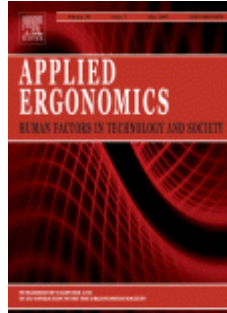


Applied Ergonomics - rok 2010, ročník 41

Číslo 4 (July 2010)



SPECIAL SECTION: The First International Symposium on Visually Induced Motion Sickness, Fatigue, and Photosensitive Epileptic Seizures (VIMS2007)

Richard H.Y. So, Hiroyasu Ujike. *Visually induced motion sickness, visual stress and photosensitive epileptic seizures : what do they have in common? : preface to the special issue.* Pages 491-493.

- bez abstraktu a klíčových slov

Robert S. Kennedy, Julie Drexler, Robert C. Kennedy. *Research in visually induced motion sickness.* Pages 494-503.

While humans have experienced motion sickness symptoms in response to inertial motion from early history through the present day, motion sickness symptoms also occur from exposure to some types of visual displays. Even in the absence of physical motion, symptoms may result from visually perceived motion, which are often classified as effects of visually induced motion sickness (VIMS). This paper provides a brief discussion of general motion sickness and then reviews findings from three lines of recent VIMS investigations that we have conducted.

- **Keywords:** Motion sickness; Visually induced motion sickness; Simulator sickness; Cybersickness; Sospite Syndrome; Visual displays

G.F.A. Harding, P.F. Harding. *Photosensitive epilepsy and image safety.* Pages 504-508.

Photosensitive epilepsy came to prominence in the 1950s with the advent of television. Photosensitive epilepsy occurs in 1 in 4000 of the population. The incidence is 1.1 per 100,000 per annum, however amongst 7–19 year-olds the incidence is more than five times as common. Photosensitive epilepsy is twice as common in females as in males. The onset is around puberty, but less than 25 per cent of patients lose their photosensitivity in their twenties. Patients are investigated in the EEG laboratory using intermittent photic stimulation. Peak sensitivity is between 16 and 20 flashes/s but 49 per cent of patients are sensitive to 50 flashes/s, explaining the sensitivity to PAL television systems. From 1993 the development of broadcast guidelines was developed restricting both flash rates and the areas of screen involved, as well as the use of long-

wavelength red. Automatic analysis systems can now test material for compliance with guidelines in real time.

- **Keywords:** Photosensitive epilepsy; TV broadcast regulations; Video game guidelines; Flash and pattern analysis; Provocative image incidents

Arnold Jonathan Wilkins, Bruce J.W. Evans. *Visual stress, its treatment with spectral filters, and its relationship to visually induced motion sickness. Pages 509-515.*

We review the concept of visual stress and its relation to neurological disease. Visual stress can occur from the observation of images with unnatural spatial structure and an excess of contrast energy at spatial frequencies to which the visual system is generally most sensitive. Visual stress can often be reduced using spectral filters, provided the colour is selected with precision to suit each individual. The use of such filters and their effects on reading speed are reviewed. The filters have been shown to benefit patients with a variety of neurological conditions other than reading difficulty, all associated with an increased risk of seizures.

- **Keywords:** Pattern glare; Spectral filters; Dyslexia; Cortical hyper-excitability; Coloured filters; Reading speed; Photosensitivity; Visual stress; Migraine; Photosensitive epilepsy; Multiple sclerosis; Autism; Meares-Irlen syndrome

Jelte E. Bos, Sjoerd C. de Vries, Martijn L. van Emmerik, Eric L. Groen. *The effect of internal and external fields of view on visually induced motion sickness. Pages 516-521.*

Field of view (FOV) is said to affect visually induced motion sickness. FOV, however, is characterized by an *internal* setting used by the graphics generator (iFOV) and an *external* factor determined by screen size and viewing distance (eFOV). We hypothesized that especially the incongruence between iFOV and eFOV would lead to sickness. To that end we used a computer game environment with different iFOV and eFOV settings, and found the opposite effect. We speculate that the relative large differences between iFOV and eFOV used in this experiment caused the discrepancy, as may be explained by assuming an observer model controlling body motion.

- **Keywords:** Field of view; Cybersickness; Internal model

REGULAR PAPERS

R. Lloyd, B. Parr, S. Davies, C. Cooke. *Subjective perceptions of load carriage on the head and back in Xhosa women. Pages 522-529.*

The purpose of this study was to compare the subjective perceptual responses to both head-loading and back-loading in a group of Xhosa women. Thirty two women were divided into three groups based on their experience of head-loading and walked on a treadmill on two occasions, head-loading and back-loading, at a self selected walking speed for 4 min with a variety of loads until pain or discomfort caused the test to be terminated or a load of 70% body mass was successfully carried. After each workload there was a 1 min rest period during which the women indicated feelings of pain or discomfort in particular areas of the body via visual analogue scales. At the end of each test the women were asked to complete further questionnaires relating to pain and discomfort and on completion of the second test were also asked to compare the two loading conditions. Finally the women were interviewed to establish their history of load carriage and associated pain and discomfort. The data indicate that whilst back-loading was generally associated with more areas of discomfort than head-loading, the pain and

discomfort in the neck associated with head-loading was the predominant factor in the termination of tests and that this was independent of head-loading experience. This early termination meant that, on average, the women could carry greater loads on their backs than on their heads. The study suggests that further work needs to be carried out to establish viable alternatives to head-loading for rural dwellers in Africa.

- **Keywords:** Load carriage; Subjective perceptions; Head-loading; African women

Stephan Milosavljevic, Frida Bergman, Borje Rehn, Allan B. Carman. *All-terrain vehicle use in agriculture : exposure to whole body vibration and mechanical shock. Pages 530-535.*

Whole body vibration (WBV) and mechanical shock were measured in 12 New Zealand farmers during their daily use of all-terrain vehicles (ATVs). As per the International Organization for Standardization (ISO) guidelines for WBV exposure, frequencies between 0 and 100 Hz were recorded via a seat-pad tri-axial accelerometer during 20 min of ATV use. The farmers were also surveyed to estimate seasonal variation in daily ATV usage as well as 7-day and 12-month prevalence of spinal pain. Frequency-weighted vibration exposure and total riding time were calculated to determine the daily vibration dose value (VDV). The daily VDV of $16.6 \text{ m/s}^{1.75}$ was in excess of the $9.1 \text{ m/s}^{1.75}$ action limit set by ISO guidelines suggesting an increased risk of low back injury from such exposure. However, the mean shock factor R , representing cumulative adverse health effects, was 0.31 indicating that these farmers were not exposed to excessive doses of mechanical shock. Extrapolation of daily VDV data to estimated seasonal variations of farmers in ATV riding time demonstrated that all participants would exceed the ISO recommended maximum permissible limits during the spring lambing season, as compared to lower exposures calculated for summer, autumn and winter. Low back pain was the most commonly reported complaint for both 7 day (50%) and 12 month prevalence (67%), followed by the neck (17% and 42%) and the upper back (17% and 25%) respectively. The results demonstrate high levels of vibration exposure within New Zealand farmers and practical recommendations are needed to reduce their exposure to WBV.

- **Keywords:** Farmers; Vibration dose value; Low back pain; Seasonal variation

Caroline Damecour, Mohammad Abdoli-Eramaki, Ahmad Ghasempoor, W. Patrick Neumann. *Comparison of two heights for forward-placed trunk support with standing work. Pages 536-541.*

Two forward-placed supports with different heights are investigated using human motion capture and EMG. Ten male participants stood in 10° increments of trunk flexion between 0 and 40° for three conditions; leaning on a desk adjusted to the height of the pelvis, leaning on a prototype support at the height of the sternum and with no external support. Low back and hip extensor muscle activity was reduced by an average 60% with leaning against the prototype compared to the no-support condition whereas leaning on a desk produced no significant change in muscle activity. Supported conditions resulted in greater forward displacement of the trunk by at least two-fold compared to no-support representing a longer reach distance. No adverse changes in kinematics indicate that either support blocked segmental flexion of the pelvis, lumbar spine or thoracic spine. These findings suggest that leaning against a higher-placed trunk support could be beneficial for tasks requiring forward flexion.

- **Keywords:** Dynamic support; Forward flexed standing; Low back pain; Electromyography

Toivo Niskanen, Jouni Lehtelä, Ritva Ketola, Erkki Nykyri. *Results of Finnish national survey on EU legislation concerning computer work.* Pages 542-548.

The European Directive on computer work (VDU 90/270/EEC) is implemented in the Finnish Government Decree. The aim of the present study was to evaluate the effects of the legislation and its applications in practice. The quantitative method used an online questionnaire. The respondents were employers ($N = 934$), employees ($N = 1872$) and occupational health care (OHC) units ($N = 289$). The majority of all these three groups considered the provisions clear and easy to understand, comprehensive, and easy to comply with. The provisions had a great impact on preventing mental overloading, arranging sight tests at the employer's cost, and on the refunding of eyeglasses for computer work. Most employers felt they did not need any more specific provisions, whereas half of the employees and OHC professionals would have liked the provisions to be more detailed. More explicit and specific regulations were also needed for practice applications in particular, as well as for the refunding of the costs of special eyeglasses for computer work. A total of 59% of the employers reported that costs of glasses are refunded, whereas the figure for employees was clearly lower (37%). OHC professionals reported that the costs of glasses were refunded in 82% of their customer workplaces. The practical conclusion is that employees' sight examinations and compensation for eyeglasses should be promoted in computer work. Moreover, ergonomic applications are best carried out in co-operation with OHC personnel.

- **Keywords:** Ergonomics; Effect; Legislation; Health; Safety; Computer; EU; Directive

Robin Burgess-Limerick, Veronica Krupenia, Christine Zupanc, Guy Wallis, Lisa Steiner. *Reducing control selection errors associated with underground bolting equipment.* Pages 549-555.

Selecting the incorrect control during the operation of underground bolting and drilling equipment causes serious injuries. Shape coding and the layout of dual control banks are two aspects of control design which require further examination. The aims of this research were: (i) to determine whether arbitrary shape coding was effective in reducing selection error rates in a virtual analogy of roof-bolting; and (ii) to determine whether any advantages exist for mirror or place layouts for dual control situations in this situation. Two experiments were conducted to address these questions. No benefits of arbitrary shape coding were evident while control location remained constant. When control location was altered, shape coding did provide a significant reduction in selection error rate. No differences between mirror or place arrangements were detected and this question remains open.

- **Keywords:** Equipment design; Shape coding; Simulation; Mining

P. Drinkaus, T. Armstrong, J. Foulke, G. Malone. *A standardized method for measuring the force required to join wire harnesses and sparkplugs.* Pages 556-562.

Understanding the forces required to insert a sparkplug wire (wire) onto a sparkplug (plug), independent of worker variation, is important for ergonomists, engineers, and designers. This paper describes a methodology for measuring the forces required to seat a wire onto a plug. A three-axis programmable mill was used to insert wires onto plugs mounted on a force transducer. Inflection points and slopes of the force-displacement curves were found to correspond to mechanical events as the plug and wire were joined. These events were further isolated by dissecting the wires to better understand the force contribution of each wire component. Linear superposition was then used to show that

each of these force elements may be added to estimate the total force required to seat a wire onto a plug. This methodology may be used to quantify the effects of design choices, lubricants (wet and dry), and pre-working on axial insertion forces associated with sparkplugs and other insertions. This paper does not address worker abilities or variation, however, the methodology and equipment described may provide a foundation for the exploration of worker ability, variation and work techniques.

- **Keywords:** Hand; Forces; Insertion; Sparkplugs

H.I. Castellucci, P.M. Arezes, C.A. Viviani. *Mismatch between classroom furniture and anthropometric measures in Chilean schools.* Pages 563-568.

Children spend about five hours per day sitting down while doing their school work. Considering this as well as the potential inadequate use of school furniture, it is likely that some anatomical-functional changes and problems in the learning process may occur. The aim of this study was to compare furniture sizes within three different schools with the anthropometric characteristics of Chilean students in the Valparaíso region, in order to evaluate the potential mismatch between them. The sample consisted of 195 volunteer students (94 male, 101 female) of the 8th grade, ranging from 12.5 to 14.5 years of age from 3 different schools. Regarding the methodology, 6 anthropometric measures (Stature, Popliteal height, Buttock-popliteal length, Elbow height while sitting, Hip width, Thigh thickness and Subscapular height) were gathered, as well as 8 dimensions from the school furniture. For the evaluation of classroom furniture a match criterion equation was defined. After considering the existing classroom furniture dimensions in each match criterion equation, the anthropometric characteristics of the considered population were compared in order to determine the mismatch between them. Results indicated that seat height, which should be considered as the starting point for the design of classroom furniture, was appropriate for students' popliteal height in only 14% of the 2 out of the 3 schools, and 28% in the third. Seat to desk height was too high and mismatched 99% of the students in one school and 100% in the others. Therefore, it was possible to conclude that the classroom's furniture was inadequate in almost all the analyzed cases and subjects. It is possible that the high mismatch percentage found between furniture and students' anthropometry can be associated to the fact that the acquisition and selection of the furniture was made without any ergonomic concern or criteria.

- **Keywords:** School; Furniture; Anthropometry; Children; Mismatch

Robert B. Isler, Nicola J. Starkey. *Evaluation of a sudden brake warning system : effect on the response time of the following driver.* Pages 569-576.

This study used a video-based braking simulation dual task to carry out a preliminary evaluation of the effect of a sudden brake warning system (SBWS) in a leading passenger vehicle on the response time of the following driver. The primary task required the participants ($N = 25$, 16 females, full NZ license holders) to respond to sudden braking manoeuvres of a lead vehicle during day and night driving, wet and dry conditions and in rural and urban traffic, while concurrently performing a secondary tracking task using a computer mouse. The SBWS in the lead vehicle consisted of g-force controlled activation of the rear hazard lights (the rear indicators flashed), in addition to the standard brake lights. Overall, the results revealed that responses to the braking manoeuvres of the leading vehicles when the hazard lights were activated by the warning system were 0.34 s (19%) faster compared to the standard brake lights. The SBWS was particularly effective when the simulated braking scenario of the leading vehicle did not require an immediate and abrupt braking response. Given this, the SBWS may also be beneficial for allowing smoother deceleration, thus reducing fuel consumption. These

preliminary findings justify a larger, more ecologically valid laboratory evaluation which may lead to a naturalistic study in order to test this new technology in 'real world' braking situations.

- **Keywords:** Driving; Rear-end collision; Sudden brake warning system; Hazard lights; Stopping distance; Dual task; Braking

Desre M. Kramer, Philip L. Bigelow, Niki Carlan, Richard P. Wells, Enzo Garritano, Peter Vi, Marek Plawinski. *Searching for needles in a haystack: Identifying innovations to prevent MSDs in the construction sector.* Pages 577-584.

This study identified innovations that could potentially reduce the risk of MSDs in the construction sector. The action research approach was based on a collaborative model of researchers working with workplace representatives. We searched for innovations being used by construction companies. From a potential database of 125 innovations, the study focused on 20 innovations that varied in their penetration into worksites in the geographical area, represented a variety of trades, and were a cross-section of tools and work organizational processes. It examined the attributes of the innovations, and the barriers to their adoption. The analysis was based on observations of workers, surveys of workers and construction-safety consultants, and company interviews. The study found that innovations were adopted by companies for multiple advantages including productivity and quality, but not necessarily ability to reduce MSD risks, their non-complexity, and cost. The major barriers for adoption were the traditional culture of the construction sector rather than financial ones.

- **Keywords:** Diffusion of innovations; Prevention of musculoskeletal disorders; Collaborative research; Construction sector

Stewart A. Birrell, Roger A. Haslam. *The effect of load distribution within military load carriage systems on the kinetics of human gait.* Pages 585-590.

Military personnel carry their equipment in load carriage systems (LCS) which consists of webbing and a Bergen (aka backpack). In scientific terms it is most efficient to carry load as close to the body's centre of mass (CoM) as possible, this has been shown extensively with physiological studies. However, less is known regarding the kinetic effects of load distribution. Twelve experienced load carriers carried four different loads (8, 16, 24 and 32 kg) in three LCS (backpack, standard and AirMesh). The three LCS represented a gradual shift to a more even load distribution around the CoM. Results from the study suggest that shifting the CoM posteriorly by carrying load solely in a backpack significantly reduced the force produced at toe-off, whilst also decreasing stance time at the heavier loads. Conversely, distributing load evenly on the trunk significantly decreased the maximum braking force by 10%. No other interactions between LCS and kinetic parameters were observed. Despite this important findings were established, in particular the effect of heavy load carriage on maximum braking force. Although the total load carried is the major cause of changes to gait patterns, the scientific testing of, and development of, future LCS can modify these risks.

- **Keywords:** Load carriage; Load distribution; Kinetics; Military

S. Caroly, F. Coutarel, A. Landry, I. Mary-Cheray. *Sustainable MSD prevention : management for continuous improvement between prevention and production : ergonomic intervention in two assembly line companies.* Pages 591-599.

To increase output and meet customers' needs, companies have turned to the development of production management systems: Kaizen, one piece flow, Kanban, etc. The aim of such systems is to accelerate decisions, react to environmental issues and manage various productions. In the main, this type of management system has led to the continuous improvement of production performance. Consequently, such production management systems can have unexpected negative effects on operators' health and safety. Conversely, regulation and control systems focusing on work-related risks have obliged firms to implement health and safety management systems such as OHSAS 18001. The purpose of this type of system, also based on continuous improvement, is to reduce risks, facilitate work-related activities and identify solutions in terms of equipment and tools. However, the prevention actions introduced through health and safety systems often result in other unexpected and unwanted effects on production. This paper shows how companies can improve the way they are run by taking into account both types of management system.

- **Keywords:** Continuous improvement; OHS management systems; Musculoskeletal disorder prevention

Gemma M. Paech, Sarah M. Jay, Nicole Lamond, Gregory D. Roach, Sally A. Ferguson. *The effects of different roster schedules on sleep in miners.* Pages 600-606.

Shiftwork involving early morning starts and night work can affect both sleep and fatigue. This study aimed to assess the impact of different rostering schedules at an Australian mine site on sleep and subjective sleep quality. Participants worked one of four rosters;

- 4 × 4 ($n = 14$) 4D4O4N4O
- 7 × 4 ($n = 10$) 7D4O7N4O
- 10 × 5 ($n = 17$) 5D5N5O
- 14 × 7 ($n = 12$) 7D7N7O

Sleep (wrist actigraphy and sleep diaries) was monitored for a full roster cycle including days off. Total sleep time (TST) was longer on days off (7.0 ± 1.9) compared to sleep when on day (6.0 ± 1.0) and nightshifts (6.2 ± 1.6). Despite an increase in TST on days off, this may be insufficient to recover from the severe sleep restriction occurring during work times. Restricted sleep and quick shift-change periods may lead to long-term sleep loss and associated fatigue.

- **Keywords:** Shift work; Total sleep time; Subjective sleep quality

Bo Johansson, Kjell Rask, Magnus Stenberg. *Piece rates and their effects on health and safety : a literature review.* Pages 607-614.

The purpose of this study was to carry out a broad survey and analysis of relevant research articles about piece rate wages and their effects on health and safety that were published internationally until the fall of 2008. The aim was to summarize and describe the state of the art of the research in this field and if possible draw conclusions from the accumulated research results. A total of 75 research articles were examined extensively and 31 of these were found relevant and had sufficient quality to serve the purpose of this study. The findings of these relevant articles are summarized and analyzed in the survey. Since the late 1980s, there has been a change of research focus regarding piece rates and their effects on health and safety. More recent research shows a clear interest for health, musculoskeletal injuries, physical workload, pains and occupational injuries. The previous interest in risk behavior, security and accidents is still there, but no longer

dominates the research scene. Although research is still sparse and fragmented, much of the accumulated knowledge about the effects of piece rate work tells us that piece rates in many situations have a negative effect on health and safety. The fact that 27 of the 31 studied articles found negative effects of piece rates on different aspects of health and safety does not prove causality, but together they give very strong support for the hypothesis that in most situations piece rates have negative effects on health and safety. In order to achieve better knowledge about the effects of piece rates in branches where piece rates are regarded problematic, further research is needed and such research has to be designed to meet the specific questions that are to be answered.

- **Keywords:** Piece rate; Piece work; Piece wage; Health; Safety

Swei-Pi Wu, Shu-Yu Chang. *Effects of carrying methods and box handles on two-person team carrying capacity for females. Pages 615-619.*

This study used a psychophysical approach to examine the effects of carrying methods and the presence or absence of box handles on the maximum acceptable weight carried and resulting responses (heart rate and rating of perceived exertion) in a two-person carrying task. After training, 16 female subjects performed a two-person carrying task at knuckle height for an 8-h work period. Each subject performed 4 different carrying combinations two times. The independent variables were carrying methods (parallel and tandem walking) and box handles (with and without handles). For comparison with two-person carrying, the subjects also performed one-person carrying. The results showed that the maximum acceptable weight carried (MAWC), heart rate (HR), and rating of perceived exertion (RPE) were significantly affected by the presence of box handles. However, the subjects' MAWC, HR, and RPE values were not significantly influenced by the carrying methods. The test-retest reliability of the psychophysical approach was 0.945. The carrying efficiency of two-person carrying was 96.2% of the one-person carrying method. In general, the use of box with handles allows the subjects to carry a higher MAWC (with lower HR and RPE) compared to carrying boxes without handles.

- **Keywords:** Carrying; Two-person carrying; Manual materials handling; Psychophysics

Stathis Malakis, Tom Kontogiannis, Barry Kirwan. *Managing emergencies and abnormal situations in air traffic control (part I) : taskwork strategies. Pages 620-627.*

A lot of research in Air Traffic Control (ATC) has focused on human errors in decision making whilst little attention has been paid to the cognitive strategies employed by controllers in managing abnormal situations. This study looks into cognitive strategies in taskwork that enable controllers to become resilient decision-makers. Two field studies were carried out where novice and experienced controllers were observed in simulator training in emergency and unusual scenarios. A prototype model of taskwork strategies in air traffic management was developed and its construct validity was tested in the context of the field studies. A companion study (part II), follows that investigates aspects of teamwork in the same field and contributes to the development of a generic model of Taskwork & Teamwork strategies in Emergencies in Air traffic Management (T²EAM). The final section addresses the difficulties experienced by novice controllers and explains taskwork strategies employed by experts to manage uncertainty and balance workload in simulator emergencies.

- **Keywords:** Air traffic control; Cognitive strategies; Decision making; Taskwork

Stathis Malakis, Tom Kontogiannis, Barry Kirwan. *Managing emergencies and abnormal situations in air traffic control (part II) : teamwork strategies.* Pages 628-635.

Team performance has been studied in many safety-critical organizations including aviation, nuclear power plant, offshore oil platforms and health organizations. This study looks into teamwork strategies that air traffic controllers employ to manage emergencies and abnormal situations. Two field studies were carried out in the form of observations of simulator training in emergency and unusual scenarios of novices and experienced controllers. Teamwork strategies covered aspects of team orientation and coordination, information exchange, change management and error handling. Several performance metrics were used to rate the efficiency of teamwork and test the construct validity of a prototype model of teamwork. This is a companion study to an earlier investigation of taskwork strategies in the same field (part I) and contributes to the development of a generic model for Taskwork and Teamwork strategies in Emergencies in Air traffic Management (T²EAM). Suggestions are made on how to use T²EAM to develop training programs, assess team performance and improve mishap investigations.

- **Keywords:** Air traffic control; Cognitive strategies; Decision making; Teamwork

Aitor Coca, W. Jon Williams, Raymond J. Roberge, Jeffrey B. Powell. *Effects of fire fighter protective ensembles on mobility and performance.* Pages 636-641.

Many studies have shown that fire fighter turnout gear and equipment may restrict mobility. The restriction of movement is usually due to a decrease in range of motion (ROM). It is important to know how much the decrease in ROM affects performance. The aim of this study was to determine the effects of fire fighter protective ensembles on mobility and performance by measuring static and dynamic range of motion (ROM) and job-related tasks. Eight healthy adults (5 males, 3 females), aged 20–40 years, participated in this study. The study consisted of measuring a battery of motions and fire fighter specific tasks while wearing a standard fire fighter ensemble (SE) or regular light clothing (baseline or BL). Several BL ROM tests were significantly ($p < 0.05$) different from the SE test, including a decrease in shoulder flexion, cervical rotation and flexion, trunk lateral flexion, and stand and reach. There was a significant decrease in time from SE to baseline performing the one-arm search task and object lift. These overall findings support the need for a comprehensive ergonomic evaluation of protective clothing systems to ascertain human factors issues. The development of a Standard Ergonomics Test Practice for further use in laboratories that conduct personal protective systems evaluations using human test subjects is recommended.

- **Keywords:** Protective clothing; ROM; Fire fighters