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AVIATION AND AEROSPACE

Annemarie Landman, Eric L. Groen, M. M. (René) van Paassen, Adelbert W. Bronkhorst, Max Mulder. [Dealing With Unexpected Events on the Flight Deck: A Conceptual Model of Startle and Surprise](#). pp. 1161–1172.

Objective: A conceptual model is proposed in order to explain pilot performance in surprising and startling situations. **Background:** Today's debate around loss of control following in-flight events and the implementation of upset prevention and recovery training has highlighted the importance of pilots' ability to deal with unexpected events. Unexpected events, such as technical malfunctions or automation surprises, potentially induce a "startle factor" that may significantly impair performance. **Method:** Literature on surprise, startle, resilience, and decision making is reviewed, and findings are combined into a conceptual model. A number of recent flight incident and accident cases are then used to illustrate elements of the model. **Results:** Pilot perception and actions are conceptualized as being guided by "frames," or mental knowledge structures that were previously learned. Performance issues in unexpected situations can often be traced back to insufficient adaptation of one's frame to the situation. It is argued that such sensemaking or reframing processes are especially vulnerable to issues caused by startle or acute stress. **Conclusion:** Interventions should focus on (a) increasing the supply and quality of pilot frames (e.g., through practicing a variety of situations), (b) increasing pilot reframing skills (e.g., through the use of unpredictability in training scenarios), and (c) improving pilot metacognitive skills, so that inappropriate automatic responses to startle and surprise can be avoided. **Application:** The model can be used to explain pilot behavior in accident cases, to design experiments and training simulations, to teach pilots metacognitive skills, and to identify intervention methods.

- **Keywords:** aviation, mental models, pilot performance, resilience, training

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY"

Jose-Antonio Diego-Mas, Jorge Alcaide-Marzal, Rocio Poveda-Bautista. [Errors Using Observational Methods for Ergonomics Assessment in Real Practice](#). pp. 1173–1187.

Objective: The degree in which practitioners use the observational methods for musculoskeletal disorder risks assessment correctly was evaluated. **Background:** Ergonomics assessment is a key issue for the prevention and reduction of work-related musculoskeletal disorders in workplaces. Observational assessment methods appear to be better matched to the needs of practitioners than direct measurement methods, and for this reason, they are the most widely used techniques in real work situations. Despite the simplicity of observational methods, those responsible for assessing risks using these techniques should have some experience and know-how in order to be able to use them correctly. **Method:** We analyzed 442 risk assessments of actual jobs carried out by 290 professionals from 20 countries to determine their reliability. **Results:** The results show that approximately 30% of the assessments performed by practitioners had errors. In 13% of the assessments, the errors were severe and completely invalidated the results of the evaluation. **Conclusion:** Despite the simplicity of observational method, approximately 1 out of 3 assessments conducted by practitioners in actual work situations do not adequately evaluate the level of potential musculoskeletal disorder risks. **Application:** This study reveals a problem that suggests greater effort is needed to ensure that practitioners possess better knowledge of the techniques used to assess work-related musculoskeletal disorder risks and that laws and regulations should be stricter as regards qualifications and skills required by professionals.

- **Keywords:** job risk assessment, industrial/workplace ergonomics, human error analysis, measures, physical work

COGNITION

Coral J. Dando, Thomas C. Ormerod. *Analyzing Decision Logs to Understand Decision Making in Serious Crime Investigations*. pp. 1188–1203.

Objective: To study decision making by detectives when investigating serious crime through the examination of decision logs to explore hypothesis generation and evidence selection. **Background:** Decision logs are used to record and justify decisions made during serious crime investigations. The complexity of investigative decision making is well documented, as are the errors associated with miscarriages of justice and inquests. The use of decision logs has not been the subject of an empirical investigation, yet they offer an important window into the nature of investigative decision making in dynamic, time-critical environments. **Method:** A sample of decision logs from British police forces was analyzed qualitatively and quantitatively to explore hypothesis generation and evidence selection by police detectives. **Results:** Analyses revealed diversity in documentation of decisions that did not correlate with case type and identified significant limitations of the decision log approach to supporting investigative decision making. Differences emerged between experienced and less experienced officers' decision log records in exploration of alternative hypotheses, generation of hypotheses, and sources of evidential inquiry opened over phase of investigation. **Conclusion:** The practical use of decision logs is highly constrained by their format and context of use. Despite this, decision log records suggest that experienced detectives display strategic decision making to avoid confirmation and satisficing, which affect less experienced detectives. **Application:** Potential applications of this research include both training in case documentation and the development of new decision log media that encourage detectives, irrespective of experience, to generate multiple hypotheses and optimize the timely selection of evidence to test them.

- **Keywords:** decision logs, crime investigation, heuristics and biases, hypothesis generation, expertise

HUMAN-COMPUTER INTERACTION, COMPUTER SYSTEMS

Kristi R. Campoe, Karen K. Giuliano. *Impact of Frequent Interruption on Nurses' Patient-Controlled Analgesia Programming Performance.* pp. 1204–1213.

Objective: The purpose was to add to the body of knowledge regarding the impact of interruption on acute care nurses' cognitive workload, total task completion times, nurse frustration, and medication administration error while programming a patient-controlled analgesia (PCA) pump. **Background:** Data support that the severity of medication administration error increases with the number of interruptions, which is especially critical during the administration of high-risk medications. Bar code technology, interruption-free zones, and medication safety vests have been shown to decrease administration-related errors. However, there are few published data regarding the impact of number of interruptions on nurses' clinical performance during PCA programming. **Method:** Nine acute care nurses completed three PCA pump programming tasks in a simulation laboratory. Programming tasks were completed under three conditions where the number of interruptions varied between two, four, and six. Outcome measures included cognitive workload (six NASA Task Load Index [NASA-TLX] subscales), total task completion time (seconds), nurse frustration (NASA-TLX Subscale 6), and PCA medication administration error (incorrect final programming). **Results:** Increases in the number of interruptions were associated with significant increases in total task completion time ($p = .003$). We also found increases in nurses' cognitive workload, nurse frustration, and PCA pump programming errors, but these increases were not statistically significant. **Applications:** Complex technology use permeates the acute care nursing practice environment. These results add new knowledge on nurses' clinical performance during PCA pump programming and high-risk medication administration.

- **Keywords:** patient safety, medical devices and technologies, distractions and interruptions, nursing and nursing systems, simulation

PHYSIOLOGICAL AND PSYCHOLOGICAL CONDITIONS ("INTERNAL ENVIRONMENT")

Jamie Pigman, William Sullivan, Steven Leigh, Peter A. Hosick. *The Effect of a Backpack Hip Strap on Energy Expenditure While Walking.* pp. 1214–1221.

Objective: To examine the effect of backpack hip strap use on walking energy expenditure while carrying a loaded backpack. **Background:** Previous studies have demonstrated that energy cost increases as the mass of the load carried increases. However, few investigations have focused on backpack carriage design. **Methods:** Fifteen young, healthy, male subjects walked at a self-selected pace for 10 minutes in two backpack loading conditions: with a hip strap (strapped) and without a hip strap (nonstrapped). Oxygen consumption (VO_2), rating of perceived exertion (RPE), respiratory exchange ratio (RER), and heart rate (HR) were monitored throughout each 10-minute trial. Change scores from the 4th to 10th minute were calculated for each variable. A t test was used to evaluate the difference between conditions for each variable. **Results:** The changes in VO_2 (-0.62 ± 0.40 vs. 0.33 ± 0.23 , $p = .04$) and RPE (1 ± 0.25 vs. 2 ± 0.21 , $p < .01$) from the 4th to the 10th minute were different for the strapped versus nonstrapped condition. There was no difference in the change in RER (0.04 ± 0.01 vs. 0.03 ± 0.01 , $p > .05$) or HR (3.53 ± 0.93 vs. 4.07 ± 1.39 , $p > .05$) for the strapped versus unstrapped condition. **Conclusions:** Wearing a hip strap reduced the energy expenditure and perceived exertion in as little as 10 minutes of walking compared to the nonstrapped condition. Future work should consider the effect of a hip strap on these variables while hiking for extended periods. **Application:** Wearing a hip strap may

increase the comfort and reduce the energy required of wearing a backpack. This is useful information for backpack designers, military personnel, and recreational hikers.

- **Keywords:** energy, physical work, physiology, fatigue, internal environment

SIMULATION AND VIRTUAL REALITY

Arthur Stewart, Eyad Elyan, John Isaacs, Leah McEwen, Lyn Wilson. *The Effect of Person Order on Egress Time: A Simulation Model of Evacuation From a Neolithic Visitor Attraction.* pp. 1222–1232.

Objective: The aim of this study was to model the egress of visitors from a Neolithic visitor attraction. **Background:** Tourism attracts increasing numbers of elderly and mobility-impaired visitors to our built-environment heritage sites. Some such sites have very limited and awkward access, were not designed for mass visitation, and may not be modifiable to facilitate disabled access. As a result, emergency evacuation planning must take cognizance of robust information, and in this study we aimed to establish the effect of visitor position on egress. **Method:** Direct observation of three tours at Maeshowe, Orkney, informed typical time of able-bodied individuals and a mobility-impaired person through the 10-m access tunnel. This observation informed the design of egress and evacuation models running on the Unity gaming platform. **Results:** A slow-moving person at the observed speed typically increased time to safety of 20 people by 170% and reduced the advantage offered by closer tunnel separation by 26%. Using speeds for size-specific characters of 50th, 95th, and 99th percentiles increased time to safety in emergency evacuation by 51% compared with able-bodied individuals. **Conclusion:** Larger individuals may slow egress times of a group; however, a single slow-moving mobility-impaired person exerts a greater influence on group egress, profoundly influencing those behind. **Application:** Unidirectional routes in historic buildings and other visitor attractions are vulnerable to slow-moving visitors during egress. The model presented in this study is scalable, is applicable to other buildings, and can be used as part of a risk assessment and emergency evacuation plan in future work.

- **Keywords:** simulation, risk assessment, designing for the elderly, architecture, discrete-event simulation

SURFACE TRANSPORTATION

Alexander Eriksson, Neville A. Stanton. *Driving Performance After Self-Regulated Control Transitions in Highly Automated Vehicles.* pp. 1233–1248.

Objective: This study aims to explore whether driver-paced, noncritical transitions of control may counteract some of the aftereffects observed in the contemporary literature, resulting in higher levels of vehicle control. **Background:** Research into control transitions in highly automated driving has focused on urgent scenarios where drivers are given a relatively short time span to respond to a request to resume manual control, resulting in seemingly scrambled control when manual control is resumed. **Method:** Twenty-six drivers drove two scenarios with an automated driving feature activated. Drivers were asked to read a newspaper or monitor the system and relinquish or resume control from the automation when prompted by vehicle systems. Driving performance in terms of lane positioning and steering behavior was assessed for 20 seconds post resuming control to capture the resulting level of control. **Results:** It was found that lane positioning was virtually unaffected for the duration of the 20-second time span in both automated conditions compared to the manual baseline when drivers resumed manual control; however, significant increases in the standard deviation of steering input were found for both automated conditions compared to baseline. No significant differences

were found between the two automated conditions. **Conclusion:** The results indicate that when drivers self-paced the transfer back to manual control they exhibit less of the detrimental effects observed in system-paced conditions. **Application:** It was shown that self-paced transitions could reduce the risk of accidents near the edge of the operational design domain. Vehicle manufacturers must consider these benefits when designing contemporary systems.

- **Keywords:** automation, automated driving, control transitions, takeover requests, driving performance, task regulation, distributed cognition, cognitive systems engineering

Sai Praveen Velagapudi, Gaur Gopal Ray. *Development of a Seating Comfort Questionnaire for Motorcycles.* pp. 1249–1262.

Objective: The aim of this study is to develop a reliable and valid Motorcycle Seating Comfort Questionnaire (MSCQ). **Background:** Motorcycle seat development is an iterative process based on subjective evaluations; however, there are no established subjective tools for evaluation of seating comfort. Research also suggests that seating comfort in motorcycles is poor and needs improvement. The development of a MSCQ therefore is an important step that can enable further research and aid in improving the design of motorcycle seats. **Method:** The MSCQ is developed following guidelines available in literature and referring to established questionnaires for seating comfort in passenger cars. The MSCQ is further refined based on pilot studies and interviews with experts. The final version of the MSCQ is then statistically evaluated for reliability and validity. The reliability is evaluated using a test-retest protocol with 31 volunteers. The validity is evaluated by comparing the ratings of the MSCQ with that of the Category Partitioning Scale (CP50 scale). The validity test is carried out with 15 volunteers evaluating five motorcycles using both scales. **Results:** The results show that the MSCQ is reliable with a significant test-retest reliability coefficient ($r = 0.72, p < .01, n = 31$) and internal consistency (Cronbach's $\alpha = 0.81, n = 31$). The results also show that ratings of the MSCQ have a significant correlation ($r = -0.765, p < .05, n = 15$) with that of CP50, establishing its validity. **Conclusions:** A Motorcycle Seating Comfort Questionnaire is developed in this study with statistically established reliability and validity. **Applications:** The MSCQ can be used as a tool for evaluation of seating comfort in motorcycles. The MSCQ can also form a basis for further research on motorcycle seating to develop prediction models and guidelines for the design of motorcycle seats.

- **Keywords:** seating comfort, motorcycle ergonomics, automobile ergonomics, subjective evaluation, rating scales

TEAMS AND GROUPS

Aaron P. J. Roberts, Neville A. Stanton, Daniel Fay. *Land Ahoy! Understanding Submarine Command and Control During the Completion of Inshore Operations.* pp. 1263–1288.

Objective: The aim of this study was to use multiple command teams to provide empirical evidence for understanding communication flow, information pertinence, and tasks undertaken in a submarine control room when completing higher- and lower-demand inshore operation (INSO) scenarios. **Background:** The focus of submarine operations has changed, and submarines are increasingly required to operate in coastal littoral zones. However, submarine command team performance during INSO is not well understood, particularly from a sociotechnical systems perspective. **Method:** A submarine control-room simulator was built. The creation of networked workstations allowed a team of nine operators to perform tasks completed by submarine command teams during INSO. The Event Analysis of Systematic Teamwork method was used to model the social, task, and information networks and to describe command team

performance. Ten teams were recruited for the study, affording statistical comparisons of how command-team roles and level of demand affected performance. **Results:** Results indicated that the submarine command-team members are required to rapidly integrate sonar and visual data as the periscope is used, periodically, in a “duck-and-run” fashion, to maintain covertness. The fusion of such information is primarily completed by the operations officer (OPSO), with this operator experiencing significantly greater demand than any other operator. **Conclusion:** The OPSO was a bottleneck in the command team when completing INSO, experiencing similar load in both scenarios, suggesting that the command team may benefit from data synthesis tasks being more evenly distributed within the command team. **Application:** The work can inform future control-room design and command-team ways of working by identifying bottlenecks in terms of information and task flow between operators.

- **Keywords:** submarine, teamwork, communications, networks