

Human Factors – rok 2021, roč. 63

Číslo 3 (May)



AT THE FOREFRONT OF HF/E

Daniel G. Morrow, H. Chad Lane, Wendy A. Rogers. *A Framework for Design of Conversational Agents to Support Health Self-Care for Older Adults*. pp. 369–378.

Objective: We examined the potential of conversational agents (CAs) to support older adults' self-care related to chronic illness in light of lessons learned from decades of pedagogical agent research, which investigates the impact and efficacy of CAs for a wide range of learners. **Background:** The role of CAs in education (i.e., pedagogical agents) has been long studied, but their potential for supporting self-care has received less attention, especially for older adults. **Methods:** We reviewed work on pedagogical agents and considered how it informs the design of CAs for older adults. We propose a framework for designing CAs to support older adult self-care, which organizes a review of work in this area and integration with the pedagogical agent literature. **Results:** Our review of the pedagogical agent literature revealed an evolution from teaching machines to interactive, social systems that influence student motivational as well as learning outcomes. To integrate this review with work on CAs and self-care, we developed a framework that specifies how self-care goals evolve with stages of an illness, communication goals that support self-care at each stage, patient needs, and requirements for CAs to support these needs. The review identified an agenda for future research on CA functions and features that help older adults accept need for self-care, establish self-care, and sustain self-care over time. **Conclusions:** Integrating insights from the pedagogical agent literature with research on developing CAs for self-care defines an agenda for developing and evaluating CAs to help older adults manage illness.

- **Keywords:** conversational agents, pedagogical agents, learning, motivation, aging, self-care

AUTOMATION, EXPERT SYSTEMS

Gyrd Skraaning, Greg A. Jamieson. *Human Performance Benefits of The Automation Transparency Design Principle: Validation and Variation*. pp. 379–401.

Objective: Test the automation transparency design principle using a full-scope nuclear power plant simulator. **Background:** Automation transparency is a long-held human factors design principle espousing that the responsibilities, capabilities, goals, activities, and/or effects of automation should be directly observable in the human–system interface. The anticipated benefits of transparency include more effective reliance, more appropriate trust, better understanding, and greater user satisfaction. Transparency has enjoyed a recent upsurge in use in the context of human interaction with agent-oriented automation. **Method:** Three full-scope nuclear power plant simulator studies were conducted with licensed operating crews. In the first two experiments, transparency was implemented for interlocks, controllers, limitations, protections, and automatic programs that operate at the local component level of the plant. In the third experiment, procedure automation assumed control of plant operations and was represented in dedicated agent displays. **Results:** Results from Experiments 1 and 2 appear to validate the human performance benefits of automation transparency for automation at the component level. However, Experiment 3 failed to replicate these findings for automation that assumed control for executing procedural actions. **Conclusion:** Automation transparency appears to yield expected benefits for component-level automation, but caution is warranted in generalizing the design principle to agent-oriented automation. **Application:** The automation transparency design principle may offer a powerful means of compensating for the detrimental impacts of hidden automation influence at the component level of complex systems. However, system developers should exercise caution in assuming that the principle extends to agent-oriented automation.

- **Keywords:** automation, human–automation interaction, function allocation, supervisory control, trust in automation, display design principles, supervisory displays

COGNITION

Daniel Sturman, Mark W. Wiggins. [*Drivers' Cue Utilization Predicts Cognitive Resource Consumption During a Simulated Driving Scenario*](#). pp. 402–414.

Objective: This study was designed to examine whether cue utilization differentiates drivers' consumption of cognitive resources during a simulated driving task. **Background:** Outcomes from previous research have demonstrated that a general capacity for cue utilization differentiates cognitive load during novel process control tasks. However, it was previously unclear whether similar results would be demonstrated during familiar operational tasks. **Method:** Based on an assessment of cue utilization within a driving context, participants were classified into higher or lower cue utilization typologies. During a simulated driving task, cognitive load was assessed through changes against baseline in cerebral oxygenation in the prefrontal cortex, through eye behavior metrics (fixation rates and fixation dispersion), and through driving performance (frequency of missed traffic signals and speed exceedances). **Results:** Drivers with higher cue utilization recorded smaller mean fixation dispersions, smaller increases in cerebral oxygenation, and fewer missed traffic signals compared with drivers with lower cue utilization. These results suggest that compared with drivers with lower cue utilization, drivers with higher cue utilization experienced lower cognitive load during the

simulated driving task while maintaining a higher level of performance. **Conclusion:** The results provide support for the assertion that, among qualified operators, a greater capacity for cue utilization is associated with lower cognitive load during operational tasks. **Application:** Cue-based assessments of driving may be beneficial in predicting performance and assisting in targeted training for recently qualified and/or older drivers.

- **Keywords:** attentional processes, cue utilization, driver behavior, eye movements, mental workload, near-infrared spectroscopy (NIRS)

Christoph Bernhard, Heiko Hecht. *The Ups and Downs of Camera-Monitor Systems: The Effect of Camera Position on Rearward Distance Perception.* pp. 415–432.

Objective: This study investigates the effects of different positions of side-mounted rear-view cameras on distance estimation of drivers. **Background:** Camera-monitor systems bring advantages as compared to conventional rear-view mirrors, such as improved aerodynamics and enlarged field-of-view. Applied research has mainly focused on the comparison between cameras and mirrors or on positioning of in-vehicle monitors. However, the positioning of the exterior camera awaits investigation given that the perspective of the observer at does affect depth perception at large. **Method:** In two experiments, a total of 50 students estimated metric distances to static vehicles presented in realistic or 3D-rendered pictures. The pictures depicted the rearward scene of a car following the driver as viewed through a camera at varying vertical and horizontal positions. The following vehicle's size and environmental information varied among conditions and experiments. **Results:** Lower camera positions led to distance overestimation and higher positions to underestimation. The effect increased as the distance to the following vehicle decreased. Moreover, larger vehicles led to stronger distance underestimation, especially in low camera positions. Interestingly, the main effect of camera position disappeared when the ego-vehicles' back was visible. **Conclusion:** Different rearward viewpoints affect distance estimation of drivers, especially in close distances. However, a visible reference of one's own vehicle seems to mostly compensate this effect. **Application:** In general, the rear-view camera should be mounted rather higher and to the front of the vehicle. Also, the vehicle's back should always be visible. Low camera positions are not recommended.

- **Keywords:** camera-monitor systems, perspective, camera placement, distance estimation, design recommendations

CONSUMER PRODUCTS, TOOLS

Kaitlin M. Gallagher, Laura Cameron, Diana De Carvalho, Madison Boulé. *Does Using Multiple Computer Monitors for Office Tasks Affect User Experience?: A Systematic Review.* pp. 433–449.

Objective: To compare the impact of multiple computer monitor configurations on health and performance outcomes compared to the use of a single monitor. **Background:** Multiple monitor configurations are used in office settings to promote increased productivity by providing more screen space; however, it is unknown if there are health-related trade-offs to increased productivity. **Method:** A systematic review was conducted according to the PRISMA statement guidelines and adapted the best evidence synthesis. **Results:** Eighteen studies were included in our review. There was strong evidence that implementing dual monitors is in line with users' preference. There was also moderate evidence for controlled laboratory studies demonstrating that multiple monitors may increase task efficiency with decreased desktop interaction; however, implementing multiple monitors may also result in nonneutral neck postures for users. **Conclusion:**

More research needs to be conducted on biomechanical exposures when using larger displays. Longitudinal field studies should be conducted to determine the influence of monitor interventions on health, productivity, and well-being. All studies must consider task complexity and user positioning and should measure health and productivity outcomes together. Researchers must also consider up-to-date purchasing trends when choosing the monitor configurations and sizes for their studies. **Application:** Regulatory bodies and practitioners can use the results to develop evidence-based monitor guidelines and inform decision-making in practice, respectively. Researchers can use this information to design future studies on monitor configurations that incorporate current purchasing trends.

- **Keywords:** visual display terminal, dual monitor, ergonomics, human–computer interaction, performance

HEALTH CARE/HEALTH SYSTEMS

Laura H. Barg-Walkow, Rickey P. Thomas, Christopher D. Wickens, Wendy A. Rogers. *Modeling Task Scheduling Decisions of Emergency Department Physicians*. pp. 450–461.

Objective: This study evaluated task-scheduling decisions in the context of emergency departments by comparing patterns of emergency physicians' task-scheduling models across levels of experience. **Background:** Task attributes (priority, difficulty, salience, and engagement) influence task-scheduling decisions. However, it is unclear how attributes interact to affect decisions, especially in complex contexts. An existing model of task scheduling, strategic task overload management-no priority (STOM-NP), found that an equal weighting of attributes can predict task-scheduling behavior. Alternatively, mathematical modeling estimated that priority alone could make similar predictions as STOM-NP in a parsimonious manner. Experience level may also influence scheduling decisions. **Method:** An experimental design methodology shortened a judgment analysis approach to compare a priori task-scheduling decision strategies. Emergency physicians with two levels of experience rank-ordered 10 sets of 3 tasks varying on 4 task attributes in this complex environment. **Results:** Bayesian statistics were used to identify best-fit decision strategies. STOM-NP and priority-only provided the best model fits. STOM-NP fit the lower-experienced physicians best, whereas priority-only—using only one cue—fit the higher-experienced physicians best. **Conclusion:** Models of decision strategies for task-scheduling decisions were extended to complex environments. Experts' level of experience influenced task-scheduling decisions, where the scheduling decisions of more-experienced experts was consistent with a more frugal decision process. Findings have implications for training and evaluation. **Application:** We assessed models of cues that influence task-scheduling decisions, including a parsimonious model for task priority only. We provided a sample approach for shortening methods for understanding decisions.

- **Keywords:** decision-making, mathematical modeling, expert–novice differences, skilled performance, emergency medicine and resuscitation

MACROERGONOMICS AND THE ENVIRONMENT

Panagiotis Matsangas, Nita Lewis Shattuck. *Habitability in Berthing Compartments and Well-Being of Sailors Working on U.S. Navy Surface Ships*. pp. 462–473.

Objective: The study had two objectives: (a) to assess the prevalence of sleep-related habitability concerns in the berthing compartments of U.S. Navy surface ships and (b) to assess whether habitability issues in berthing compartments affected the sleep and well-being of crew members. **Background:** The importance of habitability for human well-being is recognized. Little is known, however, about the association between habitability factors in the sleeping/berthing compartments and sailor well-being in operational conditions. **Method:** Fit-for-duty sailors (N = 1,269; from six ships) participated in this naturalistic and longitudinal study. Sailors reported habitability factors affecting their sleep and completed four standardized questionnaires to assess daytime sleepiness, insomnia, sleep quality, and mood. Sleep was assessed through wrist-worn actigraphy and activity logs. **Results:** Noise, ambient temperature, poor bedding conditions, and ambient light were the most frequently reported factors of concern. Compared to their peers with fewer complaints, sailors with more habitability-related complaints were more likely to have elevated daytime sleepiness (by 23%) and to report insomnia symptoms (145%) and lower sleep quality (21%). Sailors who reported more habitability-related issues also tended to sleep longer. Individuals with more complaints about habitability also tended to report worse mood (total mood disturbance, tension/anxiety, depression, fatigue, and confusion/bewilderment). **Conclusion:** Habitability-related complaints are associated with sailor well-being and sleep. Future studies should expound on the various detrimental factors that degrade conditions in berthing compartments and negatively impact crew well-being. **Application:** Habitability in berthing compartments of surface ships is associated with sailors' daytime sleepiness, insomnia severity, mood, and sleep attributes. Ship designers should take these findings into consideration and investigate viable and cost-effective methods to mitigate the problems we identified.

- **Keywords:** naval ships, habitability, sleep, insomnia, mood, sleep disruptions, noise, temperature, light

SURFACE TRANSPORTATION

Giorgia Chinazzo, Kynthia Chamilothoni, Jan Wienold, Marilyne Andersen.
***Temperature–Color Interaction: Subjective Indoor Environmental Perception and Physiological Responses in Virtual Reality.* pp. 474–502.**

Objective: Temperature–color interaction effects on subjective perception and physiological responses are investigated using a novel hybrid experimental method combining thermal and visual stimuli from real and virtual reality (VR) environments, respectively. **Background:** Despite potential building design applications, studies combining temperature with daylight transmitted through colored glazing are limited due to hard-to-control light conditions. VR is identified as a promising experimental tool for such investigations that overcomes the limitations of experiments using daylight. **Method:** Fifty-seven people participated in an experiment combining three colored glazing (orange/blue/neutral) and two temperatures (24°C/29°C). Exposed to one color–temperature combination, participants evaluated their thermal, visual, and overall perception, whereas their physiological responses (heart rate, skin conductance, and skin temperature) were continuously measured. **Results:** Daylight color significantly affected thermal perception, whereas no significant effects of temperature on visual perception were found. Acceptability of the workspace was affected by both color and temperature. Cross-modal effects from either daylight color or temperature levels on physiological responses were not observed. **Conclusion:** In the VR setting, the orange daylight led to warmer thermal perception in (close-to-) comfortable temperatures, resulting in a color-induced thermal perception and indicating that orange glazing should be used with caution in a slightly warm environment. **Application:** Findings can be applied to the design of buildings using new glazing technologies with saturated colors, such as

transparent photovoltaics. Despite some limitations, the hybrid environment is suggested as a promising experimental tool for future studies on indoor factor interactions.

- **Keywords:** virtual reality, interactions, combined effects, visual comfort, thermal comfort, daylight, physiology, perception, experimental method, built environment

SENSORY AND PERCEPTUAL PROCESSES

Birsen Donmez, Maryam Merrikhpour, Mehdi Hoseinzadeh Nooshabadi. *Mitigating Teen Driver Distraction: In-Vehicle Feedback Based on Peer Social Norms.* pp. 503–518.

Objective: To investigate the efficacy of in-vehicle feedback based on peer social norms in mitigating teen driver distraction. **Background:** Distraction is a significant problem among teen drivers. Research into the use of in-vehicle technologies to mitigate this issue has been limited. In particular, there is a need to study whether social norms interventions provided through in-vehicle feedback can be effective. Peers are important social referents for teens; thus, normative intervention based on this group is promising. Socially proximal referents have a greater influence on behavior; thus, tailoring peer norm feedback based on gender may provide additional benefits. **Method:** In this study, 57 teens completed a driving simulator experiment while performing a secondary task in three between-subject conditions: (a) postdrive feedback incorporating same-gender peer norms, (b) postdrive feedback incorporating opposite-gender peer norms, and (c) no feedback. Feedback involved information based on descriptive norms (what others do). **Results:** Teens' self-reported frequency of distraction engagement was positively correlated with their perceptions of their peers' engagement in and approval of distractions. Feedback based on peer norms was effective in reducing distraction engagement and improving driving performance, with no difference between same- and opposite-gender feedback. **Conclusion/Application:** Feedback based on peer norms can help mitigate driver distraction among teens. Tailoring social norms feedback to teen gender appears to not provide any additional benefits. Longer-term effectiveness in real-world settings should be investigated.

- **Keywords:** teenage driver distraction, normative feedback, gender, in-vehicle information systems, driving simulator

Azadeh DinparastDjadid, John D. Lee, Joshua Domeyer, Chris Schwarz, Timothy L. Brown, Pujitha Gunaratne. *Designing for the Extremes: Modeling Drivers' Response Time to Take Back Control From Automation Using Bayesian Quantile Regression.* pp. 519–530.

Objective: Understanding the factors that affect drivers' response time in takeover from automation can help guide the design of vehicle systems to aid drivers. Higher quantiles of the response time distribution might indicate a higher risk of an unsuccessful takeover. Therefore, assessments of these systems should consider upper quantiles rather than focusing on the central tendency. **Background:** Drivers' responses to takeover requests can be assessed using the time it takes the driver to take over control. However, all the takeover timing studies that we could find focused on the mean response time. **Method:** A study using an advanced driving simulator evaluated the effect of takeover request timing, event type at the onset of a takeover, and visual demand on drivers' response time. A mixed effects model was fit to the data using Bayesian quantile regression. **Results:** Takeover request timing, event type that precipitated the takeover, and the visual demand all affect driver response time. These factors affected the 85th percentile

differently than the median. This was most evident in the revealed stopped vehicle event and conditions with a longer time budget and scenes with lower visual demand. **Conclusion:** Because the factors affect the quantiles of the distribution differently, a focus on the mean response can misrepresent actual system performance. The 85th percentile is an important performance metric because it reveals factors that contribute to delayed responses and potentially dangerous outcomes, and it also indicates how well the system accommodates differences between drivers.

- **Keywords:** automated vehicles, takeover time, quantile regression, Bayesian methods, driver behavior

TRAINING, EDUCATION, INSTRUCTIONAL SYSTEMS

Gavan Lintern, Walter R. Boot. *Cognitive Training: Transfer Beyond the Laboratory?* pp. 531–547.

Objective: To assess the evidence of general transfer from training on abstract computer-based exercises and video games to driving and flight control. **Background:** Many believe that training on abstract computer-based exercises and video games enhances cognitive capacities to the benefit of performance in operational contexts. The basic research in this area is controversial. **Method:** We summarize reviews of the basic research data on transfer from training on abstract computer-based exercises and video games and undertake a detailed methodological review of flight and driving transfer studies. **Results:** Reviews of basic transfer research fail to reveal evidence of general transfer, although a few applied studies are said to show general transfer to driving or flight control. Our review of these applied studies identifies issues with research methods and data interpretation that compromise the credibility of their results to an extent that they do not provide robust evidence of general transfer from abstract computer-based exercises or video games. **Conclusion:** The state of cognitive training and video game training in relation to transfer has failed to meet early expectations. Much of the research in this area suffers from inadequate experimental control and flawed interpretation of results. We call for adherence to robust experimental design, critical evaluation of data patterns, and replication of keystone results. We also call for a theoretically grounded research effort, and we outline relevant theoretical conceptions of transfer. **Application:** A robust theory of transfer and better understanding of transfer effects can guide development of principles for design and use of training simulators.

- **Keywords:** cognitive training, transfer of training, operational training, training simulators, transfer theory