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Julie Bodin, Ronan Garlantézec, Nathalie Costet, Alexis Descatha, Natacha Fouquet, Sandrine Caroly, Yves Roquelaure. *Forms of work organization and associations with shoulder disorders: Results from a French working population.* Pages 1-10.

The aim of this study was to identify forms of work organization in a French region and to study associations with the occurrence of symptomatic and clinically diagnosed shoulder disorders in workers. Workers were randomly included in this cross-sectional study from 2002 to 2005. Sixteen organizational variables were assessed by a self-administered questionnaire: i.e. shift work, job rotation, repetitiveness of tasks, paced work/automatic rate, work pace dependent on quantified targets, permanent controls or surveillance, colleagues' work and customer demand, and eight variables measuring decision latitude. Five forms of work organization were identified using hierarchical cluster analysis (HCA) of variables and HCA of workers: low decision latitude with pace constraints, medium decision latitude with pace constraints, low decision latitude with low pace constraints, high decision latitude with pace constraints and high decision latitude with low pace constraints. There were significant associations between forms of work organization and symptomatic and clinically-diagnosed shoulder disorders.

- **Keywords:** Work organization; Classification; Shoulder disorders

Thierry Ellena, Sebastian Skals, Aleksandar Subic, Helmy Mustafa, Toh Yen Pang. *3D digital headform models of Australian cyclists.* Pages 11-18.

Traditional 1D anthropometric data have been the primary source of information used by ergonomists for the dimensioning of head and facial gear. Although these data are simple to use and understand, they only provide univariate measures of key dimensions. 3D anthropometric data, however, describe the complete shape characteristics of the head surface, but are complicated to interpret due to the abundance of information they contain. Consequently, current headform standards based on 1D measurements may not adequately represent the actual head shape variations of the intended user groups. The purpose of this study was to introduce a set of new digital headform models representative of the adult cyclists' community in Australia. Four models were generated based on an Australian 3D anthropometric database of head shapes and a modified hierarchical clustering algorithm. Considerable shape differences were identified between our models and the current headforms from the Australian standard. We conclude that

the design of head and facial gear based on current standards might not be favorable for optimal fitting results.

- **Keywords:** 3D anthropometric data; Digital headforms; 3D scanning; Head dimensions; Clustering algorithm; Headgear design

Steven C. Mallam, Monica Lundh, Scott N. MacKinnon. *Evaluating a digital ship design tool prototype: Designers' perceptions of novel ergonomics software.* Pages 19-26.

Computer-aided solutions are essential for naval architects to manage and optimize technical complexities when developing a ship's design. Although there are an array of software solutions aimed to optimize the human element in design, practical ergonomics methodologies and technological solutions have struggled to gain widespread application in ship design processes. This paper explores how a new ergonomics technology is perceived by naval architecture students using a mixed-methods framework. Thirteen Naval Architecture and Ocean Engineering Masters students participated in the study. Overall, results found participants perceived the software and its embedded ergonomics tools to benefit their design work, increasing their empathy and ability to understand the work environment and work demands end-users face. However, participants questioned if ergonomics could be practically and efficiently implemented under real-world project constraints. This revealed underlying social biases and a fundamental lack of understanding in engineering postgraduate students regarding applied ergonomics in naval architecture.

- **Keywords:** Participatory design; New technology adoption; Naval architecture

Kane J. Middleton, Amelia J. Carr. *The identification of combat survivability tasks associated with naval vessel damage in maritime environments.* Pages 27-33.

Effective Navy personnel have the physical ability to perform combat survivability tasks commensurate with their unique physical requirements due to the distinctive characteristics of naval platforms. The aim of this investigation was to identify the physically demanding whole-of-ship tasks that are performed by Navy personnel while at sea. A mixed method design was used to identify tasks, inclusive of focus groups and field observations. From a series of ten focus groups, nine tasks were deemed to be physically demanding whole-of-ship tasks. A subsequent field observation of a combat survivability training course resulted in a refined and expanded 33-item list of physically demanding whole-of-ship tasks across six categories, including; replenishment at sea, emergency response, firefighting, leak stop and repair, toxic hazard and casualty evacuation. The findings from this study provide the basis for the development of physical employment standards for whole-of-ship tasks within the Royal Australian Navy.

- **Keywords:** Employment standards; Task analysis; Physically demanding occupation

Richard Parker, Antonios Vitalis, Robyn Walker, David Riley, H. Grant Pearce. *Measuring wildland fire fighter performance with wearable technology.* Pages 34-44.

Wildland (rural) fire fighting is a physically demanding and hazardous occupation. An observational study was conducted to explore the use of new technologies for the field study of fire fighters at wildfires and to understand the work pressures of wildland fire fighting. The research was carried out with two fire fighters at real fires wearing microphones, miniature video cameras, heart rate monitors and GPS units to record their

actions and location at wildfire events. The fire fighters were exposed to high physiological workloads (heart rates of up to 180 beats per minute) and walked considerable distances at the fires. Results from this study have been used in presentations to fire fighters and non-operational fire personnel to understand the pressures fire fighters are under and how others complete the fire fighting tasks.

- **Keywords:** Wildland fire; Fire fighting; Performance monitoring; Wearable technology

Kin Wai Michael Siu, Mei Seung Lam, Yi Lin Wong. *Children's choice: Color associations in children's safety sign design. Pages 56-64.*

Color has been more identified as a key consideration in ergonomics. Color conveys messages and is an important element in safety signs, as it provides extra information to users. However, very limited recent research has focused on children and their color association in the context of safety signs. This study thus examined how children use colors in drawing different safety signs and how they associate colors with different concepts and objects that appear in safety signs. Drawing was used to extract children's use of color and the associations they made between signs and colors. The child participants were given 12 referents of different safety signs and were asked to design and draw the signs using different colored felt-tip pens. They were also asked to give reasons for their choices of colors. Significant associations were found between red and 'don't', orange and 'hands', and blue and 'water'. The child participants were only able to attribute the reasons for the use of yellow, green, blue and black through concrete identification and concrete association, and red through abstract association. The children's use of color quite differs from that shown in the ISO registered signs. There is a need to consider the use of colors carefully when designing signs specifically for children. Sign designers should take children's color associations in consideration and be aware if there are any misunderstandings.

- **Keywords:** Color association; Color ergonomics; Safety signs; Children; Warnings; Reasoning; Participatory ergonomics; Public design

Chao-Yang Yang, Cheng-Tse Wu. *Primary or secondary tasks? Dual-task interference between cyclist hazard perception and cadence control using cross-modal sensory aids with rider assistance bike computers. Pages 65-72.*

This research investigated the risks involved in bicycle riding while using various sensory modalities to deliver training information. To understand the risks associated with using bike computers, this study evaluated hazard perception performance through lab-based simulations of authentic riding conditions. Analysing hazard sensitivity (d') of signal detection theory, the rider's response time, and eye glances provided insights into the risks of using bike computers. In this study, 30 participants were tested with eight hazard perception tasks while they maintained a cadence of 60 ± 5 RPM and used bike computers with different sensory displays, namely visual, auditory, and tactile feedback signals. The results indicated that synchronously using different sense organs to receive cadence feedback significantly affects hazard perception performance; direct visual information leads to the worst rider distraction, with a mean sensitivity to hazards (d') of -1.03 . For systems with multiple interacting sensory aids, auditory aids were found to result in the greatest reduction in sensitivity to hazards (d' mean = -0.57), whereas tactile sensory aids reduced the degree of rider distraction (d' mean = -0.23). Our work complements existing work in this domain by advancing the understanding of how to design devices that deliver information subtly, thereby preventing disruption of a rider's perception of road hazards.

- **Keywords:** Bike computer; Signal detection theory; Road hazards

Elizabeth Reuter, Jorge D. Camba. *Understanding emergency workers' behavior and perspectives on design and safety in the workplace. Pages 73-83.*

Emergency Medical Services (EMS) is a demanding and hazardous industry. Because of the changing roles in the emergency response system, EMS workers are increasingly expected to provide treatment and care in addition to transport, which increases their task load and susceptibility to harm. This paper serves to outline the EMS field from the worker's perspective with the purpose of understanding their views on health, safety, and the work environment, and identify where gaps in worker well-being are exposed. Through direct observation, field studies, and formal interviews with EMS professionals, we discuss where reluctance lies in addressing safety issues and the current efforts to address them. A high prevalence of responses regarding the inadequacy of ambulance restraining systems was reported, as existing interventions do not take into account medic needs.

- **Keywords:** Emergency Medical Services; Paramedic; Ambulance safety; Worker assessment

Joakim Olander, Enrico Ronchi, Ruggiero Lovreglio, Daniel Nilsson. *Dissuasive exit signage for building fire evacuation. Pages 84-93.*

This work presents the result of a questionnaire study which investigates the design of dissuasive emergency signage, i.e. signage conveying a message of not utilizing a specific exit door. The work analyses and tests a set of key features of dissuasive emergency signage using the Theory of Affordances. The variables having the largest impact on observer preference, interpretation and noticeability of the signage have been identified. Results show that features which clearly negate the exit-message of the original positive exit signage are most effective, for instance a red X-marking placed across the entirety of the exit signage conveys a clear dissuasive message. Other features of note are red flashing lights and alternation of colour. The sense of urgency conveyed by the sign is largely affected by sensory inputs such as red flashing lights or other features which cause the signs to break the tendencies of normalcy.

- **Keywords:** Dissuasive; Emergency signage; Exit sign; Paired comparison; Evacuation; Dynamic signage; Route choice; Risk perception; Urgency

Carl Pankok Jr., Maryam Zahabi, Wenjuan Zhang, Inchul Choi, Yi-Fan Liao, Chang S. Nam, David Kaber. *The effects of interruption similarity and complexity on performance in a simulated visual-manual assembly operation. Pages 94-103.*

The objective of the study was to assess the effects of interruption task similarity and complexity on performance of a simulated industrial assembly operation. Eighteen participants performed a simulated industrial assembly operation, including one trial with no interruption and eight others presenting an interruption task. Interruption conditions comprised a full crossing of task similarity to the primary assembly operation (similar, dissimilar) and complexity (simple, complex) with replication for each participant. Order of condition presentation was randomized. Findings revealed greater time to return to primary visual-manual assembly performance after a similar task interruption. Results also indicated complex interruptions may promote cognitive arousal that increases productivity following assembly interruptions. The majority of results are explained in terms of the Activation-Based Memory for Goals model. Findings provide some guidance for interruption management protocol design for workers engaged in procedural visual-manual assembly operations.

- **Keywords:** Task interruptions; Manual assembly; Worker productivity

Justin R.E. Saward, Neville A. Stanton. *Latent error detection: A golden two hours for detection.* Pages 104-113.

Undetected error in safety critical contexts generates a latent condition that can contribute to a future safety failure. The detection of latent errors post-task completion is observed in naval air engineers using a diary to record work-related latent error detection (LED) events. A systems view is combined with multi-process theories to explore sociotechnical factors associated with LED. Perception of cues in different environments facilitates successful LED, for which the deliberate review of past tasks within two hours of the error occurring and whilst remaining in the same or similar sociotechnical environment to that which the error occurred appears most effective. Identified ergonomic interventions offer potential mitigation for latent errors; particularly in simple everyday habitual tasks. It is thought safety critical organisations should look to engineer further resilience through the application of LED techniques that engage with system cues across the entire sociotechnical environment, rather than relying on consistent human performance.

- **Keywords:** Latent error detection; Aircraft maintenance; System cues; Human performance variability

Christopher James Vincent, Ann Blandford. *How do health service professionals consider human factors when purchasing interactive medical devices? A qualitative interview study.* Pages 114-122.

We present findings of a UK study into how those involved in purchasing interactive medical devices go about evaluating usability, the challenges that arise, and opportunities for improvement. The study focused on procurement of infusion devices because these are used by various professionals across healthcare. A semi-structured interview study was carried out involving a range of stakeholders (20 in total) involved in or impacted by medical device procurement. Data was analysed using thematic analysis, a qualitative method designed to support the identification, analysis and reporting of patterns. In principle, health service purchasing was found to accommodate consideration of equipment usability. In practice, the evaluation process was driven primarily by engineering standards; assessment of local needs did not accommodate substantive assessment of usability; and choice was limited by the availability of equipment on the marketplace. We discuss ways in which purchasing could be improved through techniques that account for social circumstances.

- **Keywords:** Interface; User computer; Purchasing; Medical device design

J. Navarro, J. Deniel, E. Yousfi, C. Jallais, M. Bueno, A. Fort. *Influence of lane departure warnings onset and reliability on car drivers' behaviors.* Pages 123-131.

Lane departures represent an important cause of road crashes. The objective of the present study was to assess the effects of an auditory Lane Departure Warning System (LDWS) for partial and full lane departures (onset manipulation) combined with missed warnings (reliability manipulation: 100% reliable, 83% reliable and 66% reliable) on drivers' performances and acceptance. Several studies indicate that LDWS improves drivers' performances during lane departure episodes. However, little is known about the effects of the warning onset and reliability of LDWS. Results of studies which looked at forward collision warning systems show that early warnings tend to improve drivers' performances and receive a better trust judgement from the drivers when compared to later warnings. These studies also suggest that reliable assistances are more effective

and trusted than unreliable ones. In the present study, lane departures were brought about by means of a distraction task whilst drivers simulated driving in a fixed-base simulator with or without an auditory LDWS. Results revealed steering behaviors improvements with LDWS. More effective recovery maneuvers were found with partial lane departure warnings than with full lane departure warnings and assistance unreliability did not impair significantly drivers' behaviors. Regarding missed lane departure episodes, drivers were found to react later and spend more time out of the driving lane when compared to properly warned lane departures, as if driving without assistance. Subjectively, LDWS did not reduce mental workload and partial lane departure warnings were judged more trustworthy than full lane departure ones. Data suggests the use of partial lane departure warnings when designing LDWS and that even unreliable LDWS may draw benefits compared to no assistance.

- **Keywords:** Steering; Lane departure warning; Alert timing; Alert miss; Driving simulator

Markus Ahola, Ruth Mugge. *Safety in passenger ships: The influence of environmental design characteristics on people's perception of safety.* Pages 143-152.

Although objective safety is a widely studied topic in ergonomics, subjective safety has received far less research attention. Nevertheless, most of human decision-making and behavior depends on how we perceive our environment. This study investigates the effects of various environmental design characteristics on people's safety perception in a passenger ship context. Five different environmental design characteristics were manipulated to increase the openness of the space or to create more clear navigation, resulting in 20 different cabin corridors for a passenger ship. Ninety-seven respondents were asked to rate these corridors on the perceived safety in an experiment. The results showed that people feel more safe when the corridors have a curved ceiling, when the walls do not have a split-level design, and when there is a view to the outside. Designers can use these insights when designing future environments.

- **Keywords:** Perception; Safety; Architectural design; Environmental design

Chia-Fen Chi, Ratna Sari Dewi, Min-Hua Huang. *Psychophysical evaluation of auditory signals in passenger vehicles.* Pages 153-164.

Twenty-one experienced drivers were recruited for the evaluation of sounds of four functions (horn, indicator, door open warning, and parking sensor) made by 11 car brand names. Each participant was required to evaluate all of the above sound signals by a pair-comparison test. After the comparison test, each participant was shown his/her pair-comparison result and was asked to comment on their preference and appropriateness of a sound. The physical properties and interview data were compared and summarized to propose design recommendations. Our results indicate that complex tones and a fundamental frequency between 500 and 1000 Hz were most preferred for horns while for indicators the preferred sounds had a higher dominant frequency. To reduce monotony, the indicators with double clicks and an OFF time interval of between 330 and 400 ms between two clicks were most preferred. Regarding door warning sounds, the waveform starting with a higher intensity then fading towards zero intensity is most preferred while for parking sensors, sounds beginning with a longer OFF time (about 500 ms) and having 3 or 4 distinctive tempo variations were most preferred. The relationship between pleasurability and pitch, loudness, and the tempo of sound signals basically followed an inverted-U function. Sound designers should avoid using very extreme parameter values when generating sound for a given function.

- **Keywords:** Sound quality; Paired comparison; Psychoacoustics

Allison Kabel, Jessica Dimka, Kerri McBee-Black. *Clothing-related barriers experienced by people with mobility disabilities and impairments*. Pages 165-169.

Clothing-related issues can create barriers to social participation and other desired activities for people living with disabilities and their families. The purpose of this study was to identify clothing-related barriers people living with disabilities and their families are facing. An online survey was administered to people living with disabilities and parents/caregivers, resulting in a sample of 113 participants indicating mobility impairments. Survey results indicated that the clothing needs of people living with disabilities and impairments are not being met, the lack of appropriate clothing prevented individuals from fully engaging in social activities and relationships, employment or everyday life events. The design fields and apparel industry could play a vital role in helping people with mobility disabilities navigate these barriers.

- **Keywords:** Disability; Human factors; Textiles and apparel; Social participation

Annette Kluge, Anatoli Termer. *Human-centered design (HCD) of a fault-finding application for mobile devices and its impact on the reduction of time in fault diagnosis in the manufacturing industry*. Pages 170-181.

The present article describes the design process of a fault-finding application for mobile devices, which was built to support workers' performance by guiding them through a systematic strategy to stay focused during a fault-finding process. In collaboration with a project partner in the manufacturing industry, a fault diagnosis application was conceptualized based on a human-centered design approach (ISO 9241-210:2010). A field study with 42 maintenance workers was conducted for the purpose of evaluating the performance enhancement of fault finding in three different scenarios as well as for assessing the workers' acceptance of the technology. Workers using the mobile device application were twice as fast at fault finding as the control group without the application and perceived the application as very useful. The results indicate a vast potential of the mobile application for fault diagnosis in contemporary manufacturing systems.

- **Keywords:** Mobile device; Troubleshooting; Manufacturing

Anette Karlton, Johan Karlton, Martina Berglund, Jörgen Eklund. *HTO: a complementary ergonomics approach*. Pages 182-190.

The field of human factors and ergonomics constitutes a strong potential in systems analysis, design and improvement. However, it is difficult to communicate its potential value. This paper addresses how the human-technology-organization (HTO) concept can be defined and supports the understanding, communication and development of the systems' character and potential of human factors and ergonomics. Empirical examples from the authors' experiences of working with the HTO concept in R&D and teaching are illustrated, including its usefulness as: 1) a conceptual model; 2) an analysis framework; 3) a meta methodology; 4) a pedagogical tool; and 5) a design tool. The use of HTO provides guidance on how the system can be designed to better support health, individual and systems performance. It is further suggested that there is a strong potential for developing the theory, applications and methodological aspects of HTO.

- **Keywords:** Human-technology-organization; Systems approach; Interaction; Activity

Torgeir K. Haavik, Trond Kongsvik, Rolf Johan Bye, Jens Olgard Dalseth Røyrvik, Petter Grytten Almklov. *Johnny was here: From airmanship to airlineship*. Pages 191-202.

In this article we explore the phenomenon of airmanship in commercial passenger flights, in a context of increasing standardisation of procedures and technologies. Through observation studies in cockpits and interviews we have studied pilots' practices and how they relate to the larger system of procedures and the technical environment. We find that practices are to a large extent guided by standard operating procedures, and that interchangeability of pilots and aircrafts is both a prerequisite for and enabled by this standardised regime. However, since sociotechnical systems in general – and operation of aircrafts is no exception – are inherently underspecified, the pilots' exercise of discretion in their context-sensitive adaptation of the procedures and technical environments is another prerequisite for well-functioning systems. Mastering these adaptations – and recognising the absolute delimitations of adaptations – is a central aspect of airmanship. Outside this space of manoeuvre for the pilots, the aircrafts are managed by what we call airlineship: The inter-organisational efforts to create predictability and safe practices through de-identification and interchangeability of personnel and aircrafts. Pilots are actors in sociotechnical systems that are not demarcated by the cockpits. To understand pilots' work, studies must account also for the wider sociotechnical context of organisational, regulative and techno-material structures. The article is a contribution to the a generic attempt in the field of ergonomics to contribute with models and theories that portray individuals, groups, organisations and systems in ways that keep sight of the individuals in the systems and the systems in the individuals at the same time.

- **Keywords:** Airmanship; Airlineship; Standardisation; Adaptation

Toyin Ajisafe, Jianhua Wu, Mark Geil. *Toe spatiotemporal differences between transition steps when ascending shorter flight stairways of different heights. Pages 203-208.*

Background: Studies have typically treated the first and second floor-to-stair transition steps (TS1 and TS2) as one stride. However, because the foot is devoid of plantar cutaneous input from the stair surface at TS1, these steps may have different toe spatiotemporal profiles, and resultantly, different susceptibilities to a trip and/or a fall. This study compared vertical toe clearance, forward velocity, and their respective variability magnitudes between TS1 and TS2 when ascending stairs of different heights.

Methods: Twenty young adults (seven males and 13 females) (21.68 ± 2.49 years; 169.70 ± 9.56 cm; 63.91 ± 9.62 kg) negotiated an intervening three-step staircase placed midpoint on a 10 m walkway. There were three stair heights: low stairs (LS), medium stairs (MS), and high stairs (HS). Vertical toe clearance, forward velocity, and their variability magnitudes were calculated. **Results:** Vertical toe clearance was only higher ($P < 0.05$) at TS1 than TS2 in the medium and high stairs. Vertical toe clearance was more variable ($P < 0.05$) in the low compared to medium stairs. Also, forward toe velocity was greater at TS1 than TS2, but was lower in the medium and high stairs. **Conclusion:** The locomotor system appeared cautious by exaggerating vertical toe clearance at both TS1 and TS2 only in low stairs, possibly due to higher forward toe velocity. If the exaggeration strategy consistently persists, this finding may suggest decreased trip or fall risk at both TS1 and TS2 only when transitioning onto low stairs.

- **Keywords:** Stair ascent; Locomotor; Spatiotemporal variability; Floor-to-stair transition; Fall risk

Michael E. Young, Anthony W. McCoy, John P. Hutson, Meredith Schlabach, Steven Eckels. *Hot under the collar: The impact of heat on game play. Pages 209-214.*

High temperatures have been documented to affect behavior in a variety of ways depending on the nature of the task. We extended this prior research by examining the effects of dynamically changing temperature on various aspects of performance in a

video game task. In the span of approximately an hour, temperature was gradually increased, stayed constant for a period of time, and gradually decreased to baseline. The gaming task was a variation on one used to assess impulsivity in participants thus allowing the possibility of assessing the effects of temperature on impulsive choice. Rather than heat increasing impulsivity and thus decreasing wait times, participants showed increases in wait times as temperature increased which either suggests that participants were becoming more self-controlled under heat or that the documented negative impact of heat on motor functioning was dominating their performance. Importantly, the participant's sensitivity to the changing task requirements was not affected by changes in temperature.

- **Keywords:** Temperature; Game; Impulsivity; Decision making; Choice; Learning

Zhe Chen, Pei-Luen Patrick Rau. *The role of size of input box, location of input box, input method and display size in Chinese handwriting performance and preference on mobile devices.* Pages 215-224.

This study presented two experiments on Chinese handwriting performance (time, accuracy, the number of protruding strokes and number of rewritings) and subjective ratings (mental workload, satisfaction, and preference) on mobile devices. Experiment 1 evaluated the effects of size of the input box, input method and display size on Chinese handwriting performance and preference. It was indicated that the optimal input sizes were 30.8 × 30.8 mm, 46.6 × 46.6 mm, 58.9 × 58.9 mm and 84.6 × 84.6 mm for devices with 3.5-inch, 5.5-inch, 7.0-inch and 9.7-inch display sizes, respectively. Experiment 2 proved the significant effects of location of the input box, input method and display size on Chinese handwriting performance and subjective ratings. It was suggested that the optimal location was central regardless of display size and input method.

- **Keywords:** Input size; Location; Input method; Display size; Chinese handwriting

Paul Rothmore, Paul Aylward, Jodi Oakman, David Tappin, Jodi Gray, Jonathan Karnon. *The stage of change approach for implementing ergonomics advice – Translating research into practice.* Pages 225-233.

The Stage of Change (SOC) approach has been proposed as a method to improve the implementation of ergonomics advice. However, despite evidence for its efficacy there is little evidence to suggest it has been adopted by ergonomics consultants. This paper investigates barriers and facilitators to the implementation, monitoring and effectiveness of ergonomics advice and the adoption of the SOC approach in a series of focus groups and a subsequent survey of members of the Human Factors Societies of Australia and New Zealand. A proposed SOC assessment tool developed for use by ergonomics practitioners is presented. Findings from this study suggest the limited application of a SOC based approach to work-related musculoskeletal injury prevention by ergonomics practitioners is due to the absence of a suitable tool in the ergonomists' repertoire, the need for training in this approach, and their limited access to relevant research findings. The final translation of the SOC assessment tool into professional ergonomics practice will require accessible demonstration of its real-world usability to practitioners and the training of ergonomics practitioners in its application.

- **Keywords:** Stage of change; Implementation; Ergonomics interventions; Translation

Laura Pickup, Sarah Atkinson, Erik Hollnagel, Paul Bowie, Sandra Gray, Sam Rawlinson, Kate Forrester. *Blood sampling: Two sides to the story.* Pages 234-242.

This study aimed to investigate why there is variability in taking blood. A multi method Pilot study was completed in four National Health Service Scotland hospitals. Human Factors/Ergonomics principles were applied to analyse data from 50 observations, 15 interviews and 12-months of incident data from all Scottish hospitals. The Functional Resonance Analysis Method (FRAM) was used to understand why variability may influence blood sampling functions. The analysis of the 61 pre blood transfusion sampling incidents highlighted limitations in the data collected to understand factors influencing performance. FRAM highlighted how variability in the sequence of blood sampling functions and the number of practitioners involved in a single blood sampling activity was influenced by the working environment, equipment, clinical context, work demands and staff resources. This pilot study proposes a realistic view of why blood sampling activities vary and proposes the need to consider the system's resilience in future safety management strategies.

- **Keywords:** Blood sampling; Wrong blood in tube; Resilience

Matthew Hill, Roozbeh Naemi, Helen Branthwaite, Nachiappan Chockalingam. *The relationship between arch height and foot length: Implications for size grading. Pages 243-250.*

Objective: Medial longitudinal Arch Height is synonymous with classifying foot type and conversely foot function. Detailed knowledge of foot anthropometry is essential in the development of ergonomically sound footwear. Current Footwear design incorporates a direct proportionate scaling of instep dimensions with those of foot length. The objective of this paper is to investigate if a direct proportional relationship exists between human arch height parameters and foot length in subjects with normal foot posture. **Method:** A healthy convenience sample of 62 volunteers was recruited to participate in this observational study. All subjects were screened for normal foot health and posture. Each subject's foot dimensions were scanned and measured using a 3D Foot Scanner. From this foot length and arch height parameters were obtained. Normalised ratios of arch height with respect to foot length were also calculated. The arch height parameters and the normalised arch ratios were used interchangeably as the dependent variables with the foot length parameters used as the independent variable for Simple Linear Regression and Correlation. **Results:** Analysis of foot length measures demonstrated poor correlation with all arch height parameters. **Conclusion:** No significant relationships between arch height and foot length were found. The predictive value of the relationship was found to be poor. This holds significant implications for the current method of proportionate scaling of footwear in terms of fit and function to the midfoot region for a normative population.

- **Keywords:** Anthropometry; Allometry; Footwear; Medial longitudinal arch; Footwear last; Footwear sizing; Footwear grading

Mary Beth Privitera, Mark Evans, Darren Southee. *Human factors in the design of medical devices: Approaches to meeting international standards in the European Union and USA. Pages 251-263.*

This paper focuses on the challenges of meeting agency requirements as it pertains to the application of human factors in the medical device development (MDD) process. Individual case studies of the design and development process for 18 medical device manufacturers located in the US and EU were analyzed and compared using a multiple case study design. The results indicate that there are four main challenges in implementing international standards. These include a lack of direct access to users for the purposes of device development; a lack of understanding by users with regards to the impact of their feedback on the development process; contract formalities limiting user exchanges; and the attitude of clinical users directly impacting on the device developer's invitation to participate in the development processes. The barriers presented

in this research have the potential to be resolved but only with greater commitment by both medical device users and developers.

- **Keywords:** Medical device; User-centered design; Regulatory requirements

Sonja Th. Kwee-Meier, Alexander Mertens, Christopher M. Schlick. *Age-related differences in decision-making for digital escape route signage under strenuous emergency conditions of tilted passenger ships. Pages 264-273.*

This age-differentiated study investigated preferences for new digital, situation-adaptive escape route signage with informative and flashing elements under simulated emergency conditions of tilted passenger ships. The decision-making behaviour of 26 young (20–30 years) and 26 elderly (60–77 years) participants was observed in four conditions varying in applied stressors and in level versus uphill walking at 7° and 14°. In line with previous studies, decisions of young participants were significantly influenced by flashing elements on signs. In contrast, elderly participants based their decisions significantly stronger on integrated information about the sign's updatedness and reported irritation by flashing elements. These preferences were also persistent under increased mental, emotional and physical strain, evaluated by ratings and (psycho-)physiological measures. The findings demonstrate the importance to carefully design digital, situation-adaptive signage for passenger ships in a way that it not only attracts attention but also inspires trust especially for the elderly population.

- **Keywords:** Digital escape route signage; Elderly; Ship evacuation

Mariel Grassmann, Elke Vlemincx, Andreas von Leupoldt, Omer Van den Bergh. *Individual differences in cardiorespiratory measures of mental workload: An investigation of negative affectivity and cognitive avoidant coping in pilot candidates. Pages 274-282.*

Cardiorespiratory measures provide useful information in addition to well-established self-report measures when monitoring operator capacity. The purpose of our study was to refine the assessment of operator load by considering individual differences in personality and their associations with cardiorespiratory activation. Physiological and self-report measures were analyzed in 115 pilot candidates at rest and while performing a multiple task covering perceptual speed, spatial orientation, and working memory. In the total sample and particularly in individuals with a general tendency to worry a lot, a cognitive avoidant coping style was associated with a smaller task-related increase in heart rate. Negative affectivity was found to moderate the association between cardiac and self-reported arousal. Given that physiological and self-report measures of mental workload are usually combined when evaluating operator load (e.g., in pilot selection and training), our findings suggest that integrating individual differences may reduce unexplained variance and increase the validity of workload assessments.

- **Keywords:** Individual differences; Cardiorespiratory reactivity; Mental workload

John O'Neill, Dawn A. O'Neill, William J. Lewinski. *Toward a taxonomy of the unintentional discharge of firearms in law enforcement. Pages 283-292.*

An unintentional discharge (UD) is an activation of the trigger mechanism that results in an unplanned discharge that is outside of the firearm's prescribed use. UD's can result in injury or death, yet have been understudied in scientific literature. Pre-existing (1974–2015) UD reports (N = 137) from seven law enforcement agencies in the United States of America were analyzed by context, officer behavior, type of firearm, and injuries. Over

50% of UDs occurred in contexts with low threat potential while engaged in routine firearm tasks. The remaining UDs occurred in contexts with elevated to high threat potential during muscle co-activation, unfamiliar firearm tasks, contact with inanimate objects, and a medical condition. An antecedent-behavior-consequence (A-B-C) taxonomy as well as a standardized reporting form, based on the current findings and the existing literature, are offered as tools for identifying the conditions under which UDs may be likely to occur.

- **Keywords:** Firearm; Gun; Law enforcement; Police; Unintentional discharge

Xiaoxu Ji, Tammy R. Eger, James P. Dickey. *Evaluation of the vibration attenuation properties of an air-inflated cushion with two different heavy machinery seats in multi-axis vibration environments including jolts.* Pages 293-301.

Seats and cushions can attenuate whole-body vibration (WBV) exposures and minimize health risks for heavy machine operators. We successfully developed neural network (NN) algorithms to identify the vibration attenuation properties for four different seating conditions (seat/cushion combinations), and implemented each of the NN models to predict the equivalent daily exposure A(8) values for various vehicles in the forestry and mining environments. We also evaluated the performance of the new prototype No-Jolt™ air-inflated cushion and the original cushion of each seat with jolt exposures. We observed that the air cushion significantly improved the vibration attenuation properties of the seat that initially had good performance, but not for the seat that had relatively poor vibration attenuation properties. In addition, operator's anthropometrics and sex influenced the performance of the air-inflated cushion when the vibration environment included jolt exposures.

- **Keywords:** Whole-body vibration; Seats; Neural network

Arie P. van den Beukel, Mascha C. van der Voort. *How to assess driver's interaction with partially automated driving systems: A framework for early concept assessment.* Pages 302-312.

The introduction of partially automated driving systems changes the driving task into supervising the automation with an occasional need to intervene. To develop interface solutions that adequately support drivers in this new role, this study proposes and evaluates an assessment framework that allows designers to evaluate driver-support within relevant real-world scenarios. Aspects identified as requiring assessment in terms of driver-support within the proposed framework are Accident Avoidance, gained Situation Awareness (SA) and Concept Acceptance. Measurement techniques selected to operationalise these aspects and the associated framework are pilot-tested with twenty-four participants in a driving simulator experiment. The objective of the test is to determine the reliability of the applied measurements for the assessment of the framework and whether the proposed framework is effective in predicting the level of support offered by the concepts. Based on the congruency between measurement scores produced in the test and scores with predefined differences in concept-support, this study demonstrates the framework's reliability. A remaining concern is the framework's weak sensitivity to small differences in offered support. The article concludes that applying the framework is especially advantageous for evaluating early design phases and can successfully contribute to the efficient development of driver's in-control and safe means of operating partially automated vehicles.

- **Keywords:** Assessment framework; Driving automation; Interface design

Khoirul Muslim, Maury A. Nussbaum. *The effects of a simple intervention on exposures to low back pain risk factors during traditional posterior load carriage.* Pages 313-319.

Traditional posterior load carriage (PLC), typically performed without the use of an assistive device, is associated with a high prevalence of low back pain (LBP). However, there are few studies that have evaluated potential interventions to reduce exposures to LBP risk factors. This work examined the effects of a simple, potentially low-cost intervention using an assistive device (i.e., carrying aid) on exposures to factors related to LBP risk during PLC. Torso kinematics and kinetics, slip risk, and ratings of perceived discomfort (RPD) were obtained during simulated PLC on a walkway. Consistent with earlier results, increasing load mass substantially increased torso flexion and lumbosacral flexion moment, as well as RPDs in all anatomical regions evaluated. Using the carrying aid with a higher load placement resulted in substantially lower mean lumbosacral moments when carrying the heaviest load. In contrast, using the carrying aid with a lower load placement resulted in substantially higher torso flexion angles, higher mean lumbosacral moments when carrying heavier loads, and higher peak lumbosacral moments across all load masses. With use of the carrying aid, both higher and lower load placement resulted in significantly lower RPDs in the elbows and hands compared to the control condition. In summary, use of a carrying aid with higher load placement may be beneficial in reducing the risk of LBP during PLC. Future studies are needed, though, to improve the device design and to enhance external validity.

- **Keywords:** Low back pain; Assistive device; Intervention; Spine; Kinematics; Kinetics

Torbjörn Åkerstedt, Göran Kecklund. *What work schedule characteristics constitute a problem to the individual? A representative study of Swedish shift workers.* Pages 320-325.

The purpose was to investigate which detailed characteristics of shift schedules that are seen as problems to those exposed. A representative national sample of non-day workers (N = 2031) in Sweden was asked whether they had each of a number of particular work schedule characteristics and, if yes, to what extent this constituted a "big problem in life". It was also inquired whether the individual's work schedules had negative consequences for fatigue, sleep and social life. The characteristic with the highest percentage reporting a big problem was "short notice (<1 month) of a new work schedule" (30.5%), <11 h off between shifts (27.8%), and split duty (>1.5 h break at mid-shift, 27.2%). Overtime (>10 h/week), night work, morning work, day/night shifts showed lower prevalences of being a "big problem". Women indicated more problems in general. Short notice was mainly related to negative social effects, while <11 h off between shifts was related to disturbed sleep, fatigue and social difficulties. It was concluded that schedules involving unpredictable working hours (short notice), short daily rest between shifts, and split duty shifts constitute big problems. The results challenge current views of what aspects of shift work need improvement, and negative social consequences seem more important than those related to health.

- **Keywords:** Shift work; Night work; Daily rest; Split duty; Health

Amir Tjolleng, Kihyo Jung, Wongi Hong, Wonsup Lee, Baekhee Lee, Heecheon You, Joonwoo Son, Seikwon Park. *Classification of a Driver's cognitive workload levels using artificial neural network on ECG signals.* Pages 326-332.

An artificial neural network (ANN) model was developed in the present study to classify the level of a driver's cognitive workload based on electrocardiography (ECG). ECG

signals were measured on 15 male participants while they performed a simulated driving task as a primary task with/without an N-back task as a secondary task. Three time-domain ECG measures (mean inter-beat interval (IBI), standard deviation of IBIs, and root mean squared difference of adjacent IBIs) and three frequencydomain ECG measures (power in low frequency, power in high frequency, and ratio of power in low and high frequencies) were calculated. To compensate for individual differences in heart response during the driving tasks, a three-step data processing procedure was performed to ECG signals of each participant: (1) selection of two most sensitive ECG measures, (2) definition of three (low, medium, and high) cognitive workload levels, and (3) normalization of the selected ECG measures. An ANN model was constructed using a feed-forward network and scaled conjugate gradient as a back-propagation learning rule. The accuracy of the ANN classification model was found satisfactory for learning data (95%) and testing data (82%).

- **Keywords:** Cognitive workload classification; Heart rate variability; Artificial neural network

Wen-Ruey Chang, Chien-Chi Chang, Mary F. Lesch, Simon Matz. *Gait adaptation on surfaces with different degrees of slipperiness. Pages 333-341.*

Gait adaptation to employ different ways to avoid a potential slip is needed to continue walking safely on a new surface, especially when transitioning to a slippery surface. In this experiment, participants walked back and forth five times (trials) on surfaces with different degrees of slipperiness. The results show that trial 1 was significantly different from other trials for most of the dependent variables, especially for the low and high friction conditions. Kinematics on high and medium friction surfaces were very similar, but more adjustments were needed for low friction surfaces. The data for the first trial reflect gait after walking for 2.4 m on the walkway, not the first step onto the walkway. The current data show that gait adaptation continued beyond the first trial. Since participants in this experiment were aware of the floor conditions, the results could have important safety implications that user awareness alone might be insufficient for safe floor designs.

- **Keywords:** Gait adaptation; Coefficient of friction; Human locomotion; Friction utilization

J. Mackrill, P. Marshall, S.R. Payne, E. Dimitrokali, R. Cain. *Using a bespoke situated digital kiosk to encourage user participation in healthcare environment design. Pages 342-356.*

Involving users through participation in healthcare service and environment design is growing. Existing approaches and toolkits for practitioners and researchers are often paper based involving workshops and other more traditional design approaches such as paper prototyping. The advent of digital technology provides the opportunity to explore new platforms for user participation. This paper presents results from three studies that used a bespoke situated user participation digital kiosk, engaging 33 users in investigating healthcare environment design. The studies, from primary and secondary care settings, allowed participant feedback on each environment and proved a novel, engaging "21st century" way to participate in the appraisal of the design process. The results point toward this as an exciting and growing area of research in developing not just a new method of user participation but also the technology that supports it. Limitations were noted in terms of data validity and engagement with the device. To guide the development of user participation using similar situated digital devices, key lessons and reflections are presented.

- **Keywords:** User participation; Technology; Healthcare; Design

Qun Liu, Jindong Ren, Qian Zhang, Meng Hua. *Seated reach capabilities for ergonomic design and evaluation with consideration of reach difficulties*. Pages 357-363.

This paper aimed to identify the reach capabilities of 26 seated subjects considering the reach difficulty, orientation and other potential factors, and to find a method to model the minimum reach capability surfaces for fixed and adjustable seats. The reach capability radius was used as a measure of the reach capability and theoretically modeled. Based on the test data of seated reach, the distribution of the reach capability radius was analyzed. The strategy to select the minimum reach envelopes was constructed to accommodate a sufficient percentage of the target population for both fixed and adjustable seats. For adjustable seats, a method was developed to derive the reach capability data from the tested individual reach capability data by introducing seating position models to re-position the individual reach capability data. An application case was realized based on the cab packaging data of a mini-van, and the minimum reach envelopes of different difficulties were created and validated to accommodate 90% of the target population.

- **Keywords:** Reach; Capability; Envelope; Difficulty; Accommodation

Stefan C. Christov, Jenna L. Marquard, George S. Avrunin, Lori A. Clarke. *Assessing the effectiveness of five process elicitation methods: A case study of chemotherapy treatment plan review*. Pages 364-376.

To reduce the probability of failures and to improve outcomes of safety-critical human-intensive processes, such as health care processes, it is important to be able to rigorously analyze such processes. The quality of that analysis often depends on having an accurate, detailed, and sufficiently complete understanding of the process being analyzed, where this understanding is typically represented as a formal process model that could then drive various rigorous analysis approaches. Developing this understanding and the corresponding formal process model may be difficult and, thus, a variety of process elicitation methods are often used. The work presented in this paper evaluates the effectiveness of five common elicitation methods in terms of their ability to elicit detailed process information necessary to support rigorous process analysis. These methods are employed to elicit typical steps and steps for responding to exceptional situations in a safety-critical health care process, the chemotherapy treatment plan review process. The results indicate strengths and weaknesses of each of the elicitation methods and suggest that it is preferable to apply multiple elicitation methods.

- **Keywords:** Elicitation methods; Workflow understanding; Human-intensive process; Exception handling; Safety

S. Camille Peres, Ranjana K. Mehta, Paul Ritchey. *Assessing ergonomic risks of software: Development of the SEAT*. Pages 377-386.

Software utilizing interaction designs that require extensive dragging or clicking of icons may increase users' risks for upper extremity cumulative trauma disorders. The purpose of this research is to develop a Self-report Ergonomic Assessment Tool (SEAT) for assessing the risks of software interaction designs and facilitate mitigation of those risks. A 28-item self-report measure was developed by combining and modifying items from existing industrial ergonomic tools. Data were collected from 166 participants after they completed four different tasks that varied by method of input (touch or keyboard and mouse) and type of task (selecting or typing). Principal component analysis found distinct factors associated with stress (i.e., demands) and strain (i.e., response). Repeated measures analyses of variance showed that participants could discriminate the different strain induced by the input methods and tasks. However, participants' ability to

discriminate between the stressors associated with that strain was mixed. Further validation of the SEAT is necessary but these results indicate that the SEAT may be a viable method of assessing ergonomics risks presented by software design.

- **Keywords:** Office ergonomics; Self-report risk assessment tool; Software interaction design; Musculoskeletal disorders

Baizhan Li, Yu Yang, Runming Yao, Hong Liu, Yongqiang Li. *A simplified thermoregulation model of the human body in warm conditions.* Pages 387-400.

Thermoregulation models of the human body have been widely used in thermal comfort studies. The existing models are complicated and not fully verified for application in China. This paper presents a simplified thermoregulation model which has been statistically validated by the predicted and measured mean skin temperature in warm environments, including 21 typical conditions with 400 Chinese subjects. This model comprises three parts: i) the physical model; ii) the controlled system; and iii) the controlling system, and considers three key questions formerly ignored by the existing models including: a) the evaporation efficiency of regulatory sweat; b) the proportional relation of total skin blood flow and total heat loss by regulatory sweating against body surface area; and c) discrepancies in the mean skin temperatures by gender. The developed model has been validated to be within the 95% confidence interval of the population mean skin temperature in three cases.

- **Keywords:** Thermoregulation model; Thermal response; Skin temperature

Hadi Ibrahim Masoud, Yaser Zerehsaz, Jionghua (Judy) Jin. *Analysis of human motion variation patterns using UMPCA.* Pages 401-409.

The rapid development of motion capture technologies has greatly increased the use of human motion data in many applications. This has increased the demand to have an effective means to systematically analyze those massive data in order to understand human motion variation patterns. This paper studies one typical type of motion data, which are recorded as multi-stream trajectories of human joints. Such a high dimensional multi-stream data structure makes it difficult to directly perform visual comparisons or simply apply conventional methods such as PCA to capture the variation of human motion patterns. In this paper, a high order array (tensor) is suggested for data representation, based on which the Uncorrelated Multilinear Principal Component Analysis (UMPCA) is applied to analyze the variation of human motion patterns. A simulation study is presented to show the superiority of UMPCA over PCA in preserving the cross-correlation among multi-stream trajectories. The effectiveness of UMPCA is also demonstrated using a case study for analyzing vehicle ingress test data.

- **Keywords:** Human motion; Variation analysis; UMPCA

Nicholas J. La Delfa, Jim R. Potvin. *The 'Arm Force Field' method to predict manual arm strength based on only hand location and force direction.* Pages 410-421.

This paper describes the development of a novel method (termed the 'Arm Force Field' or 'AFF') to predict manual arm strength (MAS) for a wide range of body orientations, hand locations and any force direction. This method used an artificial neural network (ANN) to predict the effects of hand location and force direction on MAS, and included a method to estimate the contribution of the arm's weight to the predicted strength. The AFF method predicted the MAS values very well ($r^2 = 0.97$, $\text{RMSD} = 5.2 \text{ N}$, $n = 456$) and maintained good generalizability with external test data ($r^2 = 0.842$, $\text{RMSD} = 13.1 \text{ N}$, $n = 80$). The

AFF can be readily integrated within any DHM ergonomics software, and appears to be a more robust, reliable and valid method of estimating the strength capabilities of the arm, when compared to current approaches.

- **Keywords:** Manual arm strength; Acceptable hand loads; Strength capabilities; Artificial neural network

Iman Dianat, Soleyman Rahimi, Moein Nedaei, Mohammad Asghari Jafarabadi, Ali E. Oskouei. *Effects of tool handle dimension and workpiece orientation and size on wrist ulnar/radial torque strength, usability and discomfort in a wrench task.* Pages 422-430.

The effects of tool handle dimension (three modified designs of wrenches with 30–50 mm diameter cylindrical handles and traditional design with rectangular cross-sectional (5 mm × 25 mm) handle), workpiece orientation (vertical/horizontal) and workpiece size (small/large) as well as user's hand size on wrist ulnar/radial (U/R) torque strength, usability and discomfort, and also the relationship between these variables were evaluated in a maximum torque task using wrenches. The highest and lowest levels of maximal wrist U/R torque strength were recorded for the 30 mm diameter handle and traditional wrench design, respectively. The prototype handle with 30 mm diameter, together with 40 mm diameter handle, was also better than other designs as they received higher usability ratings and caused less discomfort. The mean wrist torque strength exerted on a vertically oriented workpiece (in the sagittal plane) was 23.8% higher than that exerted on a horizontally oriented one (in the transverse plane). The user's hand size had no effect on torque exertions. The wrist torque strength and usability were negatively correlated with hand and finger discomfort ratings. The results are also discussed in terms of their implications for hand tool and workstation configuration in torque tasks involving wrenches.

- **Keywords:** Hand tools; Wrist torque; Handle diameter; Spanner wrench

Victoria Filingeri, Ken Eason, Patrick Waterson, Roger Haslam. *Factors influencing experience in crowds: The participant perspective.* Pages 431-441.

Humans encounter crowd situations on a daily basis, resulting in both negative and positive experiences. Understanding how to optimise the participant experience of crowds is important. In the study presented in this paper, 5 focus groups were conducted (35 participants, age range: 21–71 years) and 55 crowd situations observed (e.g. transport hubs, sport events, retail situations). Influences on participant experience in crowds identified by the focus groups and observations included: physical design of crowd space and facilities (layout, queuing strategies), crowd movement (monitoring capacity, pedestrian flow), communication and information (signage, wayfinding), comfort and welfare (provision of facilities, environmental comfort), and public order. It was found that important aspects affecting participant experience are often not considered systematically in the planning of events or crowd situations. The findings point to human factors aspects of crowds being overlooked, with the experiences of participants often poor.

- **Keywords:** Crowds; Participant experience; Satisfaction

Cory L. Butts, Cody R. Smith, Matthew S. Ganio, Brendon P. McDermott. *Physiological and perceptual effects of a cooling garment during simulated industrial work in the heat.* Pages 442-448.

Objective: Evaluate physiological and perceptual responses using a phase change cooling (PCC) garment during simulated work in the heat. **Methods:** Twenty males wearing compression undergarments, coverall suit, gloves, and hard-hat, completed two randomly assigned trials (with PCC inserts or control, CON) of simulated industrial tasks in the heat (34.2 ± 0.05 °C, $54.7 \pm 0.3\%$ RH). Trials consisted of two 20 min work bouts, a maximum performance bout, and 10 min of recovery. **Results:** Physiological strain index (PSI) was lower during PCC after the second work bout and during recovery (all $P < 0.05$). PCC reduced heat storage (27.0 ± 7.6 W m⁻²) compared to CON (42.7 ± 9.9 W m⁻², $P < 0.001$). Perceptual strain index (PeSI) was reduced with PCC compared to CON ($P < 0.001$), however performance outcomes were not different between trials ($P = 0.10$). **Conclusions:** PCC during work in the heat attenuated thermal, physiological, and perceptual strain. This PCC garment could increase safety and reduce occupational heat illness risk.

- **Keywords:** Phase change clothing; Exertional hyperthermia; Heat illness prevention

Karl Grainger, Zoe Dodson, Thomas Korff. *Predicting bicycle setup for children based on anthropometrics and comfort.* Pages 449-459.

Bicycling is a popular activity for children. In order for children to enjoy cycling and to minimize injury, it is important that they are positioned appropriately on the bicycle. The purpose of this study was therefore to identify a suitable bicycle setup for children aged between 7 and 16 years which accommodates developmental differences in anthropometrics, flexibility and perceptions of comfort. Using an adjustable bicycle fitting rig, we found the most comfortable position of 142 children aged 7 to 16. In addition, a number of anthropometric measures were recorded. Seat height and the horizontal distance between seat and handlebars were strongly predictable ($R^2 > 0.999$, $p < 0.001$ and $R^2 = 0.649$, $p < 0.001$ respectively), whilst the predictability of the vertical distance between seat and handlebars was weaker ($R^2 = 0.231$, $p < 0.001$). These results have practical implications for children and parents, paediatric researchers and clinicians as well as bicycle manufacturers.

- **Keywords:** Bicycle setup; Children; Comfort

P. Simeonov, H. Hsiao, J. Powers, D. Ammons, T. Kau, D. Cantis, J. Zwiener, D. Weaver. *Evaluation of a "walk-through" ladder top design during ladder-roof transitioning tasks.* Pages 460-469.

This study evaluated the effect of an extension ladder "walk-through" top design on kinetic and kinematic behaviors and the outward destabilizing forces induced on the ladder during transitioning at elevation. Thirty-two male participants performed stepping tasks between a ladder top and a roof at simulated elevation in a surround-screen virtual-reality system. The experimental conditions included a "walk-through" and a standard ladder top section supported on flat and sloped roof surfaces. Three force platforms were placed under the ladder section and in the roof to measure propulsion forces during transitions. A motion measurement system was used to record trunk kinematics. The frictional demand at the virtual ladder base was also calculated. The results indicate that under optimal ladder setup (angle 75.5 °), the frictional demand at the ladder base remains relatively small for all experimental conditions. Also, the "walk through" ladder top eased the ladder-to-roof transitions but not the roof-to-ladder transitions.

- **Keywords:** Ladder; Fall; Stability

Heather E. Douglas, Magdalena Z. Raban, Scott R. Walter, Johanna I. Westbrook. *Improving our understanding of multi-tasking in healthcare:*

Drawing together the cognitive psychology and healthcare literature. Pages 45-55.

Multi-tasking is an important skill for clinical work which has received limited research attention. Its impacts on clinical work are poorly understood. In contrast, there is substantial multi-tasking research in cognitive psychology, driver distraction, and human-computer interaction. This review synthesises evidence of the extent and impacts of multi-tasking on efficiency and task performance from health and non-healthcare literature, to compare and contrast approaches, identify implications for clinical work, and to develop an evidence-informed framework for guiding the measurement of multi-tasking in future healthcare studies. The results showed healthcare studies using direct observation have focused on descriptive studies to quantify concurrent multi-tasking and its frequency in different contexts, with limited study of impact. In comparison, non-healthcare studies have applied predominantly experimental and simulation designs, focusing on interleaved and concurrent multi-tasking, and testing theories of the mechanisms by which multi-tasking impacts task efficiency and performance. We propose a framework to guide the measurement of multi-tasking in clinical settings that draws together lessons from these siloed research efforts.

- **Keywords:** Multi-tasking; Medical staff; Hospital; Medical errors/prevention and control

Yanfei Xie, Grace Szeto, Jie Dai. Prevalence and risk factors associated with musculoskeletal complaints among users of mobile handheld devices: A systematic review. Pages 132-142.

This systematic review aimed at evaluating the prevalence and risk factors for musculoskeletal complaints associated with mobile handheld device use. Pubmed, Medline, Web of Science, CINAHL and Embase were searched. The methodological quality of included studies was assessed. Strength of evidence for risk factors was determined based on study designs, methodological quality and consistency of results. Five high-quality, eight acceptable-quality and two low-quality peer-reviewed articles were included. This review demonstrates that the prevalence of musculoskeletal complaints among mobile device users ranges from 1.0% to 67.8% and neck complaints have the highest prevalence rates ranging from 17.3% to 67.8%. This study also finds some evidence for neck flexion, frequency of phone calls, texting and gaming in relation to musculoskeletal complaints among mobile device users. Inconclusive evidence is shown for other risk factors such as duration of use and human-device interaction techniques due to inconsistent results or a limited number of studies.

- **Keywords:** Mobile handheld devices; Musculoskeletal complaints; Systematic review