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AT THE FOREFRONT OF HF/E

Frank A. Drews, Lindsay C. Visnovsky, Jeanmarie Mayer. *Human Factors Engineering Contributions to Infection Prevention and Control*. S. 693–701.

Objective: This article provides a review of areas that present significant challenges in infection prevention and control and describes human factors engineering (HFE) approaches that have been applied successfully to these areas. In addition, implications and recommendations for HFE use in future research are discussed. **Background:** Infection prevention and control aims to prevent patients and health care personnel from acquiring preventable infections in healthcare. Effective infection control practices of healthcare-associated infections have recently become even more critical with the emergence of life-threatening infections. HFE could benefit infection prevention and control in addressing older and more recent challenges, but uptake has been limited. **Method/Results:** This literature review is an integration and synthesis of recently published research that describes HFE-based approaches in infection prevention and control to address the challenges for three specific topics. The results of the review suggests that HFE is in a position to support work in infection prevention and control and improve overall healthcare safety. **Conclusion:** HFE provides conceptual frameworks and methods that have significant potential to improve infection prevention and control. **Application:** The work reviewed can provide potential solutions for current infection prevention and control challenges by applying HFE based recommendations.

- **Keywords:** infection prevention and control, personal protective equipment, hand hygiene, bloodstream infections, adherence engineering

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Xingyu Chen, Xingda Qu. *Age-Related Differences in the Relationships Between Lower-Limb Joint Proprioception and Postural Balance*. S. 702–711.

Objective: In the present study we aimed to investigate the relationships between lower-limb joint proprioception and postural balance. Age-related differences in such relationships were also identified. **Background:** Impaired postural balance is reportedly one of the most common risk factors for fall accidents. Interventions have been proposed to improve postural balance by enhancing proprioceptive feedback. However, there is still no consensus on the optimal design for these interventions; therefore, there is a need to better reveal the contributions of lower-limb joint proprioception to postural balance. **Method:** Twenty-eight young and 28 older adults participated. Lower-limb joint proprioception was assessed by joint position sense errors measured at the ankle, knee, and hip of the dominant side, respectively. Postural balance was assessed by using center-of-pressure measures during bilateral static stance. **Results:** Ankle joint position sense error was positively correlated with root mean squared distance of the center of pressure in the anterior-posterior and medial-lateral directions in both young and older adults. Different from young adults, hip joint position sense error was positively correlated with root mean squared distance of the center of pressure in the anterior-posterior and medial-lateral directions in older adults only. **Conclusion:** Declined ankle and hip proprioception could be risk factors for falls in older adults. Age-related differences in the effects of hip proprioception suggests that hip proprioception is more important for maintaining balance in older adults. Ankle proprioception contributes the most to balance maintenance. Thus, ankle proprioception enhancement exercises should be considered in fall prevention interventions.

- **Keywords:** fall accidents, lower-limb joint proprioception, postural balance, joint position sense, center of pressure

Xueke Wang, Steven A. Lavender, Carolyn Sommerich. *The Effects of Load Stability and Visual Access During Asymmetric Lifting Tasks on Back and Upper Extremity Biomechanical Responses.* S. 712–721.

Objective: To explore the change of muscular and biomechanical responses in different load stability and visual access conditions during an asymmetric lifting task. **Background:** Previous studies found that lifting unstable loads resulted in changes to the biomechanical loads experienced by the spine and upper extremities. However, researchers have not extensively investigated behaviors when people lift potentially unstable loads. It was hypothesized that lifting a potentially unstable load can lead to changes in lifting behavior, which may be mitigated by visual access to the load. **Method:** Fourteen volunteers lifted either a stable load or a potentially unstable load that could move within the container during the lifting task. In half of the lifting conditions, the box was covered to restrict visual access when lifting. Spine kinematic and kinetic measures and surface electromyographic (EMG) signals from back, shoulder, and arm muscles were obtained. **Results:** Lifts of the stable load were faster and generally had higher peak muscle activations than lifts of the potentially unstable load. Participants had less spine flexion when handling the potentially unstable load without visual access. **Conclusion:** When lifting and moving a potentially unstable load that could lead to a perturbation, people tended to lift the container more slowly comparing with lifting a stable load, which in turn reduced the peak muscle activities. **Application:** In industry, there are many work situations where workers need to lift or carry unstable loads that can shift during transport. Providing visual access to the load may help mitigate some of these effects.

- **Keywords:** container design, unstable load, sudden loading, musculoskeletal disorders

Federico Quinzi, Martina Scalia, Arrigo Giombini, Alessandra Di Cagno, Fabio Pigozzi, Maurizio Casasco, Andrea Macaluso. *The Effect of an*

Orthotic Device for Balancing Neck Muscles During Daily Office Tasks. S. 722–735.

Objective: This study aimed at evaluating the acute effect of the combined and single use of two orthotic devices (neck balance system [NBS] and lumbar support [LS]) on muscle activity of neck and back muscles during typical computer working tasks.

Background: An excessive activation of neck muscles could threaten the balance between agonist and antagonist muscles, resulting in a lower stability of the head and possibly leading to neck pain. At present, no study evaluated the effect of a specific orthotic device in reducing neck muscles activation. **Methods:** Surface electromyography (sEMG) from neck flexor (sternocleidomastoid [SCMD]) and extensor muscles (semispinalis capitis [SPC]) and back extensor muscles (erector spinae [ERS]) of 20 healthy individuals was recorded during three computer working tasks performed with the NBS, with NBS and LS, with the LS, and without devices (ND). **Results:** In the NBS condition, the SPC showed a reduced activation (NBS = 3.97%; NBS + LS = 4.49%; LS = 4.48%; ND = 4.61% of the maximal voluntary contraction) compared to the other conditions. **Conclusions:** The use of the NBS promotes a reduction of neck extensor muscles, possibly due to the inertial mass added in the occipital part of the head, producing an external neck extensor moment that cooperates with that produced by neck extensor muscles. **Application:** Orthotic devices such as the NBS may be used by computer workers to reduce the activation of their neck extensor muscles and possible risks of developing neck pain.

- **Keywords:** sEMG, neck balance system, orthotic devices, neck muscles

Sam Chesebrough, Babak Hejrati, John Hollerbach. The Treadport: Natural Gait on a Treadmill. S. 736–748.

Objective: To evaluate the differences between walking on an advanced robotic locomotion interface called the Treadport and walking overground with healthy subjects.

Background: Previous studies have compared treadmill-based and overground walking in terms of gait parameters. The Treadport's unique features including self-selected speed capability, large belt, kinesthetic force feedback, and virtual reality environment distinguish it from other locomotion interfaces and could provide a natural walking experience for the users. **Method:** Young, healthy subjects (N = 17) walked 10 meters 10 times each for both overground and the Treadport environments. Comparison between walking conditions used spatiotemporal and kinematic parameters. In addition, electromyographic data was collected for five of the 17 subjects to compare muscle activity between the two conditions. **Results:** Gait on the Treadport was found to have no significant differences ($p > .05$) with overground walking in terms of hip and knee joint angles, cadence and stride length and stride speed, and muscle activation of the four muscle groups measured. Differences ($p < .05$) were observed in ankle dorsiflexion which was reduced by 2.47 ± 0.01 degrees on the Treadport. **Conclusion:** Walking overground and on the Treadport is highly correlated and not significantly different in 13 of 14 parameters. **Application:** This study suggests that the Treadport creates an environment for natural walking experience, where natural gait of users is almost preserved, with great potential to be useful for other applications, such as gait rehabilitation of individuals with walking impairments.

- **Keywords:** assistive technologies, biomechanics, electromyography (EMG), kinematics, rehabilitation, virtual environments

COGNITION

Lisa Vangsness, Michael Young. *Central and Peripheral Cues to Difficulty in a Dynamic Task*. S. 749–762.

Objective: We used this experiment to determine the degree to which cues to difficulty are used to make judgments of difficulty (JODs). **Background:** Traditional approaches involve seeking to standardize the information people used to evaluate subjective workload; however, it is likely that conscious and unconscious cues underlie peoples' JODs. **Method:** We designed a video game task that tested the degree to which time-on-task, performance-based feedback, and central cues to difficulty informed JODs. These relationships were modeled along five continuous dimensions of difficulty. **Results:** Central cues most strongly contributed to JODs; judgments were supplemented by peripheral cues (performance-based feedback and time-on-task) even though these cues were not always valid. In addition, participants became more likely to rate the task as "easier" over time. **Conclusion:** Although central cues are strong predictors of task difficulty, people confuse task difficulty (central cues), effort allocation and skill (performance-based feedback), and proxy cues to difficulty (time) when making JODs. **Application:** Identifying the functional relationships between cues to difficulty and JODs will provide valuable insight regarding the information that people use to evaluate tasks and to make decisions.

- **Keywords:** dynamic environments, mathematical modeling, task difficulty, judgments of difficulty, subjective workload

Justin G. Hollands, Tzvi Spivak, Eric W. Kramkowski. *Cognitive Load and Situation Awareness for Soldiers: Effects of Message Presentation Rate and Sensory Modality*. S. 763–773.

Objective: We sought to determine the influence of message presentation rate (MPR) and sensory modality on soldier cognitive load. **Background:** Soldiers commonly communicate tactical information by radio. The Canadian Army is equipping soldiers with a battle management system (BMS), which also allows them to communicate by text. **Method:** We varied presentation modality (auditory vs. visual) and MPR (fast or slow) in an experiment involving a tactical scenario. Participants (soldiers) received messages and periodically provided situation reports to higher level command, and the scored reports were used to provide a measure of situation awareness (SA). The detection response task (DRT) and NASA-TLX were used to measure cognitive load. **Results:** The fast MPR reduced DRT accuracy and increased response times relative to slow MPR. The NASA-TLX results also showed higher subjective workload ratings for several subscales with fast MPR. Messages presented visually produced greater cognitive load, with slower DRT response times for the visual than the auditory condition. SA scores were higher with slower MPR and auditory presentation. There was no statistical interaction of presentation modality and rate for any measure. **Conclusion:** Fast MPR and visual presentation increased cognitive load and degraded SA. **Application:** These findings show that the DRT can be used to measure workload effectively in a tactical military context and that the method of information presentation affects how soldiers process information in a BMS.

- **Keywords:** mental workload, cognitive load, situation awareness, detection response task

DISPLAYS AND CONTROL

Lisa Graichen, Matthias Graichen, Josef F. Krems. *Evaluation of Gesture-Based In-Vehicle Interaction: User Experience and the Potential to Reduce Driver Distraction*. S. 774–792.

Objective: We observe the effects of in-vehicle system gesture-based interaction versus touch-based interaction on driver distraction and user experience. **Background:** Driver distraction is a major problem for traffic safety, as it is a contributing factor to a number of accidents. Visual distraction in particular has a highly negative impact on the driver. One possibility for reducing visual driver distraction is to use new forms of interaction in the vehicle, such as gesture-based interaction. **Method:** In this experiment, participants drove on a motorway or in a city scenario while using touch-based interaction or gesture-based interaction. Subjective data, such as acceptance and workload, and objective data, including glance behavior, were gathered. **Results:** As a result, participants rated their subjective impressions of safe driving as higher when using gesture-based interaction. More specifically, acceptance and attractiveness were higher, and workload was lower. The participants performed significantly fewer glances to the display and the glances were much shorter. **Conclusion:** Gestures are a positive alternative for in-vehicle interaction since effects on driver distraction are less significant when compared to touch-based interaction. **Application:** Potential application of this research includes interaction design of typical in-vehicle information and entertainment functions.

- **Keywords:** in-vehicle interaction systems (IVIS), human-machine interaction (HMI), driver distraction

HEALTH CARE/HEALTH SYSTEMS

Natalie R. Lodinger, Patricia R. DeLucia. *Angle of Camera View Influences Resumption Lag in a Visual-Motor Task*. S. 793–804.

Objective: To determine whether top-view and side-view camera angles, which putatively impose different cognitive demands, differentially affect the resumption lag in a visual-motor task relevant to laparoscopic surgery. **Background:** Prior research showed that the time to resume a primary task after performing an interrupting task (resumption lag) increases with increases in the subjective workload of the primary task. Camera views used in laparoscopic surgery provide different views of the anatomy and have different cognitive costs and associated levels of workload. **Method:** Participants completed a peg transfer task while interrupted with a mental rotation task of different durations and angles of stimulus rotation. **Results:** Participants required significantly more time to resume the peg transfer task when using a side view than a top view and when interrupted for a longer duration. Participants' ratings of subjective workload were consistent with these patterns of performance data; the side view resulted in longer resumption lags and was rated as greater in mental demand. Additionally, the time needed to resume the peg transfer task decreased across trials for both views. **Conclusion:** More time is required to resume an interrupted visual-motor task when it is more cognitively demanding than when it is less cognitively demanding possibly due to needing more time to learn the visual-motor mapping of the task higher in cognitive demand. **Application:** Training for laparoscopic surgery should include interruptions to allow surgeons to practice resuming a surgery-related task after an interruption and consequently shorten the time needed to resume the surgery-related task.

- **Keywords:** interruptions, resumption lag, laparoscopic camera view

HUMAN-ROBOT INTERACTION

William G. Volante, Janine Sosna, Theresa Kessler, Tracy Sanders, P. A. Hancock. *Social Conformity Effects on Trust in Simulation-Based Human-Robot Interaction*. S. 805–815.

Objective: We investigated the co-acting influences of communication and social conformity on trust in human-robot interaction. **Background:** Previous work has investigated aspects of the robot, the human, and the environment as influential factors in the human-robot relationship. Little work has examined the conjoint effects of social conformity and communication on this relationship. As social conformity and communication have been shown to affect human-human trust, there are a priori reasons to believe that they will play an influential role in human-robot trust also. **Method:** The experiment examined the influences of social conformity and robot communication on trust. A 2 × 2 (communication × social group) design was implemented with each variable having two levels (communication, no communication; positive social group, negative social group). **Results:** We created a communication manipulation which we then demonstrated to mediate the trust level between human and robot. However, this influence on trust was overcome by social information in which the subsequent trust level, attributed to the robot, was dominated by expressed social group attitudes to that robot. **Conclusion:** The results confirm the importance of human social assessments over direct robot communication in setting human-robot trust levels. When social opinions are expressed, observers appear to conform to the trust displayed by the group than relying on their own judgment. **Application:** In human-robot teams, the perceptions of the group may exert a greater impact than even robot communication. This may be especially important when new human members are introduced into such teams.

- **Keywords:** HRI, trust, social conformity, communication, individual differences

MACROERGONOMICS AND THE ENVIRONMENT

Pankaj Parag Sharma, Ranjana K. Mehta, Adam Pickens, Gang Han, Mark Benden. *Sit-Stand Desk Software Can Now Monitor and Prompt Office Workers to Change Health Behaviors*. S. 816–824.

Objective: To determine the effectiveness of a computer-based intervention designed to increase sit-stand desk usage and help reverse workplace physical inactivity. **Background:** Sit-stand desks have been successful in reducing workplace sedentary behavior, but the challenge remains for an effective method to increase the usage in order to experience the health and productivity benefits. **Method:** Data collection (1-year field study with 194 workers) used a novel method of computer software that continuously recorded objective electric sit-stand desk usage, while taking into account the time a worker spends away from their desk (breaks, meetings). During the baseline period, all workers' desk usage was recorded by the software, and the intervention period consisted of software reminders and real-time feedback to all workers to change desk positions. Pooled means were calculated to determine desk usage patterns, and effect sizes and pairwise mean differences were analyzed to test for intervention significance. **Results:** The intervention doubled desk usage by increasing ~1 change to ~2 changes per work day. There was a 76% reduction in workers who never used the sit-stand function of the desk. Medium to large effect sizes from the intervention were observed in all three primary outcome measures (desk in sitting/standing position and desk position changes per work day). **Conclusion:** These findings demonstrate an effective intervention that increased postural transitioning and interrupted prolonged inactivity while remaining at the workstation. **Application:** The methods and results in this

research study show that we can quantify an increase in desk usage and collect aggregate data continuously.

- **Keywords:** workplace ergonomics, software, workstation, work measurement

SPECIAL POPULATIONS

Mark W. Wiggins, Barbara Griffin, Sue Brouwers. *The Potential Role of Context-Related Exposure in Explaining Differences in Water Safety Cue Utilization*. S. 825–838.

Objective: To examine whether differences in water safety-related cue utilization might be associated with differences in exposure to water-related recreational contexts. **Background:** A disproportionate number of incidents of drowning were attributable to recent visitors to New South Wales in the 2016–2017 summer swimming season. This was due to their assumed lack of exposure to the water-related recreational settings in which Australians engage and therefore, the absence of cues that are associated with danger. **Method:** In Study 1, the water safety cue utilization of 101 Australian residents and 328 recent visitors to the country was compared using the Expert Intensive Skills Evaluation (EXPERTise 2.0) program. Accounting for differences between the samples, Australian residents demonstrated significantly superior water safety cue utilization. In Study 2, the water safety cue utilization of a sample of 219 Australian residents was examined, the outcomes of which indicated that those participants who learned to swim before the age of 11 years demonstrated superior water safety cue utilization to participants who learned to swim at a later age. **Results:** Overall, the results suggest that there are individual differences in water safety cue utilization that are explained, in part, by differences in country of residence and the age at which participants first learned to swim. **Conclusion:** Water safety cue utilization is likely to be dependent upon exposure to water-related activities. Identifying individual differences enables the development of more targeted, drowning-prevention strategies.

- **Keywords:** drowning, water safety, cue utilization

SURFACE TRANSPORTATION

Fabienne Roche, Anna Somieski, Stefan Brandenburg. *Behavioral Changes to Repeated Takeovers in Highly Automated Driving: Effects of the Takeover-Request Design and the Nondriving-Related Task Modality*. S. 839–849.

Objective: We investigated drivers' behavior and subjective experience when repeatedly taking over their vehicles' control depending on the design of the takeover request (TOR) and the modality of the nondriving-related task (NDRT). **Background:** Previous research has shown that taking over vehicle control after highly automated driving provides several problems for drivers. There is evidence that the TOR design and the NDRT modality may influence takeover behavior and that driver behavior changes with more experience. **Method:** Forty participants were requested to resume control of their simulated vehicle six times. The TOR design (auditory or visual-auditory) and the NDRT modality (auditory or visual) were varied. Drivers' takeover behavior, gaze patterns, and subjective workload were recorded and analyzed. **Results:** Results suggest that drivers change their behavior to the repeated experience of takeover situations. An auditory TOR leads to safer takeover behavior than a visual-auditory TOR. And with an auditory TOR,

the takeover behavior improves with experience. Engaging in the visually demanding NDRT leads to fewer gazes on the road than the auditory NDRT. Participants' fixation duration on the road decreased over the three takeovers with the visually demanding NDRT. **Conclusions:** The results imply that (a) drivers change their behavior to repeated takeovers, (b) auditory TOR designs might be preferable over visual-auditory TOR designs, and (c) auditory demanding NDRTs allow drivers to focus more on the driving scene. **Application:** The results of the present study can be used to design TORs and determine allowed NDRTs in highly automated driving.

- **Keywords:** auditory displays, driver behavior, eye tracking, human-automation interaction, interface evaluation, vehicle automation, visual displays