

## **Applied Ergonomics - rok 2012, ročník 43**

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#### **Harshada Patel, Michael Pettitt, John R. Wilson. *Factors of collaborative working : a framework for a collaboration model.* Pages 1-26.**

The ability of organisations to support collaborative working environments is of increasing importance as they move towards more distributed ways of working. Despite the attention collaboration has received from a number of disparate fields, there is a lack of a unified understanding of the component factors of collaboration. As part of our work on a European Integrated Project, CoSpaces, collaboration and collaborative working and the factors which define it were examined through the literature and new empirical work with a number of partner user companies in the aerospace, automotive and construction sectors. This was to support development of a descriptive human factors model of collaboration – the CoSpaces Collaborative Working Model (CCWM). We identified seven main categories of factors involved in collaboration: Context, Support, Tasks, Interaction Processes, Teams, Individuals, and Overarching Factors, and summarised these in a framework which forms a basis for the model. We discuss supporting evidence for the factors which emerged from our fieldwork with user partners, and use of the model in activities such as collaboration readiness profiling.

- **Keywords:** Collaboration; Collaborative work; Virtual teams; Collaborative engineering; CoSpaces collaborative working model

#### **Denis Alves Coelho, Sven Dahlman. *Articulation at shoulder level : a pilot experimental study on car seat comfort.* Pages 27-37.**

This article reports on a pilot experimental study aimed at a first evaluation of the introduction of an articulation in the upper part of the seat backrest. The idea of introducing this articulation sprang from prevention of whiplash injuries and this study tentatively assesses its potential for improvement in comfort. This was done considering a pre-defined articulation height. A height for the articulation of 43.5 cm above the H-point of a reference seat was theoretically deduced based on a population with an average sitting height of 88 cm. Participants evaluated the articulated seat in comparison with the reference seat. Twelve participants were divided into three groups of sitting height. In a laboratory environment subjective comfort evaluations and preferred values of deployment of the articulation and of counter-tilting of the headrest were registered. Driving on the roads completed and validated the laboratory assessments. The reference seat was deemed less comfortable for the participants with short and medium sitting height than for the tall ones. There was a notable improvement in comfort for most of

the medium and short sitting height participants when using the articulated seat. The articulation was fully deployed by most participants.

- **Keywords:** Car seat backrest; Seat comfort; Road driving

**Richard McMaster, Chris Baber. *Multi-agency operations : cooperation during flooding. Pages 38-47.***

This paper presents an investigation of command and control during Multi-Agency Operations; the purpose of this study was to elaborate on known themes associated with multi-agency emergency response, through a study of the successful combined military and civilian defence of Walham electricity substation from rising flood water in July 2007. This case study demonstrates that effective coordination during major emergencies requires the development of a deeper, shared understanding of the incident and a high level of trust between responding organisations, both of which are effortful to achieve and difficult to support with current communications systems. Adoption of a sociotechnical systems approach during the development process may enable future communications systems to support these important social processes.

- **Keywords:** Command and control; Communications; Emergency services; Sociotechnical systems

**Martin C. Cölln, Kerstin Kusch, Jens R. Helmert, Petra Kohler, Boris M. Velichkovsky, Sebastian Pannasch. *Comparing two types of engineering visualizations : task-related manipulations matter. Pages 48-56.***

This study focuses on the comparison of traditional engineering drawings with a CAD (computer aided design) visualization in terms of user performance and eye movements in an applied context. Twenty-five students of mechanical engineering completed search tasks for measures in two distinct depictions of a car engine component (engineering drawing vs. CAD model). Besides spatial dimensionality, the display types most notably differed in terms of information layout, access and interaction options. The CAD visualization yielded better performance, if users directly manipulated the object, but was inferior, if employed in a conventional static manner, i.e. inspecting only predefined views. An additional eye movement analysis revealed longer fixation durations and a stronger increase of task-relevant fixations over time when interacting with the CAD visualization. This suggests a more focused extraction and filtering of information. We conclude that the three-dimensional CAD visualization can be advantageous if its ability to manipulate is used.

- **Keywords:** Eye movements; Engineering drawing; CAD viewer

**Kuo-Wei Lee, Ying-Chu Lee. *Design and validation of an improved graphical user interface with the 'Tool ball'. Pages 57-68.***

The purpose of this research is introduce the design of an improved graphical user interface (GUI) and verifies the operational efficiency of the proposed interface. Until now, clicking the toolbar with the mouse is the usual way to operate software functions. In our research, we designed an improved graphical user interface – a tool ball that is operated by a mouse wheel to perform software functions. Several experiments are conducted to measure the time needed to operate certain software functions with the traditional combination of “mouse click + tool button” and the proposed integration of “mouse wheel + tool ball”. The results indicate that the tool ball design can accelerate the speed of operating software functions, decrease the number of icons on the screen, and enlarge the applications of the mouse wheel.

- **Keywords:** Graphical user interface; Mouse wheel; Software; Tool ball

**José Pérez-Alonso, Ángel Carreño-Ortega, Fernando J. Vázquez-Cabrera, Ángel Jesús Callejón-Ferre. *Accidents in the greenhouse-construction industry of SE Spain. Pages 69-80.***

This work analyses the labour accidents in the greenhouse-construction industry of SE Spain for the period 1999–2007 through a sample of 180 accident reports. The accidents were characterised by studying 5 variables in order to know the day of the week in which the accident occurred, the hour of the day of the accident, type of accident, the region of Spain in which the accident happened, and the resulting injury. The data characterising the accidents were submitted to a descriptive multiple-correspondence analysis. The incidence of accidents in the greenhouse-construction industry presented a high mean

value of 15133.7 per 100 000 workers per year. The days with the greatest incidence of

accidents were Thursday and Monday, while the period of greatest number of accidents occurred in the first 4 h of the workday. No significant correspondence was found between the day of the week, the hour of the day, or any of the other 3 variables studied. The types of accidents with most frequency were: cuts, punctures, contact with hard or rough material, overexertion, and falls from one level to another. The most affected parts of the anatomy were the eyes, thorax, back, sides, lower legs, and feet. The most common types of injury were bone fractures, twists and sprains, distended muscles, contusions, and being crushed. The study calls attention to the high number of accidents at work, which needs to be corrected by fulfilment of safety regulations at work, on the part of the company. Finally, recommendations are made to correct this situation of high number of accidents at work.

- **Keywords:** Accidents; Construction; Greenhouses; Safety; Incidence rate

**Javier Roca, Cándida Castro, Mercedes Bueno, Sergio Moreno-Ríos. *A driving-emulation task to study the integration of goals with obligatory and prohibitory traffic signs. Pages 81-88.***

This research aims to analyse how drivers integrate the information provided by traffic signs with their general goals (i.e. where they want to go). Some previous studies have evaluated the comparative advantages of obligatory and prohibitory traffic signs using a judgement task. In this work, a new experimental task with greater similarity to driving situations is proposed. Participants imagine they are driving a vehicle and must make right or left turn manoeuvres according to a previously indicated objective and the information from obligatory and prohibitory traffic signs. Eighty-two participants took part in two different experiments. According to the results, an obligatory traffic sign is associated with faster and more accurate responses only when the participant's initial objective is allowed. When the initial objective was not allowed, an advantage in accuracy was observed with prohibitory traffic signs and there was no significant difference in reaction time between the two types of sign. These results suggest that having an obligatory traffic sign may facilitate a correct response when the driver's goal is effectively allowed, whereas a prohibitory traffic sign could be more effective in preventing error when the driver has a not-allowed goal in mind. However, processing a prohibitory sign requires an extra inference (i.e. deciding which is the allowed manoeuvre), and thus the potential advantage in reaction time of the prohibitory sign may disappear. A second experiment showed that the results could not be explained by a potential congruency effect between the location (left or right) of the road signs and the position of the key or the hand used to respond (such as the Simon effect or the spatial Stroop effect). Also, an increase in the difficulty of the task (using an incongruent hand to respond) affected performance more strongly in experimental conditions that required making inferences. This made the advantage of the obligatory sign over the prohibitory

sign in this condition more noteworthy. The evidence gathered in the current study could be of particular interest in some applied research areas, such as the assessment of road traffic signalling strategies or the ergonomic design of GPS navigation systems.

- **Keywords:** Traffic signs; Navigation systems; Driver behaviour; Mental models; Mental representations

**Liam Chadwick, Enda F. Fallon. *Human reliability assessment of a critical nursing task in a radiotherapy treatment process. Pages 89-97.***

Radiotherapy treatment, like many other fields of medicine, has changed significantly in the last decade with the introduction of more advanced technology and automation. This change has often resulted in aspects of the system which cannot be automated due to technological feasibility and local implementation constraints. This has resulted in a requirement for significant human interaction. This combination of human operations and automation has introduced new error pathways. Traditionally, recommendations to improve the safety of such systems are typically made after the analysis of an adverse event or a significant series of incidents. In contrast, adopting a proactive approach to safety would enable prior identification of potential errors and the specification of appropriate defences against them, thus avoiding costs associated with adverse outcomes. In this paper, a modified version of the proactive Human Reliability Assessment (HRA) method Human Error Assessment and Reduction Technique (HEART) was used to analyse a critical nursing task within a modern radiotherapy system. The modified technique used a participative team approach to complete the assessment in contrast to the normal approach, which uses a single expert assessor. The HEART technique quantifies the likelihood of unreliability of a task and ranks the conditions which most affect the successful completion of that task. HEART has been proposed as a potentially useful HRA tool for applications in healthcare, but such applications have not previously been formally documented. As a result of the modified HEART analysis reported in this paper, remedial measures were identified which were both cost effective and easy to implement.

- **Keywords:** HEART; Radiotherapy; Human reliability assessment; Human error

**Michael Sonne, Dino L. Villalta, David M. Andrews. *Development and evaluation of an office ergonomic risk checklist : ROSA – Rapid office strain assessment. Pages 98-108.***

The Rapid Office Strain Assessment (ROSA) was designed to quickly quantify risks associated with computer work and to establish an action level for change based on reports of worker discomfort. Computer use risk factors were identified in previous research and standards on office design for the chair, monitor, telephone, keyboard and mouse. The risk factors were diagrammed and coded as increasing scores from 1 to 3. ROSA final scores ranged in magnitude from 1 to 10, with each successive score representing an increased presence of risk factors. Total body discomfort and ROSA final scores for 72 office workstations were significantly correlated ( $R = 0.384$ ). ROSA final scores exhibited high inter- and intra-observer reliability (ICCs of 0.88 and 0.91, respectively). Mean discomfort increased with increasing ROSA scores, with a significant difference occurring between scores of 3 and 5 (out of 10). A ROSA final score of 5 might therefore be useful as an action level indicating when immediate change is necessary. ROSA proved to be an effective and reliable method for identifying computer use risk factors related to discomfort.

- **Keywords:** Office ergonomics; Checklists; Risk assessment

**David R. Mullineaux, Stacy M. Underwood, Robert Shapiro, John W. Hall. *Real-time biomechanical biofeedback effects on top-level rifle shooters.* Pages 109-114.**

The aim was to examine the effects of training with real-time biomechanical biofeedback on technique and performance of rifle shooters. Top-level shooters were randomly assigned to biofeedback- ( $n = 5$ ) and control- ( $n = 4$ ) groups. Bi-weekly training of 20 shots air-rifle for 4 weeks, with pre- and post-tests of 20 shots air-rifle and smallbore, were performed. The biofeedback group received individualized real-time auditory biofeedback on postural- and barrel-stabilities. Results revealed a technique of reducing postural- and barrel-stabilities towards triggering (e.g. barrel speed  $8.0 \pm 1.2$  mm/s at 3.0–1.0 s reducing to  $5.4 \pm 0.8$  mm/s at 0.3–0.1 s). There were no changes pre- to post-tests and no differences between groups in these measures of stability. The biofeedback group showed meaningful improvements in performance measures, whereas the control group showed no improvement (e.g. smallbore shot group diameter change: biofeedback group  $-2.6$  mm; control group  $0.1$  mm). Biomechanical biofeedback is proposed to have improved performance, possibly through training better decision making, but the actual cause requires further research.

- **Keywords:** Biofeedback; Performance; Stability

**Xu Xu, Chien-Chi Chang, Gert S. Faber, Idsart Kingma, Jack T. Dennerlein. *Estimation of 3-D peak L5/S1 joint moment during asymmetric lifting tasks with cubic spline interpolation of segment Euler angles.* Pages 115-120.**

Previous research proposed a method using interpolation of the joint angles in key frames extracted from a field-survey video to estimate the dynamic L5/S1 joint loading for symmetric lifting tasks. The advantage of this method is that there is no need to use unwieldy equipment for capturing full body movement for the lifting tasks. The current research extends this method to asymmetric lifting tasks. The results indicate that 4-point cubic spline interpolation of segment Euler angles combined with a biomechanical model can provide a good estimation of 3-D peak L5/S1 joint moments for asymmetric lifting tasks. The average absolute error in the coronal, sagittal, and transverse planes with respect to the local pelvis axes was 16 N m, 22 N m, and 11 N m, respectively. It was also found that the dynamic component of the peak L5/S1 joint moment was not monotonously convergent when the number of interpolation points was increased. These results can be helpful for developing applied ergonomic field-survey tools such as video bases systems for estimating L5/S1 moments of manual materials handling tasks.

- **Keywords:** Lifting tasks; 3-D L5/S1 joint moments; Interpolation; Euler angles

**Caroline Damecour, Mohammad Abdoli-Eramaki, Ahmad Ghasempoor, Joan Stevenson. *Comparison of three strategies of trunk support during asymmetric two-handed reach in standing.* Pages 121-127.**

No trunk support (NTS) was compared to a lower trunk support (LTS) of leaning against a worktable and a dynamic upper trunk support (UTS) using postural kinematics, trunk extensor muscle activity and subjective rating of both comfort and effort. Ten females completed 3 repetitions where they lifted 0 and 5 kg load from a symmetrical position at hip-height to a  $45^\circ$  asymmetric position at: i) hip-height and ii) shoulder-height. Human motion capture showed trunk flexion decreased by  $12^\circ \pm 10$  with trunk support with hip-height reach. The table blocked axial rotation of the pelvis which was compensated by an additional  $8^\circ \pm 6$  rotation of the thoracic segment. Surface EMG of the lumbar erector spinae, contralateral to reach, showed the UTS to be almost twice as effective as the LTS with shoulder-height reach with a  $30\% \pm 18$  reduction. With hip-height reach, UTS

resulted in a smaller reduction equal to  $23\% \pm 27$  while the LTS had no effect. Further investigation is needed to determine optimal performance parameters for trunk support with complex, dynamic trunk postures and whether altered kinematics arising from LTS have higher risk of upper back discomfort.

- **Keywords:** Standing work; Trunk support; Reach; Low back; Ergonomics; Assistive device

**Alan H.S. Chan, Errol R. Hoffmann. *Movement compatibility for configurations of displays located in three cardinal orientations and ipsilateral, contralateral and overhead controls.* Pages 128-140.**

Stereotype strength and reversibility were determined for displays that were in the Front, Right and Left orientations relative to the operator, along with rotary, horizontally and vertically-moving controls located in the overhead, left-sagittal and right-sagittal planes. In each case, responses were made using the left and right hands. The arrangements used were (i) rotary control with a circular display (ii) horizontal/transverse control moving forward/rearward in the left and right-sagittal planes or transversely in the overhead plane and (iii) vertical/longitudinal control moving vertically in the left and right-sagittal planes and longitudinally in the overhead plane. These are all combinations not previously researched. Stereotype strength varied with display plane, type of control and plane of control. Models for the stereotype strength are developed, showing the contribution of various components to the overall stereotype strength. The major component for horizontally-moving controls comes from the "visual field" model of Worringham and Beringer (1998); for the rotary control important factors are "clockwise-for-clockwise" and the hand/control location effect (Hoffmann, 2009a). Vertically-moving controls are governed by a simple 'up-for-up' relationship between displays and controls. Overall stereotype strength is a maximum when all components add positively.

- **Keywords:** Movement stereotypes; Control/display; Stereotype components

**Shih-Miao Huang. *The rating consistency of aesthetic preferences for icon-background color combinations.* Pages 141-150.**

This study explored the degree of rating consistency for different icon-background color combinations, and identified the color combinations with the highest rating for consistency. Rating consistency is the degree of agreement among subjective aesthetic preferences for a specific color combination. In total, 3306 color combinations were rated in this study. The standard deviation of each color combination was calculated as the performance measure for assessing rating consistency among subjects for each color combination. Analysis of variance (ANOVA) results demonstrated that the gender effect was insignificant and rating consistency was very low for both males and females. Furthermore, the experimental results showed that the color combinations affected rating consistency. Hence, cluster analysis with non-hierarchical procedures was then used to categorize color combinations via the clustering variable, the standard deviation of aesthetic preference ratings. Few color combinations in clusters had an extremely high rating consistency. The results indicated that the degree of rating consistency among subjects varied with color combinations. Therefore, using a single average of user aesthetic preference scores may not be appropriate for application to color combinations. Finally, the 30 color combinations determined experimentally can be used as default color combinations as the color scheme for an interface that can be changed because they have consistently high preference scores.

- **Keywords:** Color combination; Rating consistency; Aesthetic preference

**Der-Song Lee. *Preferred viewing distance of liquid crystal high-definition television.* Pages 151-156.**

This study explored the effect of TV size, illumination, and viewing angle on preferred viewing distance in high-definition liquid crystal display televisions (HDTV). Results showed that the mean preferred viewing distance was 2856 mm. TV size and illumination significantly affected preferred viewing distance. The larger the screen size, the greater the preferred viewing distance, at around 3–4 times the width of the screen (W). The greater the illumination, the greater the preferred viewing distance. Viewing angle also correlated significantly with preferred viewing distance. The more deflected from direct frontal view, the shorter the preferred viewing distance seemed to be.

- **Keywords:** Liquid crystal display high-definition television; Preferred viewing distance; TV size; Illumination; Viewing angle

**Takanori Chihara, Koetsu Yamazaki. *Evaluation function of drinking ease from aluminum beverage bottles relative to optimum bottle opening diameter and beverage type.* Pages 157-165.**

In recent years, aluminum beverage bottles having screw tops with opening diameters of 28 and 38 mm have been launched in the Japanese market in keeping with the modern-day drinking habits of consumers. Although Japanese consumers are familiar with such bottles, a majority of them feel that the 28 mm opening is too small and the 38 mm opening is too large. Therefore, we felt the need to develop a method for evaluating consumer feelings when they drink a beverage directly from the bottle opening. For this purpose, we propose an evaluation function of drinking ease that calculates the optimum opening diameter of the bottle. From results of our previous study, we know that there exists an ideal volume of beverage flowing into the mouth, at which consumers feel most comfortable while drinking directly from bottles. Therefore, we define the evaluation function of drinking ease in terms of the difference between the actual volume of fluid in the mouth and the expected ideal volume. If this difference is small, consumers probably feel comfortable while drinking the beverage. We consider a design variable, i.e., the opening diameter, and two state variables, i.e., the volume of beverage remaining in the bottle and the height of consumers, and construct the response surface of the evaluation function by using radial basis function networks. In addition, for investigating the influence of beverage type on the evaluation function, we select green tea and a carbonated beverage (Coke) as test beverages. Results of optimization of the proposed function show that when the opening diameters are 35.4 mm and 34.4 mm in the case of green tea and Coke, respectively, the actual volume of fluid in the mouth is closest to the ideal volume and the participants feel most comfortable. These results are in agreement with results of our previous study that an opening diameter of 33 mm is optimum for young Japanese adults. Thus, we confirm that the proposed function is accurate; it can be used to design bottle openings to suit consumers of various age groups and types of beverages.

- **Keywords:** Ergonomics; Drinking ease; Optimization; Aluminum beverage bottle

**Donghun Lee, Sunghyuk Kwon, Min K. Chung. *Effects of user age and target-expansion methods on target-acquisition tasks using a mouse.* Pages 166-175.**

Target expansion, i.e., the increase of target size according to cursor movement, can be a practical scheme to improve the usability of target-selection tasks using a mouse. This study examined the effects of different user age groups and target-expansion methods on target-acquisition tasks with grouped icons. Twenty-eight subjects performed acquisition tasks under eight experimental conditions: combinations of four expansion areas (no, one-icon, fish-eye, and group expansion) and two expansion techniques (occlusion and push). Older users took longer to acquire targets than younger users; however, they showed no significant difference in accuracy. Target expansion did not substantially improve performance speed compared to the static condition. However, the

error rate was lowest when group area was expanded with the push technique, and both age groups were most satisfied with one-icon area expansion with the occlusion technique. We suggest alternative guidelines in designing target-expansion schemes.

- **Keywords:** Target expansion; Target acquisition; Older adults

**M.A. Sinclair, C.E. Siemieniuch, R.A. Haslam, M.J.d.C. Henshaw, L. Evans. *The development of a tool to predict team performance. Pages 176-183.***

The paper describes the development of a tool to predict quantitatively the success of a team when executing a process. The tool was developed for the UK defence industry, though it may be useful in other domains. It is expected to be used by systems engineers in initial stages of systems design, when concepts are still fluid, including the structure of the team(s) which are expected to be operators within the system. It enables answers to be calculated for questions such as "What happens if I reduce team size?" and "Can I reduce the qualifications necessary to execute this process and still achieve the required level of success?". The tool has undergone verification and validation; it predicts fairly well and shows promise. An unexpected finding is that the tool creates a good a priori argument for significant attention to Human Factors Integration in systems projects. The simulations show that if a systems project takes full account of human factors integration (selection, training, process design, interaction design, culture, etc.) then the likelihood of team success will be in excess of 0.95. As the project derogates from this state, the likelihood of team success will drop as low as 0.05. If the team has good internal communications and good individuals in key roles, the likelihood of success rises towards 0.25. Even with a team comprising the best individuals, p(success) will not be greater than 0.35. It is hoped that these results will be useful for human factors professionals involved in systems design.

- **Keywords:** Methodology; Performance prediction; Small groups

**Jennifer L. Martin, Daniel J. Clark, Stephen P. Morgan, John A. Crowe, Elizabeth Murphy. *A user-centred approach to requirements elicitation in medical device development : a case study from an industry perspective. Pages 184-190.***

The healthcare industry is dependent upon the provision of well designed medical devices. To achieve this it is recommended that user-centred design should begin early, and continue throughout device development. This is a challenge, particularly for smaller companies who may lack the necessary expertise and knowledge. The aim of this study was to conduct a rigorous yet focused investigation into the user requirements for a new medical imaging device. Open-ended semi-structured interviews were conducted with potential clinical users of the device to investigate the clinical need for the device and the potential benefits for patients and clinical users. The study identified a number of new and significant clinical needs that suggested that the concept of the device should be fundamentally changed. The clinical and organisational priorities of the clinical users were identified, as well as a number of factors that would act as barriers to the safe and effective adoption of the device. The developers reported that this focused approach to early requirements elicitation would result in an improved product, reduce the time to market, and save the time and cost of producing and evaluating an inappropriate prototype.

- **Keywords:** User requirements; Medical device; Healthcare

**Cara Lord, Kevin Netto, Aaron Petersen, David Nichols, Jace Drain, Matthew Phillips, Brad Aisbett. *Validating 'fit for duty' tests for Australian volunteer fire fighters suppressing bushfires. Pages 191-197.***

Introduction: This study compared fire fighter's work-rates and performance between the Pack Hike Test (PHT), Field Walk Test (FWT) and critical bushfire suppression tasks. Methods: Nineteen volunteer fire fighters undertook the PHT, whilst a further 11 also performed the FWT. All 30 fire fighters completed four critical tasks. Physical, physiological and subjective ratings were measured during tasks and tests. Results: Peak and mean heart rate during the Hose Drag was lower than during the FWT. Mean velocities for the PHT and FWT were higher than in all tasks except Hose Drag. Finishing times in the PHT and FWT were strongly correlated with finishing times for three and four of the critical tasks. Conclusions: The PHT and FWT may be valid fit for duty tests for Australian rural fire fighters though the clear differences between the tests and some tasks may prompt fire agencies to consider other tests that more accurately simulate bushfire suppression work.

- **Keywords:** Pack hike test; Field walk test; Validity

**Jonathan R. Studnek, J. Mac Crawford, Antonio R. Fernandez. *Evaluation of occupational injuries in an urban emergency medical services system before and after implementation of electrically powered stretchers.* Pages 198-202.**

Musculoskeletal injuries are frequently reported among Emergency Medical Services (EMS) professionals. The objective of this study was to evaluate occupational injuries in an urban EMS system before and after implementation of hydraulic stretchers. Data for this analysis were obtained from Austin Travis County EMS (A/TCEMS). In December 2006, A/TCEMS placed into service electrically powered patient stretchers. The pre-intervention period was between 01/01/1999 and 12/31/2006, and the post-intervention period was between 01/01/2007 and 4/30/2008. Incidence rate calculations were performed for four injury sub-groups and rate ratios (RRs) and corresponding 95% confidence interval (CI) were presented. There were 2087 and 706 person-years of observation pre- and post-intervention, respectively. The incidence rates for overall injury pre-intervention and post-intervention were 61.1 and 28.8 per 100 FTE, with a corresponding RR of 0.47 (95% CI 0.41–0.55) indicating a significant decrease in the rate of injury. The subcategory of stretcher-related injuries had the lowest RR (0.30; 95% CI 0.17–0.52) when comparing pre- and post-intervention time periods.

- **Keywords:** Emergency medical services; Emergency medical technician; Occupational health; Back injuries

**Khaled Al-Rashidi, Dennis loveday, Nawaf Al-Mutawa, George Havenith. *A comparison of methods for assessing the thermal insulation value of children's schoolwear in Kuwait.* Pages 203-210.**

In this study, three methods were used to determine the thermal insulation values of different school clothing worn by 6 to 17 year old girls and boys in Kuwait classrooms for both summer and winter seasons. The different clothing ensembles' insulations were determined by 1: measurement using adult-sized versions of the clothing on thermal manikins, 2: estimations from adult clothing data obtained from the standards tables in ISO 9920 and ASHRAE 55, and 3: calculations using a regression equation from McCullough et al. (1985) that was adapted to accommodate children's sizes for ages 6–17 years. Values for the clothing area factor,  $f_{cl}$ , were also determined by measurement and by using a prediction equation from ISO 9920. Results in this study suggested that the clothing insulation values found from the measured and adapted data were similar to the adult's data in standards tables for the same summer and winter seasons. Further, the effect of the insulation values on the different scholars' age groups were investigated using the clothing temperature rating technique and compared to the scholars' comfort temperature found in recent field studies. Results showed that the temperature ratings of the clothing using the three methods described above are close and in agreement with

the scholars' comfort temperature. Though estimated and measured fcl data differed, the impact on the temperature ratings was limited. An observed secular change in the children's heights and weights in the last few decades implies that, for adolescents, the children's body surface areas are similar to those of adults, making the use of adult clothing tables even more acceptable. In conclusion, this study gives some evidence to support the applicability of using adults' data in ASHRAE 55 and ISO 9920 standards to assess the thermal insulation values of different children's clothing ensembles, provided that careful selection of the garments, ensembles material and design takes place.

- **Keywords:** Children; Kuwait; School; Temperature rating; Thermal insulation; Thermal manikin

**Gook-Sup Song, Jae-Han Lim, Tae-Kyung Ahn. *Air conditioner operation behaviour based on students' skin temperature in a classroom.* Pages 211-216.**

A total of 25 college students participated in a study to determine when they would use an air conditioner during a lecture in a university classroom. The ambient temperature and relative humidity were measured 75 cm above the floor every minute. Skin temperatures were measured every minute at seven points, according to the recommendation of Hardy and Dubois. The average clothing insulation value (CLO) of subjects was  $0.53 \pm 0.07$  CLO. The mean air velocity in the classroom was  $0.13 \pm 0.028$  m/s. When the subjects turned the air conditioner both on and off, the average ambient temperatures, relative humidity and mean skin temperatures were 27.4 and 23.7 °C ( $p = 0.000$ ), 40.9 and 40.0% ( $p = 0.528$ ) and 32.7 and 32.2 °C ( $p = 0.024$ ), respectively. When the status of the air conditioner was changed, the differences of skin temperatures in core body parts (head, abdomen and thigh) were not statistically significant. However, in the extremities (mid-lower arm, hand, shin and instep), the differences were statistically significant. Subjects preferred a fluctuating environment to a constant temperature condition. We found that a changing environment does not affect classroom study.

- **Keywords:** Thermal behaviour; Air conditioner; Skin temperature; Classroom

**Hillevi Hemphälä, Jörgen Eklund. *A visual ergonomics intervention in mail sorting facilities : effects on eyes, muscles and productivity.* Pages 217-229.**

Visual requirements are high when sorting mail. The purpose of this visual ergonomics intervention study was to evaluate the visual environment in mail sorting facilities and to explore opportunities for improving the work situation by reducing visual strain, improving the visual work environment and reducing mail sorting time. Twenty-seven postmen/women participated in a pre-intervention study, which included questionnaires on their experiences of light, visual ergonomics, health, and musculoskeletal symptoms. Measurements of lighting conditions and productivity were also performed along with eye examinations of the postmen/women. The results from the pre-intervention study showed that the postmen/women who suffered from eyestrain had a higher prevalence of musculoskeletal disorders (MSD) and sorted slower, than those without eyestrain. Illuminance and illuminance uniformity improved as a result of the intervention. The two post-intervention follow-ups showed a higher prevalence of MSD among the postmen/women with eyestrain than among those without. The previous differences in sorting time for employees with and without eyestrain disappeared. After the intervention, the postmen/women felt better in general, experienced less work induced stress, and considered that the total general lighting had improved. The most pronounced decreases in eyestrain, MSD, and mail sorting time were seen among the younger participants of the group.

- **Keywords:** Lighting; Postmen; Sorting; Illuminance; MSD; Vision; Eyestrain

**Annie W.Y. Ng, Kin Wai Michael Siu, Chetwyn C.H. Chan. *The effects of user factors and symbol referents on public symbol design using the stereotype production method.* Pages 230-238.**

This study investigated the influence of user factors and symbol referents on public symbol design among older people, using the stereotype production method for collecting user ideas during the symbol design process. Thirty-one older adults were asked to draw images based on 28 public symbol referents and to indicate their familiarity with and ease with which they visualised each referent. Differences were found between the pictorial solutions generated by males and females. However, symbol design was not influenced by participants' education level, vividness of visual imagery, object imagery preference or spatial imagery preference. Both familiar and unfamiliar referents were illustrated pictorially without much difficulty by users. The more visual the referent, the less difficulty the users had in illustrating it. The findings of this study should aid the optimisation of the stereotype production method for user-involved symbol design.

- **Keywords:** Public symbol design; Stereotype production method; Symbol referents; User participation

**Diane Berthelette, Nicole Leduc, Henriette Bilodeau, Marie-Josée Durand, Cheikh Faye. *Evaluation of the implementation fidelity of an ergonomic training program designed to prevent back pain.* Pages 239-245.**

The aim of this study was to evaluate the implementation fidelity of a multidimensional ergonomic program designed to prevent back pain injuries among healthcare personnel. The program, provided by peer trainers included training intended to modify patient handling and transfer behaviour, trainee follow-up, prevention activities aimed at work environment improvements and follow-up monitors training. Two hundred twenty-one peer trainers at 139 Quebec healthcare institutions participated in our study. Only 61.5% were involved in training; most of them taught safe patient handling, positioning, transfer, and preparation techniques, which are the cornerstones of the program; 72.7% were involved in prevention activities, 46.1% in follow-up activities, and 10.7% in follow-up monitors training. The study results should help organizations anticipate and prevent potential discrepancies between prescribed and implemented programs.

- **Keywords:** Ergonomic program; Back pain; Evaluative research

**A. Lindegård, M. Gustafsson, G.-Å. Hansson. *Effects of prismatic glasses including optometric correction on head and neck kinematics, perceived exertion and comfort during dental work in the oral cavity : a randomised controlled intervention.* Pages 246-253.**

**Aim:** To quantify the effects of using prismatic glasses including optometric correction, on head and neck kinematics, perceived exertion and comfort, during work in the oral cavity. **Methods:** The study population consisted of forty-five participants. After a basic ergonomic education, baseline measurements of head and neck kinematics were made using inclinometers. Perceived exertion and comfort were rated by the participants. An intervention group (n = 25), selected at random from the participants, received prismatic glasses and optometric correction when needed and were compared with a control group (n = 20). Follow up assessments were made after the intervention. **Results:** At follow up there was a reduction in both the intervention group (8.7°) and in the control group (3.6°) regarding head flexion. Neck flexion was reduced by 8.2° in the intervention group and 3.3° in the control group. The difference between the intervention and the control groups, i.e. the effect of the intervention, was statistically significant for both head (5.1°;

p = 0.009) and neck (4.9°; p = 0.045) flexion. No effect of the intervention was seen regarding perceived exertion and comfort. Conclusion: The reduction in head and neck flexion achieved by the prismatic glasses is likely to reduce the risk of neck pain during dental work. The effect of the prismatic lenses could not be separated from the effect of the optometric correction. The possible effect of the ergonomic education was not evaluated.

- **Keywords:** Head; Neck; Inclinometry; Dental ergonomics

**Patrick Waterson, Cara Pilcher, Sian Evans, Jill Moore. *Developing safety signs for children on board trains.* Pages 254-265.**

Every year a number of young children are injured as a result of accidents that occur on board trains in Great Britain. These accidents range from being caught in internal doors, through to injuries caused by using seats. We describe our efforts to design a new set of safety signs in order to help prevent the occurrence of these types of accident. The research was funded under a Rail Safety and Standards Board (RSSB) managed UK Department for Transport research programme and was carried out in collaboration with Loughborough University. The study involved analysis of industry accident incidence data and running a set of classroom discussions with young school children (aged 5–10, n = 210). The classroom discussions initially involved showing them examples of a new design prototype sign alongside existing train signs and gathering the requirements for new designs. A second set of classroom discussions with these children was used to evaluate the new signs based on the outcomes from earlier discussions. We describe our findings alongside a set of outline guidelines for the design of safety signs for young children. A final section considers the main methodological and other lessons learnt from the study, alongside study limitations and possibilities for future research.

- **Keywords:** Warnings; Signs; Children; Safety; Railways