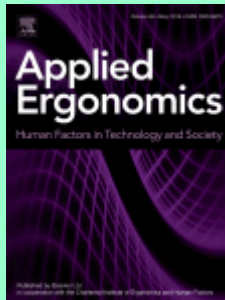


Applied Ergonomics - rok 2023, Volume 106

January



Jacinta Waack, Ben Meadley, Cameron Gosling. *Comparison of physical demanding paramedic work tasks between an Australian and Canadian ambulance service.* 103905.

Ambulance services require candidates to pass physical employment tests (PETs) to be deemed suitable for the paramedic role. Whilst some research has been undertaken to improve to relevance of these tests, they are often arbitrary and not based on research. The first phase in developing PETs is to generate a list of job tasks. To examine the utility of universal physical tasks tests for ambulance work, we conducted a cross-sectional study, utilising the results from previous work in a Canadian ambulance service to create a physical tasks checklist. These lists were then used by paramedics working for an Australian Service to identify physical tasks in their workplace, and the results from the two services were compared. Patient transfer tasks were similar in frequency and description for both services. Stretcher handling and manoeuvring was identified by Canadian paramedics as highly strenuous, (mean rating of perceived exertion (RPE) 7/10) but were rated mean RPE <3/10 by AV paramedics. Although some tasks between these two services were similar, the ambulance services in this study differed sufficiently with regard to equipment, training and policies mean that similarly titled jobs are not comparable, cross-nationally. Service specific job task analysis is required to develop PETs that ensure employees are specifically selected to meet the requirements of that service.

- **Keywords:** Physical employment standards; Physical employment tests; Task demands; Cross-national comparison; Paramedics

Ksander N. de Winkel, Tugrul Irmak, Riender Happee, Barys Shyrokau. *Standards for passenger comfort in automated vehicles: Acceleration and jerk.* 103881.

A prime concern for automated vehicles is motion comfort, as an uncomfortable ride may reduce acceptance of the technology amongst the general population. However, it is not clear how transient motions typical for travelling by car affect the experience of comfort. Here, we determine the relation between properties of vehicle motions (i.e., acceleration and jerk) and discomfort empirically, and we evaluate the ability of normative models to account for the data. 23 participants were placed in a moving-base driving simulator and presented sinusoidal and triangular motion pulses with various peak accelerations ($A_{max} 0.4 - 2 \text{ ms}^{-2}$) and jerks ($J_{max} 0.5 - 15 \text{ ms}^{-3}$), designed to recreate typical vehicle accelerations. Participants provided discomfort judgments on absolute 'Verbal Qualifiers' and relative 'Magnitude Estimates' associated with these motions. The data

show that discomfort increases with acceleration amplitude, and that the strength of this effect depends on the direction of motion. We furthermore find that higher jerks (shorter duration pulses) are considered more comfortable, and that triangular pulses are more comfortable than sinusoidal pulses. ME responses decrease (i.e., reduced discomfort) with increasing pulse duration. Evaluations of normative models of vibration and shock (ISO 2631), and perceived motion intensity provide mixed results. The vibration model could not account for the data well. Reasonable agreement between predictions and observations were found for the shock model and perceived intensity model, which emphasize the role of acceleration. We present novel statistical models that describe motion comfort as a function of acceleration, jerk, and direction. The present findings are essential to develop motion planning algorithms aimed at maximizing comfort.

- **Keywords:** Motion; Comfort; Acceleration; Jerk; Frequency; Automated; Autonomous; Self-driving; Vehicles; Cars

Seth Elkin-Frankston, Carlene Horner, Reem Alzahabi, Matthew S. Cain. *Characterizing motion prediction in small autonomous swarms.* 103909.

The use of robotic swarms has become increasingly common in research, industrial, and military domains for tasks such as collective exploration, coordinated movement, and collective localization. Despite the expanded use of robotic swarms, little is known about how swarms are perceived by human operators. To characterize human-swarm interactions, we evaluate how operators perceive swarm characteristics, including movement patterns, control schemes, and occlusion. In a series of experiments manipulating movement patterns and control schemes, participants tracked swarms on a computer screen until they were occluded from view, at which point participants were instructed to estimate the spatiotemporal dynamics of the occluded swarm by mouse click. In addition to capturing mouse click responses, eye tracking was used to capture participants eye movements while visually tracking swarms. We observed that manipulating control schemes had minimal impact on the perception of swarms, and that swarms are easier to track when they are visible compared to when they were occluded. Regarding swarm movements, a complex pattern of data emerged. For example, eye tracking indicates that participants more closely track a swarm in an arc pattern compared to sinusoid and linear movement patterns. When evaluating behavioral click-responses, data show that time is underestimated, and that spatial accuracy is reduced in complex patterns. Results suggest that measures of performance may capture different patterns of behavior, underscoring the need for multiple measures to accurately characterize performance. In addition, the lack of generalizable data across different movement patterns highlights the complexity involved in the perception of swarms of objects.

- **Keywords:** Swarms; Ensembles; Perception; Tracking

Hanna J. Barton, Ellen Pflaster, Shanmugapriya Loganathar, Allison Werner, Adati Tarfa, David Wilkins, Mary L. Ehlenbach, Barbara Katz, Ryan J. Coller, Rupa Valdez, Nicole E. Werner. *What makes a home? Designing home personas to represent the homes of families caring for children with medical complexity.* 103900.

Personas are widely recognized as valuable design tools for communicating dimensions of individuals, yet they often lack critical contextual factors. For those people managing chronic health conditions, the home is a critical context of their patient work system (PWS). We propose the development of 'home personas' to convey essential aspects of the home context to those tasked with designing technologies and interventions to fit it. We used an iterative, multi-stakeholder design process to design 'home personas' for a model population, families caring for children with medical complexity. Each of the four

resultant home personas—Multi-level, Customized, Ranch, and Rental—has a unique home layout, pain points, and are described on three dimensions that emerged from the data. This study builds on a foundation of work in the emerging field of Patient Ergonomics, describing a mechanism for distilling rich descriptions of the PWS into brief yet informative design tools.

- **Keywords:** Persona; Sociotechnical system; Macroergonomics; Patient work; Children with medical complexity

Tessa M.W. Talsma, Omar Hassanain, Riender Happee, Ksander N. de Winkel. *Validation of a moving base driving simulator for motion sickness research.* 103897.

Increasing levels of vehicle automation are envisioned to allow drivers to engage in other activities but are also likely to increase the incidence of Carsickness or Motion Sickness (MS). Ideally, MS is studied in a safe and controlled environment, such as a driving simulator. However, only few studies address the suitability of driving simulators to assess MS. In this study, we validate a moving base driving simulator for MS research by comparing the symptoms and time course of MS between a real-road driving scenario and a rendition of this scenario in a driving simulator, using a within-subjects design. 25 participants took part as passengers in an experiment with alternating sections (slaloming, stop-and-go) with normal and provocative driving styles. Participants performed Sudoku puzzles (eyes-off-road) during both scenarios and reported MIsery SScale (MISC) scores at 30 s intervals. Motion Sickness Assessment Questionnaire (MSAQ) scores were collected upon completion of either scenario. Overall, the results indicate that MS was more severe in the car than in the simulator. Nevertheless, significant correlations were found between individual MS in the car and simulator for 3 out of 4 MSAQ symptom categories ($0.48 < r < 0.73$, $p < 0.02$), with a strong overall correlation ($r = 0.57$, $p = 0.004$). MS onset times were similar between the car and the simulator, and sickness fluctuations as a result of driving style showed a similar pattern between scenarios, albeit more pronounced in the car. Based on observed similarities in MS, we conclude these simulator results to have relative validity. We attribute the observed reduction of MS severity in the simulator to the downscaling of the motion by the Motion Cueing Algorithm (MCA). These results suggest that, at least in eyes-off-road conditions, findings on MS from simulator studies may generalize to real vehicles after application of a conversion factor. This conversion factor is likely to depend on simulator and MCA characteristics.

- **Keywords:** Motion; Sickness; Driving; Simulator; Comfort; Validation

Scott Mishler, Jing Chen. *Effect of automation failure type on trust development in driving automation systems.* 103913.

The performance of a driving automation system (DAS) can influence the human drivers' trust in the system. This driving-simulator study examined how different types of DAS failures affected drivers' trust. The automation-failure type (no-failure, takeover-request, system-malfunction) was manipulated among 122 participants, when a critical hazard event occurred. The dependent measures included participants' trust ratings after each of seven drives and their takeover performance following the hazard. Results showed that trust improved before any automation failure occurred, demonstrating proper trust calibration toward the errorless system. In the takeover-request and system-malfunction conditions, trust decreased similarly in response to the automation failures, although the takeover-request condition had better takeover performance. For the drives after the automation failure, trust was gradually repaired but did not recover to the original level. This study demonstrated how trust develops and responds to DAS failures, informing future research for trust repair interventions in designing DASs.

- **Keywords:** Automation failure type; Trust repair; Partially automated driving; Takeover requests

Kylie L. Goodman, Christopher B. Mayhorn. It's not what you say but how you say it: Examining the influence of perceived voice assistant gender and pitch on trust and reliance. 103864.

Voice assistants (VA) are virtual agents used to aid information seeking. Cues contained in speech, such as perceived gender and vocal pitch, may influence attitudes towards, and interactions with these agents. Given expansion of telehealth efforts and the potential for VA to advise patients on health-related topics outside of formal healthcare settings, the influence of VA vocal characteristics is examined in the context of medication instructions. Participants rated trust and reliance on VA after viewing medication labels and hearing recommendations from male and female agents with varying pitch. Results suggest agents perceived as female were rated as more trustworthy, while vocal pitch did not significantly influence trust. However, a trend of lower reliance with increasing pitch was observed. Additionally, participants relied significantly more on VA advice than medication labels when making decisions. Post-hoc analyses revealed trust and reliance primarily varied between participants. Pitch and gender explained only a small portion of within-participant variance. We found suggestive evidence for social categorizations distilled from vocal cues influencing interactions with agents delivering health-critical information. Future work should explore additional samples, vocal cues, and participant-level sources of variation.

- **Keywords:** Virtual assistants; Vocal cues; Trust; Decision-making; Medication labels

Anjum Naweed, Philippa Murphy. One-track mind: Investigating positive and negative applications of non-technical skills in rail network control. 103840.

It is not just a rail driver but a "system" that drives a train and network controllers apply non-technical skills to facilitate their role as part of a team. However, because of siloed and distributed working, scenarios exist where network controllers may inadvertently increase operational safety risks. The aim of this study was to generate a better understanding of non-technical skill application in network controllers by identifying which skills and behaviours were associated with problematic ways of working, and which abilities were used to address error-producing scenarios, and thereby reduce risk. Use of a scenario technique and behavioural markers analysis of 61 scenarios generated from 55 network controllers in 8 organisations across Australia and New Zealand revealed a large and diverse application of non-technical skills. Careful consideration must be given to the way in which deficiencies in abilities and skills are addressed. Future research directions are given.

- **Keywords:** Rail safety; Behavioural markers; Workload; Decision making; Risk perception

Cristiane K. Brazil, Timothy A. Pottorff, Merl Miller, Malgorzata J. Rys. Using the Rapid Upper Limb Assessment to examine the effect of the new Hotel Housekeeping California Standard. 103868.

A housekeeper's job includes a variety of repetitive and strenuous tasks, which can put workers at high risk for musculoskeletal disorders. In 2018, a new standard was implemented in California aiming to prevent work-related injuries of hospitality industry workers. This paper assesses California housekeepers performing regular work tasks during their shifts from 2018 to 2020. Rapid Upper Limb Assessments (RULA) after the

standard was implemented found average right-arm scores for scrubbing tasks (M = 6.93, SD = 0.00), vacuuming (M = 6.27, SD = 0.45), and trash-collecting (M = 4.48, SD = 0.50). Forces to move housekeeping carts were also evaluated, with 98% of pushing forces and 73% of turning forces observed within the accepted range. Results show that RULA scores remain high even after the implementation of the standard, with improvements only seen in tasks that required just changing of the method.

- **Keywords:** Hospitality industry; Housekeepers; Scrubbing tasks; Risk assessment; Rapid upper limb assessment

Ilaria Pacifico, Federica Aprigliano, Andrea Parri, Giusi Cannillo, Ilenia Melandri, Angelo Maria Sabatini, Francesco Saverio Violante, Franco Molteni, Francesco Giovacchini, Nicola Vitiello, Simona Crea. *Evaluation of a spring-loaded upper-limb exoskeleton in cleaning activities.* 103877.

In the past few years, companies have started considering the adoption of upper-limb occupational exoskeletons as a solution to reduce the health and cost issues associated with work-related shoulder overuse injuries. Most of the previous research studies have evaluated the efficacy of these devices in laboratories by measuring the reduction in muscle exertion resulting from device use in stereotyped tasks and controlled conditions. However, to date, uncertainties exist about generalizing laboratory results to more realistic conditions of use. The current study aims to investigate the in-field efficacy (through electromyography and perceived exertion), usability, and acceptance of a commercial spring-loaded upper-limb exoskeleton in cleaning job activities. The operators were required to maintain prolonged overhead postures while holding and moving a pole equipped with tools for window and ceiling cleaning. Compared to the normal working condition, the exoskeleton significantly reduced the total shoulder muscle activity (~17%), the activity of the anterior deltoid (~26%), medial deltoid (~28%), and upper trapezius (~24%). With the exoskeleton, the operators perceived reduced global effort (~17%) as well as a reduced local effort in the shoulder (~18%), arm (~22%), upper back (~14%), and lower back (~16%). The beneficial effect of the exoskeleton and its suitability in cleaning settings are corroborated by the acceptance and usability scores assigned by operators, which averaged ~5.5 out of 7 points. To the authors' knowledge, this study is the first to present an experience of exoskeleton use in cleaning contexts. The outcomes of this research invite further studies to test occupational exoskeletons in various realistic applications to foster scientific-grounded ergonomic evaluations and encourage the informed adoption of the technology.

- **Keywords:** Occupational exoskeleton; Shoulder support; Muscular activity reduction; In-field evaluation; Cleaning

Dana Gutman, Samuel A. Olatunji, Noa Markfeld, Shai Givati, Vardit Sarne-Fleischmann, Tal Oron-Gilad, Yael Edan. *Evaluating levels of automation with different feedback modes in an assistive robotic table clearing task for eldercare.* 103859.

This paper focuses on how the autonomy level of an assistive robot that offers support for older adults in a daily task and its feedback affect the interaction. Identifying the level of automation (LOA) that prioritizes older adults' preferences while avoiding passiveness and sedentariness is challenging. The feedback mode should match the cognitive and perceptual capabilities of older adults and the LOA. We characterized three LOAs and paired them with two modes of feedback in a human-robot collaborative task. Twenty-seven older adults participated in evaluating the LOA-feedback variations in a mixed experimental design, utilizing an experimental setup of an assistive robot in a table clearing task. The quality of the interaction was evaluated with objective and subjective

measures. The combination of high LOA with voice feedback improved the overall interaction when compared to other LOA and feedback combinations. This study emphasizes the importance of appropriate coupling of LOA and feedback for successful interaction of the older adults with an assistive robot.

- **Keywords:** Assistive robots; Human-robot interaction; Older adults; Interaction design

Francesco N. Biondi, Babak Saberi, Frida Graf, Joel Cort, Prarthana Pillai, Balakumar Balasingam. *Distracted worker: Using pupil size and blink rate to detect cognitive load during manufacturing tasks.* 103867.

This study sets out to extend the use of blink rate and pupil size to the assessment of cognitive load of completing common automotive manufacturing tasks. Nonoptimal cognitive load is detrimental to safety. Existing occupational ergonomics approaches come short of measuring dynamic changes in cognitive load during complex assembling tasks. Cognitive demand was manipulated by having participants complete two versions of the n-back task (easy, hard). Two durations of the physical task were also considered (short, long). Pupil size and blink rate increased under greater cognitive task demand. High cognitive load also resulted in longer task completion times, and higher ratings of mental and temporal demand, and effort. This exploratory study offers relevant insights on the use of ocular metrics for cognitive load assessment in occupational ergonomics. While the existing eye-tracking technology may yet limit their adoption in the field, they offer advantages over the more popular expert-based and self-reported techniques in measuring changes in cognitive load during dynamic tasks.

- **Keywords:** Cognitive load; Blink rate; Pupil size; Manufacturing

Shannon P. Devlin, Noelle L. Brown, Sabrina Drollinger, Jawad Alami, Sara L. Riggs. *Workload transition rate matters: Evidence from growth curve modeling.* 103885.

This research examined three specific gaps in the workload transition literature: (1) the impact of workload transition rate, (2) the applicability of current theoretical explanations, and (3) the variability of performance overall and over time. Sixty Naval flight students multitasked in an unmanned aerial vehicle control testbed and workload transitioned at three rates: slow, medium, or fast. Response time and accuracy were analyzed via growth curve modeling. Slow transitions had the largest decline in performance over time. Medium transitions had some of the slowest, but most accurate and consistent performance. Fast transitions had some of the fastest, but least accurate performance. However, all performance trends significantly varied, suggesting multiple theoretical explanations may apply and performance may also depend on the individual. Design guidance on how to maximize performance goals with transition rate is provided, but future research needs to study the theoretical explanations and impact of individual differences further.

- **Keywords:** Workload transitions; Growth curve modeling; Military; UAV command and control

Marlène Cheyrouze, Béatrice Barthe. *Designing shift work: Proposal for a participatory approach deployed in a hospital setting and focusing on actual work.* 103901.

Designing the working day is not just a matter of changing the shift system. It also requires reflection on the working conditions and a negotiation of solutions with the stakeholders concerned. This article seeks to show that a participatory approach, built

using organisational simulation, provides a framework with which to understand the reality of each profession and co-construct suitable solutions. Our action-research took place in a hospital's pneumology ward. The methodology can be broken down into four phases: diagnosis, sharing of the diagnosis, organisational simulation (the focus of this article) and experimenting with solutions. The results show that the approach gave the stakeholders the opportunity to discover and discuss the rules and constraints of actual work, to compare their different views, and to develop a new and shared view of the work situation. The approach allowed them to co-construct relevant solutions and to appropriate the changes necessary for their success.

- **Keywords:** Shift work; Design; Organisational simulation; Hospital

Joel Martin, James Kearney, Sara Nestrowitz, Adam Burke, Megan Sax van der Weyden. *Effects of load carriage on measures of postural sway in healthy, young adults: A systematic review and meta-analysis.* 103893.

Load carriage (LC) is a contributing factor to musculoskeletal injury in many occupations. Given that falls are a common mechanism of injury for those frequently engaging in LC, understanding the effects of LC on postural stability (PS) is necessary. A systematic review and meta-analysis was conducted to examine effects of LC on PS. Sixteen and 9 studies were included in the qualitative and quantitative synthesis, respectively. In most studies, it was found that LC leads to a decrease in PS with significant effects on center of pressure (COP) sway area (standardized mean difference = 0.45; $p < 0.005$) and COP anterior-posterior excursion (standardized mean difference = 0.52; $p < 0.05$). Furthermore, load magnitude and load placement are factors which can significantly affect COP measures of PS. It is recommended to minimize load magnitude and equally distribute load when possible to minimize LC effects on PS. Future research should examine additional factors contributing to differences in individual PS responses to LC such as changes in muscle activation and prior LC experience.

- **Keywords:** Body-worn load; Balance; Musculoskeletal injury; Tactical

Chihab Nadri, Siddhant Kekal, Yinjia Li, Xuan Li, Seul Chan Lee, David Nelson, Pasi Lautala, Myoungsoon Jeon. *"Slow down. Rail crossing ahead. Look left and right at the crossing": In-vehicle auditory alerts improve driver behavior at rail crossings.* 103912.

Even though the rail industry has made great strides in reducing accidents at crossings, train-vehicle collisions at Highway-Rail Grade Crossings (HRGCs) continue to be a major issue in the US and across the world. In this research, we conducted a driving simulator study ($N = 35$) to evaluate a hybrid in-vehicle auditory alert (IVAA), composed of both speech and non-speech components, that was selected after two rounds of subjective evaluation studies. Participants drove through a simulated scenario and reacted to HRGCs with and without the IVAA present and through different music conditions and crossing devices. Driver simulator testing results showed that the inclusion of the hybrid IVAA significantly improved driving behavior near HRGCs in terms of gaze behavior, braking reaction, and approach speed to the crossing. The driving simulator study also showed the effects of background music and warning device types on driving performance. The study contributes to the large-scale implementation of IVAAs at HRGCs, as well as the development of guidelines toward a more standardized approach for IVAAs at HRGCs.

- **Keywords:** Automotive user displays; In-vehicle auditory alerts; Highway-rail grade crossings; Driving simulator study

Céleste Rousseau, Louna Taha, Gabor Barton, Peter Garden, Vasilios Baltzopoulos. *Assessing posture while playing in musicians: a systematic review.* 103883.

Introduction: Playing a musical instrument can potentially lead to musculoskeletal disorders. Postural loads are different considering the instrument they play; for example violin and flute require elevation from both upper limbs, asymmetrical postures are common and instrument weight can be significant. The aim was to explore how musicians' postures are investigated, and potentially if there is evidence of an association between postural impairments and pain. **Methods:** A systematic search was performed in several databases, combined with manual search. Study inclusion, data extraction and quality assessment were performed independently by two reviewers. **Results:** Twenty seven relevant studies were included in this review covering musicians with the full range of playing experience (professionals, students, teachers, amateurs). The main considered methods to investigate postures are visual assessment and three dimensional analysis using videography. **Discussion:** This review provides a synthesis of the different methods used to monitor posture in musicians and provides information in order to build protocols which will allow comparison with previous work.

- **Keywords:** Posture; Playing-related musculoskeletal disorders; Musicians; Prevention

Peng Li, K. Blake Mitchell. *A shape classification scheme for female torso.* 103904.

This paper presents a shape classification scheme for the female torso, based on anthropometric measurements and 3D body scans from a large scale anthropometric survey. The ability to classify the female body shape is highly desired by the clothing industry and apparel researchers for improving pattern design and fit. In order to objectively classify female torso shapes, we employed principal component analysis on torso related anthropometric measurements and three-dimensional (3D) torso surface data to identify the most dominant measurements. The principal component analysis of the anthropometric measurements show that Waist Circumference is the most dominant variable to define overall female torso size, and that Chest-Waist Drop and Waist-Buttock Drop jointly define the local shape of the torso. Using these findings, a torso shape classification scheme was developed, where nine shape categories were defined from Chest-Waist Drop and Waist-Buttock Drop while torso sizes were divided by Waist Circumference. The distribution of nine shape categories is dependent on the value of Waist Circumference. Mean shape of each shape category was then generated from 3D scans.

- **Keywords:** Female torso shape; Shape classification; Anthropometry; ANSUR II; Principal component analysis; Waist circumference

Jasmin Vallée Marcotte, Xavier Robert-Lachaine, Denys Denis, Antoine Muller, André Plamondon, Philippe Corbeil. *Biomechanical differences in experts' and novices' footstep patterns during a palletizing task.* 103880.

Very few studies have examined differences between experts' and novices' foot positioning and movements during manual materials handling tasks. The impact of footstep patterns on low back loading needs to be better understood. The goals of this study were to characterize foot placement and movements in novices and experts and to assess their impact on back loading considering the height of grasp. The task consisted in transferring 24 15 kg boxes from a pallet to another. Foot placement and movements were classified with a recently developed taxonomy. Results show that experts' feet

remained static more often than novices' feet during the lifting phase. Positioning the feet towards the deposit site during lifting increased asymmetrical moments, especially for novices. Positioning one foot forward increased asymmetrical moments for novices. Overall, footstep strategies are an effective indicator of low back exposure and should be considered in ergonomic studies.

- **Keywords:** Footstep strategies; Back loading; Manual materials handling; Lifting; Experience

Sarah K. Hopko, Ranjana K. Mehta, Prabhakar R. Pagilla. *Physiological and perceptual consequences of trust in collaborative robots: An empirical investigation of human and robot factors.* 103863.

Measuring trust is an important element of effective human-robot collaborations (HRCs). It has largely relied on subjective responses and thus cannot be readily used for adapting robots in shared operations, particularly in shared-space manufacturing applications. Additionally, whether trust in such HRCs differ under altered operator cognitive states or with sex remains unknown. This study examined the impacts of operator cognitive fatigue, robot reliability, and operator sex on trust symptoms in collaborative robots through both objective measures (i.e., performance, heart rate variability) and subjective measures (i.e., surveys). Male and female participants were recruited to perform a metal surface polishing task in partnership with a collaborative robot (UR10), in which they underwent reliability conditions (reliable, unreliable) and cognitive fatigue conditions (fatigued, not fatigued). As compared to the reliable conditions, unreliable robot manipulations resulted in perceived trust, an increase in both sympathetic and parasympathetic activity, and operator-induced reduction in task efficiency and accuracy but not precision. Cognitive fatigue was shown to correlate with higher fatigue scores and reduced task efficiency, more severely impacting females. The results highlight key interplays between operator states of fatigue, sex, and robot reliability on both subjective and objective responses of trust. These findings provide a strong foundation for future investigations on better understanding the relationship between human factors and trust in HRC as well as aid in developing more diagnostic and deployable measures of trust.

- **Keywords:** Cognitive fatigue; ECG; Sex; Human-robot collaboration; Reliability; Trust

Kazuki Yoshida, Daisuke Sawamura, Mikio Yagi, Yu Nakashima, Ryuji Saito, Nao Yamamura, Katsuhiko Ogasawara, Shinya Sakai. *Detecting inattentiveness caused by mind-wandering during a driving task: A behavioral study.* 103892.

This study aims to investigate whether behavioral variability and participants' self-ratings can be used to detect mind-wandering while driving and to examine their effects on braking performance during a driving task. We created a novel driving task and added a sustained attention response task (SART). We examined the effects of mind-wandering on braking performance and whether mind-wandering could be detected from SART response variability. The within-subjects results showed that self-reports of inattentiveness during driving correlated significantly with SART response variability. Multiple regression analysis with brake reaction time as the dependent variable revealed a significant relationship between self-reports of inattentiveness and mind-wandering. However, there were no other consistent linear associations between mind-wandering and SART response variability. Our results not only suggest that inattentiveness to driving caused by mind-wandering impairs braking performance but also emphasize the importance and difficulty of detecting this state from behavioral data alone.

- **Keywords:** Driving; Mind-wandering; SART; Attention; Thought probe

Lukasz M Mazur, Karthik Adapa, Samantha Meltzer-Brody, Waldemar Karwowski. Towards better understanding of workplace factors contributing to hospitalist burden and burnout prior to COVID-19 pandemic. 103884.

Background: Hospitalists are physicians trained in internal medicine and play a critical role in delivering care in in-patient settings. They work across and interact with a variety of sub-systems of the hospital, collaborate with various specialties, and spend their time exclusively in hospitals. Research shows that hospitalists report burnout rates above the national average for physicians and thus, it is important to understand the key factors contributing to hospitalists' burnout and identify key priorities for improving hospitalists' workplace. **Methods:** Hospitalists at an academic medical center and a community hospital were recruited to complete a survey that included demographics, rating the extent to which socio-technical (S-T) factors contributed to burnout, and 22-item Maslach Burnout Inventory – Human Services Survey (MBI-HSS). Twelve contextual inquiries (CIs) involving shadowing hospitalists for ~60 h were conducted varied by shift type, length of tenure, age, sex, and location. Using data from the survey and CIs, an affinity diagram was developed and presented during focus groups to 12 hospitalists to validate the model and prioritize improvement efforts. **Results:** The overall survey participation rate was 68%. 76% of hospitalists reported elevated levels on at least one sub-component within the MBI. During CIs, key breakdowns were reported in relationships, communication, coordination of care, work processes in electronic healthcare records (EHR), and physical space. Using data from CIs, an affinity diagram was developed. Hospitalists voted the following as key priorities for targeted improvement: improve relationships with other care team members, improve communication systems and prevent interruptions and disruptions, facilitate coordination of care, improve workflows in EHR, and improve physical space. **Conclusions:** This mixed-method study utilizes participatory and data-driven approaches to provide evidence-based prioritization of key factors contributing to hospitalists' burnout. Healthcare systems may utilize this approach to identify workplace factors contributing to provider burnout and consider targeting the factors identified by providers to best optimize scarce resources.

- **Keywords:** Hospitalists; Burnout; Contributing factors to workplace burden; Qualitative research; Mixed-methods

Christopher Stockinger, Lucas Polanski-Schröder, Ilka Subtil. The effect of information level of digital worker guidance systems on assembly performance, user experience and strain. 103896.

Worker guidance systems provide product-specific and digital assembly information and can make an important contribution to increasing productivity and quality and relieving employees, especially in flexible variant assembly. However, a critical factor here is the successful design of the systems. While much of the research focuses on aspects of the hardware, this article is dedicated to the question of how the configuration of the level of information, i.e. the amount and depth of information in worker guidance systems, is affected. For this purpose, two studies, a laboratory study at the Technical University of Darmstadt (N = 53) and a field study at a company (N = 30), were conducted and two variants of the information level of a worker guidance system were compared. The study results show that assembly quality in particular is significantly influenced by the level of information; to the advantage of detailed information. No significant differences were found for production times. For the subjective evaluation of the system as well as for the objective and subjectively perceived strain, it can be stated that the high level of information also performs better. The results thus help to design worker guidance systems more precisely so that they fulfill the information needs of the employees as well as possible.

- **Keywords:** Worker guidance system; Assembly; Performance; User experience; Strain; Information level; Empirical study

Wenxiu Yang, Renke He, Richard Goossens, Toon Huysmans. *Pressure sensitivity for head, face and neck in relation to soft tissue.* 103916.

Pressure sensitivity research on the head, face, and neck is critical to develop ways to reduce discomfort caused by pressure in head-related products. The aim of this paper is to provide information for designers to be able to reduce the pressure discomfort by studying the relation between pressure sensitivity and soft tissue in the head, face and neck. We collected pressure discomfort threshold (PDT) and pressure pain threshold (PPT) from 119 landmarks (unilateral) for 36 Chinese subjects. Moreover, soft tissue thickness data on the head, face and neck regions of 50 Chinese people was obtained through CT scanning while tissue deformation data under the PDT and PPT states was obtained from literature. The results of the three-elements correlation analysis revealed that soft tissue thickness is positively correlated with deformation but not an important factor in pressure sensitivity. Our high-precision pressure sensitivity maps confirm earlier findings of more rough pressure sensitivity studies, while also revealing additional fine scale sensitivity differences. Finally, based on the findings, a high-precision "recommended map" of the optimal stress-bearing area of the head, face and neck was generated.

- **Keywords:** Pressure discomfort; CT data; Product design

Amir Tjolleng, Joonho Chang, Jangwoon Park, Wonsup Lee, Myeongsup Cha, Jongchul Park, Kihyo Jung. *Development of a human-friendly visual inspection method for painted vehicle bodies.* 103911.

Visual inspections performed in the final stage of the vehicle manufacturing process are crucial for assuring the quality of painted vehicle bodies. However, lengthy visual inspections can cause fatigue and discomfort of the eyes, which may adversely affect inspection accuracy and efficiency. This study developed a new human-friendly visual inspection method for the detection of defects (e.g., scar and dent) on vehicle bodies, and compared its performance to a conventional inspection method in terms of critical fusion frequency (Hz, indirect measure of eye fatigue), defect detectability (%), and subjective satisfaction score (7-point Likert scale). The new method was devised to project bright-dark linear stripes onto the surface of the vehicle body and created emergent features (distorted stripes) where a defect existed. The critical fusion frequency of the new method decreased slightly (3.7%) after a 30-minute visual inspection task, whereas that of the conventional method dropped substantially (11.0%), which implied more severe eye fatigue. Additionally, the new method had significantly higher defect detectability (92.1%) and satisfaction score (5.8 points) than those (73.4% and 3.5 points) of the conventional method.

Nirit Yuviler-Gavish, Avi Weiss, Uri Ben-Hanan, Matan Madar. *Wheelchair users' perceptions of a system enabling them to traverse rough terrain controlling their own wheelchair.* 103866.

We recently developed a dynamic mimicking system that mounts a user's wheelchair onto a carrier platform capable of performing required manoeuvres using the wheelchair's own controls. Two wheelchair user studies were performed to evaluate users' perception of their own wheelchair and the proposed system. The first user study included ten wheelchair users who were interviewed in order to map their current perceptions toward their wheelchair and their views about its shortcomings when traversing rough terrains. In the second study, the system was explained to 33 participants who were then exposed to three simulations of its main features. Participants

were interviewed and the experimenter wrote down their answers, which were analysed using IBM SPSS Statistics 27 software. The conclusions are that special consideration should be given to motorized wheelchair users, and that the designers of the system should include a user interface that explains and demonstrates the system to users.

- **Keywords:** Automation; Safety; Mimicking; Trust; Willingness

Daniel Sturman, Chelsea Valenzuela, Oliver Plate, Tazin Tanvir, Jaime C. Auton, Piers Bayl-Smith, Mark W. Wiggins. *The role of cue utilization in the detection of phishing emails.* 103887.

This study was designed to examine the roles of cue utilization, phishing features and time pressure in the detection of phishing emails. During two experiments, participants completed an email sorting task containing both phishing and genuine emails. Participants were allocated to either a high or low time pressure condition. Performance was assessed via detection sensitivity and response bias. Participants were classified with either higher or lower cue utilization and completed a measure of phishing knowledge. When participants were blind to the nature of the study (N = 191), participants with higher cue utilization were better able to discriminate phishing from genuine emails. However, they also recorded a stronger bias towards classifying emails as phishing, compared to participants with lower cue utilization. When notified of phishing base rates prior to the email sorting task (N = 191), participants with higher cue utilization were better able to discriminate phishing from genuine emails without recording an increase in rate of false alarms, compared to participants with lower cue utilization. Sensitivity increased with a reduction in time pressure, while response bias was influenced by the number of phishing-related features in each email. The outcomes support the proposition that cue-based processing of critical features is associated with an increase in the capacity of individuals to discriminate phishing from genuine emails, above and beyond phishing-related knowledge. From an applied perspective, these outcomes suggest that cue-based training may be beneficial for improving detection of phishing emails.

- **Keywords:** Cue utilization; Cybersecurity; Information processing; Phishing; Visual search

Sander De Bock, Toon Ampe, Marco Rossini, Bruno Tassignon, Dirk Lefeber, Carlos Rodriguez-Guerrero, Bart Roelands, Joost Geeroms, Romain Meeusen, Kevin De Pauw. *Passive shoulder exoskeleton support partially mitigates fatigue-induced effects in overhead work.* 103903.

Background: Despite the potential of occupational passive shoulder exoskeletons (PSEs) to relieve overhead work, limited insights in overhead work precision performance impedes large-scale adoption in industry. **Objective:** To investigate the effect of PSE support on the reduction in task performance caused by physical fatigue. **Methods:** This experiment consisted of a randomized, counterbalanced cross-over design comparing Exo4Work PSE support and no support, in a physically fatigued state and a control condition. Precision performance was determined using execution speed and drilling errors. Muscle activity and shoulder joint kinematics were recorded. **Results:** Fatigue altered task performance, shoulder joint kinematics, muscle activity and subjective experience during overhead work. The PSE support mitigated the fatigue-induced changes in shoulder kinematics. Additionally, a part of the fatigue-induced co-activation of shoulder stabilizing muscles was avoided when working with the PSE. The PSE support also reduced the activity of the anterior and medial deltoid. **Conclusion:** Physical fatigue provokes compensatory movements and increased co-contraction of muscles when executing overhead work. These fatigue-induced alterations are generally believed to increase the overall musculoskeletal load. The support provided by the PSE reduced muscle activity of muscles working to elevate the arm, but also partially mitigated those

fatigue-induced effects. **Significance:** This study shows that the effect of PSE support on precision performance is limited, and suggested that, apart from the known effects of PSE support during overhead work, wearing the exoskeleton in a physically fatigued state may provide additional advantages.

- **Keywords:** Physical fatigue; Wearable assistive device; Task analysis; Device evaluation

Wonil Park, Minsoo Jin, Yongseok Kim, Kisu Kim, Sukki Lee. *Investigating the effect of road lighting color temperature on road visibility in night foggy conditions.* 103899.

Night foggy road conditions limit visibility distance of drivers and are associated with higher accident and fatality rates than other weather conditions. Therefore, ensuring road visibility in night foggy road is critical. However, it is difficult to reproduce fog on a real road and only a few studies have researched foggy road conditions and visibility in a laboratory as a small scale. Previous studies have suggested that a color temperature of road lighting is related to visibility. However, many have only investigated the effects of relative transmittance in limited indoor experiments, and the impacts of differences in transmittance on visibility have thus far not been studied in real-scale conditions. In this study, a real-scale test involving 91 subjects was conducted to investigate how the visibility distance under night foggy conditions is affected by different lighting color temperatures. Based on the real scale experiments, the correlation between the visibility distance and lighting color temperature was derived. Road lighting with a low color temperature (i.e., yellow) was found to provide longer visibility distances than that with high color temperatures under night foggy conditions having measured visibility of approximately 102m. The impact of the differences in lighting color increased as the visibility distance decreased. In contrast, road lighting with a high color temperature (i.e., white) improved driver visibility in higher-visibility conditions. Therefore, this study confirmed the correlation between lighting color temperature and visibility distance for different visibility conditions and could serve as a foundation for the development of roadway design standards as well as future studies.

- **Keywords:** Color temperature; Foggy road; Real-scale test; Road lighting; Visibility distance

Kurt E. Beschorner, Arnab Chanda, Brian E. Moyer, Alexander Reasinger, Sarah C. Griffin, Isaiah M. Johnston. *Validating the ability of a portable shoe-floor friction testing device, NextSTEPS, to predict human slips.* 103854.

Measuring shoe-floor friction is critical for assessing the safety of footwear products. Portable devices for measuring coefficient of friction (COF) are needed. This study introduces such a device and evaluates its ability to predict human slip events across shoe designs. A portable device (18 kg) was utilized to measure 66 unique shoe-floor-fluid coefficients of friction (COF). Consistent with the shoes, flooring, and fluid contaminants from the COF tests, participants (n = 66) were unexpectedly exposed to the fluid while walking. Slip predictions were made based on a separate training data set. Slip predictions were made prospectively and using logistic regression analyses. The slip predictions were valid ($p < 0.001$), 91% sensitive, and 64% specific. The logistic regression fit also revealed that the COF values predicted slip outcomes ($p = 0.006$). This device is expected to expand the capacity of researchers, product developers, forensic engineers, and safety professionals to prevent slips and enhance human safety.

- **Keywords:** Slips; Trips; And falls; Footwear; Coefficient of friction; Validation studies

S.J. Summers, S.N. Laing, R.A. Davidson, M.A. Jaffrey, A. Zhou, C.E. Coltman. *Do thoracoabdominal organ boundaries differ between males and females? Implications for body armour coverage and design.* 103891.

To optimise fit and protection of body armour systems, knowledge of the location of thoracoabdominal organ boundaries is required. The aims of this study were (i) determine the effect of sex on essential and desirable thoracoabdominal organ boundaries, and (ii) compare essential thoracoabdominal organ boundaries with small and large hard ballistic plate sizes from the National Institute of Justice (NIJ) and determine if coverage requirements differ between sexes. 33 males and 33 females underwent supine magnetic resonance imaging of their thoracoabdominal organs. Male participants on average displayed more laterally and inferiorly positioned essential and desirable organ boundaries than females. Based on NIJ plate sizes, insufficient coverage of essential organs was identified for male and female participants. A greater range of body armour sizes and designs that better cater to the diverse anatomy of soldier populations is warranted, but must be considered in the context of ergonomic and performance implications.

- **Keywords:** Sex; Essential organs; Soldier; Military; Protective equipment

Bat-Zion Hose, Pascale Carayon, Peter L.T. Hoonakker, Joshua C. Ross, Benjamin L. Eithun, Deborah A. Rusy, Jonathan E. Kohler, Thomas B. Brazelton, Shannon M. Dean, Michelle M. Kelly. *Managing multiple perspectives in the collaborative design process of a team health information technology.* 103846.

We need to design technologies that support the work of health care teams; designing such solutions should integrate different clinical roles. However, we know little about the actual collaboration that occurs in the design process for a team-based care solution. This study examines how multiple perspectives were managed in the design of a team health IT solution aimed at supporting clinician information needs during pediatric trauma care transitions. We focused our analysis on four co-design sessions that involved multiple clinicians caring for pediatric trauma patients. We analyzed design session transcripts using content analysis and process coding guided by D tienne's (2006) co-design framework. We expanded upon D tienne (2006) three collaborative activities to identify specific themes and processes of collaboration between care team members engaged in the design process. The themes and processes describe how team members collaborated in a team health IT design process that resulted in a highly usable technology.

- **Keywords:** Collaborative design; Team health information technology; Pediatric trauma care transitions

Katie J. Parnell, Neville A. Stanton, Victoria A. Banks, Katherine L. Plant. *Resilience engineering on the road: Using operator event sequence diagrams and system failure analysis to enhance cyclist and vehicle interactions.* 103870.

Future visions of transport systems include both a drive towards automated vehicles and the need for sustainable, active, modes of travel. The combination of these requirements needs careful consideration to ensure the integration of automated vehicles does not compromise vulnerable road users. Transport networks need to be resilient to automation integration, which requires foresight of possible challenges in their interaction with other road users. Focusing on a cyclist overtake scenario, the application of operator event sequence diagrams and a predictive systems failure method provide a novel way to

analyse resilience. The approach offers the opportunity to review how automation can be positively integrated into road transportation to overcome the shortfalls of the current system by targeting organisational, procedural, equipment and training measures.

- **Keywords:** Resilience; Automated driving; OESDs; SHERPA; Cycling; Active travel

Nancy L. Black, W. Patrick Neumann, Ian Noy, Colleen Dewis. *Applying ergonomics and human factors to congress organization in uncertain times.* 103862.

Organizational Design and Management (ODAM) elements of Ergonomics and Human Factors (E/HF) apply to congress organization. Exemplary delegate and organizer E/HF experience is constrained by shifting requirements, time pressures and financial constraints. E/HF application while organizing the International Ergonomics Association's Triennial Congress in 2021 (IEA2021) is described focusing on delivery platforms considering typical and exceptional (pandemic) constraints, emphasizing ODAM E/HF principles and generalizable lessons. Post-Congress feedback from delegates, session chairs and Congress organizers reveal the Congress as experienced. Presenting virtually allowed on-demand recording access following live sessions and increased question-and-answer flexibility. Frustrations included navigating multiple platforms and insufficient communications. Stakeholders' differing expectations increased organizer workloads and delegate frustration. Maximum virtual presentation benefits require efforts to ensure integrated, human-centered platform development. Simply digitizing traditional Congress sessions ignores potential enhancements. Embracing innovations would help meet delegate communication needs via careful selection and deployment of evolving virtual meeting technologies. Organizational learning strategies can support these efforts.

- **Keywords:** Conference; Organizational design and management; Software; Virtual

Gene M. Alarcon, August Capiola, Izz Aldin Hamdan, Michael A. Lee, Sarah A. Jessup. *Differential biases in human-human versus human-robot interactions.* 103858.

The research on human-robot interactions indicates possible differences toward robot trust that do not exist in human-human interactions. Research on these differences has traditionally focused on performance degradations. The current study sought to explore differences in human-robot and human-human trust interactions with performance, consideration, and morality trustworthiness manipulations, which are based on ability/performance, benevolence/purpose, and integrity/process manipulations, respectively, from previous research. We used a mixed factorial hierarchical linear model design to explore the effects of trustworthiness manipulations on trustworthiness perceptions, trust intentions, and trust behaviors in a trust game. We found partner (human versus robot) differences across all three trustworthiness perceptions, indicating biases towards robots may be more expansive than previously thought. Additionally, there were marginal effects of partner differences on trust intentions. Interestingly, there were no differences between partners on trust behaviors. Results indicate human biases toward robots may be more complex than considered in the literature.

Brett Pollard, Joe Van Buskirk, Lina Engelen, Fabian Held, Richard de Dear. *How many days of indoor positioning system data are required to characterise typical movement behaviours of office workers?* 103915.

Indoor Positioning Systems (IPS) appear to offer great potential to study the movement and interaction of people and their working environment, including office workplaces. But

little is known about appropriate durations for data collection. In this study, location observations collected from 24 office workers on a 1220 m² office floor over a 3-month period, were analysed to determine how many days are required to estimate their typical movement and spatial behaviours. The analysis showed that up to 8 days of data was sufficient to characterise participants' typical daily movement behaviours and 10 days were required to estimate their typical spatial mobility. However, the results also indicate that 5 weeks of data collection are required to gather the necessary 10 days of data from each participant. These findings will help researchers and workplace professionals to understand the capabilities and requirements of IPS when considering their use in indoor work environments.

- **Keywords:** Office; Physical inactivity; Spatial behaviour; Indoor positioning system; Occupant behaviour

Sol Lim, Yue Luo, Jonathan Lee-Confer, Clive D'Souza. *Obstacle clearance performance in individuals with high body mass index.* 103879.

The objective of this study was to quantify performance in an obstacle clearance task among individuals with excess body weight or body mass index (BMI). Task performance was operationalized as the maximum obstacle height cleared, four duration measures of successful task completion and compensatory movements used in the process of task completion. Eighteen participants with a BMI exceeding 30 kg/m² completed a laboratory experiment that required stepping over seven lightweight obstacles. Obstacle heights were sequentially increased from 36 cm in 5 cm increments until participants were unsuccessful or unable to clear the obstacle up to 66 cm. Successful task completions decreased from 100% at an obstacle height of 36 cm to 66.1% at 66 cm. Higher obstacle heights were associated with significantly fewer task completions, longer leading and trailing leg stance and overall task duration, and more frequent use of compensatory movements for successful obstacle clearance. Cox PH regression was used to test the association between probability of obstacle clearance and normalized obstacle height adjusting for BMI, standing balance, and type of compensatory movement used, namely, hover and pivot motions involving the leg, and hands for bracing. The probability of successful task completion significantly decreased with increases in BMI (hazard ratio, HR = 1.14, 95% CI: 1.05–1.25), and increased with use of a leg pivot motion (HR = 0.30, 95% CI: 0.09–0.96) during task completion, after adjusting for standing balance and other types of compensatory movements. Overall, the results demonstrated that obstacle clearance performance is affected by an individual's BMI and the use of compensatory behaviors for regaining stability. The ability to recruit internal and external stabilization techniques could potentially serve as a clinical indicator of reduced fall risk and be the focus of fall prevention interventions. Implications for evaluating stability, fall risk, and identifying modifiable factors for fall prevention in the obese population are discussed.

- **Keywords:** Obesity; Obstacle clearance; Dynamic balance

Saliha Ziam, Sawsen Lakhal, Elena Laroche, Julie Lane, Marie Alderson, Charles Gagné. *Musculoskeletal disorder (MSD) prevention practices by nurses working in health care settings: Facilitators and barriers to implementation.* 103895.

The incidence of musculoskeletal disorders (MSD) in the healthcare professional population is concerning. In particular, the high incidence of back injuries is an issue for nurses. Although many MSD prevention initiatives are being implemented, these practices are not succeeding in reducing MSDs. Why are these efforts struggling to close the gap between knowledge and practice? This article aims to report on individual and

organizational factors that may influence nurses' implementation of MSD prevention practices. A survey was sent to nurses in the Quebec health and social services network. A total of 399 questionnaires were completed and analyzed. The results revealed that nurses have the required knowledge on MSD prevention practices, but have difficulty applying them in their professional context. It would appear that successful implementation of MSD prevention practices relies mainly on organizational factors, including management support, organizational culture, feedback mechanisms, and training that is adapted to the work environment.

- **Keywords:** Musculoskeletal disorders; Nurses; Prevention practices

Cristina Ruscitto, Jane Ogden, Jason G. Ellis. To what extent is circadian phase predictive of subjective jet lag in long-haul cabin crew pre- and post-trip? 103882.

Long-haul cabin crew regularly report misalignment between their circadian phase and the external world (i.e. jet lag). The extent to which changes in circadian phase relate to reported levels of jet lag remains unclear. The main aim of the present study was first to evaluate the relationship between objective (circadian phase) and subjective jet lag and second to explore the relative role of both subjective and objective psycho-behavioural factors in predicting the subjective experience of jet lag. Twenty-eight long-haul cabin crew completed questionnaires measuring diurnal preference, trip characteristics and subjective jet lag as a single and as a multidimensional measure. Sleep was monitored using actigraphy and urinary melatonin peak time was measured, at baseline (T1), e.g. before a long-haul trip and post-trip on the crew's first recovery day (T2). Subjective jet lag was also measured at both time points. At T1, later circadian phase related to increased unidimensional jet lag, however, a post-trip discrepancy was found between objective and subjective uni- and multidimensional jet lag measured at T2 and change from T1 to T2. After controlling for direction and size of circadian phase, increased uni- and multidimensional subjective jet lag was predicted by depressed mood states. The regression models including phase, diurnal preference, departure time on the outbound sector and arousal levels accounted for 28% of the variance in unidimensional jet lag and 53% of the variance in multidimensional jet lag. It was concluded that there is a discordance between objective and subjective jet lag post-trip. Further, subjective jet lag in long-haul cabin crew is better explained by mood impairment than circadian phase. The results are discussed with reference to the gap between subjective and objective jet lag and the role of psychology rather than just biology in the jet lag experience. The implications for improving health and safety in the workplace, through a better understanding of the role of human factors in the management of jet lag, are discussed.

- **Keywords:** Jet lag; Circadian phase; Long-haul cabin crew

Kenneth M. Jackson, Tyler H. Shaw, William S. Helton. *Evaluating the dual-task decrement within a simulated environment: Word recall and visual search.* 103861.

Simulated environments have become better able to replicate the real world and can be used for a variety of purposes, such as testing new technology without any of the costs or risks associated with working in the real world. Because of this, it is now possible to gain a better understanding of cognitive demands when working in operational environments, where individuals are often required to multitask. Multitasking often results in performance decrements, where adding more tasks can cause a decrease in performance in each of the individual tasks. However, little research investigated multitasking performance in simulated environments. In the current study we examined how multitasking affects performance in simulated environments. Forty-eight participants performed a dual visual search and word memory task where participants were navigated through a simulated environment while being presented with words. Performance was

then compared to single-task performance (visual search and word memory alone). Results showed that participants experienced significant dual-task interference when comparing the dual-tasks to the single-tasks and subjective measures confirmed these findings. These results could provide useful insight for the design of technology in operational environments, but also serve as an evaluation of MRT in simulated environments.

- **Keywords:** Multi-tasking; Virtual reality; Vigilance; Verbal recall; Visual search

Stefanie Xiaoqiong Kang, Siu Shing Man, Alan Hoi Shou Chan. *Investigation on the effects of presentation modality for spatial signals on human performance using a dual task paradigm.* 103898.

A dual task was designed to involve a tracking mission with various tracking speeds and a spatial compatibility task with various signal-key mappings and presentation modalities. This dual task was used to investigate the effects of workload and resource competition in distinct parts of the dual-task process. The results demonstrated that increasing the tracking speed adversely affected the tracking performance but led to positive arousal to the secondary discrete response task. Visual spatial signals gave the shortest reaction time due to the optimal time-sharing of the visual resources in the focal and ambient channels. Compared with visual spatial signals, spatial signals of auditory and tactile modalities did not lead to an improved performance because of their cross-modality nature. These findings provided practical design guidelines for dual tasks in which the operators need to complete a continuous monitoring task visually and elicit timely and accurate responses to spatial information.

- **Keywords:** Human-machine interface; Spatial stimulus-response compatibility; Dual-task performance; Multimodal signals

Adam T. Biggs, Kyle A. Pettijohn, Sarah Sherwood. *How speed impacts threat assessment in lethal force decisions.* 103890.

Despite the importance of being both fast and accurate in lethal force decisions, there is little empirical evidence to identify how speed impacts threat-related decisions and perception. Two experiments used speeded and unspeeded manipulations to determine how the speed imperative impacted threat assessments. Experiment 1 used drift diffusion modeling to quantify decision parameters, including rate of information processing, decision threshold, bias, and non-decisional processes. Speeded conditions reduced the information threshold needed to make decisions and shortened non-decisional processes, yet this manipulation had no impact on the rate of information processing or starting bias. Experiment 2 explored perceptual differences in threat assessment. Participants confidently made threat assessments despite only 30 ms exposure to stimuli with little impact on their subjective threat ratings based on exposure duration. Taken together, these results document the influence of speed on decision-making parameters of threat assessments while demonstrating little impact on threat perception.

- **Keywords:** Lethal force; Speed; Decision-making; Threat perception; Response inhibition

Jacob J. Banks, Mohammad Mehdi Alemi, Brett T. Allaire, Andrew C. Lynch, Mary L. Bousein, Dennis E. Anderson. *Using static postures to estimate spinal loading during dynamic lifts with participant-specific thoracolumbar musculoskeletal models.* 103869.

Static biomechanical simulations are sometimes used to estimate in vivo kinetic demands because they can be solved efficiently, but this ignores any potential inertial effects. To

date, comparisons between static and dynamic analyses of spinal demands have been limited to lumbar joint differences in young males performing sagittal lifts. Here we compare static and dynamic vertebral compressive and shear force estimates during axial, lateral, and sagittal lifting tasks across all thoracic and lumbar vertebrae in older men and women. Participant-specific thoracolumbar full-body musculoskeletal models estimated vertebral forces from recorded kinematics both with and without consideration of dynamic effects, at an identified frame of peak vertebral loading. Static analyses under-predicted dynamic compressive and resultant shear forces, by an average of about 16% for all three lifts across the thoracic and lumbar spine but were highly correlated with dynamic forces (average $r^2 > .95$). The study outcomes have the potential to enable standard clinical and occupational estimates using static analyses.

- **Keywords:** Static analysis; Predictive equations; Musculoskeletal model

Duyen Dinh-Dang, Abdullah Khafagy, Niklas Krause, Carisa Harris-Adamson. *Assessment of cardiovascular load among hotel room cleaners.* 103886.

Hotel room cleaners are a vulnerable population at risk for cardiovascular disease. To evaluate their workload heart rate (HR), % heart rate reserve (%HRR), blood pressure (BP), metabolic equivalent (MET), and energy expenditure (EE) were measured over two workdays and two off-workdays. The mean age was 45.5 (SD 8.2) years with a mean 10.4 (SD 7.8) years of work experience. Mean average and peak HR, %HRR, MET, and EE were significantly higher during a workday than an off-workday for the entire work shift, first and last hour of work. Mean average HR and %HRR saw the largest increase between the lunch and post-lunch interim. One-fourth of subjects exceeded the recommended 30% HRR threshold for 8-hour shifts. Some workers experienced a substantial increase in HR and DBP over a workday indicating physiologic fatigue and thus may be at increased risk for cardiovascular disease and premature death due to excessive physical work demands.

- **Keywords:** Hotel room cleaners; Cardiovascular strain; Work demands

Ryan D. McMullan, Rachel Urwin, Mark Wiggins, Johanna I. Westbrook. *Are two-person checks more effective than one-person checks for safety critical tasks in high-consequence industries outside of healthcare? A systematic review.* 103906.

Double-checking has been used in high-consequence industries for decades. We aimed to determine the strength of the evidence-base regarding the effectiveness of double-checking which underpins its widespread adoption. We searched for quantitative studies of the effectiveness of two-person checking in industry sectors, excluding healthcare. We performed a systematic literature search across six databases and hand-searched key journals. We completed a narrative synthesis and quality assessment of the nine studies identified. Most studies were of fair quality. Two examined the use of two-person checks in aviation, three investigated tasks in chemical manufacturing, and four studies in psychology involved proofreading and visual search tasks. All studies found that the performance of two-people checking was not superior to that of one-person in detecting errors. Further research to compare the effectiveness of different checking processes along with factors which may support optimisation of safety checks in high-consequence industries is required.

- **Keywords:** Double-checking; High-consequence industries; Systematic review

B.K. Burian, M. Ebnali, J.M. Robertson, D. Musson, C.N. Pozner, T. Doyle, D.S. Smink, C. Miccile, P. Paladugu, B. Atamna, S. Lipsitz, S. Yule, R.D.

Dias. *Using extended reality (XR) for medical training and real-time clinical support during deep space missions.* 103902.

Medical events can affect space crew health and compromise the success of deep space missions. To successfully manage such events, crew members must be sufficiently prepared to manage certain medical conditions for which they are not technically trained. Extended Reality (XR) can provide an immersive, realistic user experience that, when integrated with augmented clinical tools (ACT), can improve training outcomes and provide real-time guidance during non-routine tasks, diagnostic, and therapeutic procedures. The goal of this study was to develop a framework to guide XR platform development using astronaut medical training and guidance as the domain for illustration. We conducted a mixed-methods study—using video conference meetings (45 subject-matter experts), Delphi panel surveys, and a web-based card sorting application—to develop a standard taxonomy of essential XR capabilities. We augmented this by identifying additional models and taxonomies from related fields. Together, this “taxonomy of taxonomies,” and the essential XR capabilities identified, serve as an initial framework to structure the development of XR-based medical training and guidance for use during deep space exploration missions. We provide a schematic approach, illustrated with a use case, for how this framework and materials generated through this study might be employed.

- **Keywords:** Extended reality; Deep space missions; Medical training; Clinical guidance; Clinical decision support

Danielle Filio, Erika Ziraldo, Lynn Dony, Diego Gonzalez, Michele Oliver. *Comparison between wrap around screens and a head mounted display on driver muscle and kinematic responses to a pedestrian hazard.* 103878.

As driving performance relies heavily on the interpretation of visual information, driving simulators require a visual display that can effectively communicate the virtual environment to the driver. Most high-fidelity visual displays include an expensive system of high-definition projectors and wraparound screens. To reduce the overall cost of a driving simulator while preserving the generalizability of results to naturalistic driving, head mounted displays (HMD) are being considered as a substitute visual cueing system. Recent innovations to virtual reality technologies are encouraging, however, differences between HMDs and more traditional visual displays have not been explored for all types of driving measures. In particular, while existing literature provides insight into the validity of HMDs as a substitute for higher fidelity visual displays in tests of driver behaviour and performance, there is a gap in the literature regarding differences in physiological responses. In the current study, upper body muscle activation and joint angle ranges were compared between an Oculus™ Rift Development Kit 2 HMD and a system of wrap around screens. Twenty-one participants each completed two simulated drives, one per display, in a counterbalanced order. During the simulation, drivers encountered unanticipated pedestrian crossings during which peak surface electromyography, root-mean-square of the surface electromyography signal and joint angles were determined bilaterally on the upper limbs. No significant differences ($p \leq 0.05$) were observed between the Oculus™ Rift HMD and the wrap around screens for all dependent variables with the exception of left joint range of motion in female participants, suggesting that the HMD reduced field of view had a minimal effect on driver kinematics and no effect on muscle activation levels. Upper body bracing was observed during the hazard response time segments characterized by significantly increased muscle activity during hazard response time segments and minimal joint movement. Considering the lack of significant kinematic and muscle activation differences between the two visual inputs, HMD technology for hazard response may provide a suitable alternative to wrap around screens for studying kinematic responses during hazardous driving scenarios.

- **Keywords:** Driving simulation; Head mounted display; Wrap around screens; Hazard reaction; Surface electromyography; Kinematics

Teresa C. D'Oliveira, Liana Persico. *Workplace isolation, loneliness and wellbeing at work: The mediating role of task interdependence and supportive behaviours.* 103894.

Despite the negative impact of social isolation on wellbeing, research has yet to address how organisations may mitigate the effects of workplace isolation and loneliness. The main objective of the study is to explore the mediating role of task interdependence and supportive behaviours of colleagues on the relationship between workplace isolation on workplace wellbeing. A total of 137 volunteers completed a survey assessing workplace isolation, loneliness, task interdependence, supportive behaviours of colleagues and wellbeing at work. SEM analyses supported the negative effects of company isolation on workplace wellbeing. While supportive behaviours had a mediating role, task interdependence did not mediate the relationships between company isolation and loneliness, and wellbeing. The findings show that increased opportunities for interpersonal interactions at work through greater task interdependence are not enough to reverse the negative effects of workplace isolation on wellbeing. In contrast, an investment in a supportive environment may reverse the negative effects of workplace isolation on wellbeing, highlighting the importance of a supportive culture.

- **Keywords:** Workplace isolation; Loneliness; Wellbeing; Task interdependence; Supportive behaviours