University of Toronto — *Canada*)

**10:45 AM** **Driver Fatigue: Is Something Missing? (30)**
J. Christopher Brill, Peter A. Hancock, Richard D. Gilson
(University of Central Florida)

**11:10 AM** **The Effects of Fatigue on Driver Performance for Single and Team Long-Haul Truck Drivers (31)**
Sheila G. Klauer, Thomas A. Dingus, Vicki L. Neale
(Virginia Tech Transportation Institute)
Robert J. Carroll
(Federal Motor Carrier Safety Administration)

**11:35 AM** **Automobile Driving with Severe Amnesia (32)**
Nicole Skaar, Steven W. Anderson, Jeffrey Dawson, Matthew Rizzo
(University of Iowa)

**12:00 PM – 1:30 PM** **LUNCH**
Outdoor Pavilion, Grand Summit Resort Hotel

**SESSION 6 – LECTURES**
**Visual Performance and Driving**
**1:45 PM – 3:25 PM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Erwin Boer (Erwin R. Boer Consulting)

**1:45 PM** **Driver Behavior as a Function of Ambient Light and Road Geometry (33)**
Michael J. Flannagan, John M. Sullivan, Scott E. Bogard
(University of Michigan Transportation Research Institute)

**2:10 PM** **Effects of a Night Vision Enhancement System (NVES) on Driving: Results from a Simulator Study (34)**
Erik Hollnagel (University of Linköping — *Sweden*)
Jan-Erik Källhammer (Autoliv Research — *Sweden*)

## Wednesday July 23, 2003

**SESSION 6 – LECTURES (cont.)**
**Visual Performance and Driving**
**1:45 PM – 3:25 PM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Erwin Boer (Erwin R. Boer Consulting)

**2:35 PM** **Car Following by Optical Parameters (35)**
Craig W. Sauer, George J. Andersen, Asad Saidpour
(University of California, Riverside)

**3:00 PM** **Reducing Crash Risk in Visually-Impaired Older Drivers: Medical-Surgical versus Educational Interventions (36)**
Gerald McGwin Jr., Cynthia Owsley
(University of Alabama at Birmingham)

**3:30 PM** **BREAK-Refreshments**
White Pine Room, Grand Summit Resort Hotel

**SESSION 7 – POSTERS**
**3:30 PM – 5:00 PM**
White Pine Room, Grand Summit Resort Hotel

**Novice Driver Training Results and Experience with a PC-Based Simulator (37)** R. Wade Allen, George Park, Marcia Cook, Theodore J. Rosenthal (Systems Technology, Inc.), Dary Fiorentino (Southern California Research Institute), Erik Viirre (University of California at San Diego)

**Assessing Spare Attentional Capacity of Drowsy Drivers: Protocol Development (38)**
J. Christopher Brill, Mustapha Mouloua, Peter A. Hancock, Richard D. Gibson (University of Central Florida), Robert S. Kennedy (RSK Assessments, Inc.)

**Influences of Knowledge on Behaviors in Automobiles (39)** S. David Leonard (University of Georgia)

**Traffic Scene Related Change Blindness in Older Drivers (40)** Sarah Batchelder, Matthew Rizzo (University of Iowa), Rick Vanderleest (Digital Artefacts, LLC), Shaun Vecera (University of Iowa) Honda Outstanding Student Paper Award Winner

**Aggressive Driving Is a Major Cause of Traffic Accidents and Road Rage in Jordan (41)**
Mohd R. Suliman, Wa'el H. Awad (Al-Balqa' Applied University — *Jordan*)

**Inattentional Blindness While Driving (42)** Chip Wood (Motorola Labs), Rob Gray, Jennifer Young (Arizona State University East), John Summers (Motorola Labs)

## Wednesday July 23, 2003

**SESSION 7 – POSTERS (cont.)**
**3:30 PM – 5:00 PM**
White Pine Room, Grand Summit Resort Hotel

**Simulator Training Improves Driver Efficiency: Transfer from the Simulator to the Real World (43)** David M. Dolan, Darrell A. Rupp, Jacob R. Allen (GE Driver Development), David L. Strayer, Frank A. Drews (University of Utah)

**On the Fast Lane to Road Rage (44)** Frank A. Drews, David L. Strayer, Bert N. Uchino, Timothy W. Smith (University of Utah)

**Test-Retest Reliability of Standard Deviation of Lane Position as Assessed on a PC-Based Driving Simulator (45)** Thomas D. Marcotte, Erica Roberts (University of California, San Diego), Theodore Rosenthal (Systems Technology, Inc.), Robert Heaton, Heather Bentley, Igor Grant (University of California, San Diego)

**Demographic and Driving Performance Factors in Simulator Adaptation Syndrome (46)** Matthew Rizzo, Rebecca A. Sheffield, Laura Stierman, Jeffrey Dawson (University of Iowa)

**Simulation Methods for Assessing Driving on Roads with Curves (47)** John A. Molino (Science Applications International Corporation), Duoduo Liao, John M. Wink, Jason R. Williams (AAI Engineering Support, Inc.), Kenneth S. Opiela, M. Joseph Moyer (Federal Highway Administration)

**Lane-Changing Behavior at Weaving and Merging Sections of Highway (48)** Ghulam H. Bham, Rahim F. Benekohal (University of Illinois, Urbana)

**An Examination of the Efficacy of a Brief Educational Program on Driver Distraction (49)** Arthur Kramer, Jason S. McCarley (University of Illinois), Scott Geisler (General Motors Corporation)

**Did You See That? A Study of Change Blindness (50)** Tara Smyser, John D. Lee, Joshua Hoffman, Robert Betts (University of Iowa)

**A Comparison of Traffic Sign Comprehension Using Static, Dynamic and Interactive Presentation Media (51)** Susan T. Chrysler, James Wright, Alicia Williams (Texas Transportation Institute)

| | |
|---|---|
| **6:00 PM – 9:00 PM** | **GENERAL MOTORS GONDOLA DINNER**<br>**Sponsored by: General Motors Corporation**<br>Red Pine Lodge |
| **6:00 PM – 7:00 PM** | **Gondola Transportation**<br>Meet at the "Flight of the Canyons" Gondola |
| **6:30 PM – 7:30 PM** | **Social Hour** (cash bar) |
| **7:30 PM – 9:00 PM** | **Dinner**<br>Welcoming remarks by General Motors |

## Thursday July 24, 2003

**7:30 AM – 12:00 PM** **Registration Open**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**7:30 AM – 8:15 AM** **Continental Breakfast**
Grand Ballroom Lobby, Grand Summit Resort Hotel

**SESSION 8 – LECTURES**
**Collision Avoidance**
**8:15 AM – 10:00 AM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Linda Angell (General Motors Corporation)

**8:20 AM** **The Effects of Lead Vehicle Size on Driver Following Behavior: Is Ignorance Truly Bliss? (52)**
James R. Sayer, Mary Lynn Mefford
(University of Michigan Transportation Research Institute)
Ritchie W. Huang
(Honda R&D Americas, Inc.)

**8:45 AM** **Stimulus-Response Compatibility Effects for Warning Signals and Steering Responses (53)**
Dong-Yuan Debbie Wang, Robert W. Proctor
(Purdue University)
David F. Pick
(Purdue University Calumet)

**9:10 AM** **Drivers' Perception of and Response to Brake Failure (54)**
Hamish Jamson, Paul Smith
(University of Leeds — *UK*)

**9:35 AM** **Risk of Fatal Rear-End Collisions: Is There More to It Than Attention? (55)**
John Sullivan, Michael J. Flannagan
(University of Michigan Transportation Research Institute)

**10:00 AM – 10:15 AM** **BREAK-Refreshments**
Grand Ballroom Lobby, Grand Summit Resort Hotel

## Thursday July 24, 2003

**SESSION 9 – LECTURES**
**Driver Characteristics and Behavior**
**10:15 AM – 12:00 PM**
Grand Ballroom, Grand Summit Resort Hotel

Session Chair: Hamish Jamsen (University of Leeds — *UK*)

**10:20 AM** **Driver Psychological Types and Car Following. Is there a Correlation? Results of a Pilot Study (56)**
Mark Brackstone
(University of Southampton — *UK*)

**10:45 AM** **The Relationship Between Collision History and a Computerized Assessment of Visual and Cognitive Skills in a Sample of School Bus Drivers (57)**
Kenneth C. Mills
(Profile Associates)
Robert C. Hubal, Brent T. Ward
(RTI International)

**11:10 AM** **Societal Violence, Driver Age, and Attained Education: Independent Contributions to Road Accidents? (58)**
Michael Sivak
(University of Michigan Transportation Research Institute)

**11:35 AM** **A Simulation Study of Path and Speed Through Double-Lane Roundabouts (59)**
Gregory W. Davis
(FHWA Office of Safety, RD & T)
Vaughan W. Inman, Ted Shafer, Bryan J. Katz
(SAIC Transportation Research Division)

**12:00 PM – 12:15 PM** **CLOSING REMARKS**
Peter Hancock (University of Central Florida)
Grand Ballroom, Grand Summit Resort Hotel

**12:15 PM – 1:30 PM** **BOX LUNCH**
Outdoor Pavilion, Grand Summit Resort Hotel

# 2nd International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design
# July 21-24, 2003

## Summaries

**Please note:** Some summaries have been edited for space and clarity. The conference proceedings will contain complete abstracts and papers.

### Keynote Speaker
### Tuesday, July 22, 2003
### 8:30 AM – 10:00 AM

**(01) On the Assessment of Criteria for Driver Impairment: In Search of the Golden Yardstick for Driving Performance** Karel Brookhuis (University of Groningen — *The Netherlands*)

Most traffic accidents are caused by driver impairment. It is estimated that at least 30% of all serious car accidents can be directly attributed to problems concerning the driver's state, such as conditions related to alcohol or drug abuse, drowsiness or fatigue, health problems, prolonged periods of inattention or divided attention. It is now technically feasible to monitor and diagnose driver behavior with respect to impairment with the aid of a limited number of in-vehicle sensors. A valid framework for the evaluation of driver impairment, however, is still lacking. In order to provide an acceptable definition of driver impairment, a method is needed to assess both absolute and relative criteria. The seemingly paradoxical goal is to develop a definition of impaired driving that is consistent, yet adaptable to inter-individual differences.

### SESSION 1 – Lectures
### Distraction and Workload
### Tuesday, July 22, 2003
### 10:15 AM – 12 PM

**(02) Multiple Resource Modeling of Task Interference in Vehicle Control, Hazard Awareness and In-vehicle Task Performance** William J. Horrey, Christopher D. Wickens (University of Illinois at Urbana-Champaign) Honda Outstanding Student Paper Award Winner

In the current presentation, we describe a computational model of multiple task performance used to predict task interference and subsequent decrements in performance in driving based on the resource demands of a particular task (i.e., the difficulty), as well as the competition between tasks over limited and overlapping resources. We describe the model's components and computational aspects, and validate it with data from a simulated driving study. The model is advantageous in that it is relatively simple in computation, relatively robust (in terms of coding for various tasks), theory-based, flexible in its application, and can make adequate performance predictions.

**(03) Loading Drivers to Their Limit: The Effect of Increasing Secondary Task on Driving** Natasha Merat (University of Leeds — *UK*)

This paper outlines the results of a number of studies that were designed to create a series of suitable 'secondary tasks' that would act as appropriate surrogate in-vehicle information systems (s-IVIS). In particular, an attempt was made to design tasks that would allow a step-by-step increase in visual or cognitive load. Following a brief introduction to the development of each s-IVIS, the paper will present results from a study that examined the effect of completing an auditory s-IVIS on a simulated driving task.

**(04) Mental Workload as a Function of Traffic Density: Comparison of Physiological, Behavioral, and Subjective Indices** Carryl L. Baldwin, Joseph T. Coyne (Old Dominion University)

Advanced in-vehicle technologies make use of visual and auditory displays to provide drivers with a wide array of information. Methods of assessing the impact of these multi-modal displays on drivers in various traffic and weather conditions are imperative to transportation safety. The current investigation is the first in

a series aimed at establishing a methodology suitable for comparing mental workload stemming from both the driving environment and from visual and auditory in-vehicle displays.

**(05) Fatal Distraction? A Comparison of the Cell-phone Driver and the Drunk Driver** David L. Strayer, Frank A. Drews, Dennis J. Crouch (University of Utah)

We used a high-fidelity driving simulator to compare the performance of cell-phone drivers with drivers who were legally intoxicated from ethanol. When drivers were conversing on either a hand-held or hands-free cell-phone, their reactions were sluggish and they attempted to compensate by driving more slowly and increasing the following distance from the vehicle immediately in front of them. By contrast, when drivers were legally intoxicated, they exhibited a more aggressive driving style, following closer to the vehicle immediately in front of them and applying more force while braking. When controlling for driving difficulty and time on task, cell-phone drivers exhibited greater impairment than intoxicated drivers.

## SESSION 2 – Lectures
## Aging and Cognition
## Tuesday, July 22, 2003
## 1:45 PM – 3:25 PM

**(06) Driver Navigation and Safety Errors in Alzheimer's Disease and Stroke** Ergun Y. Uc, Jennifer L. Smothers, Qian Shi, Matthew Rizzo (University of Iowa)

Safe automobile driving requires drivers to perform multiple competing tasks while remembering and implementing correct road rules and routes. Neurologic disorders such as Alzheimer's disease (AD) and stroke can impair these abilities. In this study, navigation and safety errors were assessed during a route-following task in drivers with AD and stroke. Each driver was required to perform a navigation task administered as part of an hour-long drive conducted in an experimental vehicle. Instrumentation and sensors on board the vehicle recorded driver speed, steering, braking and acceleration at 10 Hz, in synch with 4 video views of the driver and the roadway. Dependent measures were number of: 1) trials to correctly memorize the route prior to the drive, 2) correct turns, 3) times lost, and 4) at-fault safety errors. Safety errors were further classified into categories of perception/attention, memory, and other, based on video analysis, driver self-report, and questionnaire data. The results revealed that drivers with AD and stroke performed worse in all outcome measures than neurologically normal drivers. The findings indicate that real-world tests of driver fitness can benefit from adding controlled challenges of memory, perception, and attention, especially in cognitively impaired populations.

**(07) Older and Younger Driver Performance at Complex Intersections: Implications for Using Perception-Response Time and Driving Simulation** C.J. Edwards, J.I. Creaser, J.K. Caird, A.M. Lamsdale, S.L. Chisholm (University of Calgary — *Canada*)

Older drivers are at increased accident risk at intersections for a variety of maneuvers. To examine why, a study was conducted to assess older driver performance at complex intersections. The University of Calgary Driving Simulator was used to test healthy older drivers (65-83, $M$ = 71.4) and younger drivers (19-22, $M$ = 20.7). Critical scenarios included the sudden appearance of a pedestrian in an intersection, a last-second yellow light, an unexpected change during a left turn, and a vehicle violating a stoplight. Older drivers had significantly higher perception-response times (PRT) than younger drivers for the latter three scenarios. Analysis of specific maneuvers also revealed qualitative response differences between the younger and older groups. Contrary to expectations, more older drivers ran the yellow light than younger drivers. The capability of older drivers to respond under time constraints is implicated. The utility of driving simulators to assess older driver performance at intersections was limited by the prevalence of simulator sickness.

**(08) Can High-Risk Older Drivers Be Identified in a DMV Setting with a Brief Battery of Functional Tests?** Karlene Ball (University of Alabama at Birmingham), Daniel Roenker (Western Kentucky University), Gerald McGwin, Jr., Virginia Wadley, Jeff Edwards (University of Alabama at Birmingham), R. Raleigh (Maryland Motor Vehicle Administration)

Some laboratory measures of functional ability may discriminate between crash-involved and crash-free older adults. However, the ability of these tests to provide the same level of discriminability in a real-world setting remains to be established. In this study, a brief battery of tests was developed and evaluated in conjunction with the Maryland Department of Motor Vehicles and the National Highway Traffic Safety Administration. The battery contained cognitive tests (e.g., UFOV® subtest 2) and physical measures (e.g., Rapid Pace Walk, Head and Neck Rotation) that had previously been related to crash risk in older adults. Motor Vehicle Administration

staff were trained to administer the test battery. Older adults were approached by the staff after license renewal and asked to help evaluate the tests; 2,112 individuals aged 55-96 years of age participated. The primary outcome of interest was the occurrence of an at-fault Motor Vehicle Collision (MVC) during the 2-3 years following assessment. Rate Ratios were determined for each functional variable based on at-fault crashes adjusted for driving exposure. Univariate analyses revealed that five variables (Age, Walk Time, MVPT, Trails A and UFOV®) were significantly related to crash frequency. These variables overlapped with one another, indicating that impaired older drivers score poorly on multiple cognitive assessments. The UFOV® subtest 2 appears to be the most strongly associated within this analysis. When each variable in the model was adjusted for every other variable, only UFOV® and Rapid Pace Walk remained uniquely related to the frequency of state reported, at-fault crashes. The role of such a screening battery in field settings is discussed.

**(09) An Abstract Virtual Environment Tool to Assess Decision-Making Impaired Drivers**
Matthew Rizzo (University of Iowa), Joan Severson, James Cremer, Kerri Price (Digital Artefacts, LLC)

We describe design and pilot testing of software for evaluating decision-making abilities in drivers with neurological impairments. Instead of striving for visual realism, the virtual environment software is based on a more abstract representation that provides necessary visual cues in a single-screen setting. Pilot tests were conducted on 16 subjects with neurological impairments (14 with focal brain lesions, 2 with Alzheimer's disease), and 16 neurologically normal subjects. Preliminary results are promising, suggesting that the PC-based virtual environment tool can distinguish decision-making impaired people where traditional neurological test batteries cannot.

## SESSION 3 – Posters
## Tuesday, July 22, 2003
## 3:30 PM – 5:00 PM

**(10) Visual Attention in Stroke Patients Returning to Driving** Matthew I. Tofield, John P. Wann (University of Reading — *UK*)

The UK, like many European countries, lacks a standardized test to objectively assess visual attentional deficits in drivers, particularly following stroke injury. The ability to detect motion components in the visual scene, often the first indication of an impending collision, is overlooked in current assessment procedures. The experiments presented here used a semi-immersive virtual reality paradigm and eye gaze monitoring technology to identify deficits in peripheral processing and extend the concept of useful field of view (UFOV: Ball et al. 1988, 1993). Displays tested peripheral attention with brief (90ms) episodes of relative motion, changing size, luminosity and color gaze response. The dependant measure was accuracy of saccade to the eccentric target. Six stroke participants (mean age = 61.16) were tested, and their results compared to data gathered for three healthy aging groups of drivers. The systematic decrease in performance with increasing age found for the healthy participants was also found in the stroke group, who performed worse than the healthy groups in the same tasks. The results underpin our previous finding of deficits in processing basic components of visual control that go beyond current UFOV tests. They highlight the compounding effects of stroke injury on ability to detect motion components. We discuss the implications of treating stroke patients as a homogenous group when assessing suitability to return to driving. Younger stroke drivers' performances were comparable to those of their age-matched healthy controls. We conclude that assessment of visual attention as it relates to moving objects in a visually cluttered environment should be part of any assessment criteria for measuring fitness to drive in stroke patients.

**(11) Effects of Cell Phone Conversation Difficulty on Driving Performance** Mick Rakauskas (University of Minnesota), Leo Gugerty (Clemson University)

Although driving while talking on a cell phone is becoming more prevalent in the United States, the exact effects of this secondary task on driving performance are unclear. Also, it is unknown how the level of conversation difficulty may relate to the distraction effect of cell phone use. This study used a driving simulator to determine the extent to which conversation had an effect on driving performance and the ability to deal with hazardous situations. It also looked at whether a more difficult conversation had a greater effect on performance than an easier one. Conversations caused participants to have higher variation in steering wheel position and to report a higher subjective workload. While conversing, drivers also drove more slowly than control participants, yet had higher variation in speed. Differences between the two conversation difficulty levels were seen only in speed variation.

**(12) Commuter Behavioral Model for the Pilot Program of an Electronic Toll System on Korean Express Highways** Kyungwoo Kang (Hanyang University — *Korea*)

In recent years, congestion pricing has gained popularity as a method for managing peak-period congestion on major roads in urban areas. Intelligent Transportation Systems (ITS) technology has resulted in the electronic toll collection (ETC) system called "Hi-Pass," which the Korea Highway Cooperation is operating as part of a pilot program. The limited sections of highway using Hi-Pass have received good approval rating from motorists. In this research, the Korean highway toll system was analyzed with respect to the brief legal history of the toll road, collection method, and levels. In addition, electronic toll-collection policies in other countries, including France, Norway, and Italy, were investigated. In the review of the pilot ETC program in Korea, several important factors were found. First, a more concrete marketing strategy will be needed to encourage continued use. Frequent users and higher-income users adopted the ETC system more easily than others. Second, in order to encourage ETC system use, the costs of on-board units must be reasonably low (about $50), and aggressive discounts (about 3-5% compared to the current 1%) will be needed.

**(13) In-Vehicle Navigation Systems: Interface Characteristics and Industry Trends** Robert E. Llaneras, Jeremiah P. Singer (Westat)

A review and inventory of in-vehicle navigation systems was conducted in order to better understand the current state of practice and trends relating to their design and implementation. The review focused on human factors characteristics and interface features using accepted human factors practices, principles, and guidelines as a basis for assessing likely impacts on driver distraction. The inventory examined market-ready in-vehicle products and identified a range of interface design features, noting aspects and dimensions that have implications for potential driver distraction. Results indicated that devices tend to incorporate a large number of features and options, making it a potential challenge for drivers to learn all of the capabilities of a system and resulting in lengthy manuals. Although devices also tended to provide large amounts of information, some designs may allow for increased information presentation without necessarily sacrificing performance. Warnings or cautions against interacting with systems while driving were common; however, relatively few systems disable equipment when vehicles are in operation. A number of other observations and "industry trends" are presented and discussed.

**(14) Truck Driver Training Using Simulation in England** Andrew M. Parkes (TRL Limited (Transport Research Laboratory) — *UK*)

The UK Department for Transport, on behalf of the Road Haulage Modernization Fund, has established a research program to determine the potential role of synthetic training in both *ab initio* license acquisition and skills development in experienced drivers. TRL and EADS Dornier are commissioning an advanced full-motion-base truck simulator and developing bespoke courseware. The potential benefit of the system will be evaluated through a structured program in which approximately 700 drivers will be trained. This paper reviews the current legislative framework in the UK and the European Union, and discusses potential changes that will impact the training market. It then presents an outline of the research program and the technical capabilities of the system being developed. The evaluation framework will be introduced and the concept of grouping training objectives into tutorial modules explained. The method of developing objective evaluation measures for each tutorial module will be considered in detail, and comparisons drawn with similar initiatives in other countries. Finally, the output of the project and the way the results will be fed forward to the industry and policy makers will be explained.

**(15) Effects of Cognitive Tasks on Drivers' Eye Behavior and Performance** Xianjun Sam Zheng, Yu-chi Tai, George W. McConkie (University of Illinois at Urbana-Champaign)

Safe driving involves obtaining and using necessary visual information. Recent studies have shown that this information acquisition is compromised as a driver performs other mental tasks. We conducted an experiment, inspired by Recarte and Nunes (2000), to investigate the effect of cognitive tasks on drivers' eye behavior and performance in a single monitor, PC-based driving simulator. The results confirmed the previous observation that such tasks greatly reduce the time and frequency of safety-related behaviors such as checking the speedometer and rearview mirrors. We also found the tasks to increase variation in driving speed. The method employed here can be used to examine the effect of driver activities and devices on the monitoring of safety-related information.

**(16) Reliability of a Road Test After Stroke** Abiodun Emmanuel Akinwuntan, Willy De Weerdt, Hilde Feys (Katholieke Universiteit Leuven — *Belgium*), Guido Baten, Patricia Arno (CARA, Belgian Road Safety Institute — *Belgium*), Carlotte Kiekens (Katholieke Universiteit Leuven — *Belgium*)

The increasing importance of establishing fitness to drive after a brain injury such as stroke can not be over-emphasized. The road test is regarded as the most important test of the pre-driving assessment protocol after stroke and other brain injuries. In this study, we sought to determine the reliability of the road test performed by stroke patients in Belgium. The reliability of the items contained in the road test varied from not reliable (-0.08) to very reliable (1.0). The reliability of the overall performance varied between a modest 0.62 and a reasonable 0.80. It was concluded that some items of the road tests need further attention.

**(17) Evaluating Workload Associated with Telematic Devices Via a Secondary Task Protocol** Mustapha Mouloua, Edward Rinalducci, Peter A. Hancock, J. Christopher Brill (University of Central Florida)

A variety of driver distractions negatively affect driver workload and performance. Of particular interest are the distracting effects of telematic devices, such as traffic information systems, telecommunication, intelligent aid and control, and navigational systems. Several behavioral problems can result from poor use of these devices, which can now be found on-board automobiles. This research hypothesized that the use of telematic systems would degrade driver performance and increase workload. Participants drove three four-minute simulated (pre, during, and post) allocation phases. In the pre-allocation phase, they were asked to count and respond to a series of randomly presented visual signals while driving. During the allocation phase, the counting task was performed while either talking on the phone or tuning a radio. In the post-allocation phase, the participants again drove while performing the secondary counting task. Thirty-four subjects participated in this study. A series of ANOVA revealed that more lane deviations were made during the cell phone and radio tuning than during either the pre- or post-allocation phases. The results also showed that more crossings and more errors were made during the allocation phase than during the other two phases. The findings indicate that both cellular phone and radio systems are capacity demanding, resulting in a higher number of driving performance errors. The counting task results demonstrate the increased level of workload associated with telematic devices. Our findings suggest the need to regulate the use of such devices in order to avoid overloading the driver's attentional capacity.

**(18) Driver Preference of Collision Warning Strategy and Modality** Josh Hoffman, John D. Lee, Elizabeth M. Hayes (University of Iowa)

The success of collision warning systems depends on how well the algorithm and driver interface are tailored to driver capabilities and preferences. An effective collision warning system must promote a timely and appropriate driver response, while minimizing annoyance associated with nuisance warnings. This study examined warning strategy and modality by contrasting graded and imminent warning strategies with auditory and haptic warning modalities using a within-subject experimental design. Visual warnings were presented on a high head-down display placed directly in front of the driver. The warning consisted of graded bars representing severity or an imminent-collision icon. Visual warnings were paired with either an auditory warning or haptic warning in the form of a vibrating seat. Results suggest that haptic warnings may be preferred over auditory warnings, with graded haptic warnings being preferred more than imminent haptic warnings. These results support previous findings of greater acceptance of graded compared to imminent warnings, and no decrement in performance or acceptance of a haptic versus an auditory warning.

**(19) Naturalistic Driving/User and Task Analysis** H.C. Neil Ganey, P. Ward, P.A. Hancock, J.L. Szalma (University of Central Florida)

Naturalistic Decision Making and Cognitive Task Analysis are powerful tools that can be applied to transportation research. In conjunction with simulators, these methods allow increased understanding of real user interactions with in-vehicle systems, and the decision processes involved in the operational aspects of driving, navigating, and using infotainment support systems. Adopting this approach will allow investigation of driver performance under a range of workload and stress conditions. The ultimate goal is the development of a prototypical model which encapsulates the cognitive and perceptual-motor demands of driving in the presence of situational stressors under both high- and low-workload conditions.

**(20) Impact of Passengers on Crashes of Older Drivers** Jason Yaw, Nikiforos Stamatiadis (University of Kentucky), Lisa Aultman-Hall (University of Connecticut)

Older drivers cause a disproportionate number of traffic crashes, and with the increasing number of older drivers, there is significant motivation to further understand the many factors causing these high crash rates. Safety problems for older drivers have been related to sensory (visual), cognitive and psychomotor skills. Older drivers do practice some compensatory measures to counter their diminishing skills. This research examines one such possible compensatory measure—specifically, whether the presence of different passengers groups in the vehicle could improve the safety records of older drivers. No specific research on the effect of passengers exists for older drivers. This study involved a quasi-induced exposure analysis of four years of crashes in the state of Kentucky involving older drivers. Single and multi-vehicle crashes were disaggregated according to the number of passengers. Overall, the presence of two or more passengers was found to negatively impact drivers 75 years of age or older. The negative impact of passengers increased for some geometric road conditions. The presence or absence of passengers was not found to affect the 65-74 year old driver group. Groups of male vehicle occupants with a 75+ male driver were found to have high single vehicle crash rates. These results suggest more work is warranted to consider causes for crash rate differences in older drivers.

**(21) Role of a Driver Cognition Model in the Design of an Anti-Collision Warning System** P. C. Cacciabue, M. Martinetto (European Commission, Joint Research Centre — *Italy*), L. Andreone, F. Tango (Centro Ricerche Fiat — *Italy*), A. Amditis, A. Polychronopoulos (Institute of Communications and Computer Systems — *Greece*), D. Kempf, H. Widlroither (Fraunhofer IAO — *Germany*)

This paper focuses on the importance of a reference model of cognition in the process of designing modern technology. In particular, it discusses this issue with regard to the design of a support system for managing emergency and risky situations. EUCLIDE, a research project funded by the European Commission in the domain of automotive transport, aims to develop an emergency system capable of supporting drivers in difficult weather conditions. A *Driver Cognition Model* has been selected as the reference for designing and testing the whole EUCLIDE system and its Human-Machine Interface.

**(22) Steering a Driving Simulator Using the Queueing Network-Model Human Processor (QN-MHP)** Omer Tsimhoni, Yili Liu (University of Michigan)

The Queueing Network-Model Human Processor (QN-MHP) is a computational architecture that combines the mathematical theories and simulation methods of queueing networks (QN) with the symbolic and procedural methods of GOMS analysis and the Model Human Processor (MHP). QN-MHP has been successfully used to model reaction time tasks and visual search tasks by Feyen and Liu (2001). This paper describes the use of QN-MHP to model vehicle steering and to steer a driving simulator as a step toward modeling more complex driving scenarios. The QN-MHP steering model was interfaced with a driving simulator (DriveSafety) using an Ethernet protocol and several custom-built software modules. The model demonstrated realistic steering behavior. It steered the driving simulator within the lane boundaries of straight sections and those of varying curvature, showing the potential of QN-MHP as a model of driving behavior. Ongoing work will further develop the model by expanding the scope of the driving task and by adding secondary in-vehicle tasks.

**(23) A Systemic Model for Driver-in-Control** Erik Hollnagel (University of Linköping — *Sweden*), Arne Nåbo (Saab Automobile AB — *Sweden*), Ian V. Lau (General Motors — *USA*)

Models of driving have traditionally been couched either in terms of guidance and control or in terms of human factors. There is, however, a need for more powerful models that can match the rapidly growing complexity and sophistication of modern cars. Such models must provide a coherent and consistent way of describing driver performance to help engineers develop and validate technical concepts for semi-and fully automated systems in cars. This paper presents a qualitative model for Driver-in-Control (DiC) based on the principles of cognitive systems engineering. The model describes driving in terms of multiple, simultaneous control loops, with the joint driver-vehicle system (JVDS) as a unit. This provides the capability to explain how disturbances may propagate between control levels. The model also enables new functions to be evaluated at the specific level they are aimed at, rather than by their effects on global driving performance.

**(24) Traffic Entry Judgments by Aging Drivers** Nicole Skaar, Matthew Rizzo, Laura Stierman (University of Iowa)

We hypothesized that older, neurologically normal drivers would compensate appropriately for their slower abilities by choosing larger gaps when entering traffic. To test this we used an instrumented vehicle and radar gun to study 18 legally licensed neurologically normal drivers ranging from 22 to 72 years of age. Drivers were asked to press a button to mark the last possible moment they would cross the road in front of an oncoming vehicle. We measured speed and distance of the oncoming vehicles, and calculated time-to-contact (TTC). The older drivers made more conservative gap acceptance decisions based on higher TTC than younger drivers. This pilot study identified trends in effects of age upon traffic entry judgments, suggesting that neurologically normal older drivers are more conservative when deciding to enter traffic than younger drivers.

## SESSION 4 – Lectures
## Driver Performance Assessment
## Wednesday, July 23, 2003
## 8:15 AM – 10:00 AM

**(25) The Dimensions of Driver Performance During Secondary Manual Tasks** Richard A. Young, Linda S. Angell (General Motors Corporation — *USA*)

This analysis identified the underlying dimensions of driver performance using data obtained from drivers engaged in secondary manual tasks. Randomly chosen subjects balanced for age and gender used one of five advanced navigation and communication systems while driving on a closed roadway. Fifteen driver performance variables were averaged and standardized across subjects for 79 tasks. There were high correlations between all variables. Principal Component Analysis (PCA) found that the vector of loadings defining the first principal component (PC1) was positive for all 15 variables, accounting for 61 percent of the total variation across all tasks. It is interpreted as *overall driver demand*. PC2 loaded with one sign on event detection and response variables, but opposing sign on visual-manual workload variables. It identified tasks making drivers more inattentive to outside events than expected, given a task's visual-manual workload, and accounted for 17 percent of total variation. It is interpreted as *low-workload-but-high-inattentiveness.* PC3 had loadings of opposing sign for peripheral vs. central event variables (5 percent of total variation). It is interpreted as *peripheral insensitivity*. The first three components together accounted for 83 percent of total variation. Thus, most of the information available through the 15 original variables can be summarized by only three PC variables. Because the vectors of loadings defining the components are orthogonal to each other as defined by PCA, no single variable by itself can capture all the important variations in driver performance during secondary manual tasks.

**(26) Time-Sharing of a Visual In-Vehicle Task While Driving: The Effects of Four Key Constructs** Omer Tsimhoni, Paul Green (University of Michigan — *USA*) Honda Outstanding Student Paper Award Winner

What affects time-sharing of a visual in-vehicle task while driving? Four key constructs are considered: (1) time pressure to complete the in-vehicle task, (2) interference of concurrent driving, (3) postponed processing while looking away from the display, and (4) the cost of task partitioning. To examine these effects, 24 drivers were instructed to plan routes to destinations on an electronic map, first while driving a simulator, and then while parked. The concurrent driving task had three levels of visual demand. To force task partitioning while parked, the map was intermittently occluded, and sometimes rotated. Analysis of task completion times, total glance times, and mean glance duration suggests that while the time pressure imposed by driving resulted in shorter glances at the display, subjects maintained constant total glance time. Interference from concurrent driving was not significant enough to negate this effect, and the costs of task partitioning and the benefits of postponed processing in this task were either small or cancelled each other. The task-occlusion method described in this paper provides a framework for understanding the effects of in-vehicle tasks on driving.

**(27) Event-Based Driver Performance Assessment** Erwin R. Boer (Erwin R. Boer Consulting), Nicholas J. Ward (University of Minnesota)

Driving can be characterized as a process of maintaining sufficient safety-margins around a vehicle. The size of these margins is a function of environment and weather, as well as of driver preference, ability, and motivational factors. Normal driving is a discrete control task in which drivers manage their attention across a number of driving and non-driving sub-tasks. The multitasking nature of it forces drivers to adopt tolerances in terms of time-headway (THW), time-to-collision (TTC), time-to-line-crossing (TLC), etc., that are

acceptable in that they do not require corrective maneuvers or actions. The frequency of corrective actions, the severity of the situation associated with them, and the rate of responses to them provide a clear indicator of how drivers interact with the world while attempting to maintain safety margins. In the event-based metrics we are proposing, events are defined as situations that cause drivers to apply corrective actions in response to violations or reductions of their safety margins. Laterally, an event is defined by a local minimum in Time-to-Line-Crossing (TLC). The event-based metrics are: minimum TLC per event, maximum corrective steering rate, and frequency of events. We explain and demonstrate the value of using event-based metrics using data from 10 bus drivers who drove a fully instrumented bus either in normal 12-ft lanes or on a 10-ft shoulder. Results showed that shoulder driving was characterized by a shift towards lower minimum TLCs, higher corrective steering rates, and more events per time or distance unit. Interestingly, the three event-based metrics show different patterns for different subjects that are relatively consistent across the two conditions (lane and shoulder driving). These patterns reveal that different drivers can have larger tolerances, adopt different strategies, or have different skills. Comparisons with the bus drivers' NASA TLX scores showed good correspondence. The proposed event-based approach offers a means of quantifying performance that is both consistent with how drivers define their task and offers clear insights into the multi-faceted effects of different driving contexts on different drivers.

**(28) The Evolution of Autonomic Space as a Method of Mental Workload Assessment for Driving** John K. Lenneman (General Motors Corporation), Richard W. Backs (Central Michigan University)

Psychophysiological assessment of mental workload can be improved with an autonomic space model of sympathetic and parasympathetic influences on the heart. The model proposes that tasks will elicit differing patterns of autonomic activity that may not be reflected by differences in heart rate or other traditional cardiovascular measures of mental workload. Thus, the model will increase capability to identify differences between tasks. In addition, the model can be used to map physiological-psychological relations so as to make better inferences about the psychological processes involved in the performance of a task. The application of the autonomic space model to a simulated driving task is discussed. While the results of the study must remain tentative until more confirmatory evidence of psychological-physiological mappings is established, the utility of the autonomic space approach to the diagnosis of psychological processes involved in a small facet of the driving task was demonstrated.

## SESSION 5 – Lectures
## Driver Fatigue and Impairment
## Wednesday, July 23, 2003
## 10:15 AM – 12:00 PM

**(29) Microsleep Episodes, Attention Lapses and Circadian Variation in Psychomotor Performance in a Driving Simulation Paradigm** Henry J. Moller, Leonid Kayumov, Colin M. Shapiro (University of Toronto — *Canada*)

Numerous studies document circadian changes in sleepiness, with biphasic peaks in the early morning and late afternoon. Driving performance has also been demonstrated to be subject to time-of-day variation. This study investigated circadian variation in driving performance, attention lapses (AL) and/or frequency of microsleep (MS) episodes across the day. Sixteen healthy adults with valid driver's licenses participated in the study. Using the York Driving Simulator, subjects performed four intentionally soporific 30-minute driving simulations at two-hour intervals (i.e., at 10:00, 12:00, 14:00, and 16:00). During each session, individuals had EEG monitoring for MS episodes (defined as 15 to 30 seconds of any sleep stage by polysomnographic criteria) and AL episodes (defined as intrusion of alpha- or theta-EEG activity lasting 4-14 seconds). Measured variables included: lane accuracy, average speed, speed deviation, mean reaction time (RT) to "virtual" wind gusts and off-road events. Mean values of each variable at every time were analyzed using a general linear model and paired sample *t*- tests. RT displayed significant within-group variation, with paired samples tests at df=15 showing RT at 10:00 significantly faster than at other times of the day, but no significant within-group variation between other times of the day. All other variables and EEG-defined AL episodes failed to exhibit any statistically significant variation across the day. However, MS episodes were found to occur more often at 16:00 in comparison to all other times. As RT was optimal before noon, it appears that psychomotor performance and therefore driving ability is subject to circadian variation. Coincident with the demonstrated circadian pattern of diminished alertness, this may partially explain the high incidence of motor vehicle accidents during the mid- to late-afternoon. By better understanding circadian fluctuations in driver sleepiness and psychomotor performance, human performance researchers may be in a position to better educate the public about cautionary measures to prevent accidents.

**(30) Driver Fatigue: Is Something Missing?** J. Christopher Brill, Peter A. Hancock, Richard D. Gilson (University of Central Florida)

Drowsiness and fatigue are serious problems in all transportation systems. One persistent issue is the lack of an agreed-upon definition of these respective energetic states. Here we review the theoretical approaches (cognitive versus physiological) framing the driver fatigue problem. Known contributing factors to drowsiness include sleep debt, circadian rhythm, and shift work. However, we suggest that certain inherent physiological reactions inherent in responses to motion itself represent a previously unrecognized but significant source of fatigue. We confirm the impact of this factor through comparisons of studies that either have or have not included prolonged motion.

**(31) The Effects of Fatigue on Driver Performance for Single and Team Long-Haul Truck Drivers** Sheila G. Klauer, Thomas A. Dingus, Vicki L. Neale (Virginia Tech Transportation Institute), Robert J. Carroll (Federal Motor Carrier Safety Administration)

Driver fatigue is an important safety issue for long-haul truck drivers. To provide an efficient means of obtaining sleep, these drivers often use tractors equipped with sleeper berth units. Depending on the type of cargo and distances traveled, long-haul truck drivers either drive in teams or alone. Team drivers, therefore, typically sleep in a moving truck whereas single drivers sleep in a stationary truck. It has been hypothesized that sleeping in a moving truck could adversely affect sleep quality, and thus the alertness level of team drivers. A naturalistic data collection system was developed and installed in two Class 8 heavy trucks. This trigger-based system consisted of vehicle sensors and cameras that allowed researchers to obtain driving performance and driver alertness data for analysis of fatigue. Fatigue was measured using both objective and subjective measures that were recorded before and after sleep, and while driving. Fatigue and driving performance were compared for single versus team drivers to determine which driver type acquired the greatest sleep deficit during a trip. Results suggest that single drivers were involved in more critical incidents while exhibiting extreme drowsiness than were team drivers by a factor of 4 to 1. These results will be discussed in relation to the general safety of single versus team trucking operations.

**(32) Automobile Driving with Severe Amnesia** Nicole Skaar, Steven W. Anderson, Jeffrey Dawson, Matthew Rizzo (University of Iowa)

Automobile driving is a complex task requiring coordination of many cognitive and visuomotor processes. Disordered memory is a common result of many diseases including herpes simplex encephalitis. Amnesics may forget the rules of the road, location of controls or surrounding vehicles, forget to fasten seat belts, check mirrors and gauges, and to fuel or service the car. We studied two men (ages 46 and 50) who continued to drive despite severe persistent memory impairments resulting from herpes encephalitis. Standardized neuropsychological tests were used to evaluate cognitive abilities. We used ARGOS, a state-of-the-art instrumented vehicle, to measure driver performance on tasks that challenged critical cognitive abilities during driving. Neuropsychological testing confirmed severe and stable memory impairments with preserved abilities in other cognitive domains. Snellen visual acuity and Pelli-Robson contrast sensitivity were normal. Neither amnesic learned the directions for a navigation task in ARGOS, yet both could complete the necessary turns with assistance from an on-board experimenter. Both amnesics showed good speed and steering control compared to 59 neurologically normal controls of similar age and committed no hazardous errors. Despite profound amnesia, both subjects could learn and retain procedural knowledge needed to handle an unfamiliar vehicle, and both remembered road rules and locations of surrounding vehicles. Yet, neither could learn and follow directions for the navigation task in ARGOS, consistent with inability to learn and recall new declarative information. Their good speed and steering underscores that automatic processes of attention allowing a driver to control a vehicle can be intact despite profound memory impairment. Despite being able to handle a vehicle, both amnesics had trouble remembering the destination and purpose of the trip. There would be no reason to revoke the license of someone with isolated severe memory impairment from herpes encephalitis; however, license restriction may be advisable to mitigate problems caused by getting lost.

## SESSION 6 – Lectures
## Visual Performance and Driving
## Wednesday, July 23, 2003
## 1:45 PM – 3:25 PM

**(33) Driver Behavior as a Function of Ambient Light and Road Geometry** Michael J. Flannagan, John M. Sullivan, Scott E. Bogard (University of Michigan Transportation Research Institute)

Evidence from crash data suggests that drivers' success in negotiating the road is virtually unaffected by differences in ambient light, although their ability to perceive and avoid objects on the road, such as pedestrians, is greatly reduced when headlamps are the main source of light. One possible explanation for this is that negotiating the road is a self-paced task—drivers have continuous information about how well they can see the road, and they may adjust their driving behavior accordingly, perhaps by slowing down. However, drivers in general do not appear to markedly reduce their overall speed in conditions of low ambient light. The current analysis provides a more detailed look at this issue by using data from a fleet of instrumented vehicles to determine how individual drivers react to specific road geometries in light and dark conditions. The results have implications for how well drivers' perceptual abilities match their driving behavior, and for assessing the potential benefit of a variety of innovative headlighting systems that are currently being designed to adapt in various ways to vehicle speed and road geometry.

**(34) Effects of a Night Vision Enhancement System (NVES) on Driving: Results from a Simulator Study** Erik Hollnagel (University of Linköping — *Sweden*), Jan-Erik Källhammer (Autoliv Research — *Sweden*)

Three related experiments looked at the effects of NVES on driving performance, with differences in image size ratio, lateral position and direct/indirect viewing as parameters. The experiments used experienced drivers in a fixed-based virtual reality driving simulator. Experiment 1 found that subjects using an NVES gained time to assess the situation and choose an appropriate response, seen as better control of braking and swerving. Contrary to expectations, they did not drive significantly faster when using the NVES. Experiment 2 found that a 1:2 display ratio resulted in better anticipatory control without any adverse effects from differences in recognition distances. When using an NVES display displaced laterally from the normal line of sight, drivers kept the vehicle closer to the middle of the road. They also found the displaced position less favourable than the normal-line-of-sight position, although there were no strong negative effects of the displacement. Experiment 3 compared a virtual (collimated) display to a direct viewing Flat Panel, with the hypothesis that reduced need of accommodation would lead to smoother driving. The results showed some differences between the two display types, although they were small compared to the effects of learning. Altogether the experiments confirmed that NVESs can improve drivers' anticipatory control, and hence have considerable safety potential. This work also emphasises the need to consider the combined effects of an NVES as a system on driving, rather than doing classical controlled experiments.

**(35) Car Following by Optical Parameters** Craig W. Sauer, George J. Andersen, Asad Saidpour (University of California, Riverside)

A model for car following based solely on optical parameters was developed and compared with the performance of human drivers in a simulator. The model uses the optical size of the back of the lead car and the first derivative of its optical size as inputs. The model consists of two components: one that accelerates to maintain the visual size of the leading car, and another that accelerates to minimize changes in the rate of change of the visual size of the leading car. The simulator presented drivers with a lead car that changed its velocity according to a sum of non-harmonic sines. Comparisons of human drivers' performance with the models' show a high degree of similarity.

**(36) Reducing Crash Risk in Visually-Impaired Older Drivers: Medical-Surgical versus Educational Interventions** Gerald McGwin Jr., Cynthia Owsley (University of Alabama at Birmingham)

The aim of this paper is to compare the effectiveness of a medical-surgical intervention and an educational intervention in reducing the rate of crash involvement among visually impaired older drivers. In a prospective cohort study we focused on older drivers with cataracts. Patients who underwent cataract surgery had half the rate of crash involvement during follow-up compared with cataract patients who did not undergo surgery (rate ratio [RR] 0.47, 95% confidence interval [CI] 0.23 to 0.94; $p<0.05$). In a second study, older drivers who were visually impaired were randomly assigned to an individually administered and tailored educational

intervention focused on the use of self-regulatory driving strategies plus comprehensive eye exam or to comprehensive eye exam only. Those receiving the intervention were similar to the usual-care-only group in terms of their crash involvement rate (RR 1.40, 95% CI 0.92 to 2.12; p>0.05). The most effective public health initiatives for reducing crash risk in older drivers may be to focus on the timely treatment of chronic medical conditions in order to prevent, reverse, or slow functional decline.

## SESSION 7 – Posters
## Wednesday, July 23, 2003
## 3:30 PM – 5:00 PM

**(37) Novice Driver Training Results and Experience with a PC-Based Simulator** R. Wade Allen, George Park, Marcia Cook, Theodore J. Rosenthal (Systems Technology, Inc.), Dary Fiorentino (Southern California Research Institute), Erik Viirre (University of California at San Diego)

This paper reports on work accomplished subsequent to a pilot study that was presented at the 2001 conference. The current study will eventually involve the training of over 500 novice drivers, and a comparison of real-world accident and violation rates of the simulator-trained group with a traditionally trained control group of demographically matched novice drivers. We describe the simulator training system and present some training data for 111 student subjects collected at three sites involving different simulator configurations. These configurations include a desktop system with a single monitor narrow field of view display, a desktop system with wide field of view display, and a cab with wide field of view display. The results include performance measures, a measure of simulator sickness, and experience involved in implementing driver-training simulators in the high school environment.

**(38) Assessing Spare Attentional Capacity of Drowsy Drivers: Protocol Development** J. Christopher Brill, Mustapha Mouloua, Peter A. Hancock, Richard D. Gibson (University of Central Florida), Robert S. Kennedy (RSK Assessments, Inc.)

The National Highway Traffic Safety Administration (NHTSA) estimates that driver fatigue and sleepiness were involved in an annual average of 56,000 vehicle crashes in the mid-1990s. Assessment is a first step in addressing this national problem, but while a variety of techniques are used to assess driver drowsiness, no single measure is accepted. Some measures, such as analysis of lane deviations, tracking variability, and speed variability, are performance-based. Other measures assess behaviors beyond the driving task, such as simple reaction time to auditory signals, electroencephalography, and eye closure rate (PERCLOS). Subjective measures include the Epworth Sleepiness Scale, the Karolinska Sleepiness Scale, and the Stanford Sleepiness Scale. These measures, however, provide little theory or insight into how one ultimately might develop countermeasures for the problem. This study developed a protocol to assess how driver drowsiness affects attentional spare capacity differentially across the senses. Based on a protocol developed by Kennedy (1971), the multi-sensory workload assessment protocol (M-SWAP) was developed to assess cognitive-attentional capacities across three sensory systems: vision, audition, and touch. While driving, participants are presented with a random series of either visual, auditory, or vibrotactile signals. Their task is to count the frequencies with which specific target stimuli are presented within four-minute blocks. Counting errors are analyzed using signal detection theory methodologies, and counting performance decrements indicate the amount of reduced attentional capacity for a given sensory modality. Cross-modality comparisons of performance data provide empirical foundations for developing alarm-based countermeasures for driver drowsiness. Specifically, M-SWAP can be used to determine to which sensory modality(ies) an alarm system should appeal. Moreover, because M-SWAP provides almost real-time feedback regarding performance, it could be integrated with future automated systems designed to activate when driver incapacitation is detected.

**(39) Influences of Knowledge on Behaviors in Automobiles** S. David Leonard (University of Georgia)

Behaviors are generally a function of desired effects and the knowledge of how to produce them. In using automobiles for the general purpose of transportation, individuals may also be implicitly concerned with maintaining the safety of themselves and their passengers. This study involved self-reported practices and knowledge of procedures important for maximizing safety in the use of automobiles. Subjects described their behaviors and evaluated some warnings used to provide safety information. They were also asked to indicate how relevant they thought the information in the warnings would be for them. Responses indicated support for previous findings that warnings employing standard procedures were more likely to be effective, but also suggested that many individuals were unaware of some existing warnings and other sorts of safety information. Results are discussed in terms of the need for improving safety information, including warnings.

**(40) Traffic Scene Related Change Blindness in Older Drivers** Sarah Batchelder, Matthew Rizzo (University of Iowa), Rick Vanderleest (Digital Artefacts, LLC), Shaun P. Vecera (University of Iowa) Honda Outstanding Student Paper Award Winner

The study investigated whether a driver's age affects the detection of change in driving-related images. A touch-screen computer presented images for a maximum duration of 10 seconds. Half of the images presented included a gradually changing element, and half remained static. Participants were instructed to manually identify the change on the screen, or to depress the spacebar if no change had occurred. We found that older drivers (N = 13, 54% male, mean age 68.5 years) were less accurate ($t_{36}$ = 5.445, $p$ < .001), displayed greater response times ($t_{36}$ = -2.67, $p$ < .05), and produced more false positive responses ($t_{36}$ = -2.754, $p$ < .01) than younger drivers (N = 25, 68% female, mean age 22.3 years).

**(41) Aggressive Driving Is a Major Cause of Traffic Accidents and Road Rage in Jordan** Mohd R. Suliman, Wa'el H. Awad (Al-Balqa' Applied University — *Jordan*)

Motor vehicle accidents are a major cause of death among Jordanians. While many factors contribute to this situation, the most deadly is human error. This includes unawareness of traffic rules and roadway conditions; lack of driving skills; poor judgment; failure to interact and adjust to prevailing roadway conditions; and most importantly, aggressive driving. Preliminary findings of a survey questionnaire showed that improper engineering design, inadequate traffic control, lack of traffic management, and traffic congestion are the main factors leading to aggressive driving and road rage on Jordan's roadways. The main objective of the study is to identify aggressive driving behaviors in Jordan and to underline their effect on traffic safety. In addition, we are attempting to increase drivers' awareness of their actions on the roadway and to point out the consequences associated with them. Many drivers justify aggressive driving as a temporary retaliatory measure to counteract other aggressive drivers; this leads to road rage and traffic chaos. Aggressive driving behaviors such as pushing a car off the roadway, deliberately obstructing passing vehicles, pursuing other vehicles, driving at excessive speeds, and tailgating are at the top of the list according to the study findings.

**(42) Inattentional Blindness While Driving** Chip Wood (Motorola Labs), Rob Gray, Jennifer Young (Arizona State University East), John Summers, (Motorola Labs)

Research suggests that we perceive only those objects and events to which we directly attend. Unexpected visual information can go unnoticed. This occurs in a majority of viewers even if the unexpected object and action take place clearly, slowly, and within inches of objects being attended to. Most drivers have experienced brief moments of "inattentional blindness" and not perceived obvious events or objects clearly within their field of vision. This can produce astonishment, alarm, and possibly, over-reaction when awareness does occur. This paper will describe an experiment to test this phenomenon using a driving simulator. Unlike most driver-distraction studies, we did not ask drivers to divert their attention off the road to a secondary task, but to keep their attention focused solely on driving and the objects on the road. Results will be presented and compared to the existing literature.

**(43) Simulator Training Improves Driver Efficiency: Transfer from the Simulator to the Real World** David M. Dolan, Darrell A. Rupp, Jacob R. Allen (GE Driver Development), David L. Strayer, Frank A. Drews (University of Utah)

We report the results of a fuel management simulation study to quantify the improvement in fuel efficiency for CDL truck drivers. Forty drivers were selected from a local commercial trucking company that maintained precise records on drivers' history, fuel efficiency, type of vehicles driven, and trucking routes. These drivers participated in a two-hour training program that focused on ways to optimize shifting to maximize fuel efficiency. Transfer of training was assessed over a six-month interval using measures of fuel consumption obtained by the driver in their own vehicle driving their normal route. Training increased fuel efficiency by an average of 2.8% over the six-month interval. Analyses indicated that the benefits of training persisted throughout the post-training interval. These training benefits were obtained even for the subset of drivers who changed vehicles after training, indicating that drivers learned a general skill that transferred from one vehicle to another. Additional analyses focused on which drivers benefited the most from training. We sorted the drivers into one of four groups, based on pre-training fuel efficiency. Our analysis indicated that those drivers with the lowest pre-training fuel efficiency benefited most from training (with over 7% improvement in fuel efficiency), while those with the highest pre-training fuel efficiency did not benefit significantly. Together, our data validated the transfer of simulator training to real-world driving. Moreover, the benefits of training appear to be durable and to apply most to drivers whose performance was initially below the median on fuel efficiency.

**(44) On the Fast Lane to Road Rage** Frank A. Drews, David L. Strayer, Bert N. Uchino, Timothy W. Smith (University of Utah)

Aggressive driving and road rage are on the rise, and their triggering factors are not well understood. The first goal of this study was to identify conditions likely to lead to aggressive driving/road rage. The second goal was to develop a paradigm that allows for the controlled study of road rage in the laboratory setting. Forty-five drivers participated in the study. Twenty-three received non-contingent instructions that emphasized safely driving to a rest stop. The remaining drivers received contingent instructions that offered a $10 monetary incentive if they arrived at the rest stop in the top 50% of all drivers. Participants drove in two scenarios (regular/irregular flow) in a high-fidelity driving simulator. We recorded cardiovascular reactivity while driving, and measured driving-related anger after each scenario. Overall, the driving task evoked minimal changes in blood pressure. However, an incentive by gender interaction for systolic blood pressure (SBP) reactivity indicated that males in the contingent incentive condition displayed greater SBP responses than those in the non-contingent incentive condition or females in the contingent incentive condition. Contingent versus non-contingent incentives had no effect on females' SBP response. We found no effect of incentive or traffic flow on anger, though analysis on an individual level indicated that some subjects were affected by the manipulation of driving condition. The present findings provide psychophysiological evidence that driving under time pressure and in irregular traffic flow may contribute to the genesis of road rage.

**(45) Test-Retest Reliability of Standard Deviation of Lane Position as Assessed on a PC-Based Driving Simulator** Thomas D. Marcotte, Erica Roberts (University of California, San Diego), Theodore Rosenthal (Systems Technology, Inc.), Robert Heaton, Heather Bentley, Igor Grant (University of California, San Diego)

A frequently used metric for assessing driving ability is the standard deviation of lane position (SDLP), or the amount that subjects "swerve" within their lane. Although good test-retest reliability is critical if one is to measure change in individuals over time, there is surprisingly limited data regarding the test-retest reliability of SDLP. This study examined the test-retest reliability of SDLP in subjects tested at a 3-month retest interval, and at a year or longer retest interval. Group 1 completed retesting an average of 84 days after their initial simulator assessment. Group 2 was retested an average of 19.8 months after baseline. All subjects completed NP evaluations at baseline and follow-up. Twelve subjects (39%) were NP impaired. Subjects who remained at the same level of NP functioning at follow-up were selected for the study. SDLP was assessed in both groups using an interactive PC-based driving simulation that consisted of a monitor, steering wheel, and brake/accelerator pedals. Participants were required to maintain lane position while holding a constant speed (55 mph) and responding to divided attention tasks in the corner of the monitor. Combined reliability for Group 1 was .74. Test-retest reliability was .68 for the HIV- and .83 for the HIV+ subjects. For Group 2, SDLP was significantly correlated with NP functioning at baseline and follow-up, with impaired subjects evidencing a higher SDLP than NP normal subjects at both baseline and follow-up. Combined test-retest reliability for Group 2 was .86. The NP normal group had a test-retest reliability of .74; test-retest reliability for the NP impaired group was .87. The findings indicate that SDLP is a reliable measure for periods ranging from months to years when assessed in cognitively stable subjects. As such, it may serve as a useful tool in tracking the effects of neurologic disorders and pharmacologic treatments on driving abilities.

**(46) Demographic and Driving Performance Factors in Simulator Adaptation Syndrome** Matthew Rizzo, Rebecca A. Sheffield, Laura Stierman, Jeffrey Dawson (University of Iowa)

Simulation is an important option for testing at-risk drivers with medical impairments. Simulator Adaptation Syndrome (SAS), characterized by autonomic symptoms, presents a drawback to testing. This study investigated new issues regarding susceptibility of neurologically impaired drivers to SAS, scenario situations most likely to cause SAS, and effects of SAS on driver performance. Subjects were 164 drivers enrolled in larger ongoing studies of at-risk older drivers. Eighteen had Alzheimer's disease (AD), 44 stroke, and 102 were neurologically normal controls. Experimental drives were conducted using a fixed-base high-fidelity simulator with a 150º forward field of view. Each driver completed a questionnaire immediately after driving in the simulator, rating any feelings of discomfort along 9 dimensions; an overall discomfort score was then calculated. Of the 164 drivers, 130 completed the full drive and 34 ended the drive early. Drivers with higher overall discomfort scores were more likely to drop out. Specific symptoms strongly predicted dropping out, namely dizziness, nervousness, light-headedness, body temperature increase, and nausea. Simulator dropout rates and reported discomfort scores were significantly greater in women than men, but did not differ between drivers with AD or stroke and neurologically normal drivers. Comparisons between 32 Dropouts and 32 Non-Dropouts (matched by age, gender, neurological impairment, and scenario driven) showed no evidence that higher levels of discomfort cause a driver to perform atypically before the point of dropout. We could relate dropout to specific segments and events in the drive that required abrupt braking.

**(47) Simulation Methods for Assessing Driving on Roads with Curves** John A. Molino (Science Applications International Corporation), Duoduo Liao, John M. Wink, Jason R. Williams (AAI Engineering Support, Inc.), Kenneth S. Opiela, M. Joseph Moyer (Federal Highway Administration)

This paper describes three techniques to enhance the efficiency and realism of driving simulations. These techniques are used by the Federal Highway Administration (FHWA) in investigations of the effectiveness of pavement markings and retroreflective raised pavement markers. The three techniques are: (1) a trial-based method for presenting stimuli that avoids the need to develop and present driving scenarios, (2) a dynamic scene-generation method in which roadway scenes are generated on-the-fly to satisfy experimental conditions, and (3) a simplified motion cue calculation method for simulation of roadway superelevation. The trial-based method has been used in two experiments, and has proved to be extremely efficient. The dynamic scene-generation method is being employed in an experiment currently under development and has already significantly reduced the modeling workload. The motion cue capture method is being implemented in that same experiment, and has been successfully demonstrated to produce realistic motion stimuli. These three methods are helping the FHWA highway safety research program to realize the full potential of driving simulation as an important research tool.

**(48) Lane-Changing Behavior at Weaving and Merging Sections of Highway** Ghulam H. Bham, Rahim F. Benekohal (University of Illinois, Urbana)

This paper presents the frequency and percentage of lane changes observed at weaving and merging (on-ramp) sections of the highway. Two sets of hour-long field data were collected at 1-second intervals using aerial photography. Frequency and percentage of lane changes and the location of changes were observed for vehicles moving from the shoulder lane to the auxiliary lane and vice versa in a weaving section. The data indicates that there is intense lane changing in the first 300 feet of the weaving section. The number of changes from the shoulder lane to the auxiliary lane was double that of changes from the auxiliary lane to the shoulder lane. The paper also presents frequency and percentage of lane changes from the median to the shoulder lane; these are affected by merging and diverging behavior to and from the auxiliary lane and occur more often in the later part of the weaving section. It was found that intense lane changing began 100 feet from the gore and continued for about 200 feet. Vehicles merging onto the highway moved to the adjacent inner lane. The highest intensity of lane changes from the shoulder to the adjacent lane was observed near the end of the acceleration lane (on-ramp). This study of lane-changing behavior is important for calibrating microscopic simulation models to replicate driver behavior. Moreover, it can be used to improve traffic operations by analyzing adequacy in length of acceleration lanes and weaving sections.

**(49) An Examination of the Efficacy of a Brief Educational Program on Driver Distraction** Arthur Kramer, Jason S. McCarley (University of Illinois), Scott Geisler (General Motors Corporation)

We evaluated the influence of a set of video segments, included as part of a driver distraction education program, on self-reports of past and intended future driving behavior and on perception of the danger of various driver distractions. For the study, 1586 participants were contacted by e-mail to complete a web-based survey. Respondents filled out a series of rating scales, reporting 1) the frequency with which they participated in various distracting activities while driving, 2) the frequency with which they expected to participate in those activities while driving in the future, and 3) the perceived danger of performing those activities while driving. Half of the participants (experimental subjects) completed the rating scales after first watching a series of short animated videos from the driver education program. The remaining respondents (control subjects) filled out the questionnaire prior to viewing the video segments. As compared to the control subjects, participants who viewed the video segments prior to filling out the rating scales reported reliably higher levels of perceived danger for a number of distracting activities. Effects of the video segments on self reports of anticipated future behavior, however, were generally non-reliable, as were effects on the reported past rates of engaging in distracting activities while driving. Additional analyses suggested that demographic factors such as age may modulate both the perceived danger of various distracting activities, and the effects of the tested educational materials.

**(50) Did You See That? A Study of Change Blindness** Tara Smyser, John D. Lee, Joshua Hoffman, Robert Betts (University of Iowa)

As cell phones and other types of in-vehicle technology become increasingly prevalent, there is growing concern that these systems may degrade driving safety. To address this issue, the effect of cognitive load on visual attention merits investigation. The change blindness flicker paradigm by Rensink et al. (1997) was employed to assess the mechanisms by which the cognitive load induced by speech-based interaction can narrow attention. Twenty participants completed a series of five conditions including a visual search task, an

e-mail task, a combination of both these tasks, and a combination of the visual search task and e-mail task with errors introduced. Analyses showed that detection of scene changes took significantly longer when participants were cognitively loaded with the e-mail system (mean=5.05) as compared to when they were not (mean=4.35), ($F(3,67) = 11.16$, $p<0.0001$), and when there was no scene change (mean=5.99) as compared to when there was a change (mean=3.72), ($F(2,67) = 271.95$, $p<0.0001$). The results of this study demonstrate that cognitive load has an effect on visual attention, which could potentially be applied to driver safety. The results also show that the change blindness flicker paradigm is a sensitive tool for measuring the effects of cognitive load on change detection.

**(51) A Comparison of Traffic Sign Comprehension Using Static, Dynamic and Interactive Presentation Media** Susan T. Chrysler, James Wright, Alicia Williams (Texas Transportation Institute)

Traditionally, traffic sign comprehension has been tested using paper-and-pencil tests with line drawings of signs and uncontrolled viewing time of the test signs. This study compares these types of tests to dynamic tests using an interactive driving simulator. Multiple-choice tests concerning sign comprehension were administered to five groups of Texas drivers following exposure to traffic sign stimuli via line drawings, still computer drawings in a roadway context either with or without controlled exposure, a video of a "drive through" from the simulator, or driving in the simulator itself. Results show interesting differences among the groups which suggest that past studies may have overestimated sign comprehension.

## SESSION 8 – Lectures
## Collision Avoidance
## Thursday, July 24, 2003
## 8:15 AM – 10:00 AM

**(52) The Effects of Lead Vehicle Size on Driver Following Behavior: Is Ignorance Truly Bliss?** James R. Sayer, Mary Lynn Mefford (University of Michigan Transportation Research Institute), Ritchie W. Huang (Honda R&D Americas, Inc.)

The objective of this study was to examine whether the size of a lead vehicle (passenger car or light truck) affects the distance at which following vehicles travel. Naturalistic following data were collected from drivers using instrumented passenger cars. The results show that these drivers followed light trucks at shorter distances than they followed other passenger cars by an average of 5.6 m (or .19 s in headway time margin), but at the same velocities and range-rates. This result is discussed in the context of a passenger car driver's ability to see beyond a lead vehicle to assess and respond to the status of traffic downstream. The results of this study suggest that knowing the state of traffic beyond the lead vehicle, even by only one additional vehicle, affects gap length. Specifically, it appears that when dimensions of lead vehicles permit other drivers to see through, over, or around them, drivers maintain significantly longer (i.e., safer) distances.

**(53) Stimulus-Response Compatibility Effects for Warning Signals and Steering Responses** Dong-Yuan Debbie Wang, Robert W. Proctor (Purdue University), David F. Pick (Purdue University Calumet)

Stimulus-response compatibility is relevant to the way in which a collision avoidance system signals a hazard. If the location of the warning tone is considered to be the signal, standard spatial compatibility theory would suggest that it would be most beneficial to locate the tone in the direction of the desired response. However, because drivers typically turn away from sounds created by hazards, they may adopt a frame of reference wherein turning away from the warning tone is more compatible than turning toward it. In this experiment, tones were manipulated to simulate warning signals. Subjects responded to tones in the left or right ear by turning a steering wheel clockwise or counterclockwise. Two groups received typical compatibility instructions (tone instructions), and two received instructions specifying that the tone was a warning signal (warning instructions) indicating either the location of the danger (from which they were to turn away) or the escape direction (toward which they were to turn). The tone instructions were in the same direction and of the same magnitude as the warning instructions. The results indicated that instructions to turn away from the danger did not cause subjects to adopt an avoidance frame of reference and that spatial correspondence was the overriding factor. The findings suggest that collision avoidance systems should signal the escape direction, however, these results need to be verified in simulated and actual driving conditions.

**(54) Drivers' Perception of and Response to Brake Failure** Hamish Jamson, Paul Smith (University of Leeds — *UK*)

The behavior and emotional state of 48 drivers was investigated during both servo booster and hydraulic circuit brake failures on a proving ground. Results suggested that the most informed and least "stressed" drivers seemed to be the most successful in bringing the test vehicle to a safe stop. The interpretation of these results fed into a study using a driving simulator. Interventions were examined that tested both the "engineering" of the vehicle to a more stringent interpretation of current legislation and driver "information" with a novel visual/auditory warning system. Targeting the vehicle, not the driver, seemed to be the best way to manage the rare event of brake failure.

**(55) Risk of Fatal Rear-End Collisions: Is There More to It Than Attention?** John Sullivan, Michael J. Flannagan (University of Michigan Transportation Research Institute)

Rear-end collisions predominantly occur in the daytime under clear, unobstructed viewing conditions and usually involve a lead vehicle that is stopped at the time of collision. These facts suggest that driver inattention plays a significant causal role in rear-end collisions, and mitigation efforts have therefore focused largely on development of warning technologies to alert drivers of an impending crash. However, we note that this pattern of crash data should not lead to the conclusion that drivers have special difficulty avoiding rear-end collisions in broad daylight. Nor should it be concluded that other "environmental" factors do not influence driving behavior to increase rear-end crash risk. Crash frequency is determined *both* by the inherent risk in the driving task and by the frequency of driver exposure to conditions in which a crash is possible. In this paper, we will demonstrate that the risk of rear-end collisions is more than twice as high in darkness as in daylight by applying an analysis technique in which factors related to exposure are controlled.

## SESSION 9 – Lectures
## Driver Characteristics and Behavior
## Thursday, July 24, 2003
## 10:15 AM – 12:00 PM

**(56) Driver Psychological Types and Car Following. Is there a Correlation? Results of a Pilot Study** Mark Brackstone (University of Southampton — *UK*)

Many studies have attempted to measure driver behavior or to classify drivers' attributes according to questionnaires based on psychological indicators. Although such studies have met with success, for example correlating behavioral types with accident risk, few attempts have been made to correlate these attributes with direct, dynamically measurable quantities. In this paper we will examine whether such a correlation is possible by examining results from a pilot study using an instrumented vehicle and a group of eleven subjects. In particular, we consider how distances in car following are correlated to the Sensation Seeking and Internality-Externality Scales. We find that although some scales may be used to parameterize low-speed driving, they are not applicable to high-speed behavior, where more subjective scales seem to be more successful.

**(57) The Relationship Between Collision History and a Computerized Assessment of Visual and Cognitive Skills in a Sample of School Bus Drivers** Kenneth C. Mills (Profile Associates), Robert C. Hubal, Brent T. Ward (RTI International)

A series of studies conducted using two PC-based tests examines impairment and driver disorientation. The first is a symbolic test of divided and channelized attention used in clinical and pharmaceutical settings. The second is a video realistic version of the first test, with commercial, off-the-shelf steering wheel and foot pedals. Both tests are compared with driving performance in samples of police cadets. The video realistic assessment of visual and cognitive skills is compared with retrospective accident costs in a sample of school bus drivers. Implications for assessing driver disorientation and peak performance are discussed.

**(58) Societal Violence, Driver Age, and Attained Education: Independent Contributions to Road Accidents?** Michael Sivak (University of Michigan Transportation Research Institute)

This study examined the potential effects of societal violence, driver age, and attained education on accident causation. A regression analysis was performed using the 2000 fatal accident data for the 50 individual states (excluding D.C.). The dependent variable was the fatal accident rate per licensed driver; the independent variables were the homicide rate per person, the proportion of licensed drivers under 20 years of age, and the proportion of persons that attained at least a college degree among the population aged 25 years and

older. Each of the three independent variables proved to be a significant predictor of states' fatal accident rate. Specifically, a higher traffic fatality rate was associated with a higher homicide rate, a higher proportion of young drivers, and a lower proportion of college graduates. A multiple regression showed that each of these three independent variables has a significant and independent relationship with the dependent variable, with the three predictors accounting for a total of 63% of the variance in the traffic fatality rate. These results are consistent with the possibility of independent contributions to traffic accident causation by societal violence, inexperience/risk taking of young drivers, and level of education. The presentation will discuss the potential implication of these findings, along with methodological issues related to these kinds of analyses.

**(59) A Simulation Study of Path and Speed Through Double-Lane Roundabouts** Gregory W. Davis (FHWA Office of Safety, RD & T), Vaughan W. Inman, Ted Shafer, Bryan J. Katz (SAIC Transportation Research Division)

This presentation will highlight the methodology and results from a simulation study recently conducted at FHWA's Highway Research Facility. The study investigated the effects of geometric design and pavement markings on drivers' selection of path and speed in double-lane roundabouts. Using a fixed-base driving simulator, lane position and speed data were collected as participants drove though simulated roundabouts. The presentation will discuss the results and relevant conclusions from the simulation study, and describe relationships observed when comparing the results of the simulation study to results obtained in a separate field study.