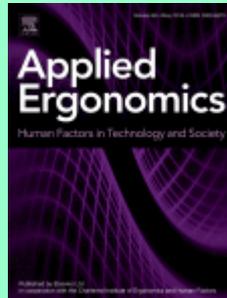


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Yuval Bitan, Scott Ramey, Paul Milgram. *Ergonomic design of new paramedic response bags.*

A two phase project is described for redesigning and evaluating paramedic response bags, one of the key pieces of equipment used by emergency medical services. Adopting a user-centred approach, Phase I involved first educating active service paramedics about ergonomic principles, and then collaborating with them to conceptualise a new type of response bag, based on separate colour coded kits, each containing related equipment items. Phase II describes a formal evaluation study, involving simulated procedures with a patient mannequin and active service paramedics in a real ambulance. Results indicated subjective preferences for the new bags, where 62% of the paramedics believed it was easier to find equipment in the new bag and 65% preferred the new bags overall. No detrimental effects were attributed to the transition to the new bag. Also discussed are the advantages of the participatory design approach, as well as design guidelines and implications for paramedic operations.

- **Keywords:** Emergency medical services; Ergonomic workspace; Paramedic services; Response bags

Ouren X. Kuiper, Jelte E. Bos, Cyriel Diels, Kia Cammaerts. *Moving base driving simulators' potential for carsickness research.*

We investigated whether motion sickness analogous to carsickness can be studied in a moving base simulator, despite the limited motion envelope. Importantly, to avoid simulator sickness, vision outside the simulator cabin was restricted. Participants (N = 16) were exposed blindfolded to 15-min lateral sinusoidal motion at 0.2Hz and 0.35Hz on separate days. These conditions were selected to realize optimal provocativeness of the stimulus given the simulator's maximum displacement and knowledge on frequency-acceleration interactions for motion sickness. Average motion sickness on an 11-point scale was 2.21 ± 1.97 for 0.2Hz and 1.93 ± 1.94 for 0.35Hz. The motion sickness increase over time was comparable to that found in studies using actual vehicles. We argue that motion base simulators can be used to incite motion sickness analogous to carsickness, provided considerable restrictions on vision. Future research on carsickness, potentially more prevalent in autonomous vehicles, could benefit from employing simulators.

- **Keywords:** Carsickness; Simulator sickness; Driving simulator

Greg Hallihan, Jeff K. Caird, Ian Blanchard, Katelyn Wiley, Jessica Martel, Matt Wilkins, Brent Thorkelson, Mike Plato, Gerald Lazarenko. *The evaluation of an ambulance rear compartment using patient simulation: Issues of safety and efficiency during the delivery of patient care.*

The purpose of this study was to evaluate the safety and efficiency of a specific ambulance while providers delivered basic and advanced life support. Forty-eight, Emergency Medical Service (EMS) teams were observed delivering care to a simulated patient during an anaphylaxis scenario in a moving ambulance that contained a complete complement of medical supplies and equipment. A detailed coding system was developed and applied to the audio and video behavioural data. Patterns of interaction among EMS personnel, the patient, equipment and the ambulance interior during the patient simulation scenario were analyzed. The results revealed a number of issues associated with the patient compartment including: potentially unsafe seated and standing positions; hazardous barriers to movement around the patient; difficulties accessing equipment and supplies; and the adequacy of work surfaces and waste disposal. A number of design recommendations are made to guide provider and patient comfort, efficiency and safety.

- **Keywords:** Ambulance design; Provider and patient safety; Human factors evaluation; Patient simulation; Ambulance patient compartment

Carolin Bontrup, William R. Taylor, Michael Fliesser, Rosa Visscher, Tamara Green, Pia-Maria Wippert, Roland Zemp. *Low back pain and its relationship with sitting behaviour among sedentary office workers.*

The relationships between sedentary lifestyle, sitting behaviour, and low back pain (LBP) remain controversial. In this study, we investigated the relationship between back pain and occupational sitting habits in 64 call-centre employees. A textile pressure mat was used to evaluate and parameterise sitting behaviour over a total of 400h, while pain questionnaires evaluated acute and chronic LBP. Seventy-five percent of the participants reported some level of either chronic or acute back pain. Individuals with chronic LBP demonstrated a possible trend (t-test not significant) towards more static sitting behaviour compared to their pain-free counterparts. Furthermore, a greater association was found between sitting behaviour and chronic LBP than for acute pain/disability, which is plausibly due to a greater awareness of pain-free sitting positions in individuals with chronic pain compared to those affected by acute pain.

- **Keywords:** Office chair; Pressure distribution; Low back pain; Sitting behaviour; Dynamic sitting

Ruth Pijls, Mirjam Galetzka, Brenda H. Groen, Ad T.H. Pruyn. *Comfortable seating: The influence of seating comfort and acoustic comfort on customers' experience of hospitality in a self-service restaurant.*

Does comfort in a restaurant influence people's experienced hospitality? Effects of seating comfort and acoustic comfort on the experience of hospitality were examined by means of a 2 x 2 between subjects experiment among 262 customers of a self-service restaurant, using the EH-scale measuring the experiential factors care, comfort and inviting. In line with theory on embodiment, MANOVA and mediation analysis showed that comfortable seating positively influences mental comfort, which subsequently increases the experience of hospitality (comfort factor). Extra ambient sound (acoustic discomfort) cancels out this effect. Also, people's desire to sit matters: people with a low desire to sit interpret comfortable seats as more caring instead of comfort. Regarding the discussion on (dis)comfort: seating comfort, not discomfort, accounted for the effects.

Altogether, the hospitality experienced in a restaurant may be enhanced by offering comfortable seats, making customers feel more comfortable, physically and mentally.

- **Keywords:** Comfort; Seating; Hospitality; Embodiment; Service environment

Annemarie Landman, Simon Davies, Eric L. Groen, M. M. (René) van Paassen, Nicholas J. Lawson, Adelbert W. Bronkhorst, Max Mulder. *In-flight spatial disorientation induces roll reversal errors when using the attitude indicator.*

We hypothesized that an incorrect expectation due to spatial disorientation may induce roll reversal errors. To test this, an in-flight experiment was performed, in which forty non-pilots rolled wings level after receiving motion cues. A No-leans condition (subthreshold motion to a bank angle) was included, as well as a Leans-opposite condition (leans cues, opposite to the bank angle) and a Leans-level condition (leans cues, but level flight). The presence of leans cues led to an increase of the roll reversal error (RRE) rate by a factor of 2.6. There was no significant difference between the Leans-opposite and Leans-level condition. This suggests that the expectation strongly affects the occurrence of an RRE, and that people tend to base their responses on motion cues instead of on information on the AI. We conclude that expectation and spatial disorientation have a large effect on piloting errors and may cause hazardous aircraft upsets.

- **Keywords:** Aviation; Displays; Spatial disorientation; Surprise; Upset recovery

Victoria A. Banks, Neville A. Stanton, Katherine L. Plant. *Who is responsible for automated driving? A macro-level insight into automated driving in the United Kingdom using the Risk Management Framework and Social Network Analysis.*

To date, vehicle manufacturers have largely been left to their own initiatives when it comes to the design, development and implementation of automated driving features. Whilst this has enabled developments within the field to accelerate at a rapid pace, we are also now beginning to see the negative aspects of automated design (e.g., driver complacency, automation misuse and ethical dilemmas). It is therefore becoming increasingly important to identify systemic aspects that can address some of these Human Factors challenges. This paper applies the principles of the Risk Management Framework to explore the wider systemic issues associated with automated driving in the United Kingdom through the novel application of network metrics. The authors propose a number of recommendations targeted at each level of the Risk Management Framework that seek to shift the power of influence away from vehicle manufacturers and back into the hands of governing bodies.

- **Keywords:** Driving automation; Network analysis; Risk management framework; Social network analysis

David R. Large, Kyle Harrington, Gary Burnett, Orestis Georgiou. *Feel the noise: Mid-air ultrasound haptics as a novel human-vehicle interaction paradigm.*

Focussed ultrasound can be used to create the sensation of touch in mid-air. Combined with gestures, this can provide haptic feedback to guide users, thereby overcoming the lack of agency associated with pure gestural interfaces, and reducing the need for vision – it is therefore particularly apropos of the driving domain. In a counter-balanced 2 × 2 driving simulator study, a traditional in-vehicle touchscreen was compared with a virtual mid-air gestural interface, both with and without ultrasound haptics. Forty-eight

experienced drivers (28 male, 20 female) undertook representative in-vehicle tasks – discrete target selections and continuous slider-bar manipulations – whilst driving. Results show that haptifying gestures with ultrasound was particularly effective in reducing visual demand (number of long glances and mean off-road glance time), and increasing performance (shortest interaction times, highest number of correct responses and least 'overshoots') associated with continuous tasks. In contrast, for discrete, target-selections, the touchscreen enabled the highest accuracy and quickest responses, particularly when combined with haptic feedback to guide interactions, although this also increased visual demand. Subjectively, the gesture interfaces invited higher ratings of arousal compared to the more familiar touch-surface technology, and participants indicated the lowest levels of workload (highest performance, lowest frustration) associated with the gesture-haptics interface. In addition, gestures were preferred by participants for continuous tasks. The study shows practical utility and clear potential for the use of haptified gestures in the automotive domain.

- **Keywords:** Ultrasound; Mid-air haptics; Gestures; Visual demand; Touchscreen; Driving

Emil Andersen, Anja Maier. *The attentional guidance of individual colours in increasingly complex displays.*

The use of colours is a prevalent and effective tool for improving design. Understanding the effect of colours on attention is crucial for designers that wish to understand how their interfaces will be used. Previous research has consistently shown that attention is biased towards colour. However, despite previous evidence indicating that colours should be treated individually, it has thus far not been investigated whether this difference is reflected in individual effects on attention. To address this, a visual search experiment was conducted that tested the attentional guidance of six individual colours (red, blue, green, yellow, orange, purple) in increasingly complex displays. Results showed that the individual colours differed significantly in their level of guidance of attention, and that these differences increased as the visual complexity of the display increased. Implications for visual design and future research on applying colour in visual attention research and design are discussed.

- **Keywords:** Colour; Attention; Design; Visual Interfaces; Load

Chia-Fen Chi, Ratna Sari Dewi, Priska Samali, Dong-Yu Hsieh. *Preference ranking test for different icon design formats for smart living room and bathroom functions.*

The current study illustrates the icon design process for 20 functions for a smart living room and smart bathroom of a commercial smart building control system. For each function name, seven icon formats (image-related, concept-related, semi-abstract, arbitrary, word, abbreviation, and combined) were developed by 30 graduate students and compared with a preference ranking test by another 13 executive MBA students. The results indicated that the combined, image-related, concept-related, semi-abstract, word, and abbreviation each had nine, four, three, two, one and one function names ranked as the most preferred format, respectively. Since all the design formats except the arbitrary format were ranked as the most preferred at least once, it is worthwhile to generate seven icon formats for a given function and chose the most preferred based on the ranking test result. The participatory design and ranking test evaluation approach can be applied for the design and evaluation of visual icons in other application contexts.

- **Keywords:** Participatory design; Function-to-object relationship; Icon taxonomy

Dana M. Womack, Nancy N. Vuckovic, Linsey M. Steege, Deborah H. Eldredge, Michelle R. Hribar, Paul N. Gorman. *Subtle cues: Qualitative elicitation of signs of capacity strain in the hospital workplace.*

Through everyday care experiences, nurses develop expertise in recognition of capacity strain in hospital workplaces. Through qualitative interview, experienced nurses identify common activity changes and adaptive work strategies that may signal an imbalance between patient demand and service supply at the bedside. Activity change examples include nurse helping behaviors across patient assignments, increased volume of nurse calls from patient rooms, and decreased presence of staff at the nurses' station. Adaptive work strategies encompass actions taken to recruit resources, move work in time, reduce work demands, or reduce thoroughness of task performance. Nurses' knowledge of perceptible signs of strain provides a foundation for future exploration and development of real-time indicators of capacity strain in hospital-based work systems.

- **Keywords:** Socio-technical systems; Capacity strain; Nursing; Workload; Strategies

Carolina Diaz-Piedra, Emilo Gomez-Milan, Leandro L. Di Stasi. *Nasal skin temperature reveals changes in arousal levels due to time on task: An experimental thermal infrared imaging study.*

Infrared thermography, thanks to technological developments and lowering prices, is now getting considerable attention as a potential arousal monitor in the safety industry. Nasal skin temperature might be a valid index to track physiological variations due to reduced arousal levels, and its use could prevent a drowsiness-related deterioration of performance. However, the few studies that have investigated nasal skin temperature in applied settings have had inconsistent results. Here, we assessed the validity of nasal skin temperature to monitor changes in arousal levels (from alertness to drowsiness). The participants performed a 2-h simulated driving task while we simultaneously recorded their nasal skin temperature, brain activity (we used frontal delta electroencephalographic [EEG] activity as the reference index of alertness), and driving performance (speeding time). For those variables, we calculated growth curve models. We also collected subjective ratings of alertness and fatigue before and after the driving session. We found that the nasal skin temperature showed a cubic trajectory (it increased for the first 75 min, and then it began to decrease, but such deceleration gradually diminished over time). As expected, frontal delta EEG activity showed an inverted U-shaped quadratic trend (EEG power increased for the first hour and half, and gradually decreased during the last thirty minutes). The speeding time exhibited a similar pattern of change. Subjective sleepiness and fatigue increased after the task. Overall, our results suggest that nasal skin temperature seems to be a valid measure of arousal variations while performing a complex and dynamic everyday task.

- **Keywords:** Driving simulation; Drowsiness; Electroencephalography; Fatigue detector; Sleepiness

Robert R. Fox, Ming-Lun Lu, Enrico Occhipinti, Matthias Jaeger. *Understanding outcome metrics of the revised NIOSH lifting equation.*

The interpretation of the calculated result of the revised NIOSH Lifting Equation (RNLE) has been problematic because the relationship of the calculated result to back injury risk has not always been either well understood nor consistently interpreted. During the revision of the ISO standard 11228-1 (Manual lifting, lowering and carrying), an extensive literature review was conducted on validation studies of the RNLE. A systematic review of exposure-risk associations between the LI metrics and various low-back health outcomes from peer-reviewed epidemiological studies was conducted. Risk

interpretations for different levels of calculated result of the RNLE are added to the ISO standard. Rationale for the risk interpretations is presented in this paper.

- **Keywords:** Revised NIOSH lifting equation; Manual lifting tasks; ISO standard

Philippa Gosine, Vicki Komisar, Alison C. Novak. *Characterizing the demands of backward balance loss and fall recovery during stair descent to prevent injury.*

Understanding the demands of balance recovery on stairs is important for developing strategies to prevent falls on stairs. This study characterized recovery strategies and whole-body movement following unexpected backward balance loss during stair descent in twelve young adults. Following balance loss, peak downward COM velocity was approximately double that experienced during non-perturbation stair descent. Participants used several balance recovery strategies: harness reliance (n = 1), no grasping reaction (n = 3), and grasping some environmental feature (n = 8). Of the five participants who used the handrail, four demonstrated grasping errors. Peak resultant handrail forces ranged from 24.2N to 238.3N. The results highlight the challenge of balance recovery during stair descent, showing that some people will use any available surface to arrest a fall. Our findings serve as a benchmark to understand the impact of stair-related interventions on fall recovery.

- **Keywords:** Balance recovery; Stair ambulation; Kinematics

Nicholas J. La Delfa, Zachary C.T. Evans, Jim R. Potvin. *The influence of hand location and handle orientation on female manual arm strength.*

Accurate estimations of manual arm strength (MAS) are crucial in the evaluation of occupational force demands relative to population capacity. Most current strength predictions assume force application with a vertically oriented handle, but it is unknown how uni-manual force capability changes as a function of handle orientation and hand location. This study evaluated the effect of handle orientation on MAS throughout the reach envelope. Fifteen female participants exerted maximum forces in six directions (i.e. superior, inferior, anterior, posterior, medial, lateral), at five different hand locations, and MAS was measured with the handle oriented at 0° (i.e. horizontal), 45°, 90° (i.e. vertical) and 135°. Handle orientation affected MAS in all but the anterior exertion direction, with significant interactions between hand location and grip orientation existing for the superior and inferior directions. These results suggest that handle orientation is important to consider in future predictive models of manual arm strength.

- **Keywords:** Manual arm strength; Handle orientation; Proactive ergonomics

Aaron P.J. Roberts, Neville A. Stanton, Daniel T. Fay, Kiome A. Pope. *The effects of team co-location and reduced crewing on team communication characteristics.*

The manner in which control rooms are configured can impact the flow of information between command teams. Previous research revealed bottlenecks of communications between the Sonar Controller (SOC) and the Operations Officer (OPSO) in submarine control rooms. One way to relieve such bottlenecks is to co-locate operators reliant on one another for task relevant information. The aim of the current studies was to use multiple command teams to empirically examine a novel submarine control room configuration and a reduced crew size in comparison to a baseline of contemporary operations to see if such bottlenecks could be removed. Ten teams performed high and low demand Dived Tracking (DT) scenarios in a simulated submarine control room. Activities and communications of the teams were recorded and quantified using the Event

Analysis of Systemic Teamwork (EAST) method affording statistical comparisons with a baseline condition of contemporary operations. The findings showed that the co-location of operators relieved the bottleneck of communications between the SOC and the OPSO. Although overall communications increased, this was more balanced across the team and was more adaptive to scenario demand. This was coupled with a significant increase in task completion, even with a reduced crew size, suggesting greater efficiency and productivity. Future research should seek to validate the changes observed with objective measures of task performance.

- **Keywords:** Submarine; Team work; Communications; Networks

Corinna Brauner, Anne M. Wöhrmann, Kilian Frank, Alexandra Michel. *Health and work-life balance across types of work schedules: A latent class analysis.*

This study explores how different aspects of working time demands (e.g., shift work) and working time control (e.g., beginning/end of workday) can be clustered into distinct types of work schedules and how they relate to health and work-life balance. Data from 13,540 full-time employees interviewed in the 2015 BAuA-Working Time Survey was used. By means of latent class analysis, we extracted six types of work schedules. Subjective health was highest in the flexible extended and flexible standard schedules, both featuring high working time control. Work-life balance was highest in the flexible standard and rigid standard schedules and lowest in schedules with high working time demands, namely the extended shift, rigid all-week, and rigid extended schedules. Employees with high working time demands and low control represent risk groups prone to impairments of well-being. Overall, this study offers an intuitive taxonomy for the design of sustainable work schedules.

- **Keywords:** Working hours; Flexibility; Well-being

Carisa Harris-Adamson, Emma Lam, Fadi Fathallah, Angela D. Tong, Stephen Hill, Andrew Smith. *The ergonomic impact of a mattress lift tool and bottom sheet type on hotel room cleaners while making beds.*

The purpose of this study was to quantify biomechanical and cardiovascular exposure while making beds with and without interventions (mattress lift tool and fitted sheet). Sixteen female hotel room cleaners participated in this multifactorial (tool and sheet) laboratory study of crossover design. Exertion in the upper extremity (<2) and back (<3) was consistently lower when using the tool and fitted sheet ($p < 0.05$). The average number of lifts per bed was reduced by 48% with an 18 s increase in cycle time per bed. Peak forearm flexor activity was significantly lower when using a tool ($p < 0.05$). Spinal lateral plane range of motion ($p < 0.02$) and maximum twisting velocity ($p < 0.03$) were lowest using the tool and fitted sheet together. Interventions such as a mattress lift tool used with a fitted sheet reduced the number of mattress lifts and lowered perceived exertion among hotel room cleaners while making beds.

- **Keywords:** Hotel room cleaners; Bed making; Physical exposure; Biomechanical exposure; Intervention

Julie Iskander, Mohammed Hossny, Saeid Nahavandi. *Using biomechanics to investigate the effect of VR on eye vergence system.*

Vergence-accommodation conflict (VAC) is the main contributor to visual fatigue during immersion in virtual environments. Many studies have investigated the effects of VAC using 3D displays and expensive complex apparatus and setup to create natural and conflicting viewing conditions. However, a limited number of studies targeted virtual

environments simulated using modern consumer-grade VR headsets. Our main objective, in this work, is to test how the modern VR headsets (VR simulated depth) could affect our vergence system, in addition to investigating the effect of the simulated depth on the eye-gaze performance. The virtual scenario used included a common virtual object (a cube) in a simple virtual environment with no constraints placed on the head and neck movement of the subjects. We used ocular biomechanics and eye tracking to compare between vergence angles in matching (ideal) and conflicting (real) viewing conditions. Real vergence angle during immersion was significantly higher than ideal vergence angle and exhibited higher variability which leads to incorrect depth cues that affects depth perception and also leads to visual fatigue for prolonged virtual experiences. Additionally, we found that as the simulated depth increases, the ability of users to manipulate virtual objects with their eyes decreases, thus, decreasing the possibilities of interaction through eye gaze. The biomechanics model used here can be further extended to study muscular activity of eye muscles during immersion. It presents an efficient and flexible assessment tool for virtual environments.

- **Keywords:** Virtual reality; Eye vergence movement; Eye tracking; Biomechanical simulation; Extraocular muscles

Yuanyuan Liu, Terry Dickerson, Paula Waddingham, P. John Clarkson.
Improving people's access to community-based back pain treatment through an inclusive design approach.

Back pain is a very common health problem and affects people across the world. This study applies an Inclusive Design approach to a community-based back pain service to understand the challenges, in relation to patients' capabilities, that can affect their access to the service. It consisted of three steps: i) online surveys and interviews with physiotherapists and collected patients' personal online care stories to gather insight into their experiences within the back pain care journeys; ii) estimated services' demands made on patients when they access the service and identified the related challenges and iii) proposed recommendations that could address the challenges for patients to access the service. The study suggests an Inclusive Design approach could help identify capability-related challenges such as vision and memory which could affect people's access to back pain treatment. In addition, the application of the approach also uncovered some non-capability-related challenges.

- **Keywords:** Accessibility; Inclusive healthcare; Capability

Brett R.C. Molesworth, Dimuth Seneviratne, Chloe Wilcock.
Communicating safety information: Investigating how distractors affect the recall of key safety information in pre-flight safety briefings.

Distractors have been shown to adversely impact individuals' ability to acquire target information. However, not all distractors are the same. Distractors that compete/interfere for the same cognitive resources as the target, are thought to be more detrimental to performance than those that do not compete for the same resources. The aim of the present research was to examine the effect of distractors on individuals' memory, namely recall of key safety messages presented in an airline's pre-flight safety briefing. In a laboratory experiment in which one-hundred and twenty-four participants watched one of four different videos, two of which were paired with a distractor task (grammatical reason and computation task), we identified the adverse effect of the distractor task on recall performance. Minor differences were noted between the two distractor task groups. These results suggest the effect of a distractor on performance may be explained, in general by the additional cognitive load imposed, as opposed to the more specific competition for the same cognitive resources. From an applied perspective, these results highlight the importance of limiting distractors when important information to be remembered is communicated.

- **Keywords:** Distraction; Attention; Cabin safety

Kai Way Li, Huiqiao Jia, Lu Peng, Lang Gan. *Line-of-sight in operating a small unmanned aerial vehicle: How far can a quadcopter fly in line-of-sight?*

A field study was conducted to investigate the probabilities of human participants to detect a small unmanned aerial vehicle (UAV) at a certain distance. A Phantom 4 quadcopter was remotely controlled to hover at one of the 32 pre-determined locations in the air. Thirty-two participants on the ground were requested to judge if they could see the quadcopter on a four-point scale: 1. definitely yes, 2. probably yes, 3. probably no, and 4. definitely no. The participants also responded whether they could hear the quadcopter on the same four-point scale. Logistic regression models were established to estimate the probability of detecting the quadcopter in the air, both visually and auditory. When navigating a quadcopter flying away from the operator, the sound stimulus diminished and then disappeared earlier than that of the sight of the quadcopter. The results of the study indicated that the probability of visual detection of the quadcopter at a distance of 300 m was approximately 0.3. When adopting a 50% probability of visual detection and the "definitely or probably yes" criterion, the estimated distance of line-of-sight was 245 m. The corresponding visual angle was 0.065° . The information in this study is valuable for drone operators, operator training institutes, and drone designers. The aviation authorities may also consider revising the codes or regulations for small UAV operation based on our findings.

- **Keywords:** Unmanned aerial vehicle; Line-of-sight; Visual detection; Drone ergonomics; Logistic regression modeling

Brian D. Lowe, Patrick G. Dempsey, Evan M. Jones. *Ergonomics assessment methods used by ergonomics professionals.*

A web-based survey was conducted of ergonomics practitioners holding certifications in the U.S., Canada, Great Britain, Australia, and New Zealand. The survey follows 12 years after an earlier initial survey reported by Dempsey et al. (2005). Approximately 1221 eligible participants were invited by e-mail to participate, and 405 surveys were included in the final analysis. The survey queried use of basic instruments relevant to ergonomic practice as well as more specific analytical tools such as observational techniques for assessing postural demands of work and instrumentation for direct measurement of such demands. Some ergonomic assessment methods appear to have increased in their overall use by U.S. ergonomists compared to 2005 data. This was observed for: RULA, REBA, Psychophysical Upper Extremity Data, Strain Index, and ACGIH TLV for Hand Activity Level. There is minimal evidence of increased overall use of direct measurement approaches in the U.S. There appear to be geographic differences between countries/continents in terms of use of various methods. The use of mobile device/smart phone "apps" by ergonomists was queried and these technologies presently appear to be in early adoption phase with 24–28% of practitioners reporting use of an app in their ergonomics practice.

- **Keywords:** Ergonomics; Musculoskeletal disorders; Certification

Seul Chan Lee, Young Woo Kim, Yong Gu Ji. *Effects of visual complexity of in-vehicle information display: Age-related differences in visual search task in the driving context.*

We aimed to investigate the effects of the visual complexity of in-vehicle information display and driver's age in a driving context. A driving simulator study was conducted where participants performed visual search tasks at different visual complexity levels

while driving. Two groups were included, 20 younger drivers (mean age = 28.75 years) and 14 older drivers (mean age = 54.87 years). Older drivers were found to be more vulnerable to the effects of increased visual complexity when performing a visual search task. The task completion time of the younger group increased by about 20% (from 7.69 s to 9.30 s), while the older group increased by about 47% (from 8.92 s to 13.14 s). Further, the driving performance of the older group deteriorated, unlike the younger group. The subjective workload score supported the results of the objective performance measures. These differences can be explained by glance behavior. The total off-road glance duration of older drivers was longer than that of younger drivers, but the average off-road glance duration of younger drivers was longer. In other words, older drivers have a more conservative strategy when dealing with increased visual complexity in a driving context so as not to affect their driving. The findings of this study show that the visual complexity level has a significant effect on driving behaviors, especially in older drivers, which provides insights for designing in-vehicle information displays.

- **Keywords:** Visual complexity; In-vehicle information display; Age-related differences

Adam Schwartz, Susan G. Gerberich, Hyun Kim, Andrew D. Ryan, Timothy R. Church, Thomas J. Albin, Patricia M. McGovern, Arthur E. Erdman, Deirdre R. Green, Rony F. Arauz. *Janitor ergonomics and injuries in the safe workload ergonomic exposure project (SWEEP) study.*

Introduction: A Minnesota union identified to researchers at the University of Minnesota a concern relevant to a possible relation between their daily workload and outcome of occupational injuries among a population of janitors. **Objective:** To assess if the ergonomic workload is related to injuries among janitors. **Methods:** Following an initial group discussion among janitors, which identified common and hazardous tasks potentially leading to occupational injuries, a questionnaire was developed, pre-tested, and distributed to the janitors. Questions addressed various exposures, including workload, and comprehensive information regarding injury occurrence over two six-month sequential periods (May 2016–October 2016, November 2016–April 2017). Quantitative ergonomic analyses were performed on a sub-group of janitors ($n = 30$); these included data collection to identify Borg Perceived Exertion (Borg) and Rapid Entire Body Assessment (REBA) scores. Descriptive, multivariable with bias adjustment analyses were conducted on the resulting data. **Results:** Eight tasks were found to be common for janitors. All average REBA scores for the tasks were identified in the high-risk category. The task of repeatedly emptying small trash cans (<25lb) was significantly related to injuries. Average Borg scores fell between the very light perceived exertion and somewhat difficult perceived exertion categories. Multivariable regression analyses indicated that age-sex-standardized ergonomic workload, measured by task frequencies and REBA or Borg scores, was positively related to injury occurrence. **Conclusions:** Standardized ergonomic workload was positively related to injury occurrence. This information serves as a basis for further research and potential intervention efforts.

- **Keywords:** Janitors; Workload; Ergonomics; Injuries; Epidemiology

Yaar Harari, Raziel Riemer, Avital Bechar. *Differences in spinal moments, kinematics and pace during single-task and combined manual material handling jobs.*

This study compared the spinal moments (i.e., peak and cumulative moments acting on the L5/S1 joint), kinematics (i.e., peak trunk and knee angles) and work pace of workers, when either removing a box from a shelf or depositing a box on a shelf, under two conditions: as a single task or as part of a combined task. An experiment was

conducted, in which the subjects performed the tasks and were recorded using a motion capture system. An automated program was developed to process the motion capture data. The results showed that, when the removing and depositing tasks were performed as part of a combined task (rather than as single tasks), subjects experienced smaller peak and cumulative spinal moments and they performed the tasks faster. The results suggest that investigations into the separate tasks that comprise a combination have a limited ability to predict kinematics and kinetics during the combined job.

- **Keywords:** Manual material handling; Spinal moment; Task duration; Kinematics

Scott P. Breloff, Amrita Dutta, Fei Dai, Erik W. Sinsel, Christopher M. Warren, Xiaopeng Ning, John Z. Wu. *Assessing work-related risk factors for musculoskeletal knee disorders in construction roofing tasks.*

Roofers often suffer from musculoskeletal disorders (MSDs) to their knees due to spending a large amount of time kneeling while performing work-related roofing activities on sloped rooftops. Several ergonomic studies have identified kneeling as a potential risk factor for knee injuries and disorders. Existing biomechanical models and sensor technologies used to assess work-related risk factors for different construction trades are not applicable in roof work settings especially on slanted rooftop surfaces. This work assesses the impacts of work-related factors, namely working posture and roof slope, on the potential risk of developing knee MSDs due to residential roofing tasks in a laboratory setting. Nine human subjects participated in the experiment and mimicked shingle installation on a slope-configurable wooden platform. Maximum angles of right and left knee flexion, abduction, adduction, and axial rotation (internal and external) were measured as risk indicators using a motion capture system under different roof slope settings. The results demonstrated that roof slope, working posture and their interaction may have significant impacts on developing knee MSDs during roofing activities. Knees are likely to be exposed to increased risk of MSDs due to working in a dynamic kneeling posture during shingle installation. In our study, flexion in both knees and adduction in the right knee were found lower in high-pitched rooftops; however, abduction in the left knee and internal rotation in the right knee were found higher during shingle installation. Hence proper attention is needed for these situations. This study provides useful information about the impact of roof work settings on knee MSDs development, which may facilitate effective interventions such as education, training, and tools to prevent knee injuries in construction roofing tasks.

- **Keywords:** Knee musculoskeletal disorders; Risk assessment; Construction safety; Ergonomic practices

Maral Babapour. *From fading novelty effects to emergent appreciation of Activity-based Flexible Offices: Comparing the individual, organisational and spatial adaptations in two case organisations.*

Activity-based Flexible Offices (AFOs) are innovations in workspace design that have been increasingly implemented in organisations in recent years. There are conflicting research results on the long-term consequences of implementing AFOs. This paper investigates the changes (if any) that occur over time, in: 1) employee satisfaction with AFO solutions and perceived work support, 2) ways of working and using AFOs and 3) the AFO solution. Two organisations participated in the study. The data collection involved: (i) semi-structured interviews with 26 employees and (ii) process enquiries involving the collection of secondary data and interviews with facility management teams. The findings indicate that limited options for improving an AFO solution lead to lingering work environment problems. By contrast, modifying the solution through systematic processes based on employee feedback helped resolving the initial problems. Over time, this led to an increased appreciation and a sense of collective ownership of the AFO solution.

- **Keywords:** Activity-based working (ABW); Work environment; Occupational health and safety (OHS)

Jessica A. Dobson, Diane L. Riddiford-Harland, Alison F. Bell, Caleb Wegener, Julie R. Steele. *Effect of work boot shaft stiffness and sole flexibility on lower limb muscle activity and ankle alignment at initial foot-ground contact when walking on simulated coal mining surfaces: Implications for reducing slip risk.*

Design features of safety work boots have the potential to influence how underground coal miners' feet interact with the challenging surfaces they walk on and, in turn, their risk of slipping. Despite the importance of work boot design in reducing the risk of miners slipping, limited research has investigated how boot design features, such as shaft stiffness and sole flexibility, affect the way miners walk. Therefore, this study aimed to investigate the effects of systematic variations to boot shaft stiffness and sole flexibility on lower limb muscle activity and ankle motion in preparation for initial foot-ground contact when 20 males walked across two simulated coal mining surfaces under four mining boot conditions. It was concluded that a boot which has different flexibility and stiffness between the shaft and sole is a better design option to reduce underground coal miners' slip risk than a boot that has a stiff shaft and stiff sole or flexible shaft and flexible sole.

- **Keywords:** Boot design; Walking; Slip risk; Gait; Coal mining

A. Cuny-Guerrier, A. Savescu, D. Tappin. *Strategies to commit senior subcontractor managers in participatory ergonomics interventions.*

The commitment of managers is one of the facilitators of participatory ergonomics (PE). However, to achieve this, practical practitioners' strategies vary depending on the organizational context and type of stakeholder and are poorly described in the literature. The purpose of this paper is to describe and to analyze the process and strategies that led to senior managers commitment during a decision-making intervention in a subcontracting context. A reflexive practice method was used to describe strategies implemented during a multi-site research project focusing on musculoskeletal disorders prevention in the meat processing sector. A 3 levels commitment method was developed which included: each subcontractor individually, subcontractors together, and subcontractors with their main contractor. Four strategies from the literature were firstly implemented: the creation of a steering committee, the identification of tendencies to act, the transfer of knowledge and moderation of collective discussion. An additional new strategy based on the sharing of a common interest – knife sharpening and maintenance was necessary to achieve the commitment. These results reinforce the importance of stakeholder strategies commitment in PE. A greater consideration for developing a valid framework is needed.

- **Keywords:** Manager commitment; Participatory ergonomics; Reflexivity; Subcontracting; Meat processing

Takanori Chihara, Akihiko Seo, Jiro Sakamoto. *A novel approach to bi-objective optimization of touch-screen installation position for minimizing physical workload and increasing screen visibility.*

The aim of this study was to propose a new method for optimizing the touch-screen installation position in order to minimize the physical workload and increase screen visibility. Ten students participated in this study. The participants utilized a touch screen at different installation heights (50, 65, and 80% of stature), tilt angles (0°, 45°, and 90° from the horizontal plane), and having different button sizes (a square with a side of

10, 20, and 30 mm). The joint angles, when using a touch screen, were measured to calculate the joint torque ratios (JTRs). Subjective screen visibility were also determined. The optimal installation position was determined by solving a bi-objective optimization problem consisting of two objective functions. The Pareto optimal solutions for the two objectives showed a range of 1124–1251 mm and 44.4–67.9°. The proposed method determined the optimal installation position of the touch screens.

- **Keywords:** Multi-objective optimization; Digital human modeling; Touch screen; Physical workload; Joint torque; Visibility

Hyeseon Han, Gwanseob Shin. *Head flexion angle when web-browsing and texting using a smartphone while walking.*

The objective of this study was to quantify head flexion when using a smartphone while walking. Head flexion angle in the sagittal plane was measured from twenty-eight young users when conducting one-handed web-browsing while walking, two-handed texting while walking, and walking upright on a 60-m walkway. Participants walked with the head flexed 38.5° (median angle) during the two-handed texting and it was significantly greater ($p < 0.05$) than that of the one-handed web-browsing (31.1°) as well as of upright walking (-1.2°). The study results indicated that using a smartphone while walking would pose a larger load to the neck musculature compared to when walking without using a phone, and the load would be greater for two-handed texting than for one-handed browsing among the two smartphone tasks. The findings of this study can be used to inform smartphone users of potential risks of smartphone use while walking.

- **Keywords:** Text neck; Smartphone; Mobile phone; Walking; Head posture

Errol R. Hoffmann, Alan H.S. Chan, S.S. Man, Liszt C.M. Chan. *Determining the validity of the visual field principle for designing control/display arrangements.*

The Visual Field (VF) principle has been found to apply in many situations, but has not been tested under many possible conditions of operator posture with different display and control locations. In this research we used four display locations, four control locations relative to a seated operator and tested the strength of population stereotype for six different types of controls with linear displays moving either horizontally or vertically and circular displays with a neutral indicator at the 12, 3, 6 and 9 o'clock positions. Apart from several minor differences in operator responses, the VF principle held up well under all these different display/control relationships. By designing the display/control arrangement to have high stereotype strength, the direction of control movement for a given direction of indicator movement can be selected to comply with the VF principle for producing fewest errors in movement direction.

- **Keywords:** Visual field principle; Control/display stereotypes; Operator location

Candida Castro, Jose-Luis Padilla, Pablo Doncel, Pedro Garcia-Fernandez, Petya Ventsislavova, Eduardo Eisman, David Crundall. *How are distractibility and hazard prediction in driving related? Role of driving experience as moderating factor.*

Distraction constitute one of the 'five fatal' behaviours that contribute to road trauma, and some people may be more susceptible to it than others. It is also known that a greater ability to predict danger is related to a lower probability of suffering accidents. It could be hypothesised that drivers with a higher tendency to distraction are worse at predicting traffic hazards, but to what extent might driving experience serve to mitigate this tendency to distraction? The current study collected self-reported attentional errors

from drivers by using the Attention-Related Driving Errors Scale (ARDES-Spain) in order to examine whether novice drivers suffered from inattention more than experienced drivers. The results demonstrated that novice drivers scored more highly on ARDES than experienced drivers. ARDES scores were then related to performance in a Hazard Prediction test, where participants had to report what hazard was about to happen in a series of video clips that occlude just as the hazard begins to develop. While experienced drivers were better at the Hazard Prediction test than novice drivers, those participants who reported fewer attention errors were also better able to detect the upcoming hazard following occlusion. In addition, our results demonstrate a relationship between self-reported attentional errors and the ability to predict upcoming hazards on the road, with driving experience having a moderating role. In the case of novice drivers, as their scores in the Manoeuvring Errors ARDES factor increase, their ability in Hazard Prediction diminishes, while for experienced drivers the increase is not significant. Guidance on how to improve training for drivers in order to mitigate the effects of inattention on driving safety can be addressed.

- **Keywords:** Hazard perception; Hazard detection; Distraction; Inattention; Risk estimation; Driving experience; Hazard prediction; Driving; Road safety; Novice; Experienced drivers

Iman Dianat, Pari Adeli, Mohammad Asgari Jafarabadi, Mohammad Ali Karimi. *User-centred web design, usability and user satisfaction: The case of online banking websites in Iran.*

The relationship of Web design attributes (personalisation, structure, navigation, layout, search and performance) and users' personal characteristics to website usability and user satisfaction was investigated among 798 online banking users in Iran. The design and usability of the evaluated websites were not satisfactory from the users' perspectives. Multivariate regression models indicated that Web layout and performance were the main predictors of website usability, while personal characteristics including gender, age and Web usage experience of users had no effect. User satisfaction was also influenced only by the Web design attributes (particularly Web structure) and not by the personal characteristics of the users. There was also a significant relationship between website usability and user satisfaction. The findings suggest that the website designers should focus more on the Web design attributes (particularly Web layout and structure), regardless of the personal characteristics of their users, to improve the usability and user satisfaction of websites.

- **Keywords:** E-banking; E-satisfaction; Internet banking; Web site

Vicki Komisar, Brian E. Maki, Alison C. Novak. *Effect of handrail height and age on the timing and speed of reach-to-grasp balance reactions during slope descent.*

We investigated the effect of handrail height on the timing and speed of reach-to-grasp balance reactions during slope descent, in fourteen younger and thirteen older adults. Participants walked along an 8° slope mounted to a robotic platform. Platform perturbations evoked reach-to-grasp reactions. Handrail height did not significantly affect handrail contact time (i.e., time from perturbation onset to handrail contact) or movement time (i.e., time from EMG latency to handrail contact). Participants appeared to compensate for the increased hand-handrail distance with higher rails via increased peak upward hand speed, and decreased vertical handrail overshoot. Aging was associated with slower EMG latency, reduced hand acceleration time, and increased hand deceleration time. Our findings suggest that participants were not disadvantaged by higher handrails from reach-to-grasp timing or speed perspectives, and that other metrics (e.g., center-of-mass control after grasping) may be more important when evaluating handrail designs for balance recovery.

- **Keywords:** Balance recovery; Handrail design; Aging; Falls; Injury prevention

Denean M. Kelson, Svend Erik Mathiassen, Divya Srinivasan. *Trapezius muscle activity variation during computer work performed by individuals with and without neck-shoulder pain.*

This study aimed at determining the extent to which individuals with neck-shoulder pain and non-symptomatic individuals differ in muscle activation patterns, when performing computer work, as quantified by exposure variation analysis (EVA). As a secondary aim, we also aimed to quantify the day-to-day reliability of EVA variables describing trapezius muscle activation in a non-symptomatic control group. Thirteen touch-typing computer users (pain: n = 5, non-symptomatic: n = 8) completed three pre-selected computer tasks in the laboratory. Upper trapezius muscle activity was recorded using electromyography and analyzed using EVA with five amplitude and five duration categories. Individuals with neck-shoulder pain spent less time at low amplitudes and exhibited longer uninterrupted periods of muscle activation compared to their non-symptomatic counterparts. Thus, non-symptomatic workers tended to switch between exposure levels more often than individuals with pain. For a majority of EVA variables, ICCs ranged from 0.6 to 0.9, and between-days coefficients of variation were between 0.4 and 2.2.

- **Keywords:** Exposure variation analysis; Motor variability; Reliability

Zulekha Mohamed Elias, Uma Mageswari Batumalai, Azam Nur Hazman Azmi. *Virtual reality games on accommodation and convergence.*

Increasing popularity of virtual reality (VR) gaming is causing increased concern, as prolonged use induces visual adaptation effects which disturbs normal vision. Effects of VR gaming on accommodation and convergence of young adults by measuring accommodative response and phoria before and after experiencing virtual reality were measured. An increase in accommodative response and a decrease in convergence was observed after immersion in VR games. It was found that visual symptoms were apparent among the subjects post VR exposure.

- **Keywords:** Virtual reality; Accommodation; Accommodative response; VAC; Phoria

Carl J. Pearson, Michael Geden, Christopher B. Mayhorn. *Who's the real expert here? Pedigree's unique bias on trust between human and automated advisers.*

Objective: We assessed the effects of source type bias (human or automation) on adviser trust in a dual adviser decision-making task. **Background:** Source type and reliability's effects on adviser trust have been studied in a dual-adviser context, but the influence of pedigree (perceived expertise) across source types lacked robust investigation. As situations with two decision-aids of uneven pedigree can easily arise, it is critical to understand how operators are biased towards a decision-aid of a certain source type and pedigree. **Method:** A decision-making task similar to the paradigm of Convoy Leader (Lyons and Stokes, 2012) was given to participants, where a military convoy route had to be selected in the presence of IEDs and insurgent activity. We measured behavioral reliance and trust attitudes. Pedigree was manipulated via controlled adviser descriptions, in a manner consistent with past investigations (Madhavan and Wiegmann, 2007a). **Results:** We found a trust bias towards the human adviser, reversed only when there is a far greater pedigree in the automated adviser. Trust attitudes were also strongly indicative of reliance behaviors. **Conclusion:** Pedigree is a strong influencer of trust in a decision-aid and biased towards human advisers. Trust is highly predictive of reliance decisions. **Application:** System designers must take care

with how “expert” automation is portrayed, particularly if it is used in conjunction with other human advisers (e.g.: conflicting advice from air-traffic control and an onboard system).

- **Keywords:** Dual adviser; Decision support system; Reliance; Decision-making; Decision aid; Trust in automation

Thomas Davidson, Youn Ji Ryu, Birgit Brecknell, Robert Loeb, Penelope Sanderson. *The impact of concurrent linguistic tasks on participants' identification of spearcons.*

Spearcons (time-compressed speech) may be a viable auditory display for patient monitoring; however, the impact of concurrent linguistic tasks remains unexamined. We tested whether different concurrent linguistic tasks worsen participants' identification of spearcons. Experiment 1 tested non-clinician participants' identification of multiple-patient spearcons representing 2 vital signs of 5 patients while participants performed no concurrent task, reading, or saying linguistic tasks. Experiment 2 tested non-clinician participants' identification of 48 single-patient spearcons while they performed no concurrent task, reading, listening, and saying linguistic tasks. In Experiment 1 the saying task worsened participants' identification of spearcons compared with no concurrent task or reading. In Experiment 2, the saying and listening tasks reduced participants' accuracy at identifying spearcons, but the reading task did not. Listening affected identification accuracy no differently than the saying task did. Concurrent auditory linguistic tasks worsen participants' identification of spearcons, probably due to auditory modality interference in verbal working memory.

- **Keywords:** Auditory displays; Spearcons; Patient monitoring

Sarah Martindale, David Golightly, James Pinchin, Dominick Shaw, John Blakey, Iker Perez, Sarah Sharples. *An interview analysis of coordination behaviours in Out-of-Hours secondary care.*

This paper seeks to elicit and structure the factors that shape the execution and, in particular, the coordination of work in Out of Hours care. Evenings and weekends in UK hospitals are managed by specific Out of Hours (OoH) care arrangements, and associated technology. Managing care within the constraints of staff availability and demands is a key concern for both patient care and staff wellbeing, yet has received little attention from healthcare human factors. A study of sixteen clinical staff used Critical Decision Method to understand how work is coordinated and the constraints and criteria that are applied by the roles managing OoH care. The analysis identified ten types of coordination decision that, in turn, underpinned three types of adaptive behaviour – pre-emption, information augmentation and self-organisation – that were crucial for the effective performance in OoH care. These behaviours explain how OoH staff manage the task demands placed on them, individually and as a team.

- **Keywords:** Out of Hours care; Healthcare; Coordination; Complex systems; Workload management