

## Human Factors – rok 2017, roč. 59

### Číslo 6 (September)



#### **AUTOMATION, EXPERT SYSTEMS**

**Megan L. Bartlett, Jason S. McCarley. *Benchmarking Aided Decision Making in a Signal Detection Task.* pp. 881–900.**

**Objective:** A series of experiments examined human operators' strategies for interacting with highly (93%) reliable automated decision aids in a binary signal detection task. **Background:** Operators often interact with automated decision aids in a suboptimal way, achieving performance levels lower than predicted by a statistically ideal model of information integration. To better understand operators' inefficient use of decision aids, we compared participants' automation-aided performance levels with the predictions of seven statistical models of collaborative decision making. **Method:** Participants performed a binary signal detection task that asked them to classify random dot images as either blue or orange dominant. They made their judgments either unaided or with assistance from a 93% reliable automated decision aid that provided either graded (Experiments 1 and 3) or binary (Experiment 2) cues. We compared automation-aided performance with the predictions of seven statistical models of collaborative decision making, including a statistically optimal model and Robinson and Sorkin's contingent criterion model. **Results and Conclusion:** Automation-aided sensitivity hewed closest to the predictions of the two least efficient collaborative models, well short of statistically ideal levels. Performance was similar whether the aid provided graded or binary judgments. Model comparisons identified potential strategies by which participants integrated their judgments with the aid's. **Application:** Results lend insight into participants' automation-aided decision strategies and provide benchmarks for predicting automation-aided performance levels.

**Joachim Meyer, Thomas B. Sheridan. *The Intricacies of User Adjustments of Alerting Thresholds.* pp. 901–910.**

**Objective:** We address the question of necessary conditions for users to adjust system settings, such as alarm thresholds, correctly. **Background:** When designing systems, we need to decide which system functions users should control. Giving control to users empowers them, but users must have the relevant information and the ability to adjust settings correctly for their control to be beneficial. **Method:** Using the example of adjusting an alerting threshold, we analyze the conditions for when users can and when

they cannot possibly adjust threshold settings adequately. **Results:** We identify two obstacles that limit users' ability to adjust thresholds adequately: (a) the difficulty of determining the correct threshold settings, especially because of users' strong response to false positive indications, and (b) the difficulty of collecting the information necessary for setting the threshold. **Conclusion:** Users often cannot identify the optimal settings for a system, so it is unlikely that they choose adequate system settings. **Application:** System designers must consider the difficulties users face and analyze them explicitly when deciding on user involvement in processes.

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

**Peter J. Sheahan, Joshua G. A. Cashaback, Steven L. Fischer. *Evaluating the Ergonomic Benefit of a Wrist Brace on Wrist Posture, Muscle Activity, Rotational Stiffness, and Peak Shovel-Ground Impact Force During a Simulated Tree-Planting Task.* pp. 911–924.**

**Background:** Tree planters are at a high risk for wrist injury due to awkward postures and high wrist loads experienced during each planting cycle, specifically at shovel-ground impact. Wrist joint stiffness provides a measure that integrates postural and loading information. **Objective:** The purpose of this study was to evaluate wrist joint stiffness requirements at the instant of shovel-ground impact during tree planting and determine if a wrist brace could alter muscular contributions to wrist joint stiffness. **Method:** Planters simulated tree planting with and without wearing a brace on their planting arm. Surface electromyography (sEMG) from six forearm muscles and wrist kinematics were collected and used to calculate muscular contributions to joint rotational stiffness about the wrist. **Results:** Wrist joint stiffness increased with brace use, an unanticipated and negative consequence of wearing a brace. As a potential benefit, planters achieved a more neutrally oriented wrist angle about the flexion/extension axis, although a less neutral wrist angle about the ulnar/radial axis was observed. Muscle activity did not change between conditions. **Conclusion:** The joint stiffness analysis, combining kinematic and sEMG information in a biologically relevant manner, revealed clear limitations with the interface between the brace grip and shovel handle that jeopardized the prophylactic benefits of the current brace design. This limitation was not as evident when considering kinematics and sEMG data independently. **Application:** A neuromechanical model (joint rotational stiffness) enhanced our ability to evaluate the brace design relative to kinematic and sEMG parameter-based metrics alone.

**Peter J. Sheahan, Joshua G. A. Cashaback, Steven L. Fischer. *Evaluating the Ergonomic Benefit of a Wrist Brace on Wrist Posture, Muscle Activity, Rotational Stiffness, and Peak Shovel-Ground Impact Force During a Simulated Tree-Planting Task.* pp. 911–924.**

**Background:** Tree planters are at a high risk for wrist injury due to awkward postures and high wrist loads experienced during each planting cycle, specifically at shovel-ground impact. Wrist joint stiffness provides a measure that integrates postural and loading information. **Objective:** The purpose of this study was to evaluate wrist joint stiffness requirements at the instant of shovel-ground impact during tree planting and determine if a wrist brace could alter muscular contributions to wrist joint stiffness. **Method:** Planters simulated tree planting with and without wearing a brace on their planting arm. Surface electromyography (sEMG) from six forearm muscles and wrist kinematics were collected and used to calculate muscular contributions to joint rotational stiffness about the wrist. **Results:** Wrist joint stiffness increased with brace use, an unanticipated and negative consequence of wearing a brace. As a potential benefit, planters achieved a more neutrally oriented wrist angle about the flexion/extension axis, although a less neutral wrist angle about the ulnar/radial axis was observed. Muscle activity did not change between conditions. **Conclusion:** The joint stiffness analysis, combining

kinematic and sEMG information in a biologically relevant manner, revealed clear limitations with the interface between the brace grip and shovel handle that jeopardized the prophylactic benefits of the current brace design. This limitation was not as evident when considering kinematics and sEMG data independently. **Application:** A neuromechanical model (joint rotational stiffness) enhanced our ability to evaluate the brace design relative to kinematic and sEMG parameter-based metrics alone.

## COGNITION

**Yu-San Chang, Yu-Hsuan Wu, Hsiang-Lan Chen, Chung-Yao Hsu. *Four Night Shifts Have a Degree of Performance Adaptation.* pp. 925–936.**

**Objective:** In this case control study, we investigated the process of adaptation to night shift (NS) work and recovery back to a day schedule among nurses working a fast-rotation three-shift schedule. **Background:** There is limited knowledge of how specific patterns of a fast-rotation shift affect nurses' performance. **Method:** The cognitive performance of off-duty nurses (OD;  $n = 21$ ), those working the first night of an NS (1NS;  $n = 21$ ) and the last night of two ( $n = 21$ ), three ( $n = 20$ ), and four (4NS;  $n = 21$ ) successive NSs were compared. Changes in sleep propensity, cognitive function, and anxiety were compared in the daytime after working four successive NSs followed by 24 hr off (4NS-off;  $n = 18$ ) and in those off duty. **Results:** The visual attention task (VAT) of cognitive function was significantly worse in the 1NS group and significantly better on the last night in the 4NS group than in the other NS groups. The nurses in the 4NS-off group were less alert and had poorer VAT performance than the OD group during the daytime. **Conclusion:** The nurses working on NS experienced a decrease in VAT performance due to acute changes in circadian rhythm but also significant performance adaptation after four consecutive NSs. One off-duty day was insufficient to recover back to a daytime shift after four consecutive NSs. **Application:** In a fast-rotation three-shift schedule, performance adaptation occurred in the nurses who worked four consecutive NSs, and more than one off-duty day are needed to recover back to daytime shift after those NSs.

## HEALTH CARE/HEALTH SYSTEMS

**Megan E. Gregory, Shirley C. Sonesh, Jennifer Feitosa, Lauren E. Benishek, Ashley M. Hughes, Eduardo Salas. [\*Decision Making on the Labor and Delivery Unit: An Investigation of Influencing Factors.\*](#) pp. 937–955.**

**Objective:** The aim of this study was to describe the relationship between negative affect (NA), decision-making style, time stress, and decision quality in health care. **Background:** Health care providers must often make swift, high-stakes decisions. Influencing factors of the decision-making process in this context have been understudied. **Method:** Within a sample of labor and delivery nurses, physicians, and allied personnel, we used self-report measures to examine the impact of trait factors, including NA, decision-making style, and perceived time stress, on decision quality in a situational judgment test (Study 1). In Study 2, we observed the influence of state NA, state decision-making style, state time stress, and their relationship with decision quality on real clinical decisions. **Results:** In Study 1, we found that trait NA significantly predicted avoidant decision-making style. Furthermore, those who were higher on trait time stress and trait avoidant decision-making style exhibited poorer decisions. In Study 2, we observed associations between state NA with state avoidant and analytical decision-making styles. We also observed that these decision-making styles, when considered in tandem with time stress, were influential in predicting clinical decision quality. **Conclusion:** NA predicts some decision-making styles, and decision-making style can affect decision quality under time stress. This is particularly true for state

factors. **Application:** Individual differences, such as affect and decision-making style, should be considered during selection. Training to reduce time stress perceptions should be provided.

## HUMAN-COMPUTER INTERACTION, COMPUTER SYSTEMS

**Sven Schmutz, Andreas Sonderegger, Juergen Sauer. *Implementing Recommendations From Web Accessibility Guidelines: A Comparative Study of Nondisabled Users and Users With Visual Impairments.* pp. 956–972.**

**Objective:** The present study examined whether implementing recommendations of Web accessibility guidelines would have different effects on nondisabled users than on users with visual impairments. **Background:** The predominant approach for making Web sites accessible for users with disabilities is to apply accessibility guidelines. However, it has been hardly examined whether this approach has side effects for nondisabled users. A comparison of the effects on both user groups would contribute to a better understanding of possible advantages and drawbacks of applying accessibility guidelines. **Method:** Participants from two matched samples, comprising 55 participants with visual impairments and 55 without impairments, took part in a synchronous remote testing of a Web site. Each participant was randomly assigned to one of three Web sites, which differed in the level of accessibility (very low, low, and high) according to recommendations of the well-established Web Content Accessibility Guidelines 2.0 (WCAG 2.0). Performance (i.e., task completion rate and task completion time) and a range of subjective variables (i.e., perceived usability, positive affect, negative affect, perceived aesthetics, perceived workload, and user experience) were measured. **Results:** Higher conformance to Web accessibility guidelines resulted in increased performance and more positive user ratings (e.g., perceived usability or aesthetics) for both user groups. There was no interaction between user group and accessibility level. **Conclusion:** Higher conformance to WCAG 2.0 may result in benefits for nondisabled users and users with visual impairments alike. **Application:** Practitioners may use the present findings as a basis for deciding on whether and how to implement accessibility best.

## HUMAN-SYSTEMS INTEGRATION

**Frank Morelli, Jennifer M. Neugebauer, Courtney A. Haynes, Thomas C. Fry, Samson V. Ortega, Douglas J. Struve, Michael E. LaFiandra, Gabriella B. Larkin. [\*Shooter-System Performance Variability as a Function of Recoil Dynamics.\*](#) pp. 973–985.**

**Objective:** The goal of this study was to quantify shooter performance relative to subtle variations in recoil energy. **Background:** Marksmanship performance remains undefined for subtle distinctions in weapon recoil energy across common small-arms platforms. **Method:** Weapons were customized using multiple components and ammunition types. Firing scenarios were designed to examine the effect of recoil energy on shooter timing and accuracy. **Results:** The results suggest that recoil condition does not affect timing during firing sequences designed to elicit differences in timed-fire performance. Recoil condition did, however, influence shot placement, with accuracy decreasing as the energy associated with firing increased. Subjective recoil estimations were quantified according to relative magnitude and spatial distribution of perceived energy transferred at shooter-weapon surface contact locations. **Conclusion:** The absence of differences in time to engage may be reflective of resistance to recoil-induced point-of-aim deviation based on experience. Distinctions in performance were revealed despite subtle differences in recoil energy between conditions. An instrument that may be sensitive to shooter perception of subtle differences in recoil energy during firing was also developed. **Application:** The

findings inform performance expectations for small-arms systems relative to recoil energy levels transferred to the shooter during dynamic firing events.

## **MOTOR BEHAVIOR**

**Errol R. Hoffmann, Alan H. S. Chan, P. T. Heung. *Head Rotation Movement Times*. pp. 986–994.**

**Objective:** The aim of this study was to measure head rotation movement times in a Fitts' paradigm and to investigate the transition region from ballistic movements to visually controlled movements as the task index of difficulty (ID) increases. **Background:** For head rotation, there are gaps in the knowledge of the effects of movement amplitude and task difficulty around the critical transition region from ballistic movements to visually controlled movements. **Method:** Under the conditions of 11 ID values (from 1.0 to 6.0) and five movement amplitudes (20° to 60°), participants performed a head rotation task, and movement times were measured. **Results:** Both the movement amplitude and task difficulty have effects on movement times at low IDs, but movement times are dependent only on ID at higher ID values. Movement times of participants are higher than for arm/hand movements, for both ballistic and visually controlled movements. The information-processing rate of head rotational movements, at high ID values, is about half that of arm movements. **Conclusion:** As an input mode, head rotations are not as efficient as the arm system either in ability to use rapid ballistic movements or in the rate at which information may be processed. **Application:** The data of this study add to those in the review of Hoffmann for the critical IDs of different body motions. The data also allow design for the best arrangement of display that is under the design constraints of limited display area and difficulty of head-controlled movements in a data-inputting task.

## **SURFACE TRANSPORTATION**

**Woojin Song, Fu L. Woon, Alice Doong, Carol Persad, Louis Tijerina, Pooja Pandit, Carol Cline, Bruno Giordani. *Fatigue in Younger and Older Drivers: Effectiveness of an Alertness-Maintaining Task*. pp. 995–1008.**

**Objective:** The aim of this study was to examine the effects of an alertness-maintaining task (AMT) in older, fatigued drivers. **Background:** Fatigue during driving increases crash risk, and previous research suggests that alertness and driving in younger adults may be improved using a secondary AMT during boring, fatigue-eliciting drives. However, the potential impact of an AMT on driving has not been investigated in older drivers whose ability to complete dual tasks has been shown to decline and therefore may be negatively affected with an AMT in driving. **Method:** Younger ( $n = 29$ ) and older drivers ( $n = 39$ ) participated in a 50-minute simulated drive designed to induce fatigue, followed by four 10-minute sessions alternating between driving with and without an AMT. **Results:** Younger drivers were significantly more affected by fatigue on driving performance than were older drivers but benefitted significantly from the AMT. Older drivers did not demonstrate increased driver errors with fatigue, and driving did not deteriorate significantly during participation in the AMT condition, although their speed was significantly more variable with the AMT. **Conclusion:** Consistent with earlier research, an AMT applied during fatiguing driving is effective in improving alertness and reducing driving errors in younger drivers. Importantly, older drivers were relatively unaffected by fatigue, and use of an AMT did not detrimentally affect their driving performance. **Application:** These results support the potential use of an AMT as a new automotive technology to improve fatigue and promote driver safety, though the benefits of such technology may differ between different age groups.

## **TEAMS AND GROUPS**

**Daniel J. Yee, Mark W. Wiggins, Ben J. Searle. *The Role of Social Cue Utilization and Closing-the-Loop Communication in the Performance of Ad Hoc Dyads*. pp. 1009–1021.**

**Objective:** To examine whether social cue utilization impacts the performance of ad hoc dyads through its relationship with closing the loop, a communication process whereby team members respond more frequently to initiating statements made by others. **Background:** There lacks unequivocal experimental evidence for any single cognitive-based process that might predict the performance of ad hoc teams. **Method:** Using a quasi-experimental design, 80 participants were classified into 40 dyads based on their levels of social cue utilization and attempted a team problem-solving task. A serial mediation model revealed an indirect effect of social cue utilization on the performance of ad hoc dyads through closing the loop. **Results:** Analyses indicated that social cue utilization impacts on the performance of ad hoc dyads independently of nonverbal reasoning ability and emotional intelligence. Further, the level of social cue utilization within dyads exhibits a positive indirect impact on the performance of ad hoc dyads through closing the loop. **Conclusion:** Ad hoc dyads with higher levels of social cue utilization engaged in a greater frequency of closing-the-loop statements and showed better subsequent performance on a problem-solving task in comparison to dyads with lower levels of social cue utilization. **Application:** Potential applications include the optimization of ad hoc team composition within high reliability environments like aviation and power control as well as improving training interventions with a specific mechanism for improving the performance of ad hoc teams.