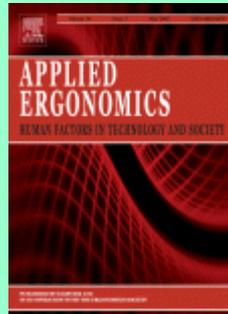


Applied Ergonomics - rok 2016, Volume 52

January 2016



C. Adam Probst, Laurie Wolf, Mara Bollini, Yan Xiao. *Human factors engineering approaches to patient identification armband design.* Pages 1-7.

The task of patient identification is performed many times each day by nurses and other members of the care team. Armbands are used for both direct verification and barcode scanning during patient identification. Armbands and information layout are critical to reducing patient identification errors and dangerous workarounds. We report the effort at two large, integrated healthcare systems that employed human factors engineering approaches to the information layout design of new patient identification armbands. The different methods used illustrate potential pathways to obtain standardized armbands across healthcare systems that incorporate human factors principles. By extension, how the designs have been adopted provides examples of how to incorporate human factors engineering into key clinical processes.

- **Keywords:** Patient identification armbands; Patient armband design; Patient safety

Mahmut Ekşioğlu. *Normative static grip strength of population of Turkey, effects of various factors and a comparison with international norms.* Pages 8-17.

Normative data are of importance in ergonomics and clinical settings. Applying normative data internationally is questionable. To this end, this study aimed to establish gender- and age-specific reference values for static (isometric) hand grip strength of normal population of Turkey with special regard to occupational demand, and compare them with the international norms. The secondary aims were to investigate the effects of gender, age-group, weight-group, job-group, hand and several anthropometric variables on static grip strength. A sample of 211 (128 male and 83 female) volunteers aged between 18 and 69 with various occupations participated in the study. Grip strength data were collected using a Jamar dynamometer with standard testing position, protocol and instructions. The mean and std deviation of maximum voluntary static grip strength values (in N) for dominant and non-dominant hands respectively were 455.2 ± 73.6 and 441.5 ± 72.6 for males, and 258 ± 46.1 and 246.2 ± 49.1 for females. The mean female strength was about 57% of the mean male strength value for both dominant and non-dominant hands. There was a curvilinear relationship of grip strength to age, significant differences between genders, hands, and some age-groups, and a correlation to height, body-mass, BMI and hand dimensions depending on the gender. The comparisons with

the norms of other world populations indicate that there are cross-national grip strength variations among some nations but not all.

- **Keywords:** Static (isometric) hand grip strength; Normative data of Turkey; Anthropometry; Ergonomic design

Richard M. Kesler, Gavin P. Horn, Karl S. Rosengren, Elizabeth T. Hsiao-Weckler. *Analysis of foot clearance in firefighters during ascent and descent of stairs. Pages 18-23.*

Slips, trips, and falls are a leading cause of injury to firefighters with many injuries occurring while traversing stairs, possibly exaggerated by acute fatigue from firefighting activities and/or asymmetric load carriage. This study examined the effects that fatigue, induced by simulated firefighting activities, and hose load carriage have on foot clearance while traversing stairs. Landing and passing foot clearances for each stair during ascent and descent of a short staircase were investigated. Clearances decreased significantly ($p < 0.05$) post-exercise for nine of 12 ascent parameters and increased for two of eight descent parameters. Load carriage resulted in significantly decreased ($p < 0.05$) clearance over three ascent parameters, and one increase during descent. Decreased clearances during ascent caused by fatigue or load carriage may result in an increased trip risk. Increased clearances during descent may suggest use of a compensation strategy to ensure stair clearance or an increased risk of over-stepping during descent.

- **Keywords:** Foot clearance; Stairs; Firefighters

Matthieu B. Trudeau, Deanna S. Asakawa, Devin L. Jindrach, Jack T. Dennerlein. *Two-handed grip on a mobile phone affords greater thumb motor performance, decreased variability, and a more extended thumb posture than a one-handed grip. Pages 24-28.*

Holding a mobile computing device with two hands may affect thumb motor performance, joint postures, and device stability compared to holding the device and tapping the touchscreen with the thumb of the holding hand. We tested the hypotheses that holding a touchscreen mobile phone with two hands lead to increased thumb motor performance, different thumb postures, and decreased device movement relative to using one hand. Ten right-handed participants completed reciprocal thumb tapping tasks between emulated keys on a smartphone in either a one- (portrait) or two-handed (landscape) grip configuration. Effective index of performance measured from Fitts' Law was 9% greater ($p < 0.001$), movement time 7% faster ($p < 0.001$), and taps were 4% more precise ($p < 0.016$) for the two-handed grip. Tapping with a two-handed grip involved significantly different wrist and thumb postures than a one-handed grip. Variability of the computing device's movement was 36–63% lower for the two-handed grip compared to the one-handed grip condition ($p < 0.001$). The support for our hypotheses suggests that a two-handed grip results in increased performance and more extended wrist and thumb postures than a single-handed grip. Device designs that allow two-handed grips may afford increased performance relative to a one-handed grip.

- **Keywords:** Mobile computing; Fitts' law; Repetitive stress

Po-Hsin Huang, Ming-Chuan Chiu. *Integrating user centered design, universal design and goal, operation, method and selection rules to improve the usability of DAISY player for persons with visual impairments. Pages 29-42.*

The Digital Accessible Information SYstem (DAISY) player is an assistive reading tool developed for use by persons with visual impairments. Certain problems have persisted

in the operating procedure and interface of DAISY players, especially for their Chinese users. Therefore, the aim of this study was to redesign the DAISY player with increased usability features for use by native Chinese speakers. First, a User Centered Design (UCD) process was employed to analyze the development of the prototype. Next, operation procedures were reorganized according to GOMS (Goals, Operators, Methods, and Selection rules) methodology. Then the user interface was redesigned according to specific Universal Design (UD) principles. Following these revisions, an experiment involving four scenarios was conducted to compare the new prototype to other players, and it was tested by twelve visually impaired participants. Results indicate the prototype had the quickest operating times, the fewest number of operating errors, and the lowest mental workloads of all the compared players, significantly enhancing the prototype's usability. These findings have allowed us to generate suggestions for developing the next generation of DAISY players for people, especially for Chinese audience.

- **Keywords:** User centered design; Universal design; GOMS; DAISY player; Visually impaired

Mary F. Lesch, Pei-Luen Patrick Rau, YoonSun Choi. *Effects of culture (China vs. US) and task on perceived hazard: Evidence from product ratings, label ratings, and product to label matching.* Pages 43-53.

In the current study, 44 Chinese and 40 US college students rated their perceived hazard in response to warning labels and products and attempted to match products with warning labels communicating the same level of hazard. Chinese participants tended to provide lower ratings of hazard in response to labels, but hazard perceived in response to products did not significantly differ as a function of culture. When asked to match a product with a warning label, Chinese participants' hazard perceptions appeared to be better calibrated, than did US participants', across products and labels. The results are interpreted in terms of constructivist theory which suggests that risk perceptions vary depending on the "frame of mind" evoked by the environment/context. Designers of warnings must be sensitive to the fact that product users' cognitive representations develop within a culture and that risk perceptions will vary based on the context in which they are derived.

- **Keywords:** Warnings; Culture; Risk

T.N. Brown, M. O'Donovan, L. Hasselquist, B. Corner, J.M. Schiffman. *Lower limb flexion posture relates to energy absorption during drop landings with soldier-relevant body borne loads.* Pages 54-61.

Fifteen military personnel performed 30-cm drop landings to quantify how body borne load (light, ~6 kg, medium, ~20 kg, and heavy, ~40 kg) impacts lower limb kinematics and knee joint energy absorption during landing, and determine whether greater lower limb flexion increases energy absorption while landing with load. Participants decreased peak hip ($P = 0.002$), and knee flexion ($P = 0.007$) posture, but did not increase hip ($P = 0.796$), knee ($P = 0.427$) or ankle ($P = 0.161$) energy absorption, despite exhibiting greater peak hip ($P = 0.003$) and knee ($P = 0.001$) flexion, and ankle ($P = 0.003$) dorsiflexion angular impulse when landing with additional load. Yet, when landing with the light and medium loads, greater hip ($R^2 = 0.500$, $P = 0.003$ and $R^2 = 0.314$, $P = 0.030$) and knee ($R^2 = 0.431$, $P = 0.008$ and $R^2 = 0.342$, $P = 0.022$) flexion posture predicted larger knee joint energy absorption. Thus, military training that promotes hip and knee flexion, and subsequently greater energy absorption during landing, may potentially reduce risk of musculoskeletal injury and optimize soldier performance.

- **Keywords:** Kinematics; Kinetics; Energy absorption; Impact force

Elizabeth A. Salas, Peter Vi, Vanesa L. Reider, Anne E. Moore. *Factors affecting the risk of developing lower back musculoskeletal disorders (MSDs) in experienced and inexperienced rodworkers. Pages 62-68.*

Injury and dropout rates during rodwork training appear to reflect difficulties encountered by apprentices adapting to increased physical demands of tying on slab, one of the rodworking tasks with the highest injury risk. Because experience influences work strategies, and consequently the risk of developing musculoskeletal disorders (MSDs), this study aimed to identify differences in work practices associated with tying rebar on slab, potentially relevant to back MSD development, in experienced and inexperienced rodworkers. Fourteen male rodworkers were recruited from either experienced (>2 years experience post apprenticeship), or inexperienced (<6 months experience) groups. Both tied an area with rebar laid on the ground. Trunk flexion/extension angles were measured. L4/L5 moments were estimated from T9 Erector Spinae EMG. Experienced workers were found to spend longer periods of time in trunk flexed postures, with lower peak L4/L5 moments. Our findings revealed practices associated with each group might have different implications on back health.

- **Keywords:** Rodwork; Low back; Prolonged trunk flexion

Ann Marie Dale, Kim Miller, Bethany T. Gardner, Ching-Ting Hwang, Bradley Evanoff, Laura Welch. *Observed use of voluntary controls to reduce physical exposures among sheet metal workers of the mechanical trade. Pages 69-76.*

Introduction: Little is known about the transfer into the workplace of interventions designed to reduce the physical demands of sheet metal workers. **Methods:** We reviewed videos from a case series of 15 sheet metal worksite assessments performed in 2007–2009 to score postures and physical loads, and to observe the use of recommended interventions to reduce physical exposures in sheet metal activities made by a NIOSH stakeholder meeting in 2002. **Results:** Workers showed consistent use of material handling devices, but we observed few uses of recommended interventions to reduce exposures during overhead work. Workers spent large proportions of time in awkward shoulder elevation and low back rotation postures. **Conclusions:** In addition to the development of new technologies and system designs, increased adoption of existing tools and practices could reduce time spent in awkward postures and other risks for musculoskeletal disorders in sheet metal work.

- **Keywords:** Intervention study; Musculoskeletal injuries; Technology transfer

Carly DeHenau, Mark W. Becker, Nora M. Bello, Sichang Liu, Laura Bix. *Tallman lettering as a strategy for differentiation in look-alike, sound-alike drug names: The role of familiarity in differentiating drug doppelgangers. Pages 77-84.*

Tallman lettering, capitalizing the dissimilar portions of easily confused drug names, is one strategy for reducing medication errors. We assessed the efficacy of Tallman lettering in a visually complex environment using a change detection method with healthcare providers and laypeople. In addition, the effect of familiarity with the drug name was assessed using a subset of responses collected from healthcare providers. Both healthcare providers and laypeople detected changes in confusable pairs of drug names more often ($P < 0.0001$) and more quickly ($P < 0.05$) when changes were presented in Tallman lettering, though the benefits were more pronounced for healthcare providers ($p < 0.05$). Familiarity with both drug names in a confusable pair mitigated the benefit of Tallman lettering. Results are discussed in terms of bottom-up and top-

down attentional systems for processing of information in the context of the varied healthcare environments.

- **Keywords:** Medication error; Tallman lettering; Drug labeling; Look-alike sound-alike drug names; Text differentiation; Name differentiation

Majid Fallahi, Majid Motamedzade, Rashid Heidarimoghadam, Ali Reza Soltanian, Shinji Miyake. *Effects of mental workload on physiological and subjective responses during traffic density monitoring: A field study.* Pages 95-103.

This study evaluated operators' mental workload while monitoring traffic density in a city traffic control center. To determine the mental workload, physiological signals (ECG, EMG) were recorded and the NASA-Task Load Index (TLX) was administered for 16 operators. The results showed that the operators experienced a larger mental workload during high traffic density than during low traffic density. The traffic control center stressors caused changes in heart rate variability features and EMG amplitude, although the average workload score was significantly higher in HTD conditions than in LTD conditions. The findings indicated that increasing traffic congestion had a significant effect on HR, RMSSD, SDNN, LF/HF ratio, and EMG amplitude. The results suggested that when operators' workload increases, their mental fatigue and stress level increase and their mental health deteriorate. Therefore, it maybe necessary to implement an ergonomic program to manage mental health. Furthermore, by evaluating mental workload, the traffic control center director can organize the center's traffic congestion operators to sustain the appropriate mental workload and improve traffic control management.

- **Keywords:** Mental workload; ECG; EMG; NASA-TLX; Traffic control center

S. Lamb, K.C.S. Kwok. *A longitudinal investigation of work environment stressors on the performance and wellbeing of office workers.* Pages 104-111.

This study uses a longitudinal within-subjects design to investigate the effects of inadequate Indoor Environmental Quality (IEQ) on work performance and wellbeing in a sample of 114 office workers over a period of 8 months. Participants completed a total of 2261 online surveys measuring perceived thermal comfort, lighting comfort and noise annoyance, measures of work performance, and individual state factors underlying performance and wellbeing. Characterising inadequate aspects of IEQ as environmental stressors, these stress factors can significantly reduce self-reported work performance and objectively measured cognitive performance by between 2.4% and 5.8% in most situations, and by up to 14.8% in rare cases. Environmental stressors act indirectly on work performance by reducing state variables, motivation, tiredness, and distractibility, which support high-functioning work performance. Exposure to environmental stress appears to erode individuals' resilience, or ability to cope with additional task demands. These results indicate that environmental stress reduces not only the cognitive capacity for work, but the rate of work (i.e. by reducing motivation). Increasing the number of individual stress factors is associated with a near linear reduction in work performance indicating that environmental stress factors are additive, not multiplicative. Environmental stressors reduce occupant wellbeing (mood, headaches, and feeling 'off') causing indirect reductions in work performance. Improving IEQ will likely produce small but pervasive increases in productivity.

- **Keywords:** Thermal comfort; Light; Noise annoyance; Work performance; Wellbeing; Stress

H. Harvey Cohen, Gary D. Sloan. *The science behind codes and standards for safe pedestrian walkways: Lighting and visual cues.* Pages 112-119.

Background: Walkway codes and standards are created through consensus by committees based on a number of factors, including historical precedence, common practice, cost, and, sometimes, empirical data. The authors maintain that codes and standards that can have an impact on human safety and welfare should give consideration in their formulation to the results of pertinent scientific research. **Purpose:** This article extends a companion one in examining many elements of common walkway codes and standards related specifically to lighting, warnings and markings. It indicates which elements are based on or supported by empirical data; and which elements could benefit from additional scientific research. **Practical applications:** This article identifies areas in which additional research leading toward scientific based codes and standards may be beneficial in enhancing the safety of pedestrian walkway surfaces.

- **Keywords:** Lighting; Illumination; Photopic; Mesopic; Scotopic; Warnings; Markings; Visual cues; Slip; Trip; Misstep; Fall; Ambulation; Pedestrian safety

Bryan Reimer, Bruce Mehler, Joseph F. Coughlin. *Reductions in self-reported stress and anticipatory heart rate with the use of a semi-automated parallel parking system.* Pages 120-127.

Drivers' reactions to a semi-autonomous technology for assisted parallel parking system were evaluated in a field experiment. A sample of 42 drivers balanced by gender and across three age groups (20–29, 40–49, 60–69) were given a comprehensive briefing, saw the technology demonstrated, practiced parallel parking 3 times each with and without the assistive technology, and then were assessed on an additional 3 parking events each with and without the technology. Anticipatory stress, as measured by heart rate, was significantly lower when drivers approached a parking space knowing that they would be using the assistive technology as opposed to manually parking. Self-reported stress levels following assisted parks were also lower. Thus, both subjective and objective data support the position that the assistive technology reduced stress levels in drivers who were given detailed training. It was observed that drivers decreased their use of turn signals when using the semi-autonomous technology, raising a caution concerning unintended lapses in safe driving behaviors that may occur when assistive technologies are used.

- **Keywords:** Automated driving; Parking technology; Mental model; Age; Workload

Yeshambel T. Nigatu, Hardy A. van de Ven, Jac J.L. van der Klink, Sandra Brouwer, Sijmen A. Reijneveld, Ute Bültmann. *Overweight, obesity and work functioning: The role of working-time arrangements.* Pages 128-134.

Background: Obesity is associated with productivity loss, but little is known about how obese workers function at work and also the role of working-time arrangements on this association is lacking. Therefore, the aim of this study was to examine the association of overweight and obesity with work functioning (WF), and to determine whether the associations differ between workers with different working-time arrangements. **Methods:** A cross-sectional study was conducted within the sampling frame of the 'Shift Your Work' study that examined the effect of irregular working-times in relation to health and functioning at work. We included N = 622 Dutch employees, of which N = 384 (62%) were shift-workers, N = 171 (27%) on-call workers and N = 67 (11%) day-workers. Overweight and obesity were defined as BMI 25–30 and ≥ 30 , respectively. WF was assessed using the Work-Role Functioning Questionnaire. **Results:** The prevalences of overweight and obesity were 48% and 10% in all workers, 49% and 11% in shift-

workers, 45% and 10% in on-call workers, and 49% and 6% in day workers, respectively. In all workers, obesity was associated with lower WF scores for physical demands (adjusted estimate, $aB = -5.5$). In shift-workers, obesity was associated with lower WF scores for output and physical demands ($aB = -8.8$ and -6.8 , respectively). In day and on-call workers, overweight and obesity were not associated with WF. **Conclusions:** Overweight and obesity are highly prevalent in the working population. Obesity might reduce the executive function performance beyond physical limitations, and limit the ability to accomplish tasks successfully, especially in shift workers.

- **Keywords:** Overweight; Obesity; Body-mass index; BMI; Work functioning; Work demands; Shift-work; Working-time arrangements; Shift-workers

Yusuke Yamani, Siby Samuel, Michael A. Knodler, Donald L. Fisher. *Evaluation of the effectiveness of a multi-skill program for training younger drivers on higher cognitive skills. Pages 135-141.*

Training programs exist that prove effective at teaching novice drivers to anticipate latent hazards (RAPT), mitigate hazards (ACT) and maintain attention (FOCAL). The current study (a) measures the effectiveness of a novel integrated training program (SAFE-T) that takes only a third as long to complete compared to the three individual training programs and (b) determines if integrating the training of all the three higher cognitive skills would yield results comparable to the existing programs. Three groups were evaluated: SAFE-T, RAPT and Placebo. The results show that the drivers in the SAFE-T-trained group were more likely to anticipate hazards, quicker and more effective at responding to hazards, and more likely to maintain glance durations under a critical threshold of 2 s as compared to drivers in the Placebo-trained group who received a control program that does not actively train on any of the three cognitive skills. Moreover, the results show that the drivers in the SAFE-T trained group were just as likely to anticipate hazards as the drivers in the RAPT trained group. Finally, when compared with prior studies, the drivers in the SAFE-T trained group showed similar effects of attention maintenance training.

- **Keywords:** Driver training; Cognitive skills

Dengchuan Cai, Hsiao-Lin Chen. *Ergonomic approach for pillow concept design. Pages 142-150.*

Sleep quality is an essential factor to human beings for health. The current paper conducted four studies to provide a suitable pillow for promoting sleep quality. Study 1 investigated the natural positions of 40 subjects during sleep to derive key-points for a pillow design. The results suggested that the supine and lateral positions were alternatively 24 times a night, and the current pillows were too high for the supine position and too low for lateral positions. Study 2 measured body dimensions related to pillow design of 40 subjects to determine pillow sizes. The results suggested that the pillow height were quite different in supine position and lateral position and needed to take into consideration for a pillow design. Study 3 created a pillow design based on the results of above studies. The pillow was a U-form in the front of view in which the pillow height in the middle area was lower for the supine position, and both sides were higher for the lateral positions. Study 4 assessed sleep quality of 6 subjects by using the proposed pillows and the current pillows. The results showed that the newly designed pillow led to significantly higher sleep quality, and the new design received an innovation patent.

- **Keywords:** Sleep position; Sleep duration; Sleep quality; Pillow design; Ergonomic design

D.C. Tappin, A. Vitalis, T.A. Bentley. *The application of an industry level participatory ergonomics approach in developing MSD interventions.* Pages 151-159.

Participatory ergonomics projects are traditionally applied within one organisation. In this study, a participative approach was applied across the New Zealand meat processing industry, involving multiple organisations and geographical regions. The purpose was to develop interventions to reduce musculoskeletal disorder (MSD) risk. This paper considers the value of an industry level participatory ergonomics approach in achieving this. The main rationale for a participative approach included the need for industry credibility, and to generate MSD interventions that address industry level MSD risk factors. An industry key stakeholder group became the primary vehicle for formal participation. The study resulted in an intervention plan that included the wider work system and industry practices. These interventions were championed across the industry by the key stakeholder group and have extended beyond the life of the study. While this approach helped to meet the study aim, the existence of an industry-supported key stakeholder group and a mandate for the initiative are important prerequisites for success.

- **Keywords:** Participatory ergonomics; Meat processing; Musculoskeletal disorders

Kristina M. Gruevski, Michael W.R. Holmes, Chad E. Gooyers, Clark R. Dickerson, Jack P. Callaghan. *Lumbar postures, seat interface pressures and discomfort responses to a novel thoracic support for police officers during prolonged simulated driving exposures.* Pages 160-168.

A high prevalence of low back pain has been reported among professional drivers, including mobile police officers. The purpose of this investigation was to develop and evaluate a novel thoracic support designed for mobile police officers. Fourteen participants (7 male, 7 female) attended two 120-min driving simulations using a Crown Victoria Interceptor seat and the same seat equipped with a surface mounted thoracic support. Time-varying spine postures, seat pressures and ratings of discomfort were measured. Averaged discomfort values were low (less than 10 mm of a possible 100 mm) for both seating conditions. The postures in the thoracic support condition were more similar to non-occupational driving without occupational equipment than the Crown Victoria seating condition. The reduction in pressure area at the low back with the thoracic support has the potential to reduce discomfort reporting in officers compared to a standard vehicle package.

- **Keywords:** Occupational driving; Low back pain; Thoracic support

Emily H. Sinitski, Andrew G. Herbert-Copley, Edward D. Lemaire, Sean S. Doyle, Markus Besemann, Nancy L. Dudek. *Center of pressure and total force analyses for amputees walking with a backpack load over four surfaces.* Pages 169-176.

Understanding how load carriage affects walking is important for people with a lower extremity amputation who may use different strategies to accommodate to the additional weight. Nine unilateral traumatic transtibial amputees (K4-level) walked over four surfaces (level-ground, uneven ground, incline, decline) with and without a 24.5 kg backpack. Center of pressure (COP) and total force were analyzed from F-Scan insole pressure sensor data. COP parameters were greater on the intact limb than on the prosthetic limb, which was likely a compensation for the loss of ankle control. Double support time (DST) was greater when walking with a backpack. Although longer DST is often considered a strategy to enhance stability and/or reduce loading forces, changes in DST were only moderately correlated with changes in peak force. High functioning

transtibial amputees were able to accommodate to a standard backpack load and to maintain COP progression, even when walking over different surfaces.

- **Keywords:** Center of pressure; Backpack; Load carriage; Amputee; F-Scan

Wei-Ting Yen, Carolyn M. Sommerich, Steven A. Lavender, Sharon R. Flinn, Elizabeth B.-N. Sanders. *Evaluation of jar lid design characteristics by older women with hand use limitations. Pages 177-184.*

The study evaluated several lid design characteristics (diameter, height, top shape, side shape, and surface texture) by means of controlled laboratory testing with older women with hand function limitations. A subjective evaluation process was applied to examine main effects and interactions of lid design characteristics on usability, determined by participants' perceptions of effort and discomfort. Results showed that lid height was the most important design characteristic associated with usability. For 42 mm diameter lids, designs perceived as best were ones with taller height, hexagonal top shape, and convex side shape. For 28 mm diameter lids, the best designs were ones with taller height and hexagonal top shape. Additionally, when the smaller lid's side shape was flat, a serrate surface texture provided some advantages, particularly for subjects with more severe hand dysfunction. This information could be used by package designers to improve jar lid usability for a growing sector of consumers.

- **Keywords:** Lid design; Older adult; Hand dysfunction; Hand pain; Activities of daily living

Rebecca J. Mitchell, Ann Williamson, Brett Molesworth. *Application of a human factors classification framework for patient safety to identify precursor and contributing factors to adverse clinical incidents in hospital. Pages 185-195:*

This study aimed to identify temporal precursor and associated contributing factors for adverse clinical incidents in a hospital setting using the Human Factors Classification Framework (HFCF) for patient safety. A random sample of 498 clinical incidents were reviewed. The framework identified key precursor events (PE), contributing factors (CF) and the prime causes of incidents. Descriptive statistics and correspondence analysis were used to examine incident characteristics. Staff action was the most common type of PE identified. Correspondence analysis for all PEs that involved staff action by error type showed that rule-based errors were strongly related to performing medical or monitoring tasks or the administration of medication. Skill-based errors were strongly related to misdiagnoses. Factors relating to the organisation (66.9%) or the patient (53.2%) were the most commonly identified CFs. The HFCF for patient safety was able to identify patterns of causation for the clinical incidents, highlighting the need for targeted preventive approaches, based on an understanding of how and why incidents occur.

- **Keywords:** Patient safety; Clinical incident; Classification framework; Error

Hao Rong, Jin Tian, Tingdi Zhao. *Temporal uncertainty analysis of human errors based on interrelationships among multiple factors: A case of Minuteman III missile accident. Pages 196-206.*

In traditional approaches of human reliability assessment (HRA), the definition of the error producing conditions (EPCs) and the supporting guidance are such that some of the conditions (especially organizational or managerial conditions) can hardly be included, and thus the analysis is burdened with incomprehensiveness without reflecting the temporal trend of human reliability. A method based on system dynamics (SD), which highlights interrelationships among technical and organizational aspects that may

contribute to human errors, is presented to facilitate quantitatively estimating the human error probability (HEP) and its related variables changing over time in a long period. Taking the Minuteman III missile accident in 2008 as a case, the proposed HRA method is applied to assess HEP during missile operations over 50 years by analyzing the interactions among the variables involved in human-related risks; also the critical factors are determined in terms of impact that the variables have on risks in different time periods. It is indicated that both technical and organizational aspects should be focused on to minimize human errors in a long run.

- **Keywords:** Human reliability; Human error probability (HEP); System dynamics; Missile accident; Error producing conditions (EPC)

T.A. Bentley, S.T.T. Teo, L. McLeod, F. Tan, R. Bosua, M. Gloet. *The role of organisational support in teleworker wellbeing: A socio-technical systems approach.* Pages 207-215.

The prevalence of telework and other forms of mobile working enabled by digital technology is increasing markedly. Following a socio-technical systems approach, this study aims to examine the role of organisational social support and specific support for teleworkers in influencing teleworker wellbeing, the mediating role of social isolation, potentially resulting from a person-environment mismatch in these relationships, and possible differences in these relationships between low-intensity and hybrid teleworkers. Teleworkers' (n = 804) perceptions of support and telework outcomes (psychological strain, job satisfaction, and social isolation) were collected using an on-line survey of teleworking employees distributed within 28 New Zealand organisations where knowledge work was undertaken. Organisational social support and teleworker support was associated with increased job satisfaction and reduced psychological strain. Social isolation mediated the relationship between organisational social support and the two outcome variables, and some differences were observed in the structural relationships for hybrid and low-intensity teleworker sub-samples. These findings suggest that providing the necessary organisational and teleworker support is important for enhancing the teleworker-environment fit and thereby ensuring desirable telework outcomes.

- **Keywords:** Telework; Telecommuting; Socio-technical systems; Organisational support; Job satisfaction; Job stress; Social isolation

Maya Calé-Benzoor, Ruth Dickstein, Michal Arnon, Moshe Ayalon, *Dynamic push-pull characteristics at three hand-reach envelopes: Applications for the workplace.* Pages 216-221.

Pushing and pulling are common tasks in the workplace. Overexertion injuries related to manual pushing and pulling are often observed, and therefore the understanding of work capacity is important for efficient and safe workstation design. The purpose of the present study was to describe workloads obtained during different reach envelopes during a seated push-pull task. Forty-five women performed an isokinetic push-pull sequence at two velocities. Strength, work and agonist/antagonist muscle ratio were calculated for the full range of motion (ROM). We then divided the ROM into three reach envelopes – neutral, medium, and maximum reach. The work capacity for each direction was determined and the reach envelope work data were compared. Push capability was best at medium reach envelope and pulling was best at maximum reach envelope. Push/pull strength ratio was approximately 1. A recommendation was made to avoid strenuous push-pull tasks at neutral reach envelopes.

- **Keywords:** Push-pull; Isokinetic; Reach envelope

Kyungah Choi, Jeongmin Lee, Hyeon-Jeong Suk. *Context-based presets for lighting setup in residential space. Pages 222-231.*

This study aims to derive context-based lighting setup presets in residential space by exploring the multilateral relationships among household activities, affects, and lighting setups. Three procedures were involved: First, sixty affective words were evaluated through which seven affect factors were extracted to facilitate the evaluation of colored illumination in the subsequent experiment. Second, in the user study, seven affect factors and thirty household activities were used to evaluate 147 lighting setups extracted from combinations of twelve hues, six illuminance levels, and three purity levels. As a result, twenty lighting setup presets were derived that were not only activity-based, but affect-based as well. Lastly, the twenty presets were prototyped as a set of testbed to further explore potentials and limitations. This study demonstrates that intuitive, context-based presets can help users explore the effects of colored illumination in creating a diverse range of user experiences.

- **Keywords:** Affective illumination; Colored illumination; Residential space

Lanndon A. Ocampo, Rosemary R. Seva. *Using analytic network process for evaluating mobile text entry methods. Pages 232-241.*

This paper highlights a preference evaluation methodology for text entry methods in a touch keyboard smartphone using analytic network process (ANP). Evaluation of text entry methods in literature mainly considers speed and accuracy. This study presents an alternative means for selecting text entry method that considers user preference. A case study was carried out with a group of experts who were asked to develop a selection decision model of five text entry methods. The decision problem is flexible enough to reflect interdependencies of decision elements that are necessary in describing real-life conditions. Results showed that QWERTY method is more preferred than other text entry methods while arrangement of keys is the most preferred criterion in characterizing a sound method. Sensitivity analysis using simulation of normally distributed random numbers under fairly large perturbation reported the foregoing results reliable enough to reflect robust judgment. The main contribution of this paper is the introduction of a multi-criteria decision approach in the preference evaluation of text entry methods.

- **Keywords:** Text entry method; QWERTY; Analytic network process

Chih-Long Lin, Si-Jing Chen, Wen-Hsin Hsiao, Rungtai Lin. *Cultural ergonomics in interactional and experiential design: Conceptual framework and case study of the Taiwanese twin cup. Pages 242-252.*

Cultural ergonomics is an approach that considers interaction- and experience-based variations among cultures. Designers need to develop a better understanding of cultural ergonomics not just to participate in cultural contexts but also to develop interactive experiences for users. Cultural ergonomics extends our understanding of cultural meaning and our ability to utilize such understanding for design and evaluate everyday products. This study aims to combine cultural ergonomics and interactive design to explore human-culture interaction in user experiences. The linnak is a typical Taiwanese aboriginal cultural object. This study examined the cultural meaning and operational interface of the linnak, as well as the scenarios in which it is used in interaction and user experiences. The results produced a cultural ergonomics interface for examining the manner in which designers communicate across cultures as well as the interweaving of design and culture in the design process.

- **Keywords:** Cultural ergonomics; Taiwanese aboriginal culture; Cultural and creative design

Enrico Ronchi, Daniel Nilsson, Henric Modig, Anders Lindgren Walter. *Variable Message Signs for road tunnel emergency evacuations. Pages 253-264.*

This paper investigates the design of Variable Message Signs (VMS) as a way-finding aid for road tunnel emergency evacuations. The use of the Theory of Affordances is suggested to provide recommendations on the design of VMS. A preliminary evaluation of 11 selected VMS systems was performed and 6 of them were further evaluated using an affordance-based within subject stated-preference questionnaire administered to a sample of 62 participants. Results are used to provide recommendations on the characteristics of the VMS systems, such as (1) size of the sign (large or small); (2) use of flashing lights; (3) colour scheme; (4) message coding (i.e., text, pictograms or a combination of them). The best performing VMS features for road tunnel emergency evacuation included the use of larger signs, flashing lights, the combination of emergency exit pictorial symbol in green in one panel and text in amber in the other panel.

- **Keywords:** Emergency evacuation; Variable Message Sign; Tunnel evacuation; Theory of Affordances; Way-finding; Notification; System design

Yutao Ba, Wei Zhang, Gavriel Salvendy, Andy S.K. Cheng, Petya Ventsislavova. *Assessments of risky driving: A Go/No-Go simulator driving task to evaluate risky decision-making and associated behavioral patterns. Pages 265-274.*

This study sought to develop and validate a Go/No-Go Simulator Driving Task (G/NG-SDT) to evaluate driver risky decision-making and associated behavioral assessments at a situation-specific level. Eighty-four participants were instructed to complete a route in as short time as possible, but avoiding any violations or crashes. To achieve this aim, they had to decide to go or wait in the dilemma scenes, paired with the baseline scenes in several scenarios. High-risk drivers with more Go decisions demonstrated more violations, in both simulator tasks and real road driving, as well as higher scores of Driving Behavior Questionnaire (DBQ) violations and more Balloon Analogue Risk Task (BART) pumps. These high-risk drivers also showed distinguishable behavioral patterns in simulator driving, moderated by the specific driving situations (e.g. scenario and scene). Several behavior assessments were consistently distinguishable in all tested situations, qualified as robust indicators to predict risk-taking in more general driving situations.

- **Keywords:** Risky driving; Simulator; Decision-making; Behavioral patterns

A.C. Novak, V. Komisar, B.E. Maki, G.R. Fernie. *Age-related differences in dynamic balance control during stair descent and effect of varying step geometry. Pages 275-284.*

The incidence of stairway falls and related injuries remains persistently high; however, the risk of stair injuries could be reduced through improved stairway design. The current study investigated dynamic balance control during stair descent and the effects of varying the step geometry. Data were collected from 20 healthy young and 20 older adults as they descended three staircases (riser heights of 7, 7.5 and 8 inches (178, 190 and 203 mm, respectively)). At each riser height, the tread run length was varied between 8 and 14 inches (203 mm and 356 mm) in one-inch (25 mm) increments. Kinematic data provided measures of segmental and whole-body dynamic control. Results demonstrated that older adults had greater lateral tilt of the upper body than young adults, but actually had larger margins of stability than the young in the antero-posterior direction as a result of their slower cadence. Nonetheless, for both age groups, the longer run lengths were found to provide the largest margins of stability. In addition, increase in run length and decrease in riser height tended to reduce forward upper body

tilt. These results help to explain the underlying biomechanical factors associated with increased risk of falls and the relationship with step geometry. Considering the importance of stair ambulation in maintaining independence and activity in the community, this study highlights the definite need for safer stair design standards to minimize the risk of falls and increase stair safety across the lifespan.

- **Keywords:** Stair ambulation; Kinematics; Dynamic balance; Ageing

Gregory D. Roach, Nicole Lamond, Drew Dawson. *Feedback has a positive effect on cognitive function during total sleep deprivation if there is sufficient time for it to be effectively processed.* Pages 285-290.

This study examined whether the provision of feedback and the interval between successive stimuli interact to affect performance on a serial simple reaction time test during sleep deprivation. Sixteen participants (9 female, 7 male, aged 18–27 yr) completed four versions of the 5-min psychomotor vigilance task for a handheld personal digital assistant (PalmPVT) every 2 h during 28 h of sustained wakefulness. The four versions differed in terms of whether or not they provided feedback immediately after each response, and whether the inter-stimulus intervals (ISIs) were long (2–10 s) or short (1–5 s). Cognitive function was assessed using reciprocal response time and percentage of responses that were lapses (i.e., had a response time \geq 500 ms). Data were analysed using repeated measures ANOVA with three within-subjects factors: test session, feedback, and ISI. For both measures, the only significant interaction was between feedback and ISI. Cognitive function was enhanced by feedback when the ISIs were long because it provided motivation. Cognitive function was not affected by feedback when the ISIs were short because there was insufficient time to both attend to the feedback and prepare for the subsequent stimulus.

- **Keywords:** Fatigue; Sustained wake; Psychomotor vigilance task; Inter-stimulus interval; Response time; Lapse

Andreas Sonderegger, Sven Schmutz, Juergen Sauer. *The influence of age in usability testing.* Pages 291-300.

The effects of age in usability testing were examined in an experiment. Sixty users from two age groups (M = 23.0 yrs, M = 58.1 yrs) operated two technical devices (keyboard-based and touchscreen-based smartphones). In addition to various performance measures (e.g. task completion time, task completion rate), several subjective measures were taken (e.g. perceived usability, affect, and workload). The results showed better performance scores for younger adults than older adults for task completion time. For older adult users there was a mismatch between usability ratings and task completion time but not between usability ratings and task completion rate. Age-related differences in the importance of speed and accuracy in task completion point to the need to consider more strongly the factor user age in usability research and practice.

- **Keywords:** Usability; Age; User experience; Performance; Affect

Naseem Ahmadpour, Jean-Marc Robert, Gitte Lindgaard. *Aircraft passenger comfort experience: Underlying factors and differentiation from discomfort.* Pages 301-308.

Previous studies defined passengers' comfort based on their concerns during the flight and a set of eight experiential factors such as 'peace of mind', 'physical wellbeing', 'pleasure', etc. One Objective of this paper was to determine whether the factors underlying the passengers' experience of comfort differ from those of discomfort. Another objective was to cross-validate those factors. In the first study, respondents provided

written reports of flight comfort and discomfort experiences separately and gave ratings on the impact of the eight factors on each experience. Follow up interviews were also conducted. Significant difference was found between comfort and discomfort ratings for two factors of 'pleasure', denoted by one's concern for stimulation, ambience and exceeded expectations, and 'physical wellbeing' characterized in terms of bodily support and energy. However, there were no significant differences between the comfort and discomfort ratings on the other six factors. The evidence does not support the proposition that passenger comfort and discomfort are underlined by different sets of factors. It is therefore suggested that the evaluation of overall passenger comfort experience, as a whole, employ one spectrum ranging from extreme comfort to discomfort. In study two, a pool of comfort descriptors was collected. Those that were less relevant to passenger comfort were eliminated in a number of steps. Factor analysis was used to classify the remaining descriptors, using respondents' ratings on their potential impact on passenger comfort. Seven factors corresponded to the pre-determined passenger comfort factors from previous research, validating those with an exception of 'proxemics' (concerning one's privacy and control over their situation) but it was argued that this is due to the nature of the factor itself, which is context dependent and generally perceived unconsciously.

- **Keywords:** Passenger; Comfort; Discomfort; Experience; Aircraft interior

Kenneth Nemire, Daniel A. Johnson, Keith Vidal. *The science behind codes and standards for safe walkways: Changes in level, stairways, stair handrails and slip resistance. Pages 309-316.*

Walkway codes and standards are often created through consensus by committees based on a number of factors, including historical precedence, common practice, cost, and empirical data. The authors maintain that in the formulation of codes and standards that impact pedestrian safety, the results of pertinent scientific research should be given significant weight. This article examines many elements of common walkway codes and standards related to changes in level, stairways, stair handrails, and slip resistance. It identifies which portions are based on or supported by empirical data; and which could benefit from additional scientific research. This article identifies areas in which additional research, codes, and standards may be beneficial to enhance pedestrian safety.

- **Keywords:** Fall; Pedestrian; Safety

J. Liebrechts, M. Sonne, J.R. Potvin. *Photograph-based ergonomic evaluations using the Rapid Office Strain Assessment (ROSA). Pages 317-324.*

The Rapid Office Strain Assessment (ROSA) was developed to assess musculoskeletal disorder (MSD) risk factors for computer workstations. This study examined the validity and reliability of remotely conducted, photo-based assessments using ROSA. Twenty-three office workstations were assessed on-site by an ergonomist, and 5 photos were obtained. Photo-based assessments were conducted by three ergonomists. The sensitivity and specificity of the photo-based assessors' ability to correctly classify workstations was 79% and 55%, respectively. The moderate specificity associated with false positive errors committed by the assessors could lead to unnecessary costs to the employer. Error between on-site and photo-based final scores was a considerable ~2 points on the 10-point ROSA scale (RMSE = 2.3), with a moderate relationship ($\rho = 0.33$). Interrater reliability ranged from fairly good to excellent (ICC = 0.667–0.856) and was comparable to previous results. Sources of error include the parallax effect, poor estimations of small joint (e.g. hand/wrist) angles, and boundary errors in postural binning. While this method demonstrated potential validity, further improvements should be made with respect to photo-collection and other protocols for remotely-based ROSA assessments.

- **Keywords:** Office ergonomics; Photo-based assessments; Rapid Office Strain Assessment (ROSA)

Leandro da Silva-Sauer, Luis Valero-Aguayo, Alejandro de la Torre-Luque, Ricardo Ron-Angevin, Sergio Varona-Moya. *Concentration on performance with P300-based BCI systems: A matter of interface features.* Pages 325-332.

People who suffer from severe motor disabilities have difficulties to communicate with others or to interact with their environment using natural, i.e., muscular channels. These limitations can be overcome to some extent by using brain-computer interfaces (BCIs), because such systems allow users to communicate on the basis of their brain activity only. Among the several types of BCIs for spelling purposes, those that rely on the P300 event related potential—P300-based spellers—are chosen preferentially due to their high reliability. However, they demand from the user to sustain his/her attention to the desired character over a relatively long period of time. Therefore, the user's capacity to concentrate can affect his/her performance with a P300-based speller. The aim of this study was to test this hypothesis using three different interfaces: one based on the classic P300 speller paradigm, another also based on that speller but including a word predictor, and a third one that was based on the T9 interface developed for mobile phones. User performance was assessed by measuring the time to complete a spelling task and the accuracy of character selection. The d2 test was applied to assess attention and concentration. Sample (N = 14) was divided into two groups basing on of concentration scores. As a result, performance was better with the predictor-enriched interfaces: less time was needed to solve the task and participants made fewer errors ($p < .05$). There were also significant effects of concentration ($p < .05$) on performance with the standard P300 speller. In conclusion, the performance of those users with lower concentration level can be improved by providing BCIs with more interactive interfaces. These findings provide substantial evidence in order to highlight the impact of psychological features on BCI performance and should be taken into account for future assistive technology systems.

- **Keywords:** Brain-computer interfaces; P300; Speller; Concentration; Attention; Word predictor

Alain Chavallaz, David Wastell, Jürgen Sauer. *System reliability, performance and trust in adaptable automation.* Pages 333-342.

The present study examined the effects of reduced system reliability on operator performance and automation management in an adaptable automation environment. 39 operators were randomly assigned to one of three experimental groups: low (60%), medium (80%), and high (100%) reliability of automation support. The support system provided five incremental levels of automation which operators could freely select according to their needs. After 3 h of training on a simulated process control task (AutoCAMS) in which the automation worked infallibly, operator performance and automation management were measured during a 2.5-h testing session. Trust and workload were also assessed through questionnaires. Results showed that although reduced system reliability resulted in lower levels of trust towards automation, there were no corresponding differences in the operators' reliance on automation. While operators showed overall a noteworthy ability to cope with automation failure, there were, however, decrements in diagnostic speed and prospective memory with lower reliability.

- **Keywords:** Reliability; Adaptable automation; Performance; Trust

**Jace Drain, Daniel Billing, Daniel Neesham-Smith, Brad Aisbett.
Predicting physiological capacity of human load carriage – A review.
Pages 85-94.**

This review article aims to evaluate a proposed maximum acceptable work duration model for load carriage tasks. It is contended that this concept has particular relevance to physically demanding occupations such as military and firefighting. Personnel in these occupations are often required to perform very physically demanding tasks, over varying time periods, often involving load carriage. Previous research has investigated concepts related to physiological workload limits in occupational settings (e.g. industrial). Evidence suggests however, that existing (unloaded) workload guidelines are not appropriate for load carriage tasks. The utility of this model warrants further work to enable prediction of load carriage durations across a range of functional workloads for physically demanding occupations. If the maximum duration for which personnel can physiologically sustain a load carriage task could be accurately predicted, commanders and supervisors could better plan for and manage tasks to ensure operational imperatives were met whilst minimising health risks for their workers.

- **Keywords:** Load carriage; Relative task intensity; Physiological work capacity