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Special Section: Peer Commentary on Assessing Cognitive Distraction in Driving



John D. Lee and Linda Ng Boyle. *Is Talking to Your Car Dangerous? : It Depends: Prologue to the Special Section.* S. 1297-1299.

Cognitive distraction represents an important and growing traffic safety issue, particularly with the increasing computerization of cars. The target paper in this special section describes a protocol for assessing the distraction potential of information and entertainment systems. Cognitive distraction has specific relevance to the challenges facing driving safety but also reflects the more pervasive challenge of generalizing findings in the face of complex contextual and compensatory influences. Peer commentaries from five driving safety experts sketch paths forward in assessing the distraction potential of in-vehicle information technology. A simple, definitive statement regarding the risk of talking to your car is appealing, but the complexity of driver behavior may make such a statement unachievable.

- **Keywords:** crashes, human error, attentional processes, cognition, decision making, distractions and interruptions

David L. Strayer, Jonna Turrill, Joel M. Cooper, James R. Coleman, Nathan Medeiros-Ward, and Francesco Biondi. *Assessing Cognitive Distraction in the Automobile.* S. 1300-1324.

Objective: The objective was to establish a systematic framework for measuring and understanding cognitive distraction in the automobile. **Background:** Driver distraction from secondary in-vehicle activities is increasingly recognized as a significant source of injuries and fatalities on the roadway. **Method:** Across three studies, participants completed eight in-vehicle tasks commonly performed by the driver of an automobile. Primary, secondary, subjective, and physiological measures were collected and integrated into a cognitive distraction scale. **Results:** In-vehicle activities, such as listening to the radio or an audio book, were associated with a low level of cognitive workload; the conversation activities of talking to a passenger in the vehicle or conversing with a friend on a handheld or hands-free cell phone were associated with a

moderate level of cognitive workload; and using a speech-to-text interfaced e-mail system involved a high level of cognitive workload. **Conclusion:** The research established that there are significant impairments to driving that stem from the diversion of attention from the task of operating a motor vehicle and that the impairments to driving are directly related to the cognitive workload of these in-vehicle activities. Moreover, the adoption of voice-based systems in the vehicle may have unintended consequences that adversely affect traffic safety. **Application:** These findings can be used to help inform scientifically based policies on driver distraction, particularly as they relate to cognitive distraction stemming from the diversion of attention to other concurrent activities in the vehicle.

- **Keywords:** cognitive workload, cognitive distraction, driving, EEG, visual scanning behavior, divided attention, multitasking

COMMENTARIES

Jeff K. Caird. *On the Effects of Listening and Talking to Humans and Devices on Driving*. S. 1325-1327.

The body of research on cognitive distraction while driving is vast and spans many decades. To this research, the authors of the target article add three experiments that measure a number of cognitive tasks across laboratory, simulation, and on-road contexts. The pattern of decrements is similar across contexts, when expressed as an index, and when compared to previous research. Measurement, task, and generalizability issues arise from the approaches taken by the authors. For example, the use of “pure” cognitive tasks may not necessarily generalize to everyday driving behavior, wherein visual and physical distractions are inherently interleaved with cognitive tasks. A valuable contribution of the authors’ future research on cognitive distractions would be to predict relative crash risk.

- **Keywords:** driver distraction, surface transportation, driver behavior, meta-analysis, methods and measures

David Shinar. *Cognitive Workload ≠ Crash Risk: Rejoinder to Study by Strayer et al. (2015)*. S. 1328-1330.

Strayer et al.’s article is a significant attempt to scale the cognitive workload of different potentially distracting tasks. It is tempting but not warranted to equate the workload with the relative risk of crash involvement. In this article, I list the reasons why the scaling should not be generalized to safety implications in real driving and argue for the combination of studies of maximal performance assessment (e.g., simulation) with behavioral assessment (e.g., naturalistic driving).

- **Keywords:** risk assessment, accidents, human error, distraction, surface transportation, intelligent vehicle systems, dual task, time sharing, task switching, cognition, mental workload

Donald L. Fisher. *Cognitive Distraction in the Wild : Next Steps—Addressing a Not-So-Humdrum Conundrum*. S. 1331-1333.

Strayer et al. in this volume show that increases in cognitive workload caused by drivers’ involvement in distracting activities that allow them to keep their eyes on the road lead to decrements in indices of safe driving performance. Although there is agreement that in-vehicle tasks that require drivers to take their eyes off the road increase crash risk, there is mounting controversy about whether in-vehicle tasks that do not require drivers to take their eyes off the forward roadway increase crash risk—thus the conundrum: How

can there be an abundance of cognitively distracting activities and controversy about whether such activities increase crash risk?

- **Keywords:** accident analysis, accidents, human error, attentional processes, cognition, distractions and interruptions, distraction, surface transportation, driver behavior

Richard A. Young. *Driver Compensation : Impairment or Improvement?* S. 1334-1338.

Strayer et al.'s conclusion that their "cognitive distraction scale" for auditory-vocal tasks indicates "significant impairments to driving" is not supported by their data. Additional analysis demonstrates that slower brake reaction times during auditory-vocal tasks were fully compensated for by longer following distances to the lead car. Naturalistic driving data demonstrate that cellular conversation decreases crash risk, the opposite of the article's assumption. Hence, the scale's internal and external validities for indicating driving impairment are highly questionable.

- **Keywords:** risk assessment, accidents, human error, attentional processes, cognition, distractions and interruptions, dual task, time sharing, task switching, mental workload, speech user interfaces (sui), displays and controls, interface evaluation, human-computer interaction, computer systems, usability/acceptance measurement and research, distraction, surface transportation, aggressive and ,risky driving

Peter A. Hancock and Ben D. Sawyer. *Judging Thieves of Attention : Commentary on "Assessing Cognitive Distraction in the Automobile," by Strayer, Turrill, Cooper, Coleman, Medeiros-Ward, and Biondi (2015).* S. 1339-1342.

The laudable effort by Strayer and his colleagues to derive a systematic method to assess forms of cognitive distraction in the automobile is beset by the problem of nonstationary in driver response capacity. At the level of the overall goal of driving, this problem conflates actual on-road behavior; characterized by underspecified task satisficing, with our own understandable, scientifically inspired aspiration for measuring deterministic performance optimization. Measures of response conceived under this latter imperative are, at best, only shadowy reflections of the actual phenomenological experience involved in real-world vehicle control. Whether we, as a research community, can resolve this issue remains uncertain. However, we believe we can mount a positive attack on what is arguably another equally important dimension of the collision problem.

- **Keywords:** Accidents, human error, cognition, consumer products, tools, displays and controls, human-computer interaction, computer systems

RESPONSE

David L. Strayer and Joel M. Cooper. *Driven to Distraction* . S. 1343-1347.

We address several themes that emerged in the commentaries related to our target article. First, we consider the relationship between cognitive distraction and crash risk. Second, we discuss the development of our cognitive distraction scale. Third, we weigh issues of self-regulation, appropriate baselines, and satisficing. Finally, we identify several areas where additional research is needed to refine our understanding of driver distraction and crash risk.

- **Keywords:** cognitive workload, cognitive distraction, driving, divided attention, multitasking
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AGING

Baekhee Lee, Mina Lee, Myeung Sook Yoh, Heecheon You, Hyunji Park, Kihyo Jung, Byung Hwa Lee, Duk L. Na, and Geon Ha Kim. *The Effects of Age, Gender, and Hand on Force Control Capabilities of Healthy Adults*. S. 1348-1358.

Objective: The present study examined the effects of age (20s to 70s), gender (male and female), and hand (dominant and nondominant) on force control capabilities (FCCs) in four force control phases (initiation, development, maintenance, and termination). **Background:** Normative data of FCCs by force control phase are needed for various populations in age and gender to identify a type of motor performance reduction and its severity. **Method:** FCCs of 360 participants (30 for each combination of age group and gender) were measured using a finger dynamometer and quantified in terms of initiation time (IT), development time (DT), maintenance error (ME), and termination time (TT). **Results:** Although gradual increases (1%~28%) by age were shown in IT, DT, and TT, a dramatic increase in ME was observed among participants in their 50s (26%), 60s (68%), and 70s (160%) compared to those in their 20s~40s. The most distinctive interaction effect of age and gender was found in ME out of the four FCC measures. Lastly, hand and its related interactions were not found significant. **Conclusion:** Normative FCC data were established for four age groups (20s~40s, 50s, 60s, and 70s) and gender. **Application:** The normative FCC data can be used for evaluating an individual's motor performance, screening patients with brain disorders, and designing input devices triggered and/or operated by the finger.

- **Keywords:** finger force, normative data, quantitative assessment

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Hongwei Hsiao, Jennifer Whitestone, Tsui-Ying Kau, and Brooke Hildreth. *Firefighter Hand Anthropometry and Structural Glove Sizing : A New Perspective*. S. 1359-1377.

Objective: We evaluated the current use and fit of structural firefighting gloves and developed an improved sizing scheme that better accommodates the U.S. firefighter population. **Background:** Among surveys, 24% to 30% of men and 31% to 62% of women reported experiencing problems with the fit or bulkiness of their structural firefighting gloves. **Method:** An age-, race/ethnicity-, and gender-stratified sample of 863 male and 88 female firefighters across the United States participated in the study. Fourteen hand dimensions relevant to glove design were measured. A cluster analysis of the hand dimensions was performed to explore options for an improved sizing scheme. **Results:** The current national standard structural firefighting glove-sizing scheme underrepresents firefighter hand size range and shape variation. In addition, mismatch between existing sizing specifications and hand characteristics, such as hand dimensions, user selection of glove size, and the existing glove sizing specifications, is significant. An improved glove-sizing plan based on clusters of overall hand size and hand/finger breadth-to-length contrast has been developed. **Conclusion:** This study presents the most up-to-date firefighter hand anthropometry and a new perspective on glove accommodation. The new seven-size system contains narrower variations (standard deviations) for almost all dimensions for each glove size than the current sizing practices. **Application:** The proposed science-based sizing plan for structural firefighting gloves

provides a step-forward perspective (i.e., including two women hand model-based sizes and two wide-palm sizes for men) for glove manufacturers to advance firefighter hand protection.

- **Keywords:** Finger, shape, sizing, cluster, fit

AUTOMATION, EXPERT SYSTEMS

Peter W. de Vries, Stéphanie M. van den Berg, and Cees Midden. *Assessing Technology in the Absence of Proof : Trust Based on the Interplay of Others' Opinions and the Interaction Process*. S. 1378-1402.

Objective: The present research addresses the question of how trust in systems is formed when unequivocal information about system accuracy and reliability is absent, and focuses on the interaction of indirect information (others' evaluations) and direct (experiential) information stemming from the interaction process. **Background:** Trust in decision-supporting technology, such as route planners, is important for satisfactory user interactions. Little is known, however, about trust formation in the absence of outcome feedback, that is, when users have not yet had opportunity to verify actual outcomes. **Method:** Three experiments manipulated others' evaluations ("endorsement cues") and various forms of experience-based information ("process feedback") in interactions with a route planner and measured resulting trust using rating scales and credits staked on the outcome. Subsequently, an overall analysis was conducted. **Results:** Study 1 showed that effectiveness of endorsement cues on trust is moderated by mere process feedback. In Study 2, consistent (i.e., nonrandom) process feedback overruled the effect of endorsement cues on trust, whereas inconsistent process feedback did not. Study 3 showed that although the effects of consistent and inconsistent process feedback largely remained regardless of face validity, high face validity in process feedback caused higher trust than those with low face validity. An overall analysis confirmed these findings. **Conclusion:** Experiential information impacts trust even if outcome feedback is not available, and, moreover, overrules indirect trust cues—depending on the nature of the former. **Application:** Designing systems so that they allow novice users to make inferences about their inner workings may foster initial trust.

- **Keywords:** system trust, process feedback, outcome feedback, consistency, face validity

COGNITION

G. Robert Arrabito, Geoffrey Ho, Behzad Aghaei, Catherine Burns, and Ming Hou. *Sustained Attention in Auditory and Visual Monitoring Tasks : Evaluation of the Administration of a Rest Break or Exogenous Vibrotactile Signals*. S. 1403-1416.

Objective: Performance and mental workload were observed for the administration of a rest break or exogenous vibrotactile signals in auditory and visual monitoring tasks. **Background:** Sustained attention is mentally demanding. Techniques are required to improve observer performance in vigilance tasks. **Method:** Participants ($N = 150$) monitored an auditory or a visual display for changes in signal duration in a 40-min watch. During the watch, participants were administered a rest break or exogenous vibrotactile signals. **Results:** Detection accuracy was significantly greater in the auditory than in the visual modality. A short rest break restored detection accuracy in both sensory modalities following deterioration in performance. Participants experienced significantly lower mental workload when monitoring auditory than visual signals, and a rest break significantly reduced mental workload in both sensory modalities. Exogenous vibrotactile signals had no beneficial effects on performance, or mental workload.

Conclusion: A rest break can restore performance in auditory and visual vigilance tasks. Although sensory differences in vigilance tasks have been studied, this study is the initial effort to investigate the effects of a rest break countermeasure in both auditory and visual vigilance tasks, and it is also the initial effort to explore the effects of the intervention of a rest break on the perceived mental workload of auditory and visual vigilance tasks. Further research is warranted to determine exact characteristics of effective exogenous vibrotactile signals in vigilance tasks. **Application:** Potential applications of this research include procedures for decreasing the temporal decline in observer performance and the high mental workload imposed by vigilance tasks.

- **Keywords:** Vigilance, performance efficiency, workload

Shayne Loft, Andreas Sadler, Janelle Braithwaite, and Samuel Huf. *The Chronic Detrimental Impact of Interruptions in a Simulated Submarine Track Management Task.* S. 1417-1426.

Objective: The objective of this article is to examine the extent to which interruptions negatively impact situation awareness and long-term performance in a submarine track management task where pre- and postinterruption display scenes remained essentially identical. **Background:** Interruptions in command and control task environments can degrade performance well beyond the first postinterruption action typically measured for sequential static tasks, because individuals need to recover their situation awareness for multiple unfolding display events. Participants in the current study returned to an unchanged display scene following interruption and therefore could be more immune to such long-term performance deficits. **Method:** The task required participants to monitor a display to detect contact heading changes and to make enemy engagement decisions. Situation awareness (Situation Present Assessment Method) and subjective workload (NASA-Task Load Index) were measured. The interruption replaced the display for 20 s with a blank screen, during which participants completed a classification task. **Results:** Situation awareness after returning from interruption was degraded. Participants were slower to make correct engagement decisions and slower and less accurate in detecting heading changes, despite these task decisions being made at least 40 s following the interruption. **Conclusion:** Interruptions negatively impacted situation awareness and long-term performance because participants needed to redetermine the location and spatial relationship between the displayed contacts when returning from interruption, either because their situation awareness for the preinterruption scene decayed or because they did not encode the preinterruption scene. **Application:** Interruption in work contexts such as submarines is unavoidable, and further understanding of how operators are affected is required to improve work design and training.

- **Keywords:** Interruption, situation awareness, submarine track management, Situation Awareness Present Method (SPAM), memory

Judi E. See. *Visual Inspection Reliability for Precision Manufactured Parts.* S. 1427-1442.

Objective: Sandia National Laboratories conducted an experiment for the National Nuclear Security Administration to determine the reliability of visual inspection of precision manufactured parts used in nuclear weapons. **Background:** Visual inspection has been extensively researched since the early 20th century; however, the reliability of visual inspection for nuclear weapons parts has not been addressed. In addition, the efficacy of using inspector confidence ratings to guide multiple inspections in an effort to improve overall performance accuracy is unknown. Further, the workload associated with inspection has not been documented, and newer measures of stress have not been applied. **Method:** Eighty-two inspectors in the U.S. Nuclear Security Enterprise inspected 140 parts for eight different defects. **Results:** Inspectors correctly rejected 85% of defective items and incorrectly rejected 35% of acceptable parts. Use of a phased

inspection approach based on inspector confidence ratings was not an effective or efficient technique to improve the overall accuracy of the process. Results did verify that inspection is a workload-intensive task, dominated by mental demand and effort. **Conclusion:** Hits for Nuclear Security Enterprise inspection were not vastly superior to the industry average of 80%, and they were achieved at the expense of a high scrap rate not typically observed during visual inspection tasks. **Application:** This study provides the first empirical data to address the reliability of visual inspection for precision manufactured parts used in nuclear weapons. Results enhance current understanding of the process of visual inspection and can be applied to improve reliability for precision manufactured parts.

- **Keywords:** visual inspection, mental workload, stress, signal detection theory, reliability issues, human error analysis

COMMUNICATION

Maranda McBride, Phuong Tran, Kimberly A. Pollard, Tomasz Letowski, and Garnett P. McMillan. *Effects of Bone Vibrator Position on Auditory Spatial Perception Tasks*. S. 1443-1458.

Objective: This study assessed listeners' ability to localize spatially differentiated virtual audio signals delivered by bone conduction (BC) vibrators and circumaural air conduction (AC) headphones. **Background:** Although the skull offers little intracranial sound wave attenuation, previous studies have demonstrated listeners' ability to localize auditory signals delivered by a pair of BC vibrators coupled to the mandibular condyle bones. The current study extended this research to other BC vibrator locations on the skull. **Method:** Each participant listened to virtual audio signals originating from 16 different horizontal locations using circumaural headphones or BC vibrators placed in front of, above, or behind the listener's ears. The listener's task was to indicate the signal's perceived direction of origin. **Results:** Localization accuracy with the BC front and BC top positions was comparable to that with the headphones, but responses for the BC back position were less accurate than both the headphones and BC front position. **Conclusion:** This study supports the conclusion of previous studies that listeners can localize virtual 3D signals equally well using AC and BC transducers. Based on these results, it is apparent that BC devices could be substituted for AC headphones with little to no localization performance degradation. **Application:** BC headphones can be used when spatial auditory information needs to be delivered without occluding the ears. Although vibrator placement in front of the ears appears optimal from the localization standpoint, the top or back position may be acceptable from an operational standpoint or if the BC system is integrated into headgear.

- **Keywords:** auditory perception, azimuth, bone conduction, localization, 3D

HEALTH CARE/HEALTH SYSTEMS

X. Jessie Yang, Christopher D. Wickens, Tazoon Park, Liesel Fong, and Kewin T. H. Siah. *Effects of Information Access Cost and Accountability on Medical Residents' Information Retrieval Strategy and Performance During Prehandover Preparation : Evidence From Interview and Simulation Study*. S. 1459-1471.

Objective: We aimed to examine the effects of information access cost and accountability on medical residents' information retrieval strategy and performance during prehandover preparation. **Background:** Prior studies observing doctors' prehandover practices witnessed the use of memory-intensive strategies when retrieving patient information. These strategies impose potential threats to patient safety as human

memory is prone to errors. Of interest in this work are the underlying determinants of information retrieval strategy and the potential impacts on medical residents' information preparation performance. **Method:** A two-step research approach was adopted, consisting of semistructured interviews with 21 medical residents and a simulation-based experiment with 32 medical residents. **Results:** The semistructured interviews revealed that a substantial portion of medical residents (38%) relied largely on memory for preparing handover information. The simulation-based experiment showed that higher information access cost reduced information access attempts and access duration on patient documents and harmed information preparation performance. Higher accountability led to marginally longer access to patient documents. **Conclusion:** It is important to understand the underlying determinants of medical residents' information retrieval strategy and performance during prehandover preparation. We noted the criticality of easy access to patient documents in prehandover preparation. In addition, accountability marginally influenced medical residents' information retrieval strategy. **Application:** Findings from this research suggested that the cost of accessing information sources should be minimized in developing handover preparation tools.

- **Keywords:** clinical handover preparation, information access cost, accountability, overconfidence, information retrieval

SURFACE TRANSPORTATION

David M. Neyens, Linda Ng Boyle, and Maria T. Schultheis. *The Effects of Driver Distraction for Individuals With Traumatic Brain Injuries*. S. 1472-1488.

Objective: The aim of this study was to evaluate the effects of secondary tasks on the driving performance of individuals with mild traumatic brain injuries (TBIs). **Background:** Studies suggest detrimental impacts of driving with TBI or while distracted but the impact of driver distraction on TBI drivers is not well documented. **Method:** Bayesian regression models were used to estimate the effect of relatively simple secondary tasks on driving performance of TBI and healthy control (HC) drivers. A driving simulator was used to develop prior distribution of task effects on driving performance for HCs. An on-road study was conducted with TBI and HC drivers to generate effect estimates for the posterior distributions. The Bayesian models were also compared to frequentist models. **Results:** During a coin-sorting task, all drivers exhibited larger maximum lateral acceleration and larger standard deviation of speed than in a baseline driving segment. There were no significant driving performance differences between the TBI and the HC drivers during the tasks. Across all tasks, TBI drivers spent more time looking at the tasks and made more frequent glances toward the tasks. **Conclusions:** The findings show that even drivers with mild TBI have significantly longer and more glances toward the tasks compared to the HCs. **Application:** This study demonstrates a Bayesian approach and how the results differ from frequentist statistics. Using prior distributions in a Bayesian model helps account for the probabilities associated with otherwise unknown parameters. This method strengthens the Bayesian parameter estimates compared to that of a frequentist model.

- **Keywords:** Bayesian analysis, TBIs, driver distraction, driving performance, instrumented vehicle study