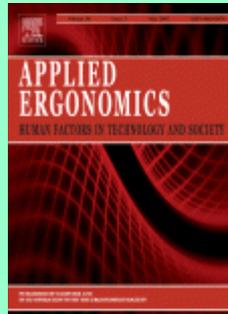


## **Applied Ergonomics - rok 2013, ročník 44**

### **Číslo 2 (March 2013)**



**Nikki S. Olsen. *Reliability studies of incident coding systems in high hazard industries: A narrative review of study methodology.* Pages 175-184.**

This paper reviews the current literature on incident coding system reliability and discusses the methods applied in the conduct and measurement of reliability. The search strategy targeted three electronic databases using a list of search terms and the results were examined for relevance, including any additional relevant articles from the bibliographies. Twenty five papers met the relevance criteria and their methods are discussed. Disagreements in the selection of methods between reliability researchers are highlighted as are the effects of method selection on the outcome of the trials. The review provides evidence that the meaningfulness of and confidence in results is directly affected by the methodologies employed by the researcher during the preparation, conduct and analysis of the reliability study. Furthermore, the review highlights the heterogeneity of methodologies employed by researchers measuring reliability of incident coding techniques, reducing the ability to critically compare and appraise techniques being considered for the adoption of report coding and trend analysis by client organisations. It is recommended that future research focuses on the standardisation of reliability research and measurement within the incident coding domain.

- **Keywords:** Reliability; Incident classification; Human error

**Biao Yang, Yandan Lin, Yaojie Sun. *Transient effects of harsh luminous conditions on the visual performance of aviators in a civil aircraft cockpit.* Pages 185-191.**

The aim of this work was to examine how harsh luminous conditions in a cockpit, such as lightning in a thunderstorm or direct sunlight immediately after an aircraft passes through clouds, may affect the visual performance of pilots, and how to improve it. Such lighting conditions can result in the temporary visual impairment of aviators, which may greatly increase the risk of accidents. Tests were carried out in a full-scale simulator cockpit in which two kinds of dynamic lighting scenes, namely pulse changed and step changed lighting, were used to represent harsh luminous conditions. Visual acuity (VA), reaction time (RT) and identification accuracy (IA) were recorded as dependent variables. Data analysis results indicate that standardized VA values decreased significantly in both pulsing and step conditions in comparison with the dark condition. Standardized RT values increased significantly in the step condition; on the contrary, less reaction time was observed in the pulsing condition. Such effects could be reduced by an ambient illumination provided by a fluorescent lamp in both conditions. The results are to be used as a principle for optimizing lighting design with a thunderstorm light.

- **Keywords:** Harsh luminous conditions; Visual performance; Aircraft cockpit

**Alberto Ranavolo, Romildo Don, Francesco Draicchio, Michelangelo Bartolo, Mariano Serrao, Luca Padua, Gianfranco Cipolla, Francesco Pierelli, Sergio Iavicoli, Giorgio Sandrini. *Modelling the spine as a deformable body: Feasibility of reconstruction using an optoelectronic system.* Pages 192-199.**

The aims of this study were to develop a kinematic model of the spine, seen as a continuous deformable body and to identify the smallest set of surface markers allowing adequate measurements of spine motion. The spine is widely considered as a rigid body or as a kinematic chain made up of a smaller number of segments, thereby introducing an approximation. It would be useful to have at our disposal a technique ensuring accurate and repeatable measurement of the shape of the whole spine. Ten healthy subjects underwent a whole-spine radiographic assessment and, simultaneously, an optoelectronic recording. Polynomial interpolations of the vertebral centroids, of the whole set of markers were performed. The similarity of the resulting curves was assessed. Our findings indicate that spine shape can be reproduced by 5th order polynomial interpolation. The best approximating curves are obtained from either 10- or 9-marker sets. Sagittal angles are systematically underestimated.

- **Keywords:** Spine modelling tool; Manual material handling; Kinematics

**Sandra Schwanitz, Martin Wittkowski, Vinzent Rolny, Mathias Basner. *Pressure variations on a train – Where is the threshold to railway passenger discomfort?* Pages 200-209.**

The implementation of recent guidelines for tunnel construction in Germany leads to extended air pressure variations inside trains and reduces pressure comfort for railway passengers. A questionnaire survey with 262 passengers revealed that pressure variations are rated less important for riding comfort than climatic and spatial aspects (study 1). A laboratory experiment (study 2) in the pressure chamber at the DLR Institute of Aerospace Medicine with 31 subjects (mean age = 37.7,  $SD = 12.7$ ; 51.6% male) investigated the effects of systematic pressure variations on discomfort. The pressure changes (pressure increases and decreases) ranged from 1 to 100 mbar and were realized within 1–100 s. We derived thresholds for healthy passengers by means of random effects linear and logistic regression analysis. Logistic dose–response curves revealed amplitude/time combinations leading to a certain percentage of passengers perceiving discomfort (e.g. 50% dissatisfied passengers regarding a pressure increase of approximately 30 mbar within 5 s). The findings may help design engineers to meet passengers' comfort requirements.

- **Keywords:** Pressure; Discomfort; Railway passenger

**Bartosz Bilski. *Exposure to audible and infrasonic noise by modern agricultural tractors operators.* Pages 210-214.**

The wheeled agricultural tractor is one of the most prominent sources of noise in agriculture. This paper presents the assessment of the operator's exposure to audible and infrasonic noise in 32 selected modern wheeled agricultural tractors designed and produced by world-renowned companies in normal working conditions. The tractors have been in use for no longer than 4 years, with rated power of 51 kW to up to 228 kW (as per 97/68 EC). Audible and infrasonic noise level measurements and occupational exposure analysis to noise were performed according to ISO 9612:2009 (strategy 1 – task-based measurements). The measurements were made in different typical work conditions inside and outside of tractors cabs.

The results indicated that exposure levels to noise perceived by the operators ( $L_{ex,Te}$  between 62,3 and 84,7 dB-A) and can make a small risk of potential adversely effects on hearing during tasks performed inside the closed cab. It should be remarked that uncertainty interval is wider and in in some conditions can occur transgression of audible noise occupational exposure limits. The measured audible noise levels can potentially develop the non-auditory effects. Analysed tractors emit considerable infrasonic noise levels that tend to exceed the occupational exposure limits (both inside and outside the driver's cab). The levels of infrasound: 83,8–111,4 dB-G. All tractors introduced for sale should be subjected to tests in terms of infrasonic noise levels. The applicable standards for low frequency noise and its measurement methods for vehicles, including agricultural tractors, should be scientifically revised. In the last years there has been a noticeable technical progress in reduction of audible noise exposure at the tractors operators workplaces with simultaneously lack of important works for limitation of exposure to infrasound. Author discuss possible health and ergonomic consequences of such exposure.

- **Keywords:** Tractors; Noise; Infrasound

**Noora Nenonen. *Analysing factors related to slipping, stumbling, and falling accidents at work: Application of data mining methods to Finnish occupational accidents and diseases statistics database.* Pages 215-224.**

The utilisation of data mining methods has become common in many fields. In occupational accident analysis, however, these methods are still rarely exploited. This study applies methods of data mining (decision tree and association rules) to the Finnish national occupational accidents and diseases statistics database to analyse factors related to slipping, stumbling, and falling (SSF) accidents at work from 2006 to 2007. SSF accidents at work constitute a large proportion (22%) of all accidents at work in Finland. In addition, they are more likely to result in longer periods of incapacity for work than other workplace accidents. The most important factor influencing whether or not an accident at work is related to SSF is the specific physical activity of movement. In addition, the risk of SSF accidents at work seems to depend on the occupation and the age of the worker. The results were in line with previous research. Hence the application of data mining methods was considered successful. The results did not reveal anything unexpected though. Nevertheless, because of the capability to illustrate a large dataset and relationships between variables easily, data mining methods were seen as a useful supplementary method in analysing occupational accident data.

- **Keywords:** Occupational accident; Data mining; Slip; Trip; Fall

**Robin Burgess-Limerick, Christine Zupanc, Guy Wallis. *Effect of control order on steering a simulated underground coal shuttle car.* Pages 225-229.**

Most terrestrial vehicles are steered via a first-order control for vehicle heading, such as a conventional steering wheel. A joystick which provides second-order control of vehicle heading is used to steer some underground coal shuttle cars. A desktop virtual simulation of the situation was employed to compare the steering accuracy of 24 novice participants randomly assigned to either first-order or second-order joystick steering conditions. The average steering accuracy of participants assigned to the first-order joystick condition was superior, however there was considerable individual variability and some participants assigned to the second-order steering condition were able to perform the task equally and successfully. Desktop virtual simulation may be a useful component of training and competency assessment for operators of these vehicles.

- **Keywords:** Control order; Joystick; Steering

**Steven A. Lavender, Pei-Ling Ko, Carolyn M. Sommerich. *Biomechanical evaluation of the Eco-Pick lift assist: A device designed to facilitate product selection tasks in distribution centers.* Pages 230-236.**

Developing lift assist devices to aid workers performing case tasks in distribution centers has been challenging given the movement of workers through a distribution facility. The objective of this work was to biomechanically evaluate a lift assist that can be integrated with pallet jacks and thereby move through the facility with the workers. Twelve participants transferred 16.4 kg boxes from one pallet to another manually and using the Eco-Pick lift assist. Electromyographic (EMG) activities were measured bilaterally in the Bicep, Deltoid, Latissimus Dorsi, and Erector Spinae muscles. The analysis showed that the 90th percentile normalized EMG values were significantly reduced in 4 of the 8 muscles sampled when using the Eco-Pick. Likewise, the 50th percentile normalized EMG data were significantly reduced for the Erector Spinae, Latissimus Dorsi, and the Bicep muscles when using the assist. For some of the muscles the advantage of the Eco-Pick was dependent upon the initial lift height or the placement height. Overall, it appears that this evaluation of the Eco-Pick's efficacy indicates that the device has the potential to be an effective means of reducing worker exposure to risk factors associated with back and shoulder injuries experienced during manual palletizing tasks found in distribution centers.

- **Keywords:** Lift assist; Back injury; Musculoskeletal disorders; Distribution centers

**Brittany Wood, Mark S. Rea, Barbara Plitnick, Mariana G. Figueiro. *Light level and duration of exposure determine the impact of self-luminous tablets on melatonin suppression.* Pages 237-240.**

Exposure to light from self-luminous displays may be linked to increased risk for sleep disorders because these devices emit optical radiation at short wavelengths, close to the peak sensitivity of melatonin suppression. Thirteen participants experienced three experimental conditions in a within-subjects design to investigate the impact of self-luminous tablet displays on nocturnal melatonin suppression: 1) tablets-only set to the highest brightness, 2) tablets viewed through clear-lens goggles equipped with blue light-emitting diodes that provided 40 lux of 470-nm light at the cornea, and 3) tablets viewed through orange-tinted glasses (dark control; optical radiation  $<525\text{ nm} \approx 0$ ). Melatonin suppressions after 1-h and 2-h exposures to tablets viewed with the blue light were significantly greater than zero. Suppression levels after 1-h exposure to the tablets-only were not statistically different than zero; however, this difference reached significance after 2 h. Based on these results, display manufacturers can determine how their products will affect melatonin levels and use model predictions to tune the spectral power distribution of self-luminous devices to increase or to decrease stimulation to the circadian system.

- **Keywords:** Melatonin; Electronic displays; Tablets

**Catarina Nordander, Kerstina Ohlsson, Ingrid Åkesson, Inger Arvidsson, Istvan Balogh, Gert-Åke Hansson, Ulf Strömberg, Ralf Rittner, Staffan Skerfving. *Exposure-response relationships in work-related musculoskeletal disorders in elbows and hands – A synthesis of group-level data on exposure and response obtained using uniform methods of data collection.* Pages 241-253.**

There is a serious lack of quantitative data regarding exposure-response relationships between occupational risk factors and musculoskeletal elbow and hand disorders. This

paper explores such relationships in group-level data from our earlier cross-sectional studies.

Prevalence of complaints (Nordic Questionnaire) and diagnoses (physical examination) were recorded in 19 groups of female workers (1891 individuals), and 8 groups of male workers (761 individuals), with highly similar work tasks within each group. Linear regression was performed on the group means of wrist postures and angular velocity (obtained by electrogoniometers), as well as muscular load (obtained using electromyography), recorded in representative sub-samples, and psychosocial exposure (Job Content Questionnaire). To tackle within-group variations in physical exposure, sensitivity analyses were performed by bootstrapping simulations, rendering confidence intervals.

The sex-adjusted slope of the regression line ( $\beta$ ) for wrist angular velocity vs. complaints during the past 7 days was 0.6%/( $^{\circ}$ /s), (95% CI 0.3–0.9), and for carpal tunnel syndrome (CTS) 0.2%/( $^{\circ}$ /s), (0.1–0.3). For palmar flexion, p50,  $\beta$  over the past 7 days was 0.8%/ $^{\circ}$  (0.4–1.2); for CTS 0.3%/ $^{\circ}$  (0.1–0.5);  $\beta$  for muscular activity p90: 0.9%/MVE (0.3–1.6), and 0.3%/MVE (–0.03–0.6) respectively and finally  $\beta$  for muscular rest: –1.2%/time (–2.4–0.03) and –0.5%/time (–0.9 to –0.01). Relationships were also demonstrated for low job control, job strain and isostrain. Women exhibited a higher prevalence of complaints than men.

In conclusion, we have established quantitative exposure–response relationships between physical work load and elbow/hand disorders. Wrist angular velocity was the most consistent risk factor.

- **Keywords:** Physical exposure; Wrist movements; Wrist postures

**Lora A. Cavuoto, Maury A. Nussbaum. *Obesity-related differences in muscular capacity during sustained isometric exertions. Pages 254-260.***

Over one-third of the world adult population is overweight or obese, and the prevalence continues to increase. Obesity is a risk factor for injury, and the growing prevalence may be associated with increases in the future incidence and cost of injuries. In this study, we examined obesity-related differences in muscular capacity during sustained isometric exertions involving hand grip, shoulder flexion, and trunk extension. Thirty-six young individuals who were obese or not obese (aged 18–29) completed these exertions at fixed levels of absolute loads involving low-moderate levels of effort. Individuals who were obese had an overall ~20% higher absolute strength, but ~20% lower relative strength. These differences were most evident in the hand grip and shoulder exertions. Parameters of fitted exponential relationships between endurance time and task demands (as a percentage of strength) were similar in both groups. Perceptual and performance responses were also consistent between groups. Accordingly, we conclude that obesity may not substantially influence muscular capacity for these tasks.

- **Keywords:** Obesity; Muscular capacity; Endurance

**Yu-Lin Hsiao, Colin Drury, Changxu Wu, Victor Paquet. *Predictive models of safety based on audit findings: Part 1: Model development and reliability. Pages 261-273.***

This consecutive study was aimed at the quantitative validation of safety audit tools as predictors of safety performance, as we were unable to find prior studies that tested audit validity against safety outcomes. An aviation maintenance domain was chosen for this work as both audits and safety outcomes are currently prescribed and regulated. In Part 1, we developed a Human Factors/Ergonomics classification framework based on

HFACS model (41 and 42), for the human errors detected by audits, because merely counting audit findings did not predict future safety. The framework was tested for measurement reliability using four participants, two of whom classified errors on 1238 audit reports. Kappa values leveled out after about 200 audits at between 0.5 and 0.8 for different tiers of errors categories. This showed sufficient reliability to proceed with prediction validity testing in Part 2.

- **Keywords:** Safety audit; Human error; Aviation maintenance; HFACS; Measurement reliability

**Kevin Netto, Cara Lord, Aaron Petersen, James Janssen, David Nichols, Brad Aisbett. *Muscle activation during the Pack Hike test and a critical wildfire fighting task. Pages 274-277.***

The aim of this study was to examine the muscle activation of six global muscles during the successful completion of the Pack Hike test (PHT) and compare this to muscle activations during a critical wildfire fighting task. In-field surface electromyography was recorded from eight male wildfire fighters during the PHT and the rakehoe task – a critical wildfire suppression activity. All participants successfully completed the PHT within the 45-min time limit. No significant changes in peak muscle activation levels as well as no significant shifts in median frequency in the six muscle analysed were recorded during the 4.83-km hike. Significantly different peak muscle activation levels were recorded in four of the six muscles tested when the PHT was compared to the rakehoe task. These results suggest the PHT should not be administered in isolation and other tests that specifically challenge upper body muscle endurance should be incorporated into a battery that accurately assesses the job-specific fitness of wildfire fighters.

- **Keywords:** Firefighter; EMG; Physical employment test

**Dan Chiappe, Mark Conger, Janet Liao, J. Lynn Caldwell, Kim-Phuong L. Vu. *Improving multi-tasking ability through action videogames. Pages 278-284.***

The present study examined whether action videogames can improve multi-tasking in high workload environments. Two groups with no action videogame experience were pre-tested using the Multi-Attribute Task Battery (MATB). It consists of two primary tasks; tracking and fuel management, and two secondary tasks; systems monitoring and communication. One group served as a control group, while a second played action videogames a minimum of 5 h a week for 10 weeks. Both groups returned for a post-assessment on the MATB. We found the videogame treatment enhanced performance on secondary tasks, without interfering with the primary tasks. Our results demonstrate action videogames can increase people's ability to take on additional tasks by increasing attentional capacity.

- **Keywords:** Multi-tasking; Videogame training; Attention

**Annette Kluge, Britta Grauel, Dina Burkolter. *Combining principles of Cognitive Load Theory and diagnostic error analysis for designing job aids: Effects on motivation and diagnostic performance in a process control task. Pages 285-296.***

Two studies are presented in which the design of a procedural aid and the impact of an additional decision aid for process control were assessed. In Study 1, a procedural aid was developed that avoids imposing unnecessary extraneous cognitive load on novices when controlling a complex technical system. This newly designed procedural aid positively affected germane load, attention, satisfaction, motivation, knowledge

acquisition and diagnostic speed for novel faults. In Study 2, the effect of a decision aid for use before the procedural aid was investigated, which was developed based on an analysis of diagnostic errors committed in Study 1. Results showed that novices were able to diagnose both novel faults and practised faults, and were even faster at diagnosing novel faults. This research contributes to the question of how to optimally support novices in dealing with technical faults in process control.

- **Keywords:** Cognitive load; Germane load; Split attention; Knowledge acquisition; Diagnostic error; Diagnostic speed

**Karen B. Chen, Anne B. Savage, Amrish O. Chourasia, Douglas A. Wiegmann, Mary E. Sesto. *Touch screen performance by individuals with and without motor control disabilities. Pages 297-302.***

Touch technology is becoming more prevalent as functionality improves and cost decreases. Therefore, it is important that this technology is accessible to users with diverse abilities. The objective of this study was to investigate the effects of button and gap size on performance by individuals with varied motor abilities. Participants with ( $n = 38$ ) and without ( $n = 15$ ) a motor control disability completed a digit entry task. Button size ranged from 10 to 30 mm and gap size was either 1 or 3 mm. Results indicated that as button size increased, there was a decrease in misses, errors, and time to complete tasks. Performance for the non-disabled group plateaued at button size 20 mm, with minimal, if any gains observed with larger button sizes. In comparison, the disabled group's performance continued to improve as button size increased. Gap size did not affect user performance. These results may help to improve accessibility of touch technology.

- **Keywords:** Touch screen; Performance; Disability

**M.E. Montoya-García, A.J. Callejón-Ferre, J. Pérez-Alonso, J. Sánchez-Hermosilla. *Assessment of psychosocial risks faced by workers in Almería-type greenhouses, using the Mini Psychosocial Factor method. Pages 303-311.***

This work reports the use of the Mini Psychosocial Factor (MPF) method for assessing the psychosocial risks faced by agricultural workers in the greenhouses of Almería (Spain) with the aim of improving their health. The variables Rhythm, Mobbing, Relationships, Health, Recognition, Autonomy, Emotional Involvement, Support, Compensation, Control, Demands, and Mental Load were recorded using a pre-validated questionnaire containing 15 questions. The sex, age, and nationality of the respondents ( $n = 310$ ) were also recorded, as were the type of greenhouse in which each worked, the size of the greenhouse, and the crop grown. The results showed psychosocial risks to exist for the workers. Multiple correspondence analysis, however, showed that moderate risks can be offset by new prevention programmes that improve Spanish legislation in terms of workers' salaries, worker-employer social days, work timetables to facilitate family life, and training courses. This could improve the work environment and health of Almería's greenhouse workers as well as their productivity.

- **Keywords:** Agricultural ergonomics; Agricultural workers; Stress

**Chih-Fu Wu, Chih-Chun Lai, Yen-Kou Liu. *Investigation of the performance of trackpoint and touchpads with varied right and left buttons function locations. Pages 312-320.***

This study investigates the relationships of the following 5 factors with commonly-used task patterns: 4 (2 existing and 2 newly-designed) built-in cursor input devices of

notebook PCs, usage experiences, genders, sensitivity of cursor movements, and 5 tasks of input applications (including click, drag-drop, click-select, select-drag-drop, and type-select-click). This experiment reveals that there are significant differences among these factors in the operating times and/or error rates of particular tasks. Although somewhat influenced by the task patterns, the results show that the touchpad with the cursor-tracking pad located on the bottom-center and the right and left buttons on the bottom-left beneath the keyboard, which avoids ulnar and radial deviation and hindrance of text-entry-pointer-manipulation switching, leads to higher performance and preference, while the trackpoint leads to lower performance and preference. In addition, the touchpads with sensitivity values of 10 and 12 for cursor movement are preferred over those with the value of 8.

- **Keywords:** Cursor input device; Touchpad; Input application

**Li-Yen Lin, Faming Wang, Kalev Kuklane, Chuansi Gao, Ingvar Holmér, Mengmeng Zhao. *A laboratory validation study of comfort and limit temperatures of four sleeping bags defined according to EN 13537 (2002)*. Pages 321-326.**

In this study, we validated comfort and limit temperatures of four sleeping bags with different levels of insulation defined according to EN 13537. Six male subjects and four female subjects underwent totally 20 two-hour exposures in four sleeping bags at four intended testing temperatures: 11.2, 3.8, 2.1 and  $-9.0$  °C. The subjective perceptions and physiological responses of these subjects were reported and analyzed. It was found that the EN 13537 defined comfort temperature and limit temperature were underestimated for sleeping bags MA3, HAG and MAM. The predictions are so conservative that further revision may be required to meet the requirements of both manufacturers and consumers. In contrast, for the sleeping bag MA0 with a low level of insulation, the limit temperature defined by EN 13537 was slightly overestimated. In addition, two individual case studies ( $-28.0$  and  $-32.0$  °C) demonstrated that low toe temperatures were widely observed among the male and female subjects, although the mean skin temperatures were almost within the thermoneutrality range ( $32.0$ – $34.0$  °C). It seems that the IREQ model (ISO 11079) overestimated both the comfort and limit temperatures of the sleeping bags. Finally, traditional sleeping bags may be required to be re-designed to provide consumers both whole body comfort as well as local thermal comfort at feet/toes or users need to be made aware of the higher need for their insulation.

- **Keywords:** Sleeping bag; Thermal comfort; EN 13537; Toe temperature; Perception; Modeling

**Stathis Malakis, Tom Kontogiannis. *A sensemaking perspective on framing the mental picture of air traffic controllers*. Pages 337-339.**

It has long been recognized that controller strategies are based on a 'mental picture' or representation of traffic situations. Earlier studies indicated that controllers tend to maintain a selective representation of traffic flows based on a few salient traffic features that point out to interesting events (e.g., potential conflicts). A field study is presented in this paper that examines salient features or 'knowledge variables' that constitute the building blocks of controller mental pictures. Verbal reports from participants, a field experiment and observations of real-life scenarios provided insights into the cognitive processes that shape and reframe the mental pictures of controllers. Several cognitive processes (i.e., problem detection, elaboration, reframing and replanning) have been explored within a particular framework of sensemaking stemming from the data/frame theory (Klein et al., 2007). Cognitive maps, representing standard and non-standard air traffic flows, emerged as an explanatory framework for making sense of traffic patterns and for reframing mental pictures. The data/frame theory proved to be a useful

theoretical tool for investigating complex cognitive phenomena. The findings of the study have implications for the design of training curricula and decision support systems in air traffic control systems.

- **Keywords:** Mental pictures; Cognitive maps; Sensemaking; Data/frame model; Air Traffic Control