Human Factors – rok 2016, roč. 58

Číslo 4 (June)

AT THE FOREFRONT OF HF/E

Thomas B. Sheridan. *Human–Robot Interaction: Status and Challenges*. Pages 525-532.

Objective: The current status of human–robot interaction (HRI) is reviewed, and key current research challenges for the human factors community are described. **Background:** Robots have evolved from continuous human-controlled master–slave servomechanisms for handling nuclear waste to a broad range of robots incorporating artificial intelligence for many applications and under human supervisory control. **Methods:** This mini-review describes HRI developments in four application areas and what are the challenges for human factors research. **Results:** In addition to a plethora of research papers, evidence of success is manifest in live demonstrations of robot capability under various forms of human control. **Conclusions:** HRI is a rapidly evolving field. Specialized robots under human teleoperation have proven successful in hazardous environments and medical application, as have specialized telerobots under human supervisory control for space and repetitive industrial tasks. Research in areas of self-driving cars, intimate collaboration with humans in manipulation tasks, human control of humanoid robots for hazardous environments, and social interaction with robots is at initial stages. The efficacy of humanoid general-purpose robots has yet to be proven. **Applications:** HRI is now applied in almost all robot tasks, including manufacturing, space, aviation, undersea, surgery, rehabilitation, agriculture, education, package fetch and delivery, policing, and military operations.

- **Keywords:** robot, human interaction, supervisory control, research needs, teleoperator, telerobot

AVIATION AND AEROSPACE

Andreas Haslbeck and Hans-Juergen Hoermann. *Flying the Needles: Flight Deck Automation Erodes Fine-Motor Flying Skills Among Airline Pilots*. Pages 533-545.

Objective: The aim of this study was to evaluate the influence of practice and training on fine-motor flying skills during a manual instrument landing system (ILS) approach.

Background: There is an ongoing debate that manual flying skills of long-haul crews suffer from a lack of flight practice due to conducting only a few flights per month and the intensive use of automation. However, objective evidence is rare. **Method:** One hundred twenty-six randomly selected airline pilots had to perform a manual flight scenario with a raw data precision approach. Pilots were assigned to four equal groups according to their level of practice and training by fleet (short-haul, long-haul) and rank (first officer, captain). **Results:** Average ILS deviation scores differed significantly in relation to the group assignments. The strongest predictor variable was fleet, indicating degraded performance among long-haul pilots. **Conclusion:** Manual flying skills are subject to erosion due to a lack of practice on long-haul fleets: All results support the conclusion that recent flight practice is a significantly stronger predictor for fine-motor flying performance than the time period since flight school or even the total or type-specific flight experience. **Application:** Long-haul crews have to be supported in a timely manner by adequate training tailored to address manual skills or by operational provisions like mixed-fleet flying or more frequent transitions between short-haul and long-haul operation.

- **Keywords:** skilled performance, automation, perceptual-motor performance, manual controls, information processing

John G. Grundy, Stefan Nazar, Shannon O'Malley, Martin v. Mohrenshildt, and Judith M. Shedden. *The Effectiveness of Simulator Motion in the Transfer of Performance on a Tracking Task Is Influenced by Vision and Motion Disturbance Cues*. Pages 546-559.

Objective: To examine the importance of platform motion to the transfer of performance in motion simulators. **Background:** The importance of platform motion in simulators for pilot training is strongly debated. We hypothesized that the type of motion (e.g., disturbance) contributes significantly to performance differences. **Methods:** Participants used a joystick to perform a target tracking task in a pod on top of a MOOG Stewart motion platform. Five conditions compared training without motion, with correlated motion, with disturbance motion, with disturbance motion isolated to the visual display, and with both correlated and disturbance motion. The test condition involved the full motion model with both correlated and disturbance motion. We analyzed speed and accuracy across training and test as well as strategic differences in joystick control. **Results:** Training with disturbance cues produced critical behavioral differences compared to training without disturbance; motion itself was less important. **Conclusion:** Incorporation of disturbance cues is a potentially important source of variance between studies that do or do not show a benefit of motion platforms in the transfer of performance in simulators. **Application:** Potential applications of this research include the assessment of the importance of motion platforms in flight simulators, with a focus on the efficacy of incorporating disturbance cues during training.

- **Keywords:** self-motion, learning, transfer of training, practice, attention

Sifra Christina Corver, Dana Unger, and Gudela Grote. *Predicting Air Traffic Controller Workload: Trajectory Uncertainty as the Moderator of the Indirect Effect of Traffic Density on Controller Workload Through Traffic Conflict*. Pages 560-573.

Objective: Our study investigates whether trajectory uncertainty moderates the relationship between traffic conflict and workload. Furthermore, we examine if the indirect effect of traffic density on workload through traffic conflict is conditional on the presence of trajectory uncertainty.

Background: Although it is widely accepted that uncertainty related to the future trajectory of an aircraft impacts air traffic controller decision making, little is known about how the presence of trajectory uncertainty impacts controller workload. A better understanding of the impact on controller workload can improve workload prediction models for en route air traffic control.

Method: We collected data in a live operation environment, including workload ratings based on over-the-shoulder observations and real-time sector data. Hierarchical linear modeling was used to analyze the data.

Results: Trajectory uncertainty interacts with traffic conflict in such a way that the positive relationship between traffic conflict and workload is strongest in the presence of trajectory uncertainty. Furthermore, we found that the mediating effect of traffic density through traffic conflict is conditional on the presence of trajectory uncertainty.

Conclusion: Our results indicate that workload prediction tools that do not incorporate trajectory uncertainty may underestimate workload under conditions of trajectory uncertainty, leading to possible overload situations of air traffic controllers.

Application: Sources that generate trajectory uncertainty, as well as their interaction effects with dynamic complexity metrics, should be acknowledged in workload prediction models to increase the predictive power of these models. Implications for future air traffic management operations as envisioned by SESAR and NextGen are discussed.

- **Keywords:** traffic conflict, traffic density, trajectory uncertainty, workload, en route air traffic control

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Michael Y. Lin, Paul Catalano, and Jack T. Dennerlein. *A Psychophysical Protocol to Develop Ergonomic Recommendations for Sitting and Standing Workstations*. Pages 574-585.

Objective: The aim of this study was to determine user self-selected setup for both sitting and standing computer workstations and identify major differences. **Background:** No current ergonomic setup guideline for standing computer workstations is available. **Methods:** Twenty adult participants completed four 45-min sessions of simulated office computer work with an adjustable sit-stand computer workstation. Placement and relative position of all workstation components, including a cordless mouse, a cordless keyboard, a height-adjustable desk, and a 22-inch monitor mounted on a mechanical-assisted arm were recorded during the four sessions, which alternated between sitting and standing for each session. Participants were interrupted four times within each session, and the workstation was "reset" to extreme locations. Participants were instructed to adjust the location to achieve the most comfortable arrangement and to make as many adjustments during the session to achieve this goal. **Results:** Overall, users placed the keyboard closer to their body (sternum), set desk height lower than their elbow, and set the monitor lower relative to their eyes with a greater upward tilt while standing compared to sitting. During the 45-min sessions, the number of adjustments participants made became smaller and over the four sessions was consistent, suggesting the psychophysical protocol was effective and consistent. **Conclusion:** Users preferred different workstation setups for sitting and standing computer workstations. Therefore, future setup guidelines and principles for standing computer workstations may not be simply translated from those for sitting. **Application:** These results can serve as the first step toward making recommendations to establish ergonomic guidelines for standing computer workstation arrangement.

- **Keywords:** psychophysical protocol, computer, workstation design, keyboard, mouse

Chelsea R. Snow and Diane E. Gregory. *Perceived Risk of Low-Back Injury Among Four Occupations*. Pages 586-594.

Objective: This study aimed to assess the perception of risk of low-back injury of individuals from four groups: office/administrative employees, dental workers (dentists/dental hygienists), firefighters, and undergraduate students. **Background:** The concept of worker's perception of injury risk has been used to set safe material-handling limits and to determine compliance with health and safety regulations but has not been used to identify perceptual differences among occupations or potential deficiencies in risk awareness. **Method:** Participants (N = 232) were presented with eight images of different low-back postures/tasks and were required to rate their perceived magnitude of low-back risk on a scale from 0 (*no risk*) to 10 (*extreme risk*). **Results:** Office/administrative and dental workers rated postures higher than firefighters and students. Individuals from all groups perceived kyphotic postures as having a higher low-back risk than lordotic postures. Further, office and dental workers, compared to firefighters and students, perceived sitting postures to have a relatively higher level of risk, likely due to these postures being typically adopted by these individuals at work. No relationship between previous low-back pain and risk rating was observed in this study. **Conclusion:** Low-back injury risk perception varies between occupations/groups and may be a result of different exposures. **Application:** The results of this study can potentially be used to implement occupation-specific training programs to ensure that the scientific research regarding low-back injuries is being properly conveyed to employees across all sectors.

- **Keywords:** risk assessment, low-back injury, ergonomics, posture, health and safety programs

COMMUNICATION

Abhizna Butchibabu, Christopher Sparano-Huiban, Liz Sonenberg, and Julie Shah. Implicit *Coordination Strategies for Effective Team Communication*. Pages 596-610.

Objective We investigated implicit communication strategies for anticipatory information sharing during team performance of tasks with varying degrees of complexity. We compared the strategies used by teams with the highest level of performance to those used by the lowest-performing teams to evaluate the frequency and methods of communications used as a function of task structure. **Background** High-performing teams share information by anticipating the needs of their teammates rather than explicitly requesting the exchange of information. As the complexity of a task increases to involve more interdependence among teammates, the impact of coordination on team performance also increases. This observation motivated us to conduct a study of anticipatory information sharing as a function of task complexity. **Method** We conducted an experiment in which 13 teams of four people performed collaborative search-and-deliver tasks with varying degrees of complexity in a simulation environment. We elaborated upon prior characterizations of communication as implicit versus explicit by dividing implicit communication into two subtypes: (a) deliberative/goal information and (b) reactive status updates. We then characterized relationships between task structure, implicit communication, and team performance. **Results** We found that the five teams with the fastest task completion times and lowest idle times exhibited higher rates of deliberative communication versus reactive communication during high-complexity tasks compared with the five teams with the slowest completion times and longest idle times (p = .039). **Conclusion** Teams in which members proactively communicated information about their next goal to teammates exhibited improved team performance. **Application**

The findings from our work can inform the design of communication strategies for team training to improve performance of complex tasks.

- **Keywords:** team collaboration, communication analysis, task complexity, implicit communication, deliberative communication

HUMAN-COMPUTER INTERACTION, COMPUTER SYSTEMS

Sven Schmutz, Andreas Sonderegger, and Juergen Sauer. *Implementing Recommendations From Web Accessibility Guidelines: Would They Also Provide Benefits to Nondisabled Users*. Pages 611-629.

Objective: We examined the consequences of implementing Web accessibility guidelines for nondisabled users. **Background:** Although there are Web accessibility guidelines for people with disabilities available, they are rarely used in practice, partly due to the fact that practitioners believe that such guidelines provide no benefits, or even have negative consequences, for nondisabled people, who represent the main user group of Web sites. Despite these concerns, there is a lack of empirical research on the effects of current Web accessibility guidelines on nondisabled users. **Method:** Sixty-one nondisabled participants used one of three Web sites differing in levels of accessibility (high, low, and very low). Accessibility levels were determined by following established Web accessibility guidelines (WCAG 2.0). A broad methodological approach was used, including performance measures (e.g., task completion time) and user ratings (e.g., perceived usability). **Results:** A high level of Web accessibility led to better performance (i.e., task completion time and task completion rate) than low or very low accessibility. Likewise, high Web accessibility improved user ratings (i.e., perceived usability, aesthetics, workload, and trustworthiness) compared to low or very low Web accessibility. There was no difference between the very low and low Web accessibility conditions for any of the outcome measures. **Conclusion:** Contrary to some concerns in the literature and among practitioners, high conformance with Web accessibility guidelines may provide benefits to users without disabilities. **Application:** The findings may encourage more practitioners to implement WCAG 2.0 for the benefit of users with disabilities and nondisabled users.

- **Keywords:** web accessibility, nondisabled users, WCAG 2.0, performance, usability

SURFACE TRANSPORTATION

John G. Gaspar, Nathan Ward, Mark B. Neider, James Crowell, Ronald Carbonari, Henry Kaczmarski, Ryan V. Ringer, Aaron P. Johnson, Arthur F. Kramer, and Lester C. Loschky. *Measuring the Useful Field of View During Simulated Driving With Gaze-Contingent Displays*. Pages 630-641.

Objective: We aimed to develop and test a new dynamic measure of transient changes to the useful field of view (UFOV), utilizing a gaze-contingent paradigm for use in realistic simulated environments. **Background:** The UFOV, the area from which an observer can extract visual information during a single fixation, has been correlated with driving performance and crash risk. However, some existing measures of the UFOV cannot be used dynamically in realistic simulators, and other UFOV measures involve constant stimuli at fixed locations. We propose a gaze-contingent UFOV measure (the GC-UFOV) that solves the above problems. **Methods:** Twenty-five participants completed four simulated drives while they concurrently performed an occasional gaze-contingent Gabor orientation discrimination task. Gabors appeared randomly at one of three retinal eccentricities (5°, 10°, or 15°). Cognitive workload was manipulated both with a concurrent auditory working memory task and with driving task difficulty (via

presence/absence of lateral wind). **Results:** Cognitive workload had a detrimental effect on Gabor discrimination accuracy at all three retinal eccentricities. Interestingly, this accuracy cost was equivalent across eccentricities, consistent with previous findings of "general interference" rather than "tunnel vision." **Conclusion:** The results showed that the GC-UFOV method was able to measure transient changes in UFOV due to cognitive load in a realistic simulated environment. **Application:** The GC-UFOV paradigm developed and tested in this study is a novel and effective tool for studying transient changes in the UFOV due to cognitive load in the context of complex real-world tasks such as simulated driving.

- **Keywords:** useful field of view (UFOV), driver distraction, gaze-contingent displays

Christian Gold, Moritz Körber, David Lechner, and Klaus Bengler. *Taking Over Control From Highly Automated Vehicles in Complex Traffic Situations: The Role of Traffic Density*. Pages 642-652.

Objective: The aim of this study was to quantify the impact of traffic density and verbal tasks on takeover performance in highly automated driving. **Background:** In highly automated vehicles, the driver has to occasionally take over vehicle control when approaching system limits. To ensure safety, the ability of the driver to regain control of the driving task under various driving situations and different driver states needs to be quantified. **Methods:** Seventy-two participants experienced takeover situations requiring an evasive maneuver on a three-lane highway with varying traffic density (zero, 10, and 20 vehicles per kilometer). In a between-subjects design, half of the participants were engaged in a verbal 20-Questions Task, representing speaking on the phone while driving in a highly automated vehicle. **Results:** The presence of traffic in takeover situations led to longer takeover times and worse takeover quality in the form of shorter time to collision and more collisions. The 20-Questions Task did not influence takeover time but seemed to have minor effects on the takeover quality. **Conclusions:** For the design and evaluation of human–machine interaction in takeover situations of highly automated vehicles, the traffic state seems to play a major role, compared to the driver state, manipulated by the 20-Questions Task. **Application:** The present results can be used by developers of highly automated systems to appropriately design human–machine interfaces and to assess the driver's time budget for regaining control.

- **Keywords:** vehicle automation, autonomous driving, driver behavior, human–automation interaction, mental workload, phoning while driving