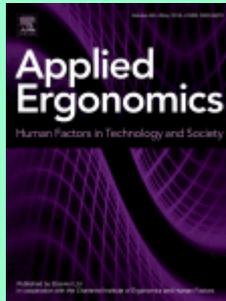


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Tomaž Čegovnik, Kristina Stojmenova, Grega Jakus, Jaka Sodnik. *An analysis of the suitability of a low-cost eye tracker for assessing the cognitive load of drivers.* Pages 1-

This paper presents a driving simulator study in which we investigated whether the Eye Tribe eye tracker (ET) is capable of assessing changes in the cognitive load of drivers through oculography and pupillometry. In the study, participants were asked to drive a simulated vehicle and simultaneously perform a set of secondary tasks with different cognitive complexity levels. We measured changes in eye properties, such as the pupil size, blink rate and fixation time. We also performed a measurement with a Detection Response Task (DRT) to validate the results and to prove a steady increase of cognitive load with increasing secondary task difficulty. The results showed that the ET precisely recognizes an increasing pupil diameter with increasing secondary task difficulty. In addition, the ET shows increasing blink rates, decreasing fixation time and narrowing of the attention field with increasing secondary task difficulty. The results were validated with the DRT method and the secondary task performance. We conclude that the Eye Tribe ET is a suitable device for assessing a driver's cognitive load.

- Keywords: Eye tracking; Pupillometry; Eye Tribe; Driver; Driving simulator; Cognitive load

Beatriz Antona, Ana Rosa Barrio, Adriana Gascó, Ana Pinar, Mariano González-Pérez, María C. Puell. *Symptoms associated with reading from a smartphone in conditions of light and dark.* Pages 12-17.

Asthenopia symptoms were investigated in visually-normal subjects without computer-related vision symptoms after prolonged reading from: smartphone versus hardcopy under photopic conditions, and smartphone in conditions of ambient versus dark room illumination. After reading from the smartphone, total symptom scores and nine out of ten questionnaire symptoms were significantly worse than for the hardcopy ("blurred vision while viewing the text", "blurred distance vision after the task", "difficulty in refocusing from one distance to another", "irritated or burning eyes", "dry eyes", "eyestrain", "tired eyes", "sensitivity to bright lights" and "eye discomfort"). Mean total symptom scores and scores for "irritated or burning eyes" and "dry eyes" were significantly higher for the dark versus photopic conditions. In conclusion, prolonged smartphone reading could cause worse asthenopic symptoms than reading from a hardcopy under similar conditions. Symptoms could be even worse when reading from a smartphone in the dark.

- **Keywords:** Smartphone; Asthenopia symptom; Reading; Dark environment

Victoria Filingeri, Ken Eason, Patrick Waterson, Roger Haslam. *Factors influencing experience in crowds – The organiser perspective. Pages 18-27.*

Crowds are a commonplace encounter but the experience for participants can be highly variable. Crowds are complex sociotechnical phenomenon, affected by many interacting factors. Little is known, however, about how those responsible for organising crowd situations approach their responsibilities. This study conducted semi-structured interviews (n = 41) with organisers responsible for different aspects of the design, planning, management and operations of events and other crowd situations. The objective was to understand organisers' priorities, along with the consideration given to the experience of crowd participants. The interviews revealed that organisers generally prioritised finance, security and health and safety aspects, whilst giving limited explicit attention to other important factors that affect participant experience. Organisers tended to approach their planning and decisions on the basis of their own experience and judgement, without accessing training or reference to guidance. It is suggested that the non-use of guidance is in part due to problems with the guidance currently available, both its content and its form. The organisers of infrequent or small-scale events have the greatest knowledge and experience gap. It is concluded that in order to achieve a consistent, high quality experience for crowd participants, there needs to be improved understanding among organisers of the complexity of crowds and the multiple factors influencing participant experience. Guidance and tools need to be usable and tailored to organisers' requirements. Organisers of infrequent or small-scale events are especially in need of support.

- **Keywords:** Event planning; Event organisation; Crowd ergonomics

Paulo Victor R. de Carvalho, Angela W. Righi, Gilbert J. Huber, Caio de F. Lemos, Alessandro Jatoba, José Orlando Gomes. *Reflections on work as done (WAD) and work as imagined (WAI) in an emergency response organization: A study on firefighters training exercises. Pages 28-41.*

Emergency response organizations need to be resilient to cope with escalating events resulting from dynamic, unexpected, or complex situations. In Brazil, the Firefighter Corps are military hierarchical organizations with a culture based on fixed structures, well defined norms and procedures. These push against innovations which are necessary to be resilient. This research describes how firefighter captains in the 30–35-year age range managed an emergency response escalation in light of standard operating procedures (SOPs) during a training exercise. The study used ethnographic methods to find and discuss gaps between the instructions and the activities carried out during the exercise, highlighting the differences between work as done (WAD) and work as imagined (WAI), as it was instantiated in the SOP prescriptions. The aim was to produce reflections on WAI and WAD as a way to raise awareness of the need for a cultural change toward resilience in firefighter organizations. This was achieved through firefighter engagement with a comprehensive visualization of the analysis results which afforded easy interaction between the experts, the data, and the researchers.

- **Keywords:** Emergency response; Simulation exercises; WAI and WAD; Resilience engineering

Dwayne Van Eerd, Era Mae Ferron, Teresa D'Elia, Derek Morgan, Frances Ziesmann, Benjamin C. Amick. *Process evaluation of a participatory organizational change program to reduce musculoskeletal and slip, trip and fall injuries. Pages 42-53.*

Background: Long-term care (LTC) workers are at significant risk for occupational-related injuries. Our objective was to evaluate the implementation process of a participatory change program to reduce risk. **Methods:** A process evaluation was conducted in three LTC sites using a qualitative approach employing structured interviews, consultant logs and a focus group. **Results:** Findings revealed recruitment/reach themes of being “voluntold”, using established methods, and challenges related to work schedules. Additional themes about dose were related to communication, iterative solution development, participation and engagement. For program fidelity and satisfaction, themes emerged around engagement, capacity building and time demands. **Conclusion:** Process evaluation revealed idiosyncratic approaches to recruitment and related challenges of reaching staff. Solutions to prioritized hazards were developed and implemented, despite time challenges. The iterative solution development approach was embraced. Program fidelity was considered good despite early program time demands. Post implementation reports revealed sustained hazard identification and solution development.

- **Keywords:** Participatory ergonomics; Process evaluation; Injury prevention

Atsuo Murata, Daichi Fukunaga. *Extended Fitts’ model of pointing time in eye-gaze input system - Incorporating effects of target shape and movement direction into modeling.* Pages 54-60.

This study attempted to investigate the effects of the target shape and the movement direction on the pointing time using an eye-gaze input system and extend Fitts' model so that these factors are incorporated into the model and the predictive power of Fitts' model is enhanced. The target shape, the target size, the movement distance, and the direction of target presentation were set as within-subject experimental variables. The target shape included: a circle, and rectangles with an aspect ratio of 1:1, 1:2, 1:3, and 1:4. The movement direction included eight directions: upper, lower, left, right, upper left, upper right, lower left, and lower right. On the basis of the data for identifying the effects of the target shape and the movement direction on the pointing time, an attempt was made to develop a generalized and extended Fitts’ model that took into account the movement direction and the target shape. As a result, the generalized and extended model was found to fit better to the experimental data, and be more effective for predicting the pointing time for a variety of human-computer interaction (HCI) task using an eye-gaze input system.

- **Keywords:** HCI; Fitts' modeling; Pointing time; Eye-gaze input system; Target shape; Movement direction

Michael Tainsh. *User Systems Architectures – Two studies in design and assessment.* Pages 61-71.

The concept of User System Architectures (USA) is introduced as part of the overall systems architecture. A USA is defined as a set of ergonomics information and knowledge assembled to represent system structure and content. It is described in the context of the system development lifecycle. The characteristics associated with a USA are outlined. These include layers of description, viewpoints, coherency and traceability. The concept of coherency between layers and the techniques for tracing the design characteristics back to the requirements (i.e. traceability) are discussed with their implications for ergonomics. Two studies (one design and one assessment) are used to demonstrate the use of USA techniques. The benefits, shortfalls and costs of using the USA technique are outlined for each case, and in a more general range of applications. The validity and reliability of the representations are discussed.

- **Keywords:** User System Architecture; Design; Assessment; Coherence; Traceability

Hyunsoo Kim, Changbum R. Ahn, Terry L. Stentz, Houtan Jebelli. *Assessing the effects of slippery steel beam coatings to ironworkers' gait stability.* Pages 72-79.

Since ironworkers walk and perform their tasks on steel beams, identifying the effects of slippery steel beam surfaces on ironworkers' gait stability—which can be related to safety risk—is critical. However, there is no accepted or validated standard for measuring the slipperiness of coated steel beams, which makes evaluating and controlling for slipperiness a challenge. In this context, this study investigated the effect of the slipperiness of steel beam coatings on ironworkers' gait stability. Accordingly, to identify the relationships between coefficient of friction, perceived slipperiness, and gait stability—represented as the Maximum Lyapunov exponent (Max LE)—an experiment was conducted with eight different surfaces and sixteen subjects with varying experience as ironworkers. The experiment's results indicate that the slipperiness of the various surfaces greatly affect ironworkers' gait stability while they walk on coated steel beam surfaces. In detail, the Max LE of two subject groups—experienced and inexperienced ironworkers—highly correlated with both the dynamic coefficient of friction values measured by following ANSI B101.3 and with the subjective rating scores of the inexperienced subject group. Unlike subjective rating scores—which were particularly incongruent among experienced workers—the Max LE of inexperienced and experienced subjects has a consistent pattern. This study result highlights an opportunity for using gait stability measurements to quantify and differentiate the safety risks caused by slippery coated steel beams in the future.

- **Keywords:** Coefficient of friction; Perceived slipperiness; Maximum Lyapunov exponents

Jeong Ho Kim, Jack T. Dennerlein, Peter W. Johnson. *The effect of a multi-axis suspension on whole body vibration exposures and physical stress in the neck and low back in agricultural tractor applications.* Pages 80-89.

Whole body vibration (WBV) exposures are often predominant in the fore-aft (x) or lateral (y) axis among off-road agricultural vehicles. However, as the current industry standard seats are designed to reduce mainly vertical (z) axis WBV exposures, they may be less effective in reducing drivers' exposure to multi-axial WBV. Therefore, this laboratory-based study aimed to determine the differences between a single-axial (vertical) and multi-axial (vertical + lateral) suspension seat in reducing WBV exposures, head acceleration, self-reported discomfort, and muscle activity (electromyography) of the major muscle of the low back, neck and shoulders. The results showed that the multi-axial suspension seat had significantly lower WBV exposures compared to the single-axial suspension seats ($p < 0.04$). Similarly, the multi-axial suspension seat had lower head acceleration and muscle activity of the neck, shoulder, and low back compared to the single-axial suspension seat; some but not all of the differences were statistically significant. These results indicate that the multi-axial suspension seat may reduce the lateral WBV exposures and associated muscular loading in the neck and low back in agricultural vehicle operators.

- **Keywords:** Whole body vibration; Off-road vehicles; Agricultural tractors; Electromyography; Seat suspension

Frank Schwarz-Müller, Russell Marshall, Steve Summerskill. *Development of a positioning aid to reduce postural variability and errors in 3D whole body scan measurements.* Pages 90-100.

Abstract: Three-dimensional (3D) body scanners have the potential to evaluate changes to the human form through different clothing configurations, the use of protective equipment, or the effects of medical interventions. To achieve this, scans of an individual need to be superimposed for each experimental condition. The literature highlights that one of the limiting factors is postural variability. This paper describes a newly developed 'positioning aid' that stabilises the posture during the scanning process and is invisible on scans. The results of a study evaluating the efficacy of the positioning aid showed that it reduces postural variability for all body parts in lateral and longitudinal directions. A reference test with a rigid mannequin indicated that the 'technical' variability due to the scanner hardware and software significantly contributes to the residual variability. Furthermore, the study showed that the newly developed positioning aid overall increased the precision of the software-assisted extraction of body dimensions.

- **Keywords:** Body scanner; Posture; Precision; Positioning aid

Eric B. Weston, Mina Alizadeh, Gregory G. Knapik, Xueke Wang, William S. Marras. *Biomechanical evaluation of exoskeleton use on loading of the lumbar spine. Pages 101-108.*

The objective of this study was to investigate biomechanical loading to the low back as a result of wearing an exoskeletal intervention designed to assist in occupational work. Twelve subjects simulated the use of two powered hand tools with and without the use of a Steadicam vest with an articulation tool support arm in a laboratory environment. Dependent measures of peak and mean muscle forces in ten trunk muscles and peak and mean spinal loads were examined utilizing a dynamic electromyography-assisted spine model. The exoskeletal device increased both peak and mean muscle forces in the torso extensor muscles ($p < 0.001$). Peak and mean compressive spinal loads were also increased up to 52.5% and 56.8%, respectively, for the exoskeleton condition relative to the control condition ($p < 0.001$). The results of this study highlight the need to design exoskeletal interventions while anticipating how mechanical loads might be shifted or transferred with their use.

- **Keywords:** Wearable; Hand tool; Ergonomic intervention

Adriana Savescu, Aude Cuny-Guerrier, Pascal Wild, Gilles Reno, Agnès Aublet-Cuvelier, Laurent Claudon. *Objective assessment of knife sharpness over a working day cutting meat. Pages 109-116.*

Knife sharpness is one of multiple factors involved in musculoskeletal disorders in industrial meat cutting. The aim of this study was to objectively evaluate, in real working situations, how knife sharpness changed over a working day cutting meat, and to analyse the impact of sharpening, steeling and meat-cutting activities on these variations. Twenty-two meat-cutting workers from three different companies participated in the study. The methods included measurements of knife sharpness in relation to real work situations and consideration of the way meat-cutting and sharpening operations were organised. Results showed that the type of meat-cutting activities, the steeling strategy adopted by the worker, including the types of tool used, and the overall organisation of the sharpening task all had a significant influence on how knife sharpness evolved over a 2-h period and over an entire working day. To improve MSD prevention, sharpening and steeling operations should not be considered as independent activities, but taken into account as a continuity of working actions. Appropriate assessment of knife sharpness by meat cutters affects how they organise meat-cutting and sharpening tasks.

- **Keywords:** Knife sharpness; MSD; Sharpness measurement system; Sharpness evolution; Objective assessment

Wen-Ruey Chang, Chien-Chi Chang. Relationship among several measurements of slipperiness obtained in a laboratory environment. Pages 117-124.

Multiple sensing mechanisms could be used in forming responses to avoid slips, but previous studies, correlating only two parameters, revealed a limited picture of this complex system. In this study, the participants walked as fast as possible without a slip under 15 conditions of different degrees of slipperiness. The relationships among various response parameters, including perceived slipperiness rating, utilized coefficient of friction (UCOF), slipmeter measurement and kinematic parameters, were evaluated. The results showed that the UCOF, perceived rating and heel angle had higher adjusted R² values as dependent variables in the multiple linear regressions with the remaining variables in the final pool as independent variables. Although each variable in the final data pool could reflect some measurement of slipperiness, these three variables are more inclusive than others in representing the other variables and were bigger predictors of other variables, so they could be better candidates for measurements of slipperiness.

- **Keywords:** Measurement of slipperiness; Perception rating of slipperiness; Coefficient of friction; Human locomotion; Friction utilization

Kirsten Huysamen, Michiel de Looze, Tim Bosch, Jesus Ortiz, Stefano Toxiri, Leonard W. O'Sullivan. Assessment of an active industrial exoskeleton to aid dynamic lifting and lowering manual handling tasks. Pages 125-131.

The aim of this study was to evaluate the effect of an industrial exoskeleton on muscle activity, perceived musculoskeletal effort, measured and perceived contact pressure at the trunk, thighs and shoulders, and subjective usability for simple sagittal plane lifting and lowering conditions. Twelve male participants lifted and lowered a box of 7.5 kg and 15 kg, respectively, from mid-shin height to waist height, five times, both with and without the exoskeleton. The device significantly reduced muscle activity of the Erector Spinae (12%-15%) and Biceps Femoris (5%). Ratings of perceived musculoskeletal effort in the trunk region were significantly less with the device (9.5%-11.4%). The measured contact pressure was highest on the trunk (91.7 kPa-93.8 kPa) and least on shoulders (47.6 kPa-51.7 kPa), whereas pressure was perceived highest on the thighs (35-44% of Max LPP). Six of the users rated the device usability as acceptable. The exoskeleton reduced musculoskeletal loading on the lower back and assisted with hip extensor torque during lifting and lowering. Contact pressures fell below the Pain Pressure Threshold. Perceived pressure was not exceptionally high, but sufficiently high to cause discomfort if used for long durations.

- **Keywords:** Exoskeleton; Wearable robotics; Power augmentation

David A. Hurtado, Lisset M. Dumet, Samuel A. Greenspan, Yaritza I. Rodriguez. *Social Network Analysis of peer-specific safety support and ergonomic behaviors: An application to safe patient handling.* Pages 132-137.

This study applied Social Network Analysis (SNA) to test whether advice-seeking interactions among peers about safe patient handling correlate with a higher frequency of equipment use. Patient-care workers (n=38) at a community hospital in Oregon nominated peers they would consult for advice regarding safe patient handling. Results show a positive correlation between identifying more peers for safe patient handling advice and using equipment more frequently. Moreover, nurses with more reciprocal advice seeking nominations used safe patient handling equipment more frequently. However, employees who would be more consulted about safe patient handling by their peers did not use equipment more frequently than nurses with fewer nominations. Despite the small sample size, the magnitude of the adjusted regressions coefficients ranged between 3 to 4 standard deviations. These results suggest that having more or

reciprocal sources of peer-based support may trigger ergonomic related behaviors such as frequent utilization of equipment.

- **Keywords:** Safe patient handling; Social Network Analysis; Safety behaviors; Peer support; Social support

Victoria A. Banks, Alexander Eriksson, Jim O'Donoghue, Neville A. Stanton. *Is partially automated driving a bad idea? Observations from an on-road study.* Pages 138-145.

The automation of longitudinal and lateral control has enabled drivers to become "hands and feet free" but they are required to remain in an active monitoring state with a requirement to resume manual control if required. This represents the single largest allocation of system function problem with vehicle automation as the literature suggests that humans are notoriously inefficient at completing prolonged monitoring tasks. To further explore whether partially automated driving solutions can appropriately support the driver in completing their new monitoring role, video observations were collected as part of an on-road study using a Tesla Model S being operated in Autopilot mode. A thematic analysis of video data suggests that drivers are not being properly supported in adhering to their new monitoring responsibilities and instead demonstrate behaviour indicative of complacency and over-trust. These attributes may encourage drivers to take more risks whilst out on the road.

- **Keywords:** Automated driving; Driver role; Level of automation; Partial automation; Mode transitions; Transitions of control

Yan Fei Xie, Grace Szeto, Pascal Madeleine, Sharon Tsang. *Spinal kinematics during smartphone texting – A comparison between young adults with and without chronic neck-shoulder pain.* Pages 160-168.

To advance our understanding about the association between smartphone use and chronic neck-shoulder pain, the objective of this study was to compare spinal kinematics between different text-entry methods in smartphone users with and without chronic neck-shoulder pain. Symptomatic (n = 19) and healthy participants (n = 18) were recruited and they performed three tasks: texting on a smartphone with one hand, with two hands, and typing on a desktop computer. Three-dimensional kinematics were examined in the cervical, thoracic and lumbar regions for each task. This study suggests that altered kinematics may be associated with pain since significantly increased angles of cervical right side flexion during smartphone texting and greater postural changes in cervical rotation were found during all text-entry tasks in the symptomatic group. Two-handed texting was associated with increased cervical flexion while one-handed texting was correlated with an asymmetric neck posture, indicating both text-entry methods are not favorable in terms of spinal postures.

- **Keywords:** Motor control; Neck pain; Repetitive movement

Ouren X. Kuiper, Jelte E. Bos, Cyriel Diels. *Looking forward: In-vehicle auxiliary display positioning affects carsickness.* Pages 169-175.

Carsickness is associated with a mismatch between actual and anticipated sensory signals. Occupants of automated vehicles, especially when using a display, are at higher risk of becoming carsick than drivers of conventional vehicles. This study aimed to evaluate the impact of positioning of in-vehicle displays, and subsequent available peripheral vision, on carsickness of passengers. We hypothesized that increased peripheral vision during display use would reduce carsickness. Seated in the front passenger seat 18 participants were driven a 15-min long slalom on two occasions while

performing a continuous visual search-task. The display was positioned either at 1) eye-height in front of the windscreen, allowing peripheral view on the outside world, and 2) the height of the glove compartment, allowing only limited view on the outside world. Motion sickness was reported at 1-min intervals. Using a display at windscreen height resulted in less carsickness compared to a display at glove compartment height.

- **Keywords:** Motion sickness; Displays; Autonomous vehicles

Arnaud Lardon, Jean-Daniel Dubois, Vincent Cantin, Mathieu Piché, Martin Descarreaux. Predictors of disability and absenteeism in workers with non-specific low back pain: A longitudinal 15-month study. Pages 176-185.

Objectives: The objective of this study was to identify baseline predictors of disability and absenteeism in workers with a history of non-specific low back pain (LBP). **Methods:** One hundred workers with a history of non-specific LBP participated in three evaluations (baseline, 7 and 15 months follow-up). Current and past history of LBP, clinical pain intensity, disability, absenteeism, fear-avoidance beliefs, pain catastrophizing, pain hypervigilance, work satisfaction and patient stratification based on "risk of poor clinical outcome assessment" (RPCO) were evaluated using questionnaires and interviews. In addition, cutaneous heat pain thresholds, cutaneous heat pain tolerance thresholds, conditioned pain modulation (CPM), trunk kinematics and muscle activity were measured during each evaluation. Logistic regression models were used to determine predictors of LBP disability and absenteeism at 15-months. **Results:** Sixty-eight workers returned for the 15-month follow-up and among this sample, 49% reported disability and 16% reported absenteeism at follow-up. Baseline clinical pain intensity predicted disability (OR = 1.08, 95%CI: 1.03-1.13) at 15-month while work satisfaction (OR = 0.93, 95%CI: 0.87-0.99) and RPCO (OR = 1.51, 95%CI: 1.05-2.16) predicted absenteeism. These results remained significant after adjustments for age, gender as well as type of work and intervention. **Conclusion:** This study highlights the importance of clinical pain and psychological factors in the prediction and potentially the prevention of future disability. Screening tools assessing these risk factors can be useful to evaluate workers with past history of low back pain.

- **Keywords:** Spinal pain; Neuromuscular adaptation; Pain inhibition; Psychological factors; Sick leave; Conditioned pain modulation; Pain perception

Emilia Irzmańska, Paulina Wójcik, Agnieszka Adamus – Włodarczyk. Manual work in cold environments and its impact on selection of materials for protective gloves based on workplace observations. Pages 186-196.

This article presents a workplace observations on manual work in cold environments and its impact on the selection of materials for protective gloves. The workplace observations was conducted on 107 workers in 7 companies and involved measurements of the temperature of air and objects in the workplaces; in addition the type of surface and shape of the objects was determined. Laboratory tests were also carried out on 11 materials for protective gloves to be used in cold environments. Protective characteristics, including mechanical properties (wear, cut, tear, and puncture resistance), insulation properties (thermal resistance), functional parameters, and hygienic properties (resistance to surface wetting, material stiffness) were evaluated. Appropriate levels of performance and quality, corresponding to the protective and functional properties of the materials, were determined. Based on the results of manual work and laboratory tests, directions for the selection of materials for the construction of protective gloves were formulated with a view to improving work ergonomics.

- **Keywords:** Protective gloves; Work in cold; Ergonomic factors

Aaron Silk, Robbie Savage, Brianna Larsen, Brad Aisbett. *Identifying and characterising the physical demands for an Australian specialist policing unit.* Pages 197-203.

Many police organisations incorporate specialist policing roles where incumbents are tasked with providing operational response capabilities above and beyond the general duties policing role. The current research utilised subjective job task analysis methods to identify and characterise the physically demanding, frequently occurring, and operationally important tasks, as well as the dominant fitness component for each task, inherent to specialist policing roles in an Australian policing organisation. This was achieved through engagement with subject matter experts and online survey responses from specialist police incumbents. In total, 11 criterion tasks were identified, which covered a range of physical capacities including muscular strength, muscular endurance, and aerobic power. The most physically demanding tasks included those with an arrest component, requiring high muscular strength and power capacities. Having identified the criterion tasks, three operational scenarios were constructed, which incorporated each of the 11 tasks in different operational contexts. The criterion tasks and composite scenarios will allow practitioners within specialised police units to develop evidence-based strategies, including physical selection procedures and physical training programs, specific to the demands of their work.

- **Keywords:** Job task analysis; Police; Physical employment tests; Criterion tasks

Takanori Chihara, Akihiko Seo. *Evaluation of physical workload affected by mass and center of mass of head-mounted display.* Pages 204-212.

A head-mounted display (HMD) with inappropriate mass and center of mass (COM) increases the physical workload of HMD users. The aim of this study was to investigate the effects of mass and COM of HMD on physical workload. Twelve subjects participated in this study. The mass and posteroanterior COM position were 0.8, 1.2, or 1.6 kg and -7.0, 0.0, or 7.0 cm, respectively. The subjects gazed at the target objects in four test postures: the neutral, look-up, body-bending, and look-down postures. The normalized joint torques for the neck and the lumbar region were calculated based on the measured segment angles. The results showed that the neck joint torque was significantly affected by mass and COM and it increased as the HMD mass increased for all test postures. The COM position that minimized the neck joint torque varied depending on the test postures, and the recommended ranges of COM were identified.

- **Keywords:** Head-mounted display; Biomechanical analysis; Physical workload

Katie J. Parnell, Neville A. Stanton, Katherine L. Plant. *Creating the environment for driver distraction: A thematic framework of sociotechnical factors.* Pages 213-228.

As modern society becomes more reliant on technology, its use within the vehicle is becoming a concern for road safety due to both portable and built-in devices offering sources of distraction. While the effects of distracting technologies are well documented, little is known about the causal factors that lead to the drivers' engagement with technological devices. The relevance of the sociotechnical system within which the behaviour occurs requires further research. This paper presents two experiments, the first aims to assess the drivers self-reported decision to engage with technological tasks while driving and their reasoning for doing so with respect to the wider sociotechnical system. This utilised a semi-structured interview method, conducted with 30 drivers to initiate a discussion on their likelihood of engaging with 22 different tasks across 7 different road types. Inductive thematic analysis provided a hierarchical thematic framework that detailed the self-reported causal factors that influence the drivers' use of

technology whilst driving. The second experiment assessed the relevance of the hierarchical framework to a model of distraction that was established from within the literature on the drivers use of distracting technologies while driving. The findings provide validation for some relationships studied in the literature, as well as providing insights into relationships that require further study. The role of the sociotechnical system in the engagement of distractions while driving is highlighted, with the causal factors reported by drivers suggesting the importance of considering the wider system within which the behaviour is occurring and how it may be creating the conditions for distraction to occur. This supports previous claims made within the literature based model. Recommendations are proposed that encourage a movement away from individual focused countermeasures towards systemic actors.

- **Keywords:** In-vehicle technology; Driver distraction; Qualitative methods; Sociotechnical systems

Toh Yen Pang, Terence Shen Tao Lo, Thierry Ellena, Helmy Mustafa, Jasmin Babalija, Aleksandar Subic. *Fit, stability and comfort assessment of custom-fitted bicycle helmet inner liner designs, based on 3D anthropometric data.* Pages 240-248.

Research has demonstrated that a better-fitted bicycle helmet offers improved protection to the rider during an impact. Nowadays, bicycle helmets in the market that range in size from small/medium to medium/large might not fit the diverse range of human head shapes and dimensions. 3D scanning was used to create 3D head shape databases of 20 participants who volunteered for the study. We developed new custom-fitted helmet inner liners, based on the 3D head shape of two sub-groups of participants, to map their head sizes and contours closely to the conventional Medium (M) and Large (L) sizes as described in from AS/NZS 2512.1: 2009. The new custom-fitted helmet was compared with the helmet available in the market place in a dynamics stability test and from participants' subjective feedback. A significant reduction in the angle of helmet rotation on the headform in the lateral direction was recorded for the custom-fitted helmet. A Wilcoxon signed-rank test was conducted to evaluate participants' feedback on the helmets according to different area definitions. The overall fit and comfort and the top region of the new helmet were significantly improved. However, no difference was found at the significant level of 0.05 for the front and rear region of the new helmet.

- **Keywords:** Anthropometry; Helmet; Mass customization; Fit and comfort; Stability

L. Dellve, M. Strömgren, A. Williamsson, R.J. Holden, A. Eriksson. *Health care clinicians' engagement in organizational redesign of care processes: The importance of work and organizational conditions.* Pages 249-257.

The Swedish health care system is reorienting towards horizontal organization for care processes. A main challenge is to engage health care clinicians in the process. The aim of this study was to assess engagement (i.e. attitudes and beliefs, the cognitive state and clinical engagement behaviour) among health care clinicians, and to investigate how engagement was related to work resources and demands during organizational redesign. A cohort study was conducted, using a questionnaire distributed to clinicians at five hospitals working with care process improvement approaches, two of them having implemented Lean production. The results show that kinds of engagement are interlinked and contribute to clinical engagement behaviour in quality of care and patient safety. Increased work resources have importance for engagements in organizational improvements, especially in top-down implementations. An extended work engagement model during organizational improvements in health care was supported. The model

contributes to knowledge about how and when clinicians are mobilized to engage in organizational changes.

- **Keywords:** Work engagement; Lean production; Health care workers; Job resources; Top-down implementation

Victoria A. Banks, Neville A. Stanton, Gary Burnett, Setia Hermawati. *Distributed Cognition on the road: Using EAST to explore future road transportation systems. Pages 258-266.*

Connected and Autonomous Vehicles (CAV) are set to revolutionise the way in which we use our transportation system. However, we do not fully understand how the integration of wireless and autonomous technology into the road transportation network affects overall network dynamism. This paper uses the theoretical principles underlying Distributed Cognition to explore the dependencies and interdependencies that exist between system agents located within the road environment, traffic management centres and other external agencies in both non-connected and connected transportation systems. This represents a significant step forward in modelling complex sociotechnical systems as it shows that the principles underlying Distributed Cognition can be applied to macro-level systems using the visual representations afforded by the Event Analysis of Systemic Teamwork (EAST) method.

- **Keywords:** Connected and Autonomous Vehicles; Distributed Cognition; EAST; Network analysis; Network metrics

John O'Neill, Mark E. Hartman, Dawn A. O'Neill, William J. Lewinski. *Further analysis of the unintentional discharge of firearms in law enforcement. Pages 267-272.*

Empirical analysis of the contexts in which UD's occur in law enforcement have only recently begun to emerge. We analyzed a novel sample of UD reports (N = 171) that occurred between 1992 and 2016, collected from one non-U.S. and three U.S. law enforcement entities. Using an established antecedent-behavior-consequence (A-B-C) taxonomy, reports were analyzed by context, officer behavior, type of firearm, injuries, deaths, and property damages. This study is the first to empirically document reports of UD's caused by the startle response and the first to analyze a substantial sample of UD's that involved handguns with a double-action only trigger mechanism. An expanded analysis of UD consequences suggested that deaths and injuries might be more prevalent than previously reported.

- **Keywords:** Accidental discharge; Firearm; Law enforcement; Negligent discharge; Unintentional discharge

Janette Rose, Chris Bearman, Jillian Dorrian. *The Low-Event Task Subjective Situation Awareness (LETSSA) technique: Development and evaluation of a new subjective measure of situation awareness. Pages 273-282.*

Situation awareness (SA) is an important component of an individual's ability to function in a complex environment. As such, it is essential to have effective measures of an individual's SA. The most widely used subjective measure of SA is the Situation Awareness Rating Technique [SART]. However, SART has been criticised for not predicting performance or objective SA, and being highly correlated with workload. This paper describes the development and testing of a new subjective measure of SA, the Low-Event Task Subjective Situation Awareness (LETSSA) measure. To evaluate LETSSA a train simulator study was conducted with 23 novice and 26 expert freight train drivers.

LETSSA was able to detect differences in manipulated SA and was comparable to an established objective SA measure (SAGAT). LETSSA was significantly associated with performance but not significantly associated with workload. While further validation is required, LETSSA shows promise as an effective subjective measure of SA.

- **Keywords:** Situation awareness; SAGAT; SART; Real-world measurement of situation awareness; Naturalistic settings

Clint Hansen, Florian Gosselin, Khalil Ben Mansour, Pierre Devos, Frederic Marin. *Design-validation of a hand exoskeleton using musculoskeletal modeling.* Pages 283-288.

Exoskeletons are progressively reaching homes and workplaces, allowing interaction with virtual environments, remote control of robots, or assisting human operators in carrying heavy loads. Their design is however still a challenge as these robots, being mechanically linked to the operators who wear them, have to meet ergonomic constraints besides usual robotic requirements in terms of workspace, speed, or efforts. They have in particular to fit the anthropometry and mobility of their users. This traditionally results in numerous prototypes which are progressively fitted to each individual person. In this paper, we propose instead to validate the design of a hand exoskeleton in a fully digital environment, without the need for a physical prototype. The purpose of this study is thus to examine whether finger kinematics are altered when using a given hand exoskeleton. Therefore, user specific musculoskeletal models were created and driven by a motion capture system to evaluate the fingers' joint kinematics when performing two industrial related tasks. The kinematic chain of the exoskeleton was added to the musculoskeletal models and its compliance with the hand movements was evaluated. Our results show that the proposed exoskeleton design does not influence fingers' joints angles, the coefficient of determination between the model with and without exoskeleton being consistently high ($R^2=0.93$) and the nRMSE consistently low ($nRMSE = 5.42^\circ$). These results are promising and this approach combining musculoskeletal and robotic modeling driven by motion capture data could be a key factor in the ergonomics validation of the design of orthotic devices and exoskeletons prior to manufacturing.

- **Keywords:** Exoskeleton; Biomechanics; Hand; Musculoskeletal modeling; Design validation; Industrial task

Al Ross, Andrea Sherriff, Jamie Kidd, Wendy Gnich, Janet Anderson, Leigh Deas, Lorna Macpherson. *A systems approach using the functional resonance analysis method to support fluoride varnish application for children attending general dental practice.* Pages 294-303.

Background: All children attending General Dental Practice in Scotland are recommended to receive twice-yearly applications of sodium fluoride varnish to prevent childhood caries, yet application is variable. Development of complex interventions requires theorizing and modelling to understand context. This study applies the Functional Resonance Analysis Method (FRAM) to produce a sociotechnical systems model and identify opportunities for intervention to support application. **Methods:** The FRAM was used to synthesise data which were: routine monitoring of fluoride varnish application in 2015/16; a longitudinal survey with practitioners ($n = 1090$); in-depth practitioner and key informant interviews ($n = 43$); and a 'world café' workshop ($n = 56$). **Results:** We describe a detailed model of functions linked to application, and use this to make recommendations for system-wide intervention. **Conclusions:** Rigorous research is required to produce accessible models of complex systems in healthcare. This novel paper shows how careful articulation of the functions associated with fluoride varnish application can support future improvement efforts.

- **Keywords:** Sociotechnical systems; Complexity; Healthcare; Dentistry

Taylor Jones, Arian Iraqi, Kurt Beschorner. *Performance testing of work shoes labeled as slip resistant.* Pages 304-312.

The variability in friction and slip propensity across slip resistant (SR) shoes is poorly understood. This study aimed to quantify the impact of shoe design features on the available coefficient of friction (ACOF) across shoes labeled as SR. Differences in ACOF and the slipping rate across SR shoes were also quantified. Twelve shoes were tested across five types of flooring and three contaminant conditions using a whole shoe mechanical slip tester. Geometric and hardness parameters were measured to determine the effect of heel outsole design on ACOF. The rate of slipping was evaluated for three of the shoes on vinyl tile with canola oil using human subjects. Differences in ACOF were significant across shoe outsole designs ($p < .001$). ACOF was correlated with geometrical and hardness parameters. Rate of slipping was lower for the highest ACOF shoe ($p < .001$). This information can be used to guide SR shoe selection and design.

- **Keywords:** Coefficient of friction; Shoe outsole; Slip and fall accidents

Devin B. Phillips, Cameron M. Ehnes, Bradley G. Welch, Lauren N. Lee, Irina Simin, Stewart R. Petersen. *Influence of work clothing on physiological responses and performance during treadmill exercise and the Wildland Firefighter Pack Test.* Pages 313-318.

This study investigated physiological responses and performance during three separate exercise challenges (Parts I, II, and III) with wildland firefighting work clothing ensemble (boots and coveralls) and a 20.4 kg backpack in four conditions: U-EX (no pack, exercise clothing); L-EX (pack, exercise clothing); U-W (no pack, work clothing); and, L-W (pack and work clothing). Part I consisted of randomly-ordered graded exercise tests, on separate days, in U-EX, L-EX and L-W conditions. Part II consisted of randomly-ordered bouts of sub-maximal treadmill exercise in the four conditions. In Part III, subjects completed, in random-order on separate days, 4.83 km Pack Tests in L-EX or L-W conditions. In Part I, peak oxygen uptake was reduced ($p < .05$) in L-W. In Part II, mass-specific oxygen uptake was significantly higher in both work clothing conditions. In Part III, Pack Test time was slower ($p < .05$) in L-W. These results demonstrate the negative impact of work clothing and load carriage on physiological responses to exercise and performance.

- **Keywords:** Load carriage; Oxygen demand; Performance; Wildland Firefighter Pack Test; Protective clothing

Ido Morag, Gil Luria. *A group-level approach to analyzing participative ergonomics (PE) effectiveness: The relationship between PE dimensions and employee exposure to injuries.* Pages 319-327.

Most studies concerned with participative ergonomic (PE) interventions, focus on organizational rather than group level analysis. By implementing an intervention at a manufacturing plant, the current study, utilizing advanced information systems, measured the effect of line-supervisor leadership on employee exposure to risks. The study evaluated which PE dimensions (i.e., extent of workforce involvement, diversity of reporter role types and scope of analysis) are related to such exposure at the group level. The data for the study was extracted from two separate computerized systems (workforce medical records of 791 employees and an intranet reporting system) during a two-year period. While the results did not confirm the effect of line-supervisor leadership on subordinates' exposure to risks, they did demonstrate relationships between PE dimensions and the employees' exposure to risks. The results support the suggested level of analysis and demonstrate that group-based analysis facilitates the assimilation of preventive interventions.

- **Keywords:** Group level analysis; Participative ergonomics dimensions; Participative leadership; Workplace analysis and injury prevention

Priscila Wachs, Tarcisio Abreu Saurin. *Modelling interactions between procedures and resilience skills*. Pages 328-337.

Although work in complex socio-technical systems needs support from several “resources for action”, the interactions between these are not usually managed systematically. This study introduces a six-step framework for analyzing the interactions between two key resources for action, namely the use of standardized operating procedures and resilience skills (RSs). The main steps for applying the framework involve: (i) a content analysis of the procedure, which allows for the identification of underspecified rules and situations that could be emphasized in scenario-based training focused on developing RSs; and (ii) the identification of factors that set the stage for the emergence of RSs, which could be accounted for by procedures and the broader work system design. An application of the framework is presented in the preparation and administration of intravenous medications in an emergency department. Data collection involved 98 h of observations, 14 interviews, and document analysis. Based on this field study, a model of the interactions between procedures and RSs is proposed as well as the lessons learned from applying the framework are discussed.

- **Keywords:** Procedures; Resilience skills; Resources for action; Preparation and administration of medications

Chia-Fen Chi, Syuan-Zih Lin. *Classification scheme and prevention measures for caught-in-between occupational fatalities*. Pages 338-348.

The current study analyzed 312 caught-in-between fatalities caused by machinery and vehicles. A comprehensive and mutually exclusive coding scheme was developed to analyze and code each caught-in-between fatality in terms of age, gender, experience of the victim, type of industry, source of injury, and causes for these accidents. Boolean algebra analysis was applied on these 312 caught-in-between fatalities to derive minimal cut set (MCS) causes associated with each source of injury. Eventually, contributing factors and common accident patterns associated with (1) special process machinery including textile, printing, packaging machinery, (2) metal, woodworking, and special material machinery, (3) conveyor, (4) vehicle, (5) crane, (6) construction machinery, and (7) elevator can be divided into three major groups through Boolean algebra and MCS analysis. The MCS causes associated with conveyor share the same primary causes as those of the special process machinery including textile, printing, packaging and metal, woodworking, and special material machinery. These fatalities can be eliminated by focusing on the prevention measures associated with lack of safeguards, working on a running machine or process, unintentional activation, unsafe posture or position, unsafe clothing, and defective safeguards. Other precise and effective intervention can be developed based on the identified groups of accident causes associated with each source of injury.

- **Keywords:** Fault tree; Boolean algebra; Minimum cut set (MCS)

Judith Tiferes, Ann M. Bisantz. *The impact of team characteristics and context on team communication: An integrative literature review*. Pages 146-159.

Many studies on teams report measures of team communication; however, these studies vary widely in terms of the team characteristics, situations, and tasks studied making it difficult to understand impacts on team communication more generally. The objective of this review is systematically summarize relationships between measures of team communication and team characteristics and situational contexts. A literature review was

conducted searching in four electronic databases (PsycINFO, MEDLINE, Ergonomics Abstracts, and SocINDEX). Additional studies were identified by cross-referencing. Articles included for final review had reported at least one team communication measure associated with some team and/or context dimension. Ninety-nine of 727 articles met the inclusion criteria. Data extracted from articles included characteristics of the studies and teams and the nature of each of the reported team and/or context dimensions–team communication properties relationships. Some dimensions (job role, situational stressors, training strategies, cognitive artifacts, and communication media) were found to be consistently linked to changes in team communication. A synthesized diagram that describes the possible associations between eleven team and context dimensions and nine team communication measures is provided along with research needs.

Pooriput Waongenngarm, Kantheera Areerak, Prawit Janwantanakul. *The effects of breaks on low back pain, discomfort, and work productivity in office workers: A systematic review of randomized and non-randomized controlled trials.* Pages 230-239.

The purpose of this study was to evaluate the effectiveness of breaks on low back pain, discomfort, and work productivity in office workers. Publications were systematically searched in several databases from 1980 to December 2016. Relevant randomized and non-randomized controlled trials were retrieved and assessed for methodological quality by two independent reviewers. Quality of evidence was assessed and rated according to GRADE guidelines. Eight randomized controlled trials and three non-randomized controlled trials were included in this review, of which 10 were rated as high-quality studies. The break programs were highly heterogeneous with work duration ranging from 5 min to 2 h and break duration ranging from 20 s to 30 min. The results showed low-quality evidence for the conflicting effect of breaks on pain and low-quality evidence for the positive effect of breaks on discomfort. When stratified by type of breaks, moderate-quality evidence was found for the positive effect of active breaks with postural change for pain and discomfort. Moderate-quality evidence indicated that the use of breaks had no detrimental effect on work productivity. More high-quality studies are needed before recommendations can be given. Within a number of methodological limitations that are present in the published studies, active breaks with postural change may be effective in reducing pain in workers with acute low back pain and to prevent discomfort in healthy subjects.

- **Keywords:** Break; Spinal pain; Musculoskeletal disorders; Computers

Robin Burgess-Limerick. *Participatory ergonomics: Evidence and implementation lessons.* Pages 289-293.

Participatory ergonomics programs have been proposed as the most effective means of eliminating, or redesigning, manual tasks with the aim of reducing the incidence of occupational musculoskeletal disorders. This review assesses the evidentiary basis for this claim; describes the range of approaches which have been taken under the banner of participatory ergonomics in diverse industries; and collates the lessons learned about the implementation of such programs.

- **Keywords:** Participatory ergonomics; Manual tasks; Musculoskeletal disorders