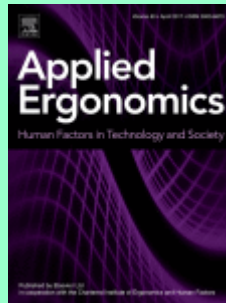


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Wilhelmus J.A. Grooten, Björn O. Äng, Maria Hagströmer, David Conradsson, Håkan Nero, Erika Franzén. *Does a dynamic chair increase office workers' movements?: results from a combined laboratory and field study.* Pages 1-11.

Purpose: Dynamic chairs have the potential to facilitate movements that could counteract health problems associated with sedentary office work. This study aimed to evaluate whether a dynamic chair can increase movements during desk-based office work. **Methods:** Fifteen healthy subjects performed desk-based office work using a dynamic office chair and compared to three other conditions in a movement laboratory. In a field study, the dynamic office chair was studied during three working days using accelerometry. **Results:** Equivocal results showed that the dynamic chair increased upper body and chair movements as compared to the conventional chair, but lesser movements were found compared to standing. No differences were found between the conditions in the field study. **Conclusions:** A dynamic chair may facilitate movements in static desk-based office tasks, but the results were not consistent for all outcome measures. Validation of measuring protocols for assessing movements during desk-based office work is warranted.

- **Keywords:** Dynamic sitting; Ergonomics; Sit-stand desk

A.J. Filtness, A. Naweed. *Causes, consequences and countermeasures to driver fatigue in the rail industry: The train driver perspective.* Pages 12-21.

Fatigue is an important workplace risk management issue. Within the rail industry, the passing of a stop signal (signal passed at danger; SPAD) is considered to be one of the most major safety breaches which can occur. Train drivers are very aware of the negative consequences associated with a SPAD. Therefore, SPADs provide a practical and applied safety relevant context within which to structure a discussion on fatigue. Focus groups discussing contributing factors to SPADs were undertaken at eight passenger rail organisations across Australia and New Zealand (n = 28 drivers). Data relating to fatigue was extracted and inductively analysed identifying three themes: causes, consequences, and countermeasures (to fatigue). Drivers experienced negative consequences of fatigue, despite existing countermeasures to mitigate it. Organisational culture was a barrier to effective fatigue management. A fatigue assessment tool consistently informed rostering, however, shift swapping was commonplace and often unregulated, reducing any potential positive impact. In discussing fatigue countermeasure strategies, drivers talked

interchangeably about mitigating task related fatigue (e.g. increasing cognitive load) and sleepiness (e.g. caffeine). Ensuring the concepts of fatigue and sleepiness are properly understood has the potential to maximise safety.

- **Keywords:** Train driving; Rail safety; Sleep; Fatigue

Chava Weiner, Leonid Kalichman, Joseph Ribak, Deborah Alperovitch-Najenson. *Repositioning a passive patient in bed: choosing an ergonomically advantageous assistive device.* Pages 22-29.

Repositioning of passive patients in bed creates health risks to the nursing personnel. Therefore, appropriate assistive devices should be used. Our aim was to find the optimal assistive device for reducing musculoskeletal load while moving a passive patient in bed. Torso kinematic inputs evaluated by the Lumbar Motion Monitor (LMM) and perceived load (Borg scale) were measured in female nurses performing 27 patient transfers [represented by a mannequin weighing 55 (12 nurses), 65 (24 nurses) and 75 kg (12 nurses) in bed] using a regular sheet, a sliding sheet and a carrier. The lowest rates of perceived exertion were found when the sliding sheet and/or carrier were used, for all tasks ($p \leq 0.009$). According to the predicted risk for Low Back Disorder (LBD) based on the LMM inputs, negligible differences between assistive devices were found. In a 75 kg mannequin, the participants were able to perform all tasks only by using a sliding sheet. Utilizing sliding sheets is an advantageous technique in comparison to traditional cotton sheets and even carriers.

- **Keywords:** Repositioning; Work related musculoskeletal disorders; Sliding sheets; Nursing; Low back disorder risk model

M. Houtenbos, J.C.F. de Winter, A.R. Hale, P.A. Wieringa, M.P. Hagenzieker. *Concurrent audio-visual feedback for supporting drivers at intersections: a study using two linked driving simulators.* Pages 30-42.

A large portion of road traffic crashes occur at intersections for the reason that drivers lack necessary visual information. This research examined the effects of an audio-visual display that provides real-time sonification and visualization of the speed and direction of another car approaching the crossroads on an intersecting road. The location of red blinking lights (left vs. right on the speedometer) and the lateral input direction of beeps (left vs. right ear in headphones) corresponded to the direction from where the other car approached, and the blink and beep rates were a function of the approaching car's speed. Two driving simulators were linked so that the participant and the experimenter drove in the same virtual world. Participants ($N = 25$) completed four sessions (two with the audio-visual display on, two with the audio-visual display off), each session consisting of 22 intersections at which the experimenter approached from the left or right and either maintained speed or slowed down. Compared to driving with the display off, the audio-visual display resulted in enhanced traffic efficiency (i.e., greater mean speed, less coasting) while not compromising safety (i.e., the time gap between the two vehicles was equivalent). A post-experiment questionnaire showed that the beeps were regarded as more useful than the lights. It is argued that the audio-visual display is a promising means of supporting drivers until fully automated driving is technically feasible.

- **Keywords:** Advanced driver assistance systems; Driving simulator; Road safety; Sonification

Nathan J. McNeese, Nancy J. Cooke, Russell Branaghan, Ashley Knobloch, Amanda Taylor. *Identification of the Emplacement of Improvised Explosive Devices by Experienced Mission Payload Operators.* Pages 43-51.

Improvised Explosive Devices (IEDs) have become one of the deadliest threats to military personnel, resulting in over 50% of American combat casualties in Iraq and Afghanistan. Identification of IED emplacement is conducted by mission payload operators (MPOs). Yet, experienced MPOs are limited in number, making MPO training a critical intervention. In this article, we implement a Cognitive Engineering Based on Expert Skill methodology to better understand how experienced MPOs identify the emplacement of IEDs for the purposes of improving training. First, expert knowledge was elicited through interviews and questionnaires to identify the types of perceptual cues used and how these cues are cognitively processed. Results indicate that there are many different static and dynamic cues that interact with each other over time and space. Using data from the interviews and questionnaires, an empirically grounded framework is presented that explains the cognitive process of IED emplacement detection. Using the overall findings and the framework, IED emplacement training scenarios were developed and built into a simulation.

- **Keywords:** Improvised explosive devices; Expertise; Training

Ismail Maakip, Tessa Keegel, Jodi Oakman. *Predictors of musculoskeletal discomfort: A cross-cultural comparison between Malaysian and Australian office workers.* Pages 52-57.

Prevalence and predictors associated with musculoskeletal disorders (MSDs) vary considerably between countries. It is plausible that socio-cultural contexts may contribute to these differences. We conducted a cross-sectional survey with 1184 Malaysian and Australian office workers with the aim to examine predictors associated with MSD discomfort. The 6-month period prevalence of self-reported MSD discomfort for Malaysian office workers was 92.8% and 71.2% among Australian workers. In Malaysia, a model regressing level of musculoskeletal discomfort against possible risk factors was significant overall ($F [6, 370] = 17.35$; $p < 0.001$) and explained 22% ($r = 0.46$) of its variance. MSD discomfort was significantly associated with predictors that included gender ($\beta = 14$), physical ($\beta = 0.38$) and psychosocial hazards ($\beta = -0.10$), and work-life balance ($\beta = -0.13$). In Australia, the regression model is also significant ($F [6, 539] = 16.47$; $p < 0.001$) with the model explaining 15.5% ($r = 0.39$) of the variance in MSD discomfort. Predictors such as gender ($\beta = 0.14$), physical ($\beta = 24$) and psychosocial hazards ($\beta = -0.17$), were associated with MSD discomfort in Australian office workers. Predictors associated with MSD discomfort were similar, but their relative importance differed. Work-life balance was significantly associated with increased MSD discomfort for the Malaysian population only. Design and implementation of MSD risk management needs to take into account the work practices and culture of the target population.

- **Keywords:** Musculoskeletal discomfort; Cross-cultural; Risk factors; Office workers; Malaysia; Australia

Atsuo Murata, Takashi Kuroda, Waldemar Karwowski. *Effects of auditory and tactile warning on response to visual hazards under a noisy environment.* Pages 58-67.

A warning signal presented via a visual or an auditory cue might interfere with auditory or visual information inside and outside a vehicle. On the other hand, such interference would be certainly reduced if a tactile cue is used. Therefore, it is expected that tactile cues would be promising as warning signals, especially in a noisy environment. In order to determine the most suitable modality of cue (warning) to a visual hazard in noisy environments, auditory and tactile cues were examined in this study. The condition of stimulus onset asynchrony (SOA) was set to 0ms, 500ms, and 1000ms. Two types of noises were used: white noise and noise outside a vehicle recorded in a real-world driving environment. The noise level LAeq (equivalent continuous A-weighted sound

pressure level) inside the experimental chamber of each type of noise was adjusted to approximately 60 dB (A), 70 dB (A), and 80 dB (A). As a result, it was verified that tactile warning was more effective than auditory warning. When the noise outside a vehicle from a real-driving environment was used as the noise inside the experimental chamber, the reaction time to the auditory warning was not affected by the noise level.

- **Keywords:** Auditory cue; Tactile cue; Automotive warning system; Noise outside a vehicle; White noise; SOA

Jonathan Dobres, Nadine Chahine, Bryan Reimer. *Effects of ambient illumination, contrast polarity, and letter size on text legibility under glance-like reading.* Pages 68-73.

Recent research on the legibility of digital displays has demonstrated a “positive polarity advantage”, in which black-on-white text configurations are more legible than their negative polarity, white-on-black counterparts. Existing research in this area suggests that the positive polarity advantage stems from the brighter illumination emitted by positive polarity displays, as opposed to the darker backgrounds of negative polarity displays. In the present study, legibility thresholds were measured under glance-like reading conditions using a lexical decision paradigm, testing two type sizes, display polarities, and ambient illuminations (near-dark and daylight-like). Results indicate that legibility thresholds, quantified as the amount of time needed to read a word accurately, were highest for the negative polarity configurations under dark ambient illumination, indicated worse performance. Conversely, the positive polarity conditions under dark ambient illumination and all conditions under bright illumination demonstrated significantly reduced thresholds, indicating greater legibility. These results are consistent with the hypothesis that the “positive polarity advantage” arises because brighter illumination produces pupillary contraction that reduces optical aberrations as light enters the eye. These results have implications for the design of automotive interfaces and other scenarios in which an interface must be optimized for glance-like reading under variations in ambient lighting conditions.

- **Keywords:** Legibility; Illumination; Visual perception

Bettina Wulff Risør, Sven Dalgas Casper, Lars Louis Andersen, Jan Sørensen. *A multi-component patient-handling intervention improves attitudes and behaviors for safe patient handling and reduces aggression experienced by nursing staff: A controlled before-after study.* Pages 74-82.

This study evaluated an intervention for patient-handling equipment aimed to improve nursing staffs' use of patient handling equipment and improve their general health, reduce musculoskeletal problems, aggressive episodes, days of absence and work-related accidents. As a controlled before-after study, questionnaire data were collected at baseline and 12-month follow-up among nursing staff at intervention and control wards at two hospitals. At 12-month follow-up, the intervention group had more positive attitudes towards patient-handling equipment and increased use of specific patient-handling equipment. In addition, a lower proportion of nursing staff in the intervention group had experienced physically aggressive episodes. No significant change was observed in general health status, musculoskeletal problems, days of absence or work-related accidents. The intervention resulted in more positive attitudes and behaviours for safe patient-handling and less physically aggressive episodes. However, this did not translate into improved health of the staff during the 12-month study period.

- **Keywords:** Occupational health; Patient-handling; Healthcare professional; Low-back pain; Aggression; Musculoskeletal disorder; Working environment; Patient moves; Assistant device; Physical disorders

A. Plamondon, C. Larivière, D. Denis, H. Mecheri, I. Nastasia. *Difference between male and female workers lifting the same relative load when palletizing boxes.* Pages 93-102.

A few biomechanical studies have contrasted the work techniques of female and male workers during manual material handling (MMH). A recent study showed that female workers differed from males mostly in the strategy they used to lift 15-kg boxes from the ground, especially regarding task duration, knee and back postures and interjoint coordination. However, the lifting technique difference observed in females compared to males was perhaps due to a strength differences. The objective of this study was to test whether female workers would repeat the same lifting technique with a load adjusted to their overall strength (females: 10 kg; males: 15 kg), which can be considered a "relative load" since the overall back strength of females is 2/3 that of males. The task for the participants consisted in transferring boxes from one pallet to another. A dynamic 3D linked segment model was used to estimate the net moments at L5/S1, and different kinematic variables were considered. The results showed that the biomechanics of the lifting techniques used by males and females were similar in terms of task duration and cumulative loading, but different in terms of interjoint coordination pattern. The sequential interjoint coordination pattern previously seen in females with an absolute load (15 kg) was still present with the relative load, suggesting the influence of factors more intrinsically linked to sex. Considering that the female coordination pattern likely stretched posterior passive tissues when lifting boxes from the ground, potentially leading to higher risk of injury, the reason for this sex effect must be identified so that preventive interventions can be proposed.

- **Keywords:** Manual material handling; Lifting; Sex; Interjoint coordination

Rachel L. Morrison, Keith A. Macky. *The demands and resources arising from shared office spaces.* Pages 103-115.

The prevalence of flexible and shared office spaces is increasing significantly, yet the socioemotional outcomes associated with these environments are under researched. Utilising the job demands-resources (JD-R) model we investigate both the demands and the resources that can accrue to workers as a result of shared work environments and hot-desking. Data were collected from work experienced respondents (n = 1000) assessing the extent to which they shared their office space with others, along with demands comprising distractions, uncooperative behaviours, distrust, and negative relationships, and resources from co-worker friendships and supervisor support. We found that, as work environments became more shared (with hot-desking being at the extreme end of the continuum), not only were there increases in demands, but co-worker friendships were not improved and perceptions of supervisory support decreased. Findings are discussed in relation to employee well-being and recommendations are made regarding how best to ameliorate negative consequences of shared work environments.

- **Keywords:** Hot-desking; Job demands-resources; Co-worker relationships

Daniël D. Heikoop, Joost C.F. de Winter, Bart van Arem, Neville A. Stanton. *Effects of platooning on signal-detection performance, workload, and stress: a driving simulator study.* Pages 116-127.

Platooning, whereby automated vehicles travel closely together in a group, is attractive in terms of safety and efficiency. However, concerns exist about the psychological state of the platooning driver, who is exempted from direct control, yet remains responsible for monitoring the outside environment to detect potential threats. By means of a driving simulator experiment, we investigated the effects on recorded and self-reported measures of workload and stress for three task-instruction conditions: (1) No Task, in which participants had to monitor the road, (2) Voluntary Task, in which participants could do whatever they wanted, and (3) Detection Task, in which participants had to detect red cars. Twenty-two participants performed three 40-min runs in a constant-speed platoon, one condition per run in counterbalanced order. Contrary to some classic literature suggesting that humans are poor monitors, in the Detection Task condition participants attained a high mean detection rate (94.7%) and a low mean false alarm rate (0.8%). Results of the Dundee Stress State Questionnaire indicated that automated platooning was less distressing in the Voluntary Task than in the Detection Task and No Task conditions. In terms of heart rate variability, the Voluntary Task condition yielded a lower power in the low-frequency range relative to the high-frequency range (LF/HF ratio) than the Detection Task condition. Moreover, a strong time-on-task effect was found, whereby the mean heart rate dropped from the first to the third run. In conclusion, participants are able to remain attentive for a prolonged platooning drive, and the type of monitoring task has effects on the driver's psychological state.

- **Keywords:** Psychophysiology; Automated driving; Vigilance; Monitoring; Supervisory control; Out-of-the-loop

Jay Cho, Andris Freivalds, Liza S. Rovniak. *Utilizing anthropometric data to improve the usability of desk bikes, and influence of desk bikes on reading and typing performance.* Pages 128-135.

This study investigated the feasibility of using a desk bike in an office setting. Workstation measurements were introduced to accommodate 95% of the general U.S. population in using desk bikes. Reading and typing performances were compared at three different cycling conditions (no cycling, 10 and 25 W). Thirty healthy individuals (15 female and 15 male; Age mean: 23.1, σ : 4.19) were recruited based on 5/50/95th percentile stature. Participants were required to select preferred workstation settings and perform reading and typing tasks while pedaling. According to anthropometric measurements and variability from user preference, recommended adjustable ranges of workstation settings for the general U.S. population were derived. Repeated measures ANOVA showed that pedaling had no significant effect on reading comprehension ($p > 0.05$), but had significant effect on typing performance ($p < 0.001$). A preferred level of cycling intensity was determined (mean 17.3 W, σ : 3.69).

- **Keywords:** Desk bike; Active workstation; Sedentary behavior; Reading and typing performance; Engineering anthropometry

Kristie L. Young, Amanda N. Stephens, David B. Logan, Michael G. Lenné. *Investigating the impact of static roadside advertising on drivers' situation awareness.* Pages 136-145.

Roadside advertising has the potential to create a crash risk for drivers as it may distract attention from driving at critical times. In an on-road instrumented vehicle study, we examined if and how static advertising billboards affect drivers' situation awareness across different driving environments. Nineteen fully licensed drivers drove an instrumented vehicle around a 38 km urban test route comprising freeway, busy urban retail and arterial road sections. The route contained a number of static billboards. Drivers provided continuous verbal protocols throughout the drive. Results indicated that the structure and content of drivers' situation awareness was not appreciably affected by the billboards in any of the road environments examined. Drivers focused their attention

on the billboards when driving demand was low, such as when driving on the freeway with light to moderate traffic, in lower speed zones, or when stationary. However, when drivers were required to perform a manoeuvre or driving demands increased, drivers directed less attention to the billboards and focussed their awareness on the immediate driving task. This suggests that drivers can, at least under some conditions, effectively self-regulate their attention to billboards when required to focus on the immediate traffic or driving situation.

- **Keywords:** Driver distraction; Situation awareness; Roadside advertising; Billboards; On-road study

Jessica A. Dobson, Diane L. Riddiford-Harland, Alison F. Bell, Julie R. Steele. *Effect of work boot type on work footwear habits, lower limb pain and perceptions of work boot fit and comfort in underground coal miners.* Pages 146-153.

Lower limb injuries are highly prevalent in underground coal mining. Wearing gumboots with inadequate ankle support was thought to contribute to these injuries. Despite the uptake of leather lace-up boots, which provide more ankle support, no recent research could be found investigating the effect of this alternative work boot in underground coal mining. Consequently, this study aimed to determine whether boot type (gumboot, leather lace-up boot) influenced work footwear habits, foot problems, lower limb pain, lower back pain, or perceptions of work boot fit and comfort in underground coal miners. Chi-squared tests were applied to 358 surveys completed by underground coal miners to determine whether responses differed significantly ($p < 0.05$) according to boot-type. There were no significant between-boot differences in regards to the presence of foot problems, lower limb pain or lower back pain. However, the types of foot problems and locations of foot pain differed according to boot type. Gumboot wearers were also more likely to state that their work boot comfort was either 'uncomfortable' or 'indifferent', their work boot fit was 'poor' and their current boot did not provide enough support. The introduction of more structured leather lace-up boots appears to have positively influenced the support and fit provided by mining work boots, although foot problems, lower limb pain and lower back pain continue to be reported. Further investigation is recommended to identify which specific boot design features caused these observed differences in work boot fit, comfort and locations of foot pain and how these design features can be manipulated to create an underground coal mining work boot that is comfortable and reduces the high incidence of foot problems and lower limb pain suffered by underground coal miners.

- **Keywords:** Boots; Mining; Fit; Comfort; Pain

Siti Hana Nasir, Olga Troynikov. *Influence of hand movement on skin deformation: a therapeutic glove design perspective.* Pages 154-162.

The fit of a therapeutic glove directly influences the hand function of the wearer as well as wear comfort. Static and dynamic hand dimensions and characteristics must be considered when designing a glove, as significant changes in hand shape, size, and skin surface morphology result from hand movements. The aim of this study is to investigate the skin relaxed-strain ratio at the dorsal side of the hand and its relationship to skin deformation behaviour during hand movements. The point cloud raw data of the right hands of 13 female participants (40–65 years, size M) were recorded using a 3D INFOOT scanner in three different hand postures. Twenty-two measurements of skin relaxed-strain ratios in each posture were calculated, and differences between them were identified using the Kruskal-Wallis H test. The results demonstrate that different hand postures cause substantial changes in hand geometry, especially in the metacarpal region. The findings of this study are valuable for the construction of functional tight-fitting therapeutic gloves with optimal fit, performance, and comfort.

- **Keywords:** Hand movement; Skin deformation; Therapeutic gloves

Erika M. Pliner, Na Jin Seo, Kurt E. Beschorner. *Factors affecting fall severity from a ladder: Impact of climbing direction, gloves, gender and adaptation.* Pages 163-170.

Ladder falls cause many fatal injuries. The factors that affect whether a ladder perturbation leads to a fall are not well understood. This study quantified the effects of several factors on a person's ability to recover from a ladder perturbation. Thirty-five participants each experienced six unexpected ladder missteps, for three glove conditions (bare hands, high friction, low friction) and two climbing directions (ascent, descent). Fall severity was increased during ladder descent ($p < 0.001$). Gloves did not affect fall severity. Females compared to males had greater fall severity during ascent ($p < 0.001$) and descent ($p = 0.018$). During ascent, females had greater fall severity during the second perturbation but similar fall severity to males during the other perturbations. Additional protection may be needed when descending a ladder. Also, females may benefit from targeted interventions like training. This study does not suggest that gloves are effective for preventing ladder falls.

- **Keywords:** Ladder falls; Climbing direction; Gender

Joonho Chang, Kihyo Jung, Wonsup Lee, Heecheon You. *Development of a usability evaluation method using natural product-use motion.* Pages 171-182.

The present study developed and tested a new usability evaluation method which considers natural product-use motions. The proposed method measures both natural product-use motions (NMs) and actual product-use motions (AMs) for a product using an optical motion capture system and examines the usability of the product based on motion similarity (MS; %) between NMs and AMs. The proposed method was applied to a usability test of four vacuum cleaners (A, B, C, and D) with 15 participants and their MSs were compared with EMG measurements and subjective discomfort ratings. Cleaners A (44.6%) and C (44.2%) showed higher MSs than cleaners B (42.9%) and D (41.7%); the MSs mostly corresponded to the EMG measurements, which could indicate that AMs deviated from NMs may increase muscular efforts. However, the MSs were slightly different from the corresponding discomfort ratings. The proposed method demonstrated its usefulness in usability testing, but further research is needed with various products to generalize its effectiveness.

- **Keywords:** Natural product-use motion; Motion similarity; Usability evaluation

Sungryul Park, Donghee Choi, Jihyeon Yi, Songil Lee, Ja Eun Lee, Byeonghwa Choi, Seungbae Lee, Gyouhyung Kyung. *Effects of display curvature, display zone, and task duration on legibility and visual fatigue during visual search task.* Pages 183-193.

This study examined the effects of display curvature (400, 600, 1200 mm, and flat), display zone (5 zones), and task duration (15 and 30 min) on legibility and visual fatigue. Each participant completed two 15-min visual search task sets at each curvature setting. The 600-mm and 1200-mm settings yielded better results than the flat setting in terms of legibility and perceived visual fatigue. Relative to the corresponding centre zone, the outermost zones of the 1200-mm and flat settings showed a decrease of 8%–37% in legibility, whereas those of the flat setting showed an increase of 26%–45% in perceived visual fatigue. Across curvatures, legibility decreased by 2%–8%, whereas perceived visual fatigue increased by 22% during the second task set. The two task sets induced an increase of 102% in the eye complaint score and a decrease of 0.3 Hz in the critical

fusion frequency, both of which indicated an increase in visual fatigue. In summary, a curvature of around 600 mm, central display zones, and frequent breaks are recommended to improve legibility and reduce visual fatigue.

- **Keywords:** Display curvature; Legibility; Visual fatigue

Andrew D. Peacock, Joel Chaney, Kristin Goldbach, Guy Walker, Paul Tuohy, Salvador Santonja, David Todoli, Edward H. Owens. *Co-designing the next generation of home energy management systems with lead-users.* Pages 194-206.

Home energy management systems are widely promoted as essential components of future low carbon economies. It is argued in this paper that assumptions surrounding their deployment, and the methods used to design them, emerge from discredited models of people and energy. This offers an explanation for why their field trial performance is so inconsistent. A first of a kind field trial is reported. Three eco communities took part in a comprehensive participatory design exercise as lead users. The challenge was to help users synchronise their energy use behaviours with the availability of locally generated renewable energy sources. To meet this aim, a set of highly novel Home Energy Management interfaces were co-designed and tested. Not only were the designs radically different to the norm, but they also yielded sustained user engagement over a six-month follow-up period. It is argued that user-centred design holds the key to unlocking the energy saving potential of new domestic technologies, and this study represents a bold step in that direction.

- **Keywords:** Participatory design; Home energy management systems; Renewable generation; Energy use behaviour; Lead users

Tai-Hua Lee, Fong-Gong Wu, Huei-Tsz Chen. *Innovation & evaluation of tangible direct manipulation digital drawing pens for children.* Pages 207-219.

Focusing on the theme of direct manipulation, in this study, we proposed a new and innovative tangible user interface (TUI) design concept for a manipulative digital drawing pen. Based on interviews with focus groups brainstorming and experts and the results of a field survey, we selected the most suitable tangible user interface for children between 4 and 7 years of age. Using the new tangible user interface, children could choose between the brush tools after touching and feeling the various patterns. The thickness of the brush could be adjusted by changing the tilt angle. In a subsequent experimental process we compared the differences in performance and subjective user satisfaction.

A total of sixteen children, aged 4–7 years participated in the experiment. Two operating system experiments (the new designed tangible digital drawing pen and traditional visual interface-icon-clicking digital drawing pens) were performed at random and in turns. We assessed their manipulation performance, accuracy, brush stroke richness and subjective evaluations. During the experimental process we found that operating functions using the direct manipulation method, and adding shapes and semantic models to explain the purpose of each function, enabled the children to perform stroke switches relatively smoothly.

By using direct manipulation digital pens, the children could improve their stroke-switching performance for digital drawing. Additionally, by using various patterns to represent different brushes or tools, the children were able to make selections using their sense of touch, thereby reducing the time required to move along the drawing pens and select icons (The significant differences ($p = 0.000$, $p < 0.01$) existed in the manipulation times for drawing thick lines using the crayon function of the two (new and old) drawing pens (new 5.8750 < old 10.7500)). The addition of direct manipulation

movements to drawing operations enhanced the drawing results, thereby increasing the children's enjoyment of drawing with tangible digital drawing pens.

- **Keywords:** Direct manipulation; Digital drawing pen; Children; Drawing

Xiaozhi Yu, Jindong Ren, Qian Zhang, Qun Liu, Honghao Liu. *Modeling study of seated reach envelopes based on spherical harmonics with consideration of the difficulty ratings. Pages 220-230.*

Reach envelopes are very useful for the design and layout of controls. In building reach envelopes, one of the key problems is to represent the reach limits accurately and conveniently. Spherical harmonics are proved to be accurate and convenient method for fitting of the reach capability envelopes. However, extensive study are required on what components of spherical harmonics are needed in fitting the envelope surfaces. For applications in the vehicle industry, an inevitable issue is to construct reach limit surfaces with consideration of the seating positions of the drivers, and it is desirable to use population envelopes rather than individual envelopes. However, it is relatively inconvenient to acquire reach envelopes via a test considering the seating positions of the drivers. In addition, the acquired envelopes are usually unsuitable for use with other vehicle models because they are dependent on the current cab packaging parameters. Therefore, it is of great significance to construct reach envelopes for real vehicle conditions based on individual capability data considering seating positions. Moreover, traditional reach envelopes provide little information regarding the assessment of reach difficulty. The application of reach envelopes will improve design quality by providing difficulty-rating information about reach operations. In this paper, using the laboratory data of seated reach with consideration of the subjective difficulty ratings, the method of modeling reach envelopes is studied based on spherical harmonics. The surface fitting using spherical harmonics is conducted for circumstances both with and without seat adjustments. For use with adjustable seat, the seating position model is introduced to relocate the test data. The surface fitting is conducted for both population and individual reach envelopes, as well as for boundary envelopes. Comparison of the envelopes of adjustable seat and the SAE J287 control reach envelope shows that the latter is nearly at the middle difficulty level. It is also found that the abilities of reach envelope models in expressing the shape of the reach limits based on spherical harmonics depends both on the terms in the model expression and on the data used to fit the envelope surfaces.

- **Keywords:** Reach; Envelope; Spherical harmonics; Difficulty rating; Surface fitting

Nilanthy Balendra, Joseph E. Langenderfer. *Effect of hammer mass on upper extremity joint moments. Pages 231-239.*

This study used an OpenSim inverse-dynamics musculoskeletal model scaled to subject-specific anthropometrics to calculate three-dimensional intersegmental moments at the shoulder, elbow and wrist while 10 subjects used 1 and 2 lb hammers to drive nails. Motion data were collected via an optoelectronic system and the interaction of the hammer with nails was recorded with a force plate. The larger hammer caused substantial increases (50–150%) in moments, although increases differed by joint, anatomical component, and significance of the effect. Moment increases were greater in cocking and strike/follow-through phases as opposed to swinging and may indicate greater potential for injury. Compared to shoulder, absolute increases in peak moments were smaller for elbow and wrist, but there was a trend toward larger relative increases for distal joints. Shoulder rotation, elbow varus-valgus and pronation-supination, and wrist radial-ulnar deviation and rotation demonstrated large relative moment increases. Trial and phase durations were greater for the larger hammer. Changes in moments and timing indicate greater loads on musculoskeletal tissues for an extended period with the larger hammer. Additionally, greater variability in timing with the larger hammer,

particularly for cocking phase, suggests differences in control of the motion. Increased relative moments for distal joints may be particularly important for understanding disorders of the elbow and wrist associated with hammer use.

- **Keywords:** Inverse-dynamics; Kinetics

Abigail R. Wooldridge, Pascale Carayon, Ann Schoofs Hundt, Peter L.T. Hoonakker. *SEIPS-based process modeling in primary care. Pages 240-254.*

Process mapping, often used as part of the human factors and systems engineering approach to improve care delivery and outcomes, should be expanded to represent the complex, interconnected sociotechnical aspects of health care. Here, we propose a new sociotechnical process modeling method to describe and evaluate processes, using the SEIPS model as the conceptual framework. The method produces a process map and supplementary table, which identify work system barriers and facilitators. In this paper, we present a case study applying this method to three primary care processes. We used purposeful sampling to select staff (care managers, providers, nurses, administrators and patient access representatives) from two clinics to observe and interview. We show the proposed method can be used to understand and analyze healthcare processes systematically and identify specific areas of improvement. Future work is needed to assess usability and usefulness of the SEIPS-based process modeling method and further refine it.

- **Keywords:** Sociotechnical systems; Process mapping; Primary care

Kane J. Middleton, Greg L. Carstairs, Joanne N. Caldwell, Daniel C. Billing, Ben Beck. *The sensitivity of a military-based occupational fitness test of muscular strength. Pages 255-259.*

The risk of low back pain and injury during manual materials handling is increased if personnel are not physically capable of safely performing such tasks. To establish predictive relationships and develop a test cut-score, 69 participants performed a critical military lifting task to a 1.5-m platform (pack lift) and two task-related predictive tests (box lift to 1.5 m and 1.3 m). The pack lift was strongly correlated with both the 1.5-m ($R^2 = 0.85$) and 1.3-m box lifts ($R^2 = 0.82$). Both tests had similar sensitivity (range 0.85–0.94) with the 1.3-m test having higher specificity when compared with the 1.5-m lift. Increasing the test cut-score with the application of a safety factor increased the number of false positives and true negatives for both tests. Organisations must carefully assess their risk acceptance when applying safety factors to test cut-scores as the classification (pass/fail) of personnel may be affected.

- **Keywords:** Physical employment standards; Task-related predictive test; Specificity; Ergonomics; Lifting

Peng Wang, Weining Fang, Beiyan Guo. *A colored petri nets based workload evaluation model and its validation through Multi-Attribute Task Battery-II. Pages 260-274.*

This paper proposed a colored petri nets based workload evaluation model. A formal interpretation of workload was firstly introduced based on the process that reflection of petri nets components to task. A petri net based description of Multiple Resources theory was given by comprehending it from a new angle. A new application of VACP rating scales named V/A-C-P unit, and the definition of colored transitions were proposed to build a model of task process. The calculation of workload mainly has the following four steps: determine token's initial position and values; calculate the weight of directed arcs

on the basis of the rules proposed; calculate workload from different transitions, and correct the influence of repetitive behaviors. Verify experiments were carried out based on Multi-Attribute Task Battery-II software. Our results show that there is a strong correlation between the model values and NASA -Task Load Index scores ($r=0.9513$). In addition, this method can also distinguish behavior characteristics between different people.

- **Keywords:** Colored petri nets; Workload; Multi-Attribute Task Battery-II

Catherine Trask, Svend Erik Mathiassen, Mehdi Rostami, Marina Heiden. *Observer variability in posture assessment from video recordings: The effect of partly visible periods.* Pages 275-281.

Observers rank partly visible postures on video frames differently than fully visible postures, but it's not clear if this is due to differences in observer perception. This study investigated the effect of posture visibility on between-observer variability in assessments of trunk and arm posture. Trained observers assessed trunk and arm postures from video recordings of 84 pulp mill shifts using a work sampling approach; postures were also categorized as 'fully' or 'partly' visible. Between-worker, between-day, and between-observer variance components and corresponding confidence intervals were calculated. Although no consistent gradient was seen for the trunk, right upper arm posture showed smaller between-observer variance when all observers rated a posture as fully visible. This suggests that, partly-visible data, especially when observers disagree as to the level of visibility, introduces more between-observer variability when compared to fully visible data. Some previously-identified differences in daily posture summaries may be related to this phenomenon.

- **Keywords:** Observation; Inter-rater agreement; Posture; Exposure assessment; Pulp mill

Joonho Chang, Bori Choi, Amir Tjolleng, Kihyo Jung. *Effects of button position on a soft keyboard: Muscle activity, touch time, and discomfort in two-thumb text entry.* Pages 282-292.

Intensive use of the thumbs for text entry on smartphones may contribute to discomfort, pain, or musculoskeletal disorders. This study investigated the effect of twenty-five button positions (5 rows \times 5 columns) on a soft keyboard for two-thumb entry. Two experiments measured muscle activity, touch time, and discomfort as a function of the button positions. In Phase I, the muscle activities of two intrinsic (abductor pollicis brevis and first dorsal interossei) and two extrinsic (abductor pollicis longus and extensor digitorum communis) muscles associated with thumb motions were observed for ten college students (age: 24.2). In Phase II, touch time and discomfort were measured for 40 college students (age: 23.6). The results demonstrated that the %MVCs of the intrinsic muscles significantly increased when the thumbs flexed and abducted. Also, the button positions near the rest positions of the thumbs resulted in significantly shorter touch times (0.66 s) and lower discomfort ratings (0.70 pt) than their peripheral buttons (0.76 s; 2.29 pt).

- **Keywords:** Soft keyboard; Two-thumb input; Smartphone

Zhenji Lu, Xander Coster, Joost de Winter. *How much time do drivers need to obtain situation awareness? A laboratory-based study of automated driving.* Pages 293-304.

Drivers of automated cars may occasionally need to take back manual control after a period of inattentiveness. At present, it is unknown how long it takes to build up situation

awareness of a traffic situation. In this study, 34 participants were presented with animated video clips of traffic situations on a three-lane road, from an egocentric viewpoint on a monitor equipped with eye tracker. Each participant viewed 24 videos of different durations (1, 3, 7, 9, 12, or 20 s). After each video, participants reproduced the end of the video by placing cars in a top-down view, and indicated the relative speeds of the placed cars with respect to the ego-vehicle. Results showed that the longer the video length, the lower the absolute error of the number of placed cars, the lower the total distance error between the placed cars and actual cars, and the lower the geometric difference between the placed cars and the actual cars. These effects appeared to be saturated at video lengths of 7–12 s. The total speed error between placed and actual cars also reduced with video length, but showed no saturation up to 20 s. Glance frequencies to the mirrors decreased with observation time, which is consistent with the notion that participants first estimated the spatial pattern of cars after which they directed their attention to individual cars. In conclusion, observers are able to reproduce the layout of a situation quickly, but the assessment of relative speeds takes 20 s or more.

- **Keywords:** Scene perception; Spatial memory; Eye tracking; Hazard perception

Jie Zhou, Neal Wiggermann. *Ergonomic evaluation of brake pedal and push handle locations on hospital beds. Pages 305-312.*

Transporting patients in hospital beds is a physically demanding activity performed by healthcare workers and bed design may moderate the risk of injury. Nine healthcare workers participated in a study to investigate how brake pedal location affected maximal voluntary exertion (MVE) force and the level of acceptable force for engagement. Preferred and acceptable push heights when maneuvering a bed were also evaluated. The method of limits was used to determine acceptable forces and push heights. Results demonstrated that pedal depth, clearance above, and clearance behind the pedal significantly affected MVE force and acceptable force. Preferred push height was approximately at elbow level and a single height would not accommodate the user population. These findings provide important considerations for hospital bed design. The method of limits was a valid and reliable approach for evaluating user acceptance of design inputs characterized by continuous variables and may be useful in other design evaluations.

- **Keywords:** Brake pedal design; Push height; Hospital bed; Force exertion; Method of limits

Jesús Vera, Raimundo Jiménez, José Antonio García, David Cárdenas. *Intraocular pressure is sensitive to cumulative and instantaneous mental workload. Pages 313-319.*

We used a repeated-measures design to assess the impact of mental-task complexity on intraocular pressure (IOP). Fourteen participants performed three continuous 11-min blocks of a mental-workload task (3-back) and an oddball version of this task. Also, heart-rate variability (HRV), cognitive-performance scores, and subjective measure of mental load (NASA-TLX) were determined. IOP was taken before each block and afterwards as well as after recovery from mental tasks. We found that IOP increased during heavy mental workloads ($p < 0.01$). Consistent with this finding, the autonomic control (HRV) and the cognitive performance were significantly lower ($p < 0.045$, and $p < 0.01$, respectively), and the NASA-TLX scores were higher during the 3-back task ($p < 0.01$). We conclude that IOP is sensitive to mental workload, and it could provide a novel neuroergonomic tool to assess mental workload. Our study highlights a potential association between IOP and the nervous system's state of activation.

- **Keywords:** Task complexity; Ocular biomarker; Neuroergonomics; NASA-TLX; Heart-rate variability

M.S. Hallbeck, B.R. Lowndes, J. Bingener, A.M. Abdelrahman, D. Yu, A. Bartley, A.E. Park. *The impact of intraoperative microbreaks with exercises on surgeons: A multi-center cohort study.* Pages 334-341.

Recent literature has demonstrated ergonomic risk to surgeons in the operating room. One method used in other industries to mitigate these ergonomic risks is the incorporation of microbreaks. Thus, intraoperative microbreaks with exercises in a non-crossover design were studied. Fifty-six attending surgeons from 4 Medical Centers volunteered first in a day of their regular surgeries and then second day where there were microbreaks with exercises that could be performed in the sterile field, answering questions after each case, without significantly increasing the duration of their surgeries. Surgeons self-reported improvement or no change in their mental focus (88%) and physical performance (100%) for the surgical day incorporating microbreaks with exercises. Discomfort in the shoulders was significantly reduced while distractions and flow impact was minimal. Eighty-seven percent of the surgeons wanted to incorporate the microbreaks with exercises into their OR routine. Intraoperative microbreaks with exercises may be a way to mitigate work-related musculoskeletal fatigue, pain and injury.

- **Keywords:** Microbreaks; Surgery; Physical and mental performance

Ethan C. Douglas, Kaitlin M. Gallagher. *The influence of a semi-reclined seated posture on head and neck kinematics and muscle activity while reading a tablet computer.* Pages 342-347.

Increased tablet computer usage calls for a proper understanding of potential injury risks from these devices. The purpose of this study was to assess the influence of tablet computer reading postures on head and neck flexion and muscle activity. Nineteen participants completed read a tablet computer in four different postures (standard computer monitor, tablet on a desk, tablet in the lap, semi-reclined with tablet in the lap). Reading the tablet in a semi-reclined trunk posture with the tablet in one's lap increased ($p < 0.001$) neck flexion angle (71.6%ROM) relative to reading from the standard computer monitor (6.39%ROM). Head flexion in the semi-reclined posture (19.7%ROM) and muscle activity (8.88%MVC) were similar to when reading from a standard computer monitor. Despite potentially reducing the gravitational moment produced by the head, the semi-reclined position could still compromise the force capabilities of the neck extensor musculature and result in increased strain on the passive tissues of the spine. Future work should assess how the semi-reclined position influences cervical intervertebral angles and passive tissue properties of the cervical spine. Overall, more research needs to be conducted on thoracic spine kinematics while reading a tablet computer.

- **Keywords:** Mobile computing; Electromyography; Spine; Kinematics

Amzar Azizan, M. Fard, Michael F. Azari, Reza Jazar. *Effects of vibration on occupant driving performance under simulated driving conditions.* Pages 348-355.

Although much research has been devoted to the characterization of the effects of whole-body vibration on seated occupants' comfort, drowsiness induced by vibration has received less attention to date. There are also little validated measurement methods available to quantify whole body vibration-induced drowsiness. Here, the effects of vibration on drowsiness were investigated. Twenty male volunteers were recruited for

this experiment. Drowsiness was measured in a driving simulator, before and after 30-min exposure to vibration. Gaussian random vibration, with 1–15 Hz frequency bandwidth was used for excitation. During the driving session, volunteers were required to obey the speed limit of 100 kph and maintain a steady position on the left-hand lane. A deviation in lane position, steering angle variability, and speed deviation were recorded and analysed. Alternatively, volunteers rated their subjective drowsiness by Karolinska Sleepiness Scale (KSS) scores every 5-min. Following 30-min of exposure to vibration, a significant increase of lane deviation, steering angle variability, and KSS scores were observed in all volunteers suggesting the adverse effects of vibration on human alertness level.

- **Keywords:** Human vibration; Drowsiness; Lane deviation; Speed deviation; Steering angle

Lindsey N. Clark, Natalie C. Benda, Sudeep Hegde, Nicolette M. McGeorge, Theresa K. Guarrera-Schick, A. Zachary Hettinger, David T. LaVergne, Shawna J. Perry, Robert L. Wears, Rollin J. Fairbanks, Ann M. Bisantz. *Usability evaluation of an emergency department information system prototype designed using cognitive systems engineering techniques. Pages 356-365.*

This article presents an evaluation of novel display concepts for an emergency department information system (EDIS) designed using cognitive systems engineering methods. EDISs assist emergency medicine staff with tracking patient care and ED resource allocation. Participants performed patient planning and orientation tasks using the EDIS displays and rated the display's ability to support various cognitive performance objectives along with the usability, usefulness, and predicted frequency of use for 18 system components. Mean ratings were positive for cognitive performance support objectives, usability, usefulness, and frequency of use, demonstrating the successful application of design methods to create useful and usable EDIS concepts that provide cognitive support for emergency medicine staff. Nurse and provider roles had significantly different perceptions of the usability and usefulness of certain EDIS components, suggesting that they have different information needs while working.

- **Keywords:** Electronic department information systems; Patient tracking systems; Usability; Human factors methods

Suzanne Nobrega, Laura Kernan, Bora Plaku-Alakbarova, Michelle Robertson, Nicholas Warren, Robert Henning. *Field tests of a participatory ergonomics toolkit for Total Worker Health. Pages 366-379.*

Growing interest in Total Worker Health® (TWH) programs to advance worker safety, health and well-being motivated development of a toolkit to guide their implementation. Iterative design of a program toolkit occurred in which participatory ergonomics (PE) served as the primary basis to plan integrated TWH interventions in four diverse organizations. The toolkit provided start-up guides for committee formation and training, and a structured PE process for generating integrated TWH interventions. Process data from program facilitators and participants throughout program implementation were used for iterative toolkit design. Program success depended on organizational commitment to regular design team meetings with a trained facilitator, the availability of subject matter experts on ergonomics and health to support the design process, and retraining whenever committee turnover occurred. A two committee structure (employee Design Team, management Steering Committee) provided advantages over a single, multilevel committee structure, and enhanced the planning, communication, and teamwork skills of participants.

- **Keywords:** Total Worker Health; Participatory ergonomics; Toolkit

Andres C. Rodriguez, Lope H. Barrero. *Job rotation: Effects on muscular activity variability*. Pages 83-92.

Job rotation strategies have been used for years as an administrative intervention to reduce the risk of musculoskeletal disorders. The benefits of job rotation have been hypothesized to occur via changes in muscular activity variability (MAV). However, the effect of job rotation on MAV has not been fully analyzed in a literature review. A wide search was conducted to identify studies testing the effect of different job rotation strategies on MAV. Twenty-six studies of acceptable quality were included. Several studies on different types of tasks supported the view that job rotation can increase muscular activity variability, particularly with strategies such as alternating tasks and pace changes. However, it remains uncertain whether such variability changes immediately translate into benefits for the worker because little evidence was found that showed simultaneous changes in different muscular groups. Additionally, variability was occasionally achieved at the expense of average activity in the assessed muscles.

- **Keywords:** Job rotation; Demands rotation; Musculoskeletal disorders; Electromyography; Muscle activity variability

Pieter Coenen, Nicholas Gilson, Genevieve N. Healy, David W. Dunstan, Leon M. Straker. *A qualitative review of existing national and international occupational safety and health policies relating to occupational sedentary behaviour*. Pages 320-333.

Prolonged sedentary time is now recognised as an emergent ergonomics issue. We aimed to review current occupational safety and health policies relevant to occupational sedentary behaviour. An electronic search for documents was conducted on websites of ergonomics and occupational safety and health organisations from 10 countries and six international/pan-European agencies. Additionally, 43 informants (nine countries) were contacted and an international conference workshop held. 119 documents (e.g. legislation, guidelines, codes of practice) were identified. Using a qualitative synthesis, it was observed that many jurisdictions had legal frameworks establishing a duty of care for employers, designers/manufacturers/suppliers and employees. While no occupational authority policies focusing specifically on sedentary behaviour were found, relevant aspects of existing policies were identified. We highlight implications for ergonomics research and practice and recommend the development of policy to specifically address occupational sedentary behaviour and support workplace initiatives to assess and control the risks of this emergent hazard.

- **Keywords:** Sedentary behaviour; Policy; Occupational health; Qualitative research; Review