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INVITED REVIEW ARTICLE

Kristy Martin, Emily McLeod, Julien Périard, Ben Rattray, Richard Keegan, David B. Pyne. *The Impact of Environmental Stress on Cognitive Performance: A Systematic Review*. S. 1205–1246.

Objective: In this review, we detail the impact of environmental stress on cognitive and military task performance and highlight any individual characteristics or interventions which may mitigate any negative effect. **Background:** Military personnel are often deployed in regions markedly different from their own, experiencing hot days, cold nights, and trips both above and below sea level. In spite of these stressors, high-level cognitive and operational performance must be maintained. **Method:** A systematic review of the electronic databases Medline (PubMed), EMBASE (Scopus), PsycINFO, and Web of Science was conducted from inception up to September 2018. Eligibility criteria included a healthy human cohort, an outcome of cognition or military task performance and assessment of an environmental condition. **Results:** The search returned 113,850 records, of which 124 were included in the systematic review. Thirty-one studies examined the impact of heat stress on cognition; 20 of cold stress; 59 of altitude exposure; and 18 of being below sea level. **Conclusion:** The severity and duration of exposure to the environmental stressor affects the degree to which cognitive performance can be impaired, as does the complexity of the cognitive task and the skill or familiarity of the individual performing the task. **Application:** Strategies to improve cognitive performance in extreme environmental conditions should focus on reducing the magnitude of the physiological and perceptual disturbance caused by the stressor. Strategies may include acclimatization and habituation, being well skilled on the task, and reducing sensations of thermal stress with approaches such as head and neck cooling.

- **Keywords:** heat, altitude, cognition, soldier, army

AGING

Pui-Ling Li, Kit-Lun Yick, Sun-Pui Ng, Joanne Yip. *Influence of Textured Indoor Footwear on Posture Stability of Older Women Based on Center-of-Pressure Measurements*. S. 1247–1260.

Objective: The objective of this study is to evaluate the efficacy of indoor footwear with a textured surface to improve control of balance and reduce excessive plantar pressure in older women. **Background:** Balance instability is a common condition in older people. Textured insoles with protrusions on the entire insole have been examined for enhancing somatosensory feedback in the elderly to improve control over balance. However, these insoles have significant challenges in distributing the plantar pressure. Textured insoles with tailored protrusions should be therefore investigated for the same purpose but provide better plantar pressure distribution. **Method:** A total of 24 older women have undergone both static standing and walking tests with the use of the in-shoe Pedar® system. **Results:** The results indicate that wearing textured indoor footwear provides a significant reduction in postural sway, particularly in the medial–lateral direction during walking. As compared to walking barefoot, the center-of-pressure trajectory when wearing the textured indoor footwear remains supported with less variance among the steps, which is statistically significant in the medial–lateral direction. A significant reduction in the peak pressure is found in the forefoot and rearfoot regions as the plantar pressure is redistributed to the midfoot regions. **Conclusion:** The textured surface of the insole improves balance control of older women and effectively reduces foot pressure at high pressure areas. **Application:** The findings enhance current understanding on textured footwear as a form of intervention associated with changes in functional impairments, therefore providing basis for footwear design in balance control.

- **Keywords:** age, textured indoor footwear, center of pressure, postural stability, women

AUTOMATION, EXPERT SYSTEMS

John Gaspar, Cher Carney. *The Effect of Partial Automation on Driver Attention: A Naturalistic Driving Study*. S. 1261–1276.

Objective: This naturalistic driving study investigated how drivers deploy visual attention in a partially automated vehicle. **Background:** Vehicle automation is rapidly increasing across vehicle fleets. This increase in automation will likely have both positive and negative consequences as drivers learn to use the new technology. Research is needed to understand how drivers interact with partially automated vehicle systems and what impact new technology has on driver attention. **Method:** Ten participants drove a Tesla Model S for 1 week during their daily commute on a stretch of busy interstate. Drivers were instructed to use Autopilot, a system that provides both lateral and longitudinal control, as much as they felt comfortable while driving on the interstate. Driver-facing video data were recorded and manually reduced to examine glance behavior. **Results:** Drivers primarily allocated their visual attention between the forward roadway (74% of glance time) and the instrument panel (13%). With partial automation engaged, drivers made longer single glances and had longer maximum total-eyes-off-road time (TEORT) associated with a glance cluster. **Conclusion:** These results provide a window into the nature of visual attention while driving with partial vehicle automation. The results suggest that drivers may be more willing to execute long, “outlier” glances and clusters of glances to off-road locations with partial automation. The findings highlight several important human factors considerations for partially automated vehicles.

- **Keywords:** automation, L2 vehicles, distraction, glance behavior, autopilot, ADAS

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Neal Wiggermann, Bruce Bradtmiller, Sue Bunnell, Cathy Hildebrand, John Archibeque, Sheila Ebert, Matthew P. Reed, Monica L. H. Jones.

[Anthropometric Dimensions of Individuals With High Body Mass Index.](#)
S. 1277–1296.

Objective: This study presents anthropometric data for individuals with high body mass index (BMI). Modified anthropometric dimensions were also developed to address the challenges of obtaining accurate and repeatable data for this population segment. **Background:** The prevalence of obesity affects approximately 40% of the U.S. adult population. Anthropometric data are needed to guide product design and safety, but few individuals with high BMI have been measured in available datasets. **Method:** Anthropometric data for a convenience sample of 288 adults with high BMI (≥ 30 kg/m²) were collected. To increase participation and minimize participant discomfort, measurements were collected at three bariatric weight loss clinics and one academic research institution. **Results:** The current obese cohort are heavier than the U.S. general population, with a difference in mean body weight of 47 kg for women and 56 kg for men. The obese cohort are also heavier and have a higher BMI compared with the NIOSH (National Institute for Occupational Safety and Health) truck driver population. Waist circumferential measures of the current obese cohort were larger than women or men in either population compared, a result indicative of meaningful body shape differences. **Conclusion:** To our knowledge, this study is the first to collect anthropometric data for the obese population segment and conduct comparisons to the U.S. general population and available occupational databases. The obese cohort differed substantially with respect to the distributions of anthropometric variables. **Application:** These data provide insights about the obese population segment that are relevant to product design, and establish a foundation for future data collection efforts.

- **Keywords:** obesity, anthropometry, bariatric, accommodation

DISPLAYS AND CONTROL

Markus Janczyk, Aiping Xiong, Robert W. Proctor. *Stimulus-Response and Response-Effect Compatibility With Touchless Gestures and Moving Action Effects.* S. 1297–1314.

Objective: To determine whether response-effect (R-E) compatibility or stimulus-response (S-R) compatibility is more critical for touchless gesture responses. **Background:** Content on displays can be moved in the same direction (S-R incompatible but R-E compatible) or opposite direction (S-R compatible but R-E incompatible) as the touchless gesture that produces the movement. Previous studies suggested that it is easier to produce a button-press response when it is R-E compatible (and S-R incompatible). However, whether this R-E compatibility effect also occurs for touchless gesture responses is unknown. **Method:** Experiments 1 and 2 employed an R-E compatibility manipulation in which participants made responses with an upward or downward touchless gesture that resulted in the display content moving in the same (compatible) or opposite (incompatible) direction. Experiment 3 employed an S-R compatibility manipulation in which the stimulus occurred at the upper or lower location on the screen. **Results:** Overall, only negligible influences of R-E compatibility on performing the touchless gestures were observed (in contrast to button-press responses), whereas S-R compatibility heavily affected the gestural responses. **Conclusion:** The R-E compatibility obtained in many previous studies with various types of responses appears not to hold for touchless gestures as responses. **Application:** The results suggest that in the design of touchless interfaces, unique factors may contribute to determining which mappings of gesture and display movements are preferred by users.

- **Keywords:** display-control compatibility, stimulus-response compatibility, interface design

HEALTH CARE/HEALTH SYSTEMS

Yuval Bitan, Yisrael Parmet, Geva Greenfield, Shelly Teng, Richard I. Cook, Mark E. Nunnally. [*Making Sense of the Cognitive Task of Medication Reconciliation Using a Card Sorting Task.*](#) **S. 1315–1325.**

Objective: To explore cognitive strategies clinicians apply while performing a medication reconciliation task, handling incomplete and conflicting information. **Background:** Medication reconciliation is a method clinicians apply to find and resolve inconsistencies in patients' medications and medical conditions lists. The cognitive strategies clinicians use during reconciliation are unclear. Controlled lab experiments can explore how clinicians make sense of uncertain, missing, or conflicting information and therefore support the development of a human performance model. We hypothesize that clinicians apply varied cognitive strategies to handle this task and that profession and experience affect these strategies. **Method:** 130 clinicians participated in a tablet-based experiment conducted in a large American teaching hospital. They were asked to simulate medication reconciliation using a card sorting task (CaST) to organize medication and medical condition lists of a specific clinical case. Later on, they were presented with new information and were asked to add it to their arrangements. We quantitatively and qualitatively analyzed the ways clinicians arranged patient information. **Results:** Four distinct cognitive strategies were identified ("Conditions first": $n = 76$ clinicians, "Medications first": $n = 7$, "Crossover": $n = 17$, and "Alternating": $n = 10$). The strategy clinicians applied was affected by their experience ($p = .02$) but not by their profession. At the appearance of new information, clinicians moved medication cards more frequently (75.2 movements vs. 49.6 movements, $p < .001$), suggesting that they match medications to medical conditions. **Conclusion:** Clinicians apply various cognitive strategies while reconciling medications and medical conditions. **Application:** Clinical information systems should support multiple cognitive strategies, allowing flexibility in organizing information.

- **Keywords:** medication reconciliation, patient safety, cognitive task, health care information systems, card sorting task"

David P. Azari, Yu Hen Hu, Brady L. Miller, Brian V. Le, Robert G. Radwin. [*Using Surgeon Hand Motions to Predict Surgical Maneuvers.*](#) **S. 1326–1339.**

Objective: This study explores how common machine learning techniques can predict surgical maneuvers from a continuous video record of surgical benchtop simulations. **Background:** Automatic computer vision recognition of surgical maneuvers (suturing, tying, and transition) could expedite video review and objective assessment of surgeries. **Method:** We recorded hand movements of 37 clinicians performing simple and running subcuticular suturing benchtop simulations, and applied three machine learning techniques (decision trees, random forests, and hidden Markov models) to classify surgical maneuvers every 2 s (60 frames) of video. **Results:** Random forest predictions of surgical video correctly classified 74% of all video segments into suturing, tying, and transition states for a randomly selected test set. Hidden Markov model adjustments improved the random forest predictions to 79% for simple interrupted suturing on a subset of randomly selected participants. **Conclusion:** Random forest predictions aided by hidden Markov modeling provided the best prediction of surgical maneuvers. Training of models across all users improved prediction accuracy by 10% compared with a random selection of participants. **Application:** Marker-less video hand tracking can predict surgical maneuvers from a continuous video record with similar accuracy as robot-assisted surgical platforms, and may enable more efficient video review of surgical procedures for training and coaching.

- **Keywords:** computer vision, marker-less hand tracking, machine learning, open surgeries, surgical skills

SIMULATION AND VIRTUAL REALITY

Jonathan Marchetto, W. Geoffrey Wright. *The Validity of an Oculus Rift to Assess Postural Changes During Balance Tasks*. S. 1340–1352.

Objective: To investigate whether shifts in head position, measured via an Oculus Rift head-mounted display (HMD), is a valid measure of whole-body postural stability. **Background:** The inverted single-link pendulum model of balance suggests shifts in whole-body center of mass can be estimated from individual body segments. However, whether head position describes postural stability such as center-of-pressure (COP) remains unclear. **Method:** Participants (N = 10) performed six conditions while wearing an HMD and performing a previously validated virtual reality (VR)-based balance assessment. COP was recorded with a Wii Balance Board force plate (WBB), while an HMD recorded linear and angular head displacement. Visual input was presented in the HMD (stable scene, dark scene, or dynamic scene) and somatosensory information (with or without foam) was varied across each condition. The HMD time series data were compared with the criterion-measure WBB. **Results:** Significant correlations were found between COP measures (standard deviation, range, sway area, velocity) and head-centered angular and linear displacements (roll, pitch, mediolateral and anteroposterior directions). **Conclusions:** The Oculus Rift HMD shows promise as a measure of postural stability without additional posturography equipment. These findings support the application of VR HMD technology for assessment of postural stability across a variety of challenging conditions. **Application:** The human factors and ergonomic benefit of such an approach is in its portability, low cost, and widespread availability for clinic and home-based investigation of postural disturbances. Fall injury affects millions of people annually, so assessment of fall risk and treatment of the underlying causes has enormous public health benefit.

- **Keywords:** virtual environments, posture, balance, fall-risk, medical devices

SURFACE TRANSPORTATION

Koen de Clercq, Andre Dietrich, Juan Pablo Núñez Velasco, Joost de Winter, Riender Happee. [External Human-Machine Interfaces on Automated Vehicles: Effects on Pedestrian Crossing Decisions](#). S. 1353–1370.

Objective: In this article, we investigated the effects of external human-machine interfaces (eHMIs) on pedestrians' crossing intentions. **Background:** Literature suggests that the safety (i.e., not crossing when unsafe) and efficiency (i.e., crossing when safe) of pedestrians' interactions with automated vehicles could increase if automated vehicles display their intention via an eHMI. **Methods:** Twenty-eight participants experienced an urban road environment from a pedestrian's perspective using a head-mounted display. The behavior of approaching vehicles (yielding, nonyielding), vehicle size (small, medium, large), eHMI type (1. baseline without eHMI, 2. front brake lights, 3. Knightrider animation, 4. smiley, 5. text [WALK]), and eHMI timing (early, intermediate, late) were varied. For yielding vehicles, the eHMI changed from a nonyielding to a yielding state, and for nonyielding vehicles, the eHMI remained in its nonyielding state. Participants continuously indicated whether they felt safe to cross using a handheld button, and "feel-safe" percentages were calculated. **Results:** For yielding vehicles, the feel-safe percentages were higher for the front brake lights, Knightrider, smiley, and text, as compared with baseline. For nonyielding vehicles, the feel-safe percentages were equivalent regardless of the presence or type of eHMI, but larger vehicles yielded lower

feel-safe percentages. The Text eHMI appeared to require no learning, contrary to the three other eHMIs. **Conclusion:** An eHMI increases the efficiency of pedestrian-AV interactions, and a textual display is regarded as the least ambiguous. **Application:** This research supports the development of automated vehicles that communicate with other road users.

- **Keywords:** Virtual reality, automated driving, pedestrians, decision-making, crossing, HMI

David L. Strayer, Joel M. Cooper, Madeleine M. McCarty, Douglas J. Getty, Camille L. Wheatley, Conner J. Motzkus, Rachel M. Goethe, Francesco Biondi, William J. Horrey. *Visual and Cognitive Demands of CarPlay, Android Auto, and Five Native Infotainment Systems*. S. 1371–1386.

Objective: The present research compared and contrasted the workload associated with using in-vehicle information systems commonly available in five different automotive original equipment manufacturers (OEMs) with that of CarPlay and Android Auto when used in the same vehicles. **Background:** A growing trend is to provide access to portable smartphone-based systems (e.g., CarPlay and Android Auto) that support an expansion of various in-vehicle infotainment system features and functions. **Method/Results:** The study involved on-road testing of 24 participants in each configuration of five vehicles crossed with the three different infotainment systems: the embedded portion of the native OEM systems, CarPlay, and Android Auto. Our analysis found that workload was significantly greater for the embedded portion of the native OEM systems than for CarPlay and Android Auto. The strengths and weaknesses of each CarPlay and Android Auto traded off in such a way that the overall demand associated with using the two systems did not differ. **Conclusion:** CarPlay and Android Auto provided more functionality and resulted in lower levels of workload than the embedded portion of the native OEM infotainment systems. **Application:** Potential applications of this research include refinements to CarPlay and Android Auto to address variations in workload as a function of task type, the modality of interaction, and OEM implementation of the system.

- **Keywords:** driver distraction, workload, in-vehicle infotainment systems, android auto, carplay