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AT THE FOREFRONT OF HF/E

Marras, William S., Walter, Benjamin A., Purmessur, Devina, Mageswaran, Prasath, Wiet, Matthew G. *The Contribution of Biomechanical-Biological Interactions of the Spine to Low Back Pain.* Pages 965-975.

Objective: The objective of this mini-review is to examine a subset of literature that demonstrates multiple interactions between mechanics and biology within the spine and propose how incorporation of these mechano-biologic interactions can be applied to improve the conceptual understanding of tissue tolerances. **Background:** Low back pain represents a major musculoskeletal problem in the workplace. Traditional biomechanical assessments have employed tissue tolerances as an approach for reducing workplace injuries; however, development of more universal biologically sensitive tolerances requires incorporation of mechano-biologic interactions. **Methods:** A focused literature review addressing the interactions between mechanical loading and biology in the spine. **Results:** Mechanical loads applied to the body are distributed across all spatial scales from the body to the tissues to the cells. These mechanical loads regulate cellular metabolism and over time can lead to tissue strengthening or weakening. Mechanical loading also interacts with the biologic environment (e.g., tissue inflammation, nerve sensitization) to influence the perception of pain, thereby changing the risk of experiencing pain. Biologic tissues also exhibit time-dependent changes in mechanical behaviors that occur throughout the day and with disease, suggesting tissue tolerances are time dependent. **Conclusion:** Incorporating mechano-biologic interactions into the traditional tissue tolerance paradigm through describing tissue tolerances as a function of multiple factors (e.g., preexisting risk factors, underlying pathology, and time) may lead to the development of tissue tolerances that are more representative of the *in vivo* situation. **Application:** Efforts must work toward incorporating biological concepts into tissue tolerances in order to improve risk assessment tools.

- **Keywords:** spine, low back, tissue loading, physiology, biomechanical models–spine, job risk assessment

ACCIDENTS, HUMAN FACTOR

Fekety, Drea K., Edewaard, Darlene E., Stafford Sewall, Ashley A., Tyrrell, Richard A. *Electroluminescent Materials Can Further Enhance the Nighttime Conspicuity of Pedestrians Wearing Retroreflective Materials.* Pages 976-985.

Objective: We investigated the nighttime conspicuity benefits of adding electroluminescent (EL) panels to pedestrian clothing that contains retroreflective elements. **Background:** Researchers have repeatedly documented that pedestrians are too often not sufficiently conspicuous to drivers at night and that retroreflective materials can enhance the conspicuity of pedestrians. However, because retroreflective elements in clothing are effective only when they are illuminated by the headlamps of an approaching driver, they are not useful for pedestrians who are positioned outside the beam pattern of an approaching vehicle's headlamps. Electroluminescent materials—flexible luminous panels that can be attached to clothing—have the potential to be well suited for these conditions. **Method:** Using an open-road course at night, we compared the distances at which observers responded to pedestrians who were positioned at one of three lateral positions (relative to the vehicle's path) wearing one of two high-visibility garments. **Results:** The garment that included both EL and retroreflective materials yielded longer response distances than the retroreflective-only garment. This effect was particularly strong when the test pedestrian was positioned farthest outside of the area illuminated by headlamps. **Conclusion:** These findings suggest that EL materials can further enhance the conspicuity of pedestrians who are wearing retroreflective materials. **Application:** EL materials can be applied to garments. They may be especially valuable to enhance the conspicuity of roadway workers, emergency responders, and traffic control officers.

- **Keywords:** bicycle and pedestrian safety, nighttime visibility, vision, driver behavior, illumination

Langer, Marie, Braithwaite, Graham R. *The Development and Deployment of a Maintenance Operations Safety Survey.* Pages 986-1006.

Objective: Based on the line operations safety audit (LOSA), two studies were conducted to develop and deploy an equivalent tool for aircraft maintenance: the maintenance operations safety survey (MOSS). **Background:** Safety in aircraft maintenance is currently measured reactively, based on the number of audit findings, reportable events, incidents, or accidents. Proactive safety tools designed for monitoring routine operations, such as flight data monitoring and LOSA, have been developed predominantly for flight operations. **Method:** In Study 1, development of MOSS, 12 test peer-to-peer observations were collected to investigate the practicalities of this approach. In Study 2, deployment of MOSS, seven expert observers collected 56 peer-to-peer observations of line maintenance checks at four stations. Narrative data were coded and analyzed according to the threat and error management (TEM) framework. **Results:** In Study 1, a line check was identified as a suitable unit of observation. Communication and third-party data management were the key factors in gaining maintainer trust. Study 2 identified that on average, maintainers experienced 7.8 threats (operational complexities) and committed 2.5 errors per observation. The majority of threats and errors were inconsequential. Links between specific threats and errors leading to 36 undesired states were established. **Conclusion:** This research demonstrates that observations of routine maintenance operations are feasible. TEM-based results highlight successful management strategies that maintainers employ on a day-to-day basis. **Application:** MOSS is a novel approach for safety data collection and analysis. It helps practitioners understand the nature of maintenance errors, promote an informed culture, and support safety management systems in the maintenance domain.

- **Keywords:** LOSA, MOSS, threat and error management, peer-to-peer observation, undesired state

AVIATION AND AEROSPACE

Trapsilawati, Fitri, Wickens, Christopher D., Qu, Xingda, Chen, Chun-Hsien. Benefits of Imperfect Conflict Resolution Advisory Aids for Future Air Traffic Control. Pages 1007-1019.

Objective: The aim of this study was to examine the human–automation interaction issues and the interacting factors in the context of conflict detection and resolution advisory (CRA) systems. **Background:** The issues of imperfect automation in air traffic control (ATC) have been well documented in previous studies, particularly in conflict-alerting systems. The extent to which the prior findings can be applied to an integrated conflict detection and resolution system in future ATC remains unknown. **Method:** Twenty-four participants were evenly divided into two groups corresponding to a medium- and a high-traffic density condition, respectively. In each traffic density condition, participants were instructed to perform simulated ATC tasks under four automation conditions, including reliable, unreliable with short time allowance to secondary conflict (TAS), unreliable with long TAS, and manual conditions. Dependent variables accounted for conflict resolution performance, workload, situation awareness, and trust in and dependence on the CRA aid, respectively. **Results:** Imposing the CRA automation did increase performance and reduce workload as compared with manual performance. The CRA aid did not decrease situation awareness. The benefits of the CRA aid were manifest even when it was imperfectly reliable and were apparent across traffic loads. In the unreliable blocks, trust in the CRA aid was degraded but dependence was not influenced, yet the performance was not adversely affected. **Conclusion:** The use of CRA aid would benefit ATC operations across traffic densities. **Application:** CRA aid offers benefits across traffic densities, regardless of its imperfection, as long as its reliability level is set above the threshold of assistance, suggesting its application for future ATC.

- **Keywords:** automation, human–automation interaction, air traffic control, conflict resolution, mental workload, situation awareness

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Barbir, Ana, Janelli, Mark V., Lin, Michael Y., Dennerlein, Jack T. Effects of Epinephrine Auto-Injector Shape and Size on Human Factors Influencing Drug Delivery. Pages 1020-1030.

Objective: The aim of this study was to assess the effects of (a) auto-injector form factor on maximum applied force capability and (b) auto-injector design and instructions on force production and orientation. **Background:** Effective delivery of epinephrine through an auto-injector is the result of a multitude of design factors. At minimum, the design needs to allow the user to apply sufficient force for the needle to penetrate clothing and tissue. **Method:** Trainer devices for three commercially available epinephrine auto-injectors with different form factors (cylindrical, elliptical, prismatic) were tested in a laboratory-based repeated-measures experiment with 20 adults. Participants applied their maximum force onto a force plate positioned over their thigh and practiced an injection using the trainer device after viewing training videos. Participants also rated force confidence and preference. **Results:** The maximum force varied significantly across devices. The greatest force observed was 64 newtons with the elliptical device, and the lowest force was 61 newtons with the cylindrical device. Participants reported the highest force confidence when using the elliptical and cylindrical devices, ranking the elliptical as their preferred device. **Conclusion:** Force capability

results for the elliptical device suggest that it may be more successful in achieving the necessary force for drug delivery in a larger set of adult users. **Application:** Results suggest that the auto-injector with the elliptical form may enable more successful drug delivery among a larger set of users.

- **Keywords:** product design, medical devices and technologies, critical care, emergency medicine and resuscitation, simulation training

COGNITION

Pilcher, June J., Jennings, Kristen S., Phillips, Ginger E., McCubbin, James A. Auditory Attention and Comprehension During a Simulated Night Shift: Effects of Task Characteristics. Pages 1031-1043.

Objective: The current study investigated performance on a dual auditory task during a simulated night shift. **Background:** Night shifts and sleep deprivation negatively affect performance on vigilance-based tasks, but less is known about the effects on complex tasks. Because language processing is necessary for successful work performance, it is important to understand how it is affected by night work and sleep deprivation.

Method: Sixty-two participants completed a simulated night shift resulting in 28 hr of total sleep deprivation. Performance on a vigilance task and a dual auditory language task was examined across four testing sessions. **Results:** The results indicate that working at night negatively impacts vigilance, auditory attention, and comprehension. The effects on the auditory task varied based on the content of the auditory material. When the material was interesting and easy, the participants performed better. Night work had a greater negative effect when the auditory material was less interesting and more difficult. **Conclusion:** These findings support research that vigilance decreases during the night. The results suggest that auditory comprehension suffers when individuals are required to work at night. Maintaining attention and controlling effort especially on passages that are less interesting or more difficult could improve performance during night shifts. **Application:** The results from the current study apply to many work environments where decision making is necessary in response to complex auditory information. Better predicting the effects of night work on language processing is important for developing improved means of coping with shiftwork.

- **Keywords:** sleep, work/rest cycles, circadian rhythms, human performance modeling, dual task, information processing, attentional processes

Lacherez, Philippe, Donaldson, Liam, Burt, Jennifer S. Do Learned Alarm Sounds Interfere With Working Memory? Pages 1044-1051.

Objective: To assess whether identifying (or ignoring) learned alarm sounds interferes with performance on a task involving working memory. **Background:** A number of researchers have suggested that auditory alarms could interfere with working memory in complex task environments, and this could serve as a caution against their use. Changing auditory information has been shown to interfere with serial recall, even when the auditory information is to be ignored. However, previous researchers have not examined well-learned patterns, such as familiar alarms. **Method:** One group of participants learned a set of alarms (either a melody, a rhythmic pulse, or a spoken nonword phrase) and subsequently undertook a digits-forward task in three conditions (no alarms, identify the alarm, or ignore the alarm). A comparison group undertook the baseline and ignore conditions but had no prior exposure to the alarms. **Results:** All alarms interfered with serial recall when participants were asked to identify them; however, only the nonword phrase interfered with recall when ignored. Moreover, there was no difference between trained and untrained participants in terms of recall performance when ignoring the alarms, suggesting that previous training does not make alarms less ignorable.

Conclusion: Identifying any alarm sound may interfere with immediate working

memory; however, spoken alarms may interfere even when ignored. **Application:** It is worth considering the importance of alarms in environments requiring high working memory performance and in particular avoiding spoken alarms in such environments.

- **Keywords:** learning, auditory alarms, distraction, interference, working memory

Loft, Shayne, Morrell, Daniel B., Ponton, Kate, Braithwaite, Janelle, Bowden, Vanessa, Huf, Samuel. *The Impact of Uncertain Contact Location on Situation Awareness and Performance in Simulated Submarine Track Management.* Pages 1052-1068.

Objective: The aim of these studies was to examine the extent to which uncertainty in contact location in submarine track management affected operator situation awareness (SA), workload, and performance and whether operator SA predicted unique variance in performance. **Background:** We extend prior research by manipulating uncertainty in contact location and by including a sample of expert track managers in a submarine combat system. **Method:** In Experiment 1, university students completed a track management task. In Experiment 2, expert submariners were embedded in a real submarine combat system. Uncertainty was manipulated and SA was measured using the situation present assessment method. **Results:** Increased uncertainty led to higher student workload and moderately impaired SA and performance, and SA predicted incremental variance in performance. Uncertainty had no effect on expert SA or the accuracy of the tactical picture compiled. On average, experts took 20 s to accept SA queries (compared with 2.18 s for students). The time taken for experts to accept SA queries, but not their subsequent response to SA queries, was positively associated with their tactical picture accuracy. **Conclusion:** Uncertainty can negatively impact SA, workload, and performance. Some key findings from the laboratory were replicated using experts, but the fact that experts took on average 20 s to accept SA queries presents a challenge for using SPAM in submarine control rooms. **Application:** Contact location is uncertain due to the use of passive sonar and hostile deception. It is essential to measure track manager SA in order to inform work design and training.

- **Keywords:** situation awareness, situation present assessment method, spatial uncertainty, submarine control room, submarine track management

SENSORY AND PERCEPTUAL PROCESSES

Bokharaei, Saleheh, Nasar, Jack L. *Perceived Spaciousness and Preference in Sequential Experience.* Pages 1069-1081.

Objective: We assessed the perceived spaciousness and preference for a destination space in relation to six attributes (size, lighting, window size, texture, wall mural, and amount of furniture) of it and of the space experienced before it. **Background:** Studies have examined effects of these attributes but not for dynamic experience or preference. **Method:** We created 24 virtual reality walks between each possible pair of two levels of each attribute. For each destination space, 31 students (13 men, 18 women) rated spaciousness and 30 students (16 men, 14 women) rated preference. We conducted separate 2×2 repeated-measure ANOVAs across each condition for perceived spaciousness and preference. **Results:** Participants judged the space that was larger, was more brightly lit, with a larger window, or with less furniture as the more spacious. These attributes also increased preference. Consonant with adaptation-level theory, participants judged offices as higher in spaciousness and preference if preceded by a space that was smaller, was more dimly lit, or had smaller windows. **Conclusion:** The findings suggest that perceived spaciousness varies with size, lightness, window size, and amount of furniture but that perception also depends on the size, lightness, and size of the space experienced before. **Application:** Designers could use the findings to manipulate features to make a space appear larger or more desirable.

- **Keywords:** architecture, environmental design, workspace, workstation, built environment, design, environmental design, affective factors, social processes, psychometrics, scaling, methods and skills, virtual environments, simulation and virtual reality, environmental design, illumination, physical/ambient environment

SIMULATION AND VIRTUAL REALITY

Deutsch, Ellen S., Dong, Yue, Halamek, Louis P., Rosen, Michael A., Taekman, Jeffrey M., Rice, John. *Leveraging Health Care Simulation Technology for Human Factors Research: Closing the Gap Between Lab and Bedside.* Pages 1082-1095.

Objective: We describe health care simulation, designed primarily for training, and provide examples of how human factors experts can collaborate with health care professionals and simulationists—experts in the design and implementation of simulation—to use contemporary simulation to improve health care delivery. **Background:** The need—and the opportunity—to apply human factors expertise in efforts to achieve improved health outcomes has never been greater. Health care is a complex adaptive system, and simulation is an effective and flexible tool that can be used by human factors experts to better understand and improve individual, team, and system performance within health care. **Method:** Expert opinion is presented, based on a panel delivered during the 2014 Human Factors and Ergonomics Society Health Care Symposium. **Results:** Diverse simulators, physically or virtually representing humans or human organs, and simulation applications in education, research, and systems analysis that may be of use to human factors experts are presented. Examples of simulation designed to improve individual, team, and system performance are provided, as are applications in computational modeling, research, and lifelong learning. **Conclusion:** The adoption or adaptation of current and future training and assessment simulation technologies and facilities provides opportunities for human factors research and engineering, with benefits for health care safety, quality, resilience, and efficiency. **Application:** Human factors experts, health care providers, and simulationists can use contemporary simulation equipment and techniques to study and improve health care delivery.

- **Keywords:** simulation, patient safety, health care, systems, health care quality

SURFACE TRANSPORTATION

Levulis, Samuel J., DeLucia, Patricia R., Oberfeld, Daniel. *Effects of Adjacent Vehicles on Judgments of a Lead Car During Car Following.* Pages 1096-1111.

Objective: Two experiments were conducted to determine whether detection of the onset of a lead car's deceleration and judgments of its time to contact (TTC) were affected by the presence of vehicles in lanes adjacent to the lead car. **Background:** In a previous study, TTC judgments of an approaching object by a stationary observer were influenced by an adjacent task-irrelevant approaching object. The implication is that vehicles in lanes adjacent to a lead car could influence a driver's ability to detect the lead car's deceleration and to make judgments of its TTC. **Method:** Displays simulated car-following scenes in which two vehicles in adjacent lanes were either present or absent. Participants were instructed to respond as soon as the lead car decelerated (Experiment 1) or when they thought their car would hit the decelerating lead car (Experiment 2). **Results:** The presence of adjacent vehicles did not affect response time to detect deceleration of a lead car but did affect the signal detection theory measure of sensitivity d' and the number of missed deceleration events. Judgments of the lead car's TTC were shorter when adjacent vehicles were present and decelerated early than when

adjacent vehicles were absent. **Conclusion:** The presence of vehicles in nearby lanes can affect a driver's ability to detect a lead car's deceleration and to make subsequent judgments of its TTC. **Application:** Results suggest that nearby traffic can affect a driver's ability to accurately judge a lead car's motion in situations that pose risk for rear-end collisions.

- **Keywords:** driving, time to collision, collision perception, rear-end collision