

# Human Factors – rok 2015, roč. 57

## Číslo 4 (June)



### **AUTOMATION, EXPERT SYSTEMS**

#### **Vlad L. Pop, Alex Shrewsbury, and Francis T. Durso. Individual Differences in the Calibration of Trust in Automation. S. 545-556.**

**Objective:** The objective was to determine whether operators with an expectancy that automation is trustworthy are better at calibrating their trust to changes in the capabilities of automation, and if so, why. **Background:** Studies suggest that individual differences in automation expectancy may be able to account for why changes in the capabilities of automation lead to a substantial change in trust for some, yet only a small change for others. **Method:** In a baggage screening task, 225 participants searched for weapons in 200 X-ray images of luggage. Participants were assisted by an automated decision aid exhibiting different levels of reliability. Measures of expectancy that automation is trustworthy were used in conjunction with subjective measures of trust and perceived reliability to identify individual differences in trust calibration. **Results:** Operators with high expectancy that automation is trustworthy were more sensitive to changes (both increases and decreases) in automation reliability. This difference was eliminated by manipulating the causal attribution of automation errors. **Conclusion:** Attributing the cause of automation errors to factors external to the automation fosters an understanding of tasks and situations in which automation differs in reliability and may lead to more appropriate trust. **Application:** The development of interventions can lead to calibrated trust in automation.

- **Keywords:** expectancy, propensity to trust, attribution, errors, reliability

### **BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY**

#### **Mohsen Damavandi, Paul Allard, and Charles-Hilaire Rivard. Head and Trunk Moments of Inertia of Able-Bodied and Unbraced Scoliotic Girls. S. 557-566.**

**Objective:** The purposes of this study were to estimate head and trunk's (HT) radii of gyration (K) and moments of inertia (I) in able-bodied and unbraced scoliotic girls using an angular momentum method, to test if the use of mean ratios calculated in this study and given by de Leva present similar values compared to the experimental data, and to determine how these methods behave in estimation of scoliotic HT's K and I with variable Cobb angles. **Background:** Scoliotic HT's I estimated from anthropometric tables can

lead to error in joint muscle moment calculations. **Method:** Twenty-one unbraced scoliotic and 20 able-bodied girls participated. HT's I values were calculated using an angular momentum method. **Results:** Angular momentum method provided greater HT's I for the scoliotic group compared with the able-bodied girls. HT's I obtained by the mean ratios calculated from this study were close to the measured values. Compared with the experimental I, de Leva method provided significantly lower I in the scoliotic group. Scoliotic HT's K and I obtained from angular momentum method showed greater correlations with the Cobb angles. **Conclusion:** The use of mean ratios obtained in this study to estimate HT's K values in unbraced scoliotic girls could overcome the drawbacks of current anthropometric methods. **Application:** These results can be used to calculate more precise moments of force during daily activities in scoliotic girls with mild scoliosis and to improve the design of corrective flexible body braces prescribed in cases of rapid interventions in young patients of moderate spinal deformities.

- **Keywords:** adolescent idiopathic scoliosis, biomechanics, moment of inertia, radius of gyration, head and trunk

## COGNITION

**Yusuke Yamani, William J. Horrey, Yulan Liang, and Donald L. Fisher.** *Sequential In-Vehicle Glance Distributions: An Alternative Approach for Analyzing Glance Data.* S. 567-572.

**Objective:** The aim of this study was to illustrate how a consideration of glance sequences to in-vehicle tasks and their associated distributions can be informative. **Background:** The rapid growth in the number of nomadic technologies and in-vehicle devices has the potential to create complex, visually intensive tasks for drivers that may incur long in-vehicle glances. Such glances place drivers at increased risk of a motor vehicle crash. **Method:** We used eye-glance data from a study of distraction training programs to examine the change in glance duration distributions across consecutive glances during the performance of various in-vehicle tasks. **Results:** The sequential analysis across trained and untrained drivers showed that the proportion of late-sequence glances longer than a 2-s threshold among untrained drivers was almost double the number of such glances for the trained drivers, that the third and later glances were particularly problematic, and that training reduced the proportion of early- and later-sequence glances. **Conclusion:** Examining how the duration of off-road glances varies as a function of their order in a sequence of glances and the visual demands of the task can offer important insights into the change in the distracting potential of in-vehicle tasks across glances and the effects of training. **Application:** The sequential analysis of in-vehicle glance data can be useful for researchers and practitioners and has implications for the development and evaluation of training programs as well as for task and interface design.

- **Keywords:** driving safety, attention maintenance

**Ruby Roberts, Rhona Flin, and Jennifer Cleland.** *Staying in the Zone: Offshore Drillers' Situation Awareness.* S. 573-590.

**Objective:** The aim of this study was to identify the cognitive components required for offshore drillers to develop and maintain situation awareness (SA) while controlling subsea hydrocarbon wells. **Background:** SA issues are often identified as contributing factors to drilling incidents, most recently in the Deepwater Horizon blowout. Yet, there is a limited body of research investigating SA in the offshore drilling environment. **Method:** In the first study, critical incident interviews were conducted with 18 experienced drilling personnel. Transcripts were subjected to theory-driven thematic analysis, producing a preliminary cognitive framework of how drillers develop and maintain SA during well control. In the second study, 24 hr of observations (in vivo and

video) of drillers managing a high fidelity well-control simulator were analyzed to further develop the framework. **Results:** The cognitive components that enable drillers to build up an understanding of what is happening in the wellbore and surrounding environment, to predict how this understanding may develop, were identified. These components included cue recognition, interpretation of information in conjunction with the current mental model, and projection through mental simulation. Factors such as distracters, expectations, and information sharing between crew members can both positively and negatively influence the drillers' SA. **Conclusion:** The findings give a preliminary understanding into the components of drillers' SA, highlighting the importance of SA for safe and effective performance and indicating that Endsley's model of SA can be applied to drilling. **Application:** The results have consequences for training, task management, and work design recommendations.

- **Keywords:** drilling, cognitive task analysis, nontechnical skills, expertise

## HEALTH CARE/HEALTH SYSTEMS

**Nadine Moacdieh and Nadine Sarter. *Clutter in Electronic Medical Records: Examining Its Performance and Attentional Costs Using Eye Tracking.* S 591-606.**

**Objective:** The objective was to use eye tracking to trace the underlying changes in attention allocation associated with the performance effects of clutter, stress, and task difficulty in visual search and noticing tasks. **Background:** Clutter can degrade performance in complex domains, yet more needs to be known about the associated changes in attention allocation, particularly in the presence of stress and for different tasks. Frequently used and relatively simple eye tracking metrics do not effectively capture the various effects of clutter, which is critical for comprehensively analyzing clutter and developing targeted, real-time countermeasures. **Method:** Electronic medical records (EMRs) were chosen as the application domain for this research. Clutter, stress, and task difficulty were manipulated, and physicians' performance on search and noticing tasks was recorded. Several eye tracking metrics were used to trace attention allocation throughout those tasks, and subjective data were gathered via a debriefing questionnaire. **Results:** Clutter degraded performance in terms of response time and noticing accuracy. These decrements were largely accentuated by high stress and task difficulty. Eye tracking revealed the underlying attentional mechanisms, and several display-independent metrics were shown to be significant indicators of the effects of clutter. **Conclusion:** Eye tracking provides a promising means to understand in detail (offline) and prevent (in real time) major performance breakdowns due to clutter. **Application:** Display designers need to be aware of the risks of clutter in EMRs and other complex displays and can use the identified eye tracking metrics to evaluate and/or adjust their display.

- **Keywords:** display design, visual search, attention, medical informatics

## HUMAN-COMPUTER INTERACTION, COMPUTER SYSTEMS

**Anna Pereira, Juan P. Wachs, Kunwoo Park, and David Rempel. *A User-Developed 3-D Hand Gesture Set for Human-Computer Interaction.* S. 607-621.**

**Objective:** The purpose of this study was to develop a lexicon for 3-D hand gestures for common human-computer interaction (HCI) tasks by considering usability and effort ratings. **Background:** Recent technologies create an opportunity for developing a free-form 3-D hand gesture lexicon for HCI. **Method:** Subjects ( $N = 30$ ) with prior experience using 2-D gestures on touch screens performed 3-D gestures of their choice for 34

common HCI tasks and rated their gestures on preference, match, ease, and effort. Videos of the 1,300 generated gestures were analyzed for gesture popularity, order, and response times. Gesture hand postures were rated by the authors on biomechanical risk and fatigue. **Results:** A final task gesture set is proposed based primarily on subjective ratings and hand posture risk. The different dimensions used for evaluating task gestures were not highly correlated and, therefore, measured different properties of the task–gesture match. **Application:** A method is proposed for generating a user-developed 3-D gesture lexicon for common HCIs that involves subjective ratings and a posture risk rating for minimizing arm and hand fatigue.

- **Keywords:** HCI, human–computer interaction, gesture, fatigue, usability

## INDIVIDUAL DIFFERENCES

**Steve Lamb and Kenny C. S. Kwok. *MSSQ-Short Norms May Underestimate Highly Susceptible Individuals: Updating the MSSQ-Short Norms.* S. 622-633.**

**Objective:** The aim of this study was to provide more reliable and robust norms for the Motion Sickness Susceptibility Questionnaire (MSSQ-Short). **Background:** The previous norms for the MSSQ-Short involved a small sample overrepresenting younger female participants, which may provide misleading estimates of susceptibility in the general population. **Method:** We measured MSSQ-Short scores in a sample of 1,711 members of the general public in New Zealand and Australia. The sample is 6.6 times larger than the original norm sample, and age and gender closely match the general population. **Results:** Compared with the current study, the original norms underrepresent those of high susceptibility by a factor of 3.6, or 0.52 standard deviations. The analysis detected higher levels of susceptibility in females and significantly lower susceptibility in those ages 65 years and older. **Conclusion:** This study provides the largest sample of MSSQ-Short scores with more representative demographic characteristics of age and gender. Despite the potential for a self-selection bias toward high levels of susceptibility, we argue that the current norms provide more reliable and robust norms than the original sample. **Application:** These updated norms provide the tools for researchers and designers to evaluate the likely effect of various motion environments on the general population. Robust norm data can inform research, including general motion sickness research and environmental design.

- **Keywords:** motion sickness, susceptibility, MSSQ norms, individual differences

## MOTOR BEHAVIOUR

**Mahmut Ekşioğlu and Ali İşeri. *An Estimation of Finger-Tapping Rates and Load Capacities and the Effects of Various Factors.* S. 634-648.**

**Objective:** The aim of this study was to estimate the finger-tapping rates and finger load capacities of eight fingers (excluding thumbs) for a healthy adult population and investigate the effects of various factors on tapping rate. **Background:** Finger-tapping rate, the total number of finger taps per unit of time, can be used as a design parameter of various products and also as a psychomotor test for evaluating patients with neurologic problems. **Method:** A 1-min tapping task was performed by 148 participants with maximum volitional tempo for each of eight fingers. For each of the tapping tasks, the participant with the corresponding finger tapped the associated key in the standard position on the home row of a conventional keyboard for touch typing. **Results:** The index and middle fingers were the fastest fingers for both hands, and little fingers the slowest. All dominant-hand fingers, except little finger, had higher tapping rates than the fastest finger of the nondominant hand. Tapping rate decreased with age and smokers tapped faster than nonsmokers. Tapping duration and exercise had also significant effect

on tapping rate. **Conclusion:** Normative data of tapping rates and load capacities of eight fingers were estimated for the adult population. In designs of psychomotor tests that require the use of tapping rate or finger load capacity data, the effects of finger, age, smoking, and tapping duration need to be taken into account. **Application:** The findings can be used for ergonomic designs requiring finger-tapping capacity and also as a reference in psychomotor tests.

- **Keywords:** design for human capacity, keyboard layout design, psychomotor test, motor control, ergonomics

## **SIMULATION AND VIRTUAL REALITY**

**Germán Gálvez-García, Marion Hay, and Catherine Gabaude. *Alleviating Simulator Sickness with Galvanic Cutaneous Stimulation*. S. 649-657.**

**Objective:** In a driving simulation, we investigated the efficacy of galvanic cutaneous stimulation (GCS) provided during curves or intermittently during the whole circuit to mitigate simulator syndrome (SS). **Background:** The literature on how GCS decreases SS, although scarce, has demonstrated the effectiveness of this technique. Stimulation with this and similar techniques has usually been provided in curves or continuously during the whole circuit but never intermittently. This stimulation method could generate a continued activation of processes related to GCS mitigating SS. **Method:** Fifteen drivers (8 men; mean age = 25.5 years) participated in this experiment. We compared the total scores of the Simulator Sickness Questionnaire (SSQ) across three stimulation conditions: (a) curve GCS condition, whereby GCS was provided in curves; (b) intermittent GCS condition, whereby GCS was provided intermittently during the whole circuit; and (c) no-stimulation condition, whereby no stimulation was provided (baseline condition). **Results:** The experimental outcomes revealed that GCS decreased SS in both the curve and intermittent stimulation conditions. **Conclusion:** We provide evidence that GCS is an effective countermeasure to decrease SS. It could be applied indifferently in curves or intermittently during the whole circuit. **Application:** For future interventions, we recommend the use of GCS to mitigate SS with similar intermittent stimulation programs. These programs have a crucial advantage as they are easily integrated into the simulator setup without the necessity of generating a complicated experimental design to stimulate during the curves.

- **Keywords:** motion sickness, simulator sickness, driving task, cognition disorder, Simulator Sickness Questionnaire

**Karen B. Chen, Kevin Ponto, Ross D. Tredinnick, and Robert G. Radwin. *Virtual Exertions: Evoking the Sense of Exerting Forces in Virtual Reality Using Gestures and Muscle Activity*. S. 658-673.**

**Objective:** This study was a proof of concept for *virtual exertions*, a novel method that involves the use of body tracking and electromyography for grasping and moving projections of objects in virtual reality (VR). The user views objects in his or her hands during rehearsed co-contractions of the same agonist-antagonist muscles normally used for the desired activities to suggest exerting forces. **Background:** Unlike physical objects, virtual objects are images and lack mass. There is currently no practical physically demanding way to interact with virtual objects to simulate strenuous activities. **Method:** Eleven participants grasped and lifted similar physical and virtual objects of various weights in an immersive 3-D Cave Automatic Virtual Environment. Muscle activity, localized muscle fatigue, ratings of perceived exertions, and NASA Task Load Index were measured. Additionally, the relationship between levels of immersion (2-D vs. 3-D) was studied. **Results:** Although the overall magnitude of biceps activity and workload were greater in VR, muscle activity trends and fatigue patterns for varying weights within VR and physical conditions were the same. Perceived exertions for varying

weights were not significantly different between VR and physical conditions. **Conclusions:** Perceived exertion levels and muscle activity patterns corresponded to the assigned virtual loads, which supported the hypothesis that the method evoked the perception of physical exertions and showed that the method was promising. **Application:** Ultimately this approach may offer opportunities for research and training individuals to perform strenuous activities under potentially safer conditions that mimic situations while seeing their own body and hands relative to the scene.

- **Keywords:** simulation and virtual reality, electromyography (EMG), forces and moments, computer interface, virtual environments

## **SURFACE TRANSPORTATION**

**Miguel A. Perez, Linda S. Angell, and Jonathan M. Hankey. *Assessment of Naturalistic Use Patterns of Advanced Infotainment Systems.* S. 674-688.**

**Objective:** The objective was to examine naturalistic usage of infotainment systems to assess use characteristics and patterns. **Background:** Infotainment systems continue to evolve in terms of their capabilities and information availability, raising concerns about their distraction potential. Assessing potential distraction requires understanding how challenging different tasks are and how frequently they occur during driving. **Method:** High-end infotainment system use was observed across 17 participants over a period of approximately 4 weeks each. One of two different infotainment systems was provided to participants. Audio, video, and driving performance data were collected and observed by trained reductionists. The two infotainment systems integrated iPod™, satellite radio, CD/DVD/MP3 playback, AM/FM, and, in one case, navigation functionalities. Systems differed in their vehicle integration and advanced infotainment features offered. **Results:** The median participant interacted with the infotainment systems once every 4 hr (90th percentile: 6.1 interactions/hr). More than 50% of these interactions involved adjusting the volume. Although there were a few lengthy interactions, the median duration was 2.2 s (90th percentile: 24.6 s), which required measurable visual involvement when compared to a matched baseline. The median total eyes-off-road time across interactions was 1 s (90th percentile: 11.4 s) and differed significantly across type of system interaction. Longer interactions tended to occur when the vehicle was stationary. **Conclusion:** Drivers habitually interact with infotainment systems while driving; this includes advanced functions. Some self-regulation was observed. **Application:** These data provide a comparison basis for use in examining driver interactions with future infotainment systems.

- **Keywords:** in-vehicle information systems, eye glance, radio, distraction, driver behavior, highway and vehicle design

**David G. Kidd, Bradly K. Hagoski, Tia G. Tucker, and Dean P. Chiang. *The Effectiveness of a Rearview Camera and Parking Sensor System Alone and Combined for Preventing a Collision With an Unexpected Stationary or Moving Object.* S. 689-700.**

**Objective:** This study measured the effectiveness of a parking sensor system, a rearview camera, and a sensor system combined with a camera for preventing a collision with a stationary or moving child-size object in the path of a backing vehicle. **Background:** An estimated 15,000 people are injured and 210 are killed every year in backover crashes involving light vehicles. Cameras and sensor systems may help prevent these crashes. **Method:** The sample included 111 drivers (55 men, 56 women), including 16 in the no-technology condition, 32 in the sensor condition, 32 in the camera condition, and 31 in the camera-plus-sensor condition. A stationary or moving child-size object was

surreptitiously deployed in the path of participants backing out of a parking stall.

**Results:** A significantly smaller proportion of participants in the camera condition hit the stationary object compared with participants in the no-technology condition; however, this benefit was greatly reduced when the stationary object was partially or completely in the shade. Significantly fewer participants hit the moving object than the stationary object. The percentage of participants in the sensor, camera, and camera-plus-sensor conditions who hit the moving object was not different from the no-technology condition.

**Conclusion:** The camera was the only technology that was effective for preventing collisions with the stationary object. The variation in collision outcomes between the stationary- and moving-object conditions illustrates how the effectiveness of these technologies is dependent on the backing situation. **Application:** This research can help the selection and development of countermeasures to prevent backovers.

- **Keywords:** rearview cameras, backup cameras, parking sensors, backover crashes, backover prevention