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#### AT THE FOREFRONT OF HF/E

#### **Matthews, Gerald. *Multidimensional Profiling of Task Stress States for Human Factors: A Brief Review.* Pages 801-813.**

**Objective:** This article advocates multidimensional assessment of task stress in human factors and reviews the use of the Dundee Stress State Questionnaire (DSSQ) for evaluation of systems and operators. **Background:** Contemporary stress research has progressed from an exclusive focus on environmental stressors to transactional perspectives on the stress process. Performance impacts of stress reflect the operators dynamic attempts to understand and cope with task demands. Multidimensional stress assessments are necessary to gauge the different forms of system-operator interaction. **Method:** This review discusses the theoretical and practical use of the DSSQ in evaluating multidimensional patterns of stress response. It presents psychometric evidence for the multidimensional perspective and illustrative profiles of subjective state response to task stressors and environments. Evidence is also presented on stress state correlations with related variables, including personality, stress process measures, psychophysiological response, and objective task performance. **Results:** Evidence supports the validity of the DSSQ as a task stress measure. Studies of various simulated environments show that different tasks elicit different profiles of stress state response. Operator characteristics such as resilience predict individual differences in state response to stressors. Structural equation modeling may be used to understand performance impacts of stress states. **Conclusion:** Multidimensional assessment affords insight into the stress process in a variety of human factors contexts. Integrating subjective and psychophysiological assessment is a priority for future research. **Application:** Stress state measurement contributes to evaluating system design, countermeasures to stress and fatigue, and performance vulnerabilities. It may also support personnel selection and diagnostic monitoring of operators.

- **Keywords:** stress, fatigu, psychometrics, multivariate models, vigilance, resilience, operator assessment, diagnostic monitoring

#### ACCIDENTS, HUMAN FACTOR

**Leaver, Meghan, Reader, Tom W. [Human Factors in Financial Trading: An Analysis of Trading Incidents](#). Pages 814-832.**

**Objective:** This study tests the reliability of a system (FINANS) to collect and analyze incident reports in the financial trading domain and is guided by a human factors taxonomy used to describe error in the trading domain. **Background:** Research indicates the utility of applying human factors theory to understand error in finance, yet empirical research is lacking. We report on the development of the first system for capturing and analyzing human factors-related issues in operational trading incidents. **Method:** In the first study, 20 incidents are analyzed by an expert user group against a referent standard to establish the reliability of FINANS. In the second study, 750 incidents are analyzed using distribution, mean, pathway, and associative analysis to describe the data. **Results:** Kappa scores indicate that categories within FINANS can be reliably used to identify and extract data on human factors-related problems underlying trading incidents. Approximately 1% of trades (n = 750) lead to an incident. Slip/lapse (61%), situation awareness (51%), and teamwork (40%) were found to be the most common problems underlying incidents. For the most serious incidents, problems in situation awareness and teamwork were most common. **Conclusion:** We show that (a) experts in the trading domain can reliably and accurately code human factors in incidents, (b) 1% of trades incur error, and (c) poor teamwork skills and situation awareness underpin the most critical incidents. **Application:** This research provides data crucial for ameliorating risk within financial trading organizations, with implications for regulation and policy.

- **Keywords:** financial trading, human error, system design, risk, teamwork, situation awareness

**Kuo, Jonny, Charlton, Judith L., Koppel, Sjaan, Rudin-Brown, Christina M., Cross, Suzanne. [Modeling Driving Performance Using In-Vehicle Speech Data From a Naturalistic Driving Study](#). Pages 833-845.**

**Objective:** We aimed to (a) describe the development and application of an automated approach for processing in-vehicle speech data from a naturalistic driving study (NDS), (b) examine the influence of child passenger presence on driving performance, and (c) model this relationship using in-vehicle speech data. **Background:** Parent drivers frequently engage in child-related secondary behaviors, but the impact on driving performance is unknown. Applying automated speech-processing techniques to NDS audio data would facilitate the analysis of in-vehicle driver-child interactions and their influence on driving performance. **Method:** Speech activity detection and speaker diarization algorithms were applied to audio data from a Melbourne-based NDS involving 42 families. Multilevel models were developed to evaluate the effect of speech activity and the presence of child passengers on driving performance. **Results:** Speech activity was significantly associated with velocity and steering angle variability. Child passenger presence alone was not associated with changes in driving performance. However, speech activity in the presence of two child passengers was associated with the most variability in driving performance. **Conclusion:** The effects of in-vehicle speech on driving performance in the presence of child passengers appear to be heterogeneous, and multiple factors may need to be considered in evaluating their impact. This goal can potentially be achieved within large-scale NDS through the automated processing of observational data, including speech. **Application:** Speech-processing algorithms enable new perspectives on driving performance to be gained from existing NDS data, and variables that were once labor-intensive to process can be readily utilized in future research.

- **Keywords:** naturalistic driving study, driver distraction, speech activity detection, speaker diarization, child passengers

## **AUTOMATION, EXPERT SYSTEMS**

**Chiou, Erin K., Lee, John D. *Cooperation in Human-Agent Systems to Support Resilience: A Microworld Experiment*. Pages 846-863.**

**Objective:** This study uses a dyadic approach to understand human-agent cooperation and system resilience. **Background:** Increasingly capable technology fundamentally changes human-machine relationships. Rather than reliance on or compliance with more or less reliable automation, we investigate interaction strategies with more or less cooperative agents. **Method:** A joint-task microworld scenario was developed to explore the effects of agent cooperation on participant cooperation and system resilience. To assess the effects of agent cooperation on participant cooperation, 36 people coordinated with a more or less cooperative agent by requesting resources and responding to requests for resources in a dynamic task environment. Another 36 people were recruited to assess effects following a perturbation in their own hospital. **Results:** Experiment 1 shows people reciprocated the cooperative behaviors of the agents; a low-cooperation agent led to less effective interactions and less resource sharing, whereas a high-cooperation agent led to more effective interactions and greater resource sharing. Experiment 2 shows that an initial fast-tempo perturbation undermined proactive cooperation--people tended to not request resources. However, the initial fast tempo had little effect on reactive cooperation--people tended to accept resource requests according to cooperation level. **Conclusion:** This study complements the supervisory control perspective of human-automation interaction by considering interdependence and cooperation rather than the more common focus on reliability and reliance. **Application:** The cooperativeness of automated agents can influence the cooperativeness of human agents. Design and evaluation for resilience in teams involving increasingly autonomous agents should consider the cooperative behaviors of these agents.

- **Keywords:** autonomous agents, human-automation interaction, technology acceptance, trust in automation, team collaboration

## **AVIATION AND AEROSPACE**

**Ahlstrom, Ulf, Ohneiser, Oliver, Caddigan, Eamon. *Portable Weather Applications for General Aviation Pilots*. Pages 864-885.**

**Objective:** The objective of this study was to examine the potential benefits and impact on pilot behavior from the use of portable weather applications. **Method:** Seventy general aviation (GA) pilots participated in the study. Each pilot was randomly assigned to an experimental or a control group and flew a simulated single-engine GA aircraft, initially under visual meteorological conditions (VMC). The experimental group was equipped with a portable weather application during flight. We recorded measures for weather situation awareness (WSA), decision making, cognitive engagement, and distance from the aircraft to hazardous weather. **Results:** We found positive effects from the use of the portable weather application, with an increased WSA for the experimental group, which resulted in credibly larger route deviations and credibly greater distances to hazardous weather ( $\geq 30$  dBZ cells) compared with the control group. Nevertheless, both groups flew less than 20 statute miles from hazardous weather cells, thus failing to follow current weather-avoidance guidelines. We also found a credibly higher cognitive engagement (prefrontal oxygenation levels) for the experimental group, possibly reflecting increased flight planning and decision making on the part of the pilots. **Conclusion:** Overall, the study outcome supports our hypothesis that portable weather displays can be used without degrading pilot performance on safety-related flight tasks, actions, and decisions as measured within the constraints of the present study. However, it also shows that an increased WSA does not automatically translate to enhanced flight behavior. **Application:** The study outcome contributes to our knowledge of the effect of portable weather applications on pilot behavior and decision making.

- **Keywords:** decision making, flight displays, mobile devices, navigation, situation awareness

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

**Kuster, Roman Peter, Bauer, Christoph Markus, Oetiker, Sarah, Kool, Jan.** [\*Physiological Motion Axis for the Seat of a Dynamic Office Chair.\*](#) Pages 886-898.

**Objective:** The aim of this study was to determine and verify the optimal location of the motion axis (MA) for the seat of a dynamic office chair. **Background:** A dynamic seat that supports pelvic motion may improve physical well-being and decrease the risk of sitting-associated disorders. However, office work requires an undisturbed view on the work task, which means a stable position of the upper trunk and head. Current dynamic office chairs do not fulfill this need. Consequently, a dynamic seat was adapted to the physiological kinematics of the human spine. **Method:** Three-dimensional motion tracking in free sitting helped determine the physiological MA of the spine in the frontal plane. Three dynamic seats with physiological, lower, and higher MA were compared in stable upper body posture (thorax inclination) and seat support of pelvic motion (dynamic fitting accuracy). Spinal kinematics during sitting and walking were compared. **Results:** The physiological MA was at the level of the 11th thoracic vertebra, causing minimal thorax inclination and high dynamic fitting accuracy. Spinal motion in active sitting and walking was similar. **Conclusion:** The physiological MA of the seat allows considerable lateral flexion of the spine similar to walking with a stable upper body posture and a high seat support of pelvic motion. **Application:** The physiological MA enables lateral flexion of the spine, similar to walking, without affecting stable upper body posture, thus allowing active sitting while focusing on work.

- **Keywords:** biomechanics, kinematics, spine, low back, physical ergonomics, measures, dynamic office seat, occupational sitting, motion axis, active sitting

## **COGNITION**

**Herdener, Nathan, Wickens, Christopher D., Clegg, Benjamin A., Smith, C. A. P.** *Overconfidence in Projecting Uncertain Spatial Trajectories.* Pages 899-914.

**Objective:** The aim of this study was to understand factors that influence the prediction of uncertain spatial trajectories (e.g., the future path of a hurricane or ship) and the role of human overconfidence in such prediction. **Background:** Research has indicated that human prediction of uncertain trajectories is difficult and may well be subject to overconfidence in the accuracy of forecasts as is found in event prediction, a finding that indicates that humans insufficiently appreciate the contributions of variance in nature to their predictions. **Method:** In two experiments, our paradigm required participants to observe a starting point, a position at time T, and then make a prediction of the location of the trajectory at time NT. They experienced several trajectories from the same underlying model but perturbed by random variance in heading and speed. **Results:** In Experiment 1A, people predicted linear paths well and were better in heading predictions than in speed predictions. However, participants greatly underestimated the variance in predicted location, indicating overconfidence. In Experiment 1B, the effect was replicated with frequencies rather than probabilities used in variance estimates. In Experiment 2, people predicted nonlinear trajectories poorly, and overconfidence was again observed. Overconfidence was reduced on the more difficult predictions. In both main experiments, those better at predicting the mean were not better at predicting the variance. **Conclusion:** Predicting the level of uncertainty in spatial trajectories is not well done and may involve qualitatively different abilities than prediction of the mean. **Application:**

Improving real-world performance at prediction demands developing better understanding of variability, not just the average case. Biases in prediction of uncertainty may be addressed through debiasing training and/or visualization tools that could assist in more calibrated action planning.

- **Keywords:** decision making, metacognition, knowledge, navigation, cognition

**Funke, Gregory J., Warm, Joel S., Baldwin, Carryl L., Garcia, Andre, Funke, Matthew E., Dillard, Michael B., Finomore, Victor S., Jr., Matthews, Gerald, Greenlee, Eric T. *The Independence and Interdependence of Coacting Observers in Regard to Performance Efficiency, Workload, and Stress in a Vigilance Task.* Pages 915-926.**

**Objective:** We investigated performance, workload, and stress in groups of paired observers who performed a vigilance task in a coactive (independent) manner. **Background:** Previous studies have demonstrated that groups of coactive observers detect more signals in a vigilance task than observers working alone. Therefore, the use of such groups might be effective in enhancing signal detection in operational situations. However, concern over appearing less competent than ones cohort might induce elevated levels of workload and stress in coactive group members and thereby undermine group performance benefits. Accordingly, we performed the initial experiment comparing workload and stress in observers who performed a vigilance task coactively with those of observers who performed the vigilance task alone. **Method:** Observers monitored a video display for collision flight paths in a simulated unmanned aerial vehicle control task. Self-reports of workload and stress were secured via the NASA-Task Load Index and the Dundee Stress State Questionnaire, respectively. **Results:** Groups of coactive observers detected significantly more signals than did single observers. Coacting observers did not differ significantly from those operating by themselves in terms of workload but did in regard to stress; posttask distress was significantly lower for coacting than for single observers. **Conclusion:** Performing a visual vigilance task in a coactive manner with another observer does not elevate workload above that of observers working alone and serves to attenuate the stress associated with vigilance task performance. **Application:** The use of coacting observers could be an effective vehicle for enhancing performance efficiency in operational vigilance.

- **Keywords:** vigilance, coacting groups, multiobserver independence/dependence, evaluation apprehension, workload, stress

## HEALTH CARE/HEALTH SYSTEMS

**Lachance, Chantelle C., Korall, Alexandra M. B., Russell, Colin M., Feldman, Fabio, Robinovitch, Stephen N., Mackey, Dawn C. *External Hand Forces Exerted by Long-Term Care Staff to Push Floor-Based Lifts: Effects of Flooring System and Resident Weight.* Pages 927-943.**

**Objective:** The aim of this study was to investigate the effects of flooring type and resident weight on external hand forces required to push floor-based lifts in long-term care (LTC). **Background:** Novel compliant flooring is designed to reduce fall-related injuries among LTC residents but may increase forces required for staff to perform pushing tasks. A motorized lift may offset the effect of flooring on push forces. **Method:** Fourteen female LTC staff performed straight-line pushes with two floor-based lifts (conventional, motor driven) loaded with passengers of average and 90th-percentile resident weights over four flooring systems (concrete+vinyl, compliant+vinyl, concrete+carpet, compliant+carpet). Initial and sustained push forces were measured by a handlebar-mounted triaxial load cell and compared to participant-specific tolerance limits. Participants rated pushing difficulty. **Results:** Novel compliant flooring increased

initial and sustained push forces and subjective ratings compared to concrete flooring. Compared to the conventional lift, the motor-driven lift substantially reduced initial and sustained push forces and perceived difficulty of pushing for all four floors and both resident weights. Participants exerted forces above published tolerance limits only when using the conventional lift on the carpet conditions (concrete+carpet, compliant+carpet). With the motor-driven lift only, resident weight did not affect push forces. **Conclusion:** Novel compliant flooring increased linear push forces generated by LTC staff using floor-based lifts, but forces did not exceed tolerance limits when pushing over compliant+vinyl. The motor-driven lift substantially reduced push forces compared to the conventional lift. **Application:** Results may help to address risk of work-related musculoskeletal injury, especially in locations with novel compliant flooring.

- **Keywords:** manual materials handling, job risk assessment, medical devices and technologies, nursing and nursing systems, usability testing and evaluation

## **SURFACE TRANSPORTATION**

**Zhang, Yu, Kaber, David. *Evaluation of Strategies for Integrated Classification of Visual-Manual and Cognitive Distractions in Driving.* Pages 944-958.**

**Background:** Prior studies have demonstrated unique driver behavior outcomes when visual and cognitive distraction occurs simultaneously as compared to the occurrence of one form of distraction alone. This situation implies additional complexity for the design of robust distraction detection systems and vehicle automation for hazard mitigation. **Objective:** This study evaluated the effectiveness of two distraction classification strategies: (a) a "two-stage" classifier, first detecting visual-manual distraction and then identifying dual or cognitive distraction states, and (b) a "direct-mapping" classifier developed to identify all distraction states at the same time. MethodDriving performance data were collected on 20 participants under different known states of distraction (none, visual-manual, cognitive, and combined). A support vector machine (SVM) was used as a base algorithm for both classifiers and performance data as well as the level of driving control (tactical and operational), which served as inputs and modifiers to the classification process. **Results:** The two-stage strategy was found to be sensitive for identifying states of visual-manual distraction; however, the strategy also produced a higher false alarm rate than direct-mapping. Consideration of driving control levels during classification also improved classification accuracy. Future work needs to account for strategic levels of vehicle control.

- **Keywords:** driving behavior, visual-manual distraction, cognitive distraction, classification problems, support vector machines