

Applied Ergonomics - rok 2009, ročník 40

Číslo 2 (March 2009)



Chetwyn C.H. Chan, Alex W.K. Wong, Tatia M.C. Lee, Iris Chi. *Modified automatic teller machine prototype for older adults : a case study of participative approach to inclusive design.* S. 151-160.

Abstract: The goal of this study was to enhance an existing automated teller machine (ATM) human-machine interface in order to accommodate the needs of older adults. Older adults were involved in the design and field test of the modified ATM prototype. The design of the user interface and functionality took the cognitive and physical abilities of older adults into account. The modified ATM system included only "cash withdrawal" and "transfer" functions based on the task demands and needs for services of older adults. One hundred and forty-one older adults (aged 60 or above) participated in the field test by operating modified or existing ATM systems. Those who operated the modified system were found to have significantly higher success rates than those who operated the existing system. The enhancement was most significant among older adults who had lower ATM-related abilities, a lower level of education, and no prior experience of using ATMs. This study demonstrates the usefulness of using a universal design and participatory approach to modify the existing ATM system for use by older adults. However, it also leads to a reduction in functionality of the enhanced system. Future studies should explore ways to develop a universal design ATM system which can satisfy the abilities and needs of all users in the entire population.

- **Keywords:** Universal design; Automatic teller machine; Technology for older adults

C.P. Bogerd, P.A. Brühwiler. *Heat loss variations of full-face motorcycle helmets.* S. 161-164.

Abstract: Heat loss of 27 full-face motorcycle helmets was studied using a thermal manikin headform. The headform was electrically heated and positioned at the exit of a wind tunnel, so that the air stream flowed onto its front side. All helmets were measured in three sessions in which all the vents were opened or closed consecutively in random order. Average heat loss was calculated from a steady state period, under controlled environmental conditions of 22 ± 0.05 °C, $50\pm 1\%$ RH and 50.4 ± 1.1 km h⁻¹ (14.0 ± 0.3 m s⁻¹) wind speed. The results show large variations in heat loss among the different helmets, ranging from 0 to 4 W for the scalp section of the headform and 8 to 18 W for the face section of the headform. Opening all the vents showed an increase in heat loss of more than 1 W (2 W) for four (two) helmets in the scalp section and six (one) helmets in the face section. These levels of heat transfer have been shown to be

the thresholds for human sensitivity in scalp and face sections. Furthermore, helmet construction features which could be identified as important for heat loss of motorcycle helmets were identified.

- **Keywords:** Heat loss; Motorcycle helmet; Forced convection

J. Sauer, D.G. Wastell, C. Schmeink. *Designing for the home: A comparative study of support aids for central heating systems. S. 165-174.*

Abstract: The study examined the influence of different types of enhanced system support on user performance during the management of a central heating system. A computer-based simulation of a central heating system, called CHESS V2.0, was used to model different interface options, providing different support facilities to the user (e.g., historical, predictive, and instructional displays). Seventy-five participants took part in the study and completed a series of operational scenarios under different support conditions. The simulation environment allowed the collection of performance measures (e.g., energy consumption), information sampling, and system control behaviour. Subjective user evaluations of various aspects of the system were also measured. The results showed performance gains for predictive displays whereas no such benefits were observed for the other display types. The data also revealed that status and predictive displays were valued most highly by users. The implications of the findings for designers of central heating systems are discussed.

- **Keywords:** Feedback; Heating; Performance; Predictive display

Tim Bentley. *The role of latent and active failures in workplace slips, trips and falls : an information processing approach. S. 175-180.*

Abstract: The vast majority of the published workplace slips, trips and falls (STF) literature is exceedingly narrow in its focus and often ignores wider systems issues in workplace STF aetiology. There is little recognition within the published literature of the importance of latent failures or the upstream organisational and cultural contexts within which workplace STF occur. This is unfortunate, as a systems approach to workplace STF analysis, that is inclusive of latent design and work organisation factors that often shape worker behaviour patterns related to STF risk (e.g. rushing, risk taking), is fundamental to the development of effective prevention measures. The aims of this paper are to provide an understanding of workplace STF causation that is cognisant of the potential role of both active and latent failures in STF causation. The paper presents an ergonomics model for workplace STF analysis that highlights information processing in STF aetiology, the STF incident process and the interaction between latent and active failures in STF causation. The paper draws upon ergonomics research conducted in a range of occupational contexts to illustrate the key features of the model as it applies to workplace STF. Implications of the model for analysis and prevention of STF are discussed.

- **Keywords:** Slips, trips and falls; Injury causation; Organisational factors; Latent failures; Information processing

Christhard Gelau, Matthias J. Henning, Josef F. Krems. *On the reliability of the occlusion technique as a tool for the assessment of the HMI of in-vehicle information and communication systems. S. 181-184.*

Abstract: In recent years considerable efforts have been spent on the development of the occlusion technique as a procedure for the assessment of the human-machine interface of in-vehicle information and communication systems (IVIS) designed to be

used by the driver while driving. The importance and significance of the findings resulting from the application of this procedure depends essentially on its reliability. Because there is a lack of evidence as to whether this basic criterion of measurement is met with this procedure, and because questionable reliability can lead to doubts about their validity, our project strove to clarify this issue. This paper reports on a statistical reanalysis of data obtained from previous experiments. To summarise, the characteristic values found for internal consistency were almost all in the range of .90 for the occlusion technique, which can be considered satisfactory.

- **Keywords:** Driver visual distraction; Occlusion technique; Reliability; Task interruptability

Steffen Torp, Jens B. Grøgaard. *The influence of individual and contextual work factors on workers' compliance with health and safety routines.* S. 185-193.

Abstract: This study investigated the relationships between workers' compliance with health and safety (H&S) routines and instructions adopted in the company (dependent variable) and psychological demands, decision authority, social support, management support, unionization and H&S management system (independent variables). A cross-sectional questionnaire study was performed among 1051 workers and the managers of 102 small- and medium-sized motor vehicle repair garages. Multilevel modeling was performed to account for the hierarchical structure of the data. At the worker level, high compliance with H&S routines correlated significantly with both social support and H&S-related management support. At the garage level, mean management support and a well-developed H&S management system correlated significantly with high workers' compliance. Changing both the individual and contextual factors in the work environment may thus increase workers' participation in H&S activities.

- **Keywords:** Health and safety; Compliance; Multilevel

Alexis Descatha, Yves Roquelaure, Sandrine Caroly, Bradley Evanoff, Diane Cyr, Jean Mariel, Annette Leclerc. *Self-administered questionnaire and direct observation by checklist : comparing two methods for physical exposure surveillance in a highly repetitive tasks plant.* S. 194-198.

Abstract: Background: We evaluated the agreement between a questionnaire and an observational checklist for exposure assessment in the setting of an upper-limb work-related musculoskeletal disorders (UWMSD) surveillance program in a population with a high level of physical exposures. **Methods:** A surveillance program was implemented in a large shoe factory. Physical exposures were assessed in 1996 by a self-administered questionnaire and by the direct observation of work tasks assessed using a checklist filled out by trained assessors. Items were summed into a "questionnaire" score and an "observational" score. These scores were compared by Pearson's correlation. The association between exposure assessment by each method and UWMSD incidence between 1996 and 1997, defined by a standardized examination, was also studied. **Results:** Correlation between the "questionnaire" score and the "observational" score was low among the 196 workers (77%) who received both evaluations ($\rho=0.06$, $p>0.05$). Only exposure assessed by the questionnaire method was significantly associated with high incidence of UWMSD between 1996 and 1997, with good sensitivity (97%) and poor specificity (27%). **Conclusion:** In this surveillance program, self-reported physical exposures assessed by questionnaire and by direct observation did not evaluate same dimensions of high physical exposures. In this sample, exposures assessed by questionnaire identified workers at high risk of incident UWMSD more precisely than exposures identified by direct observation.

- **Keywords:** Musculoskeletal disorders; Questionnaire; Physical exposure surveillance

Idsart Kingma, Jaap H. van Dieën. *Static and dynamic postural loadings during computer work in females : sitting on an office chair versus sitting on an exercise ball.* S. 199-205.

Abstract: Seated computer work results in prolonged static loading, which has been associated with the development of musculoskeletal disorders. A popular alternative to sitting on an office chair while performing computer work is to sit on an exercise ball. Sitting on an exercise ball might affect static and dynamic aspects of working posture. We monitored posture, muscle activation and spinal shrinkage in 10 females performing a 1-h typing task, while sitting on an office chair with armrests and while sitting on an exercise ball. Sitting on an exercise ball resulted in 33% more trunk motion and in 66% more variation in lumbar EMG. Both of these findings can be considered to be an advantage for the exercise ball. However, the fifth percentile and average lumbar EMG were also higher when sitting on an exercise ball, with 38% and 78%, respectively. In addition, more spinal shrinkage occurred when sitting on an exercise ball than when sitting on an office chair. Arm flexion was reduced, but trapezius activation was unaffected when sitting on an exercise ball. It is concluded that the advantages with respect to physical loading of sitting on an exercise ball may not outweigh the disadvantages.

- **Keywords:** Sitting; Posture; Low back

Guy H. Walker, Neville A. Stanton, Daniel P. Jenkins, Paul M. Salmon. *From telephones to iPhones : applying systems thinking to networked, interoperable products.* S. 206-215.

Abstract: An expanding array of consumer products have the facility to have things added in and plugged on, their firmware upgraded, and as yet un-thought of future capability supported. In short, more and more products can be connected to something and/or someone, and in doing so are slowly adapting to the current day state of modernity that is called 'the information age'. Inevitably, this brings with it changes in the way that products should be thought about and designed. The purpose of this paper is to try and help product designers and Ergonomists to get a grip on all the complexity and non-linearity that the information age brings with it, and help make themselves and their increasingly networked and interoperable products at home in it. Our case study, Apple's new iPhone, serves as a pertinent example.

- **Keywords:** Sociotechnical systems theory; Product design; Mobile phones

Brendan Ryan, John R. Wilson, Sarah Sharples, Ged Morrisroe, Theresa Clarke. *Developing a Rail Ergonomics Questionnaire (REQUEST).* S. 216-229.

Abstract: In this first of two papers the development of a shortened version of the Rail Ergonomics Questionnaire (REQUEST) is described. REQUEST has been designed to survey attitudes and opinions of railway workers on a range of human factors issues, with scales based on those used and validated elsewhere or else specially developed on the basis of studies of rail workers. Important characteristics of different roles, especially signallers, are outlined. The longer version of the questionnaire has already been used on a number of occasions for samples of 100–150. The shortened version was developed for the most recent administration of the survey to a large population. An expert group reviewed question wording, and the findings from the principal components analysis and other analyses of data from previous administrations of the survey. Improvements were

made to the design and layout of the questionnaire. The effectiveness of the process for the expert review of questions is discussed. The survey was administered to high proportions of the target groups during the company safety briefing programme and achieved a sample size of almost 4000 respondents at an overall response rate of 83%. Findings from the REQUEST national survey are presented in a companion paper [Ryan, B., Wilson, J.R., Sharples, S., Clarke, T., 2008. Attitudes and opinions of railway signallers and related staff, using the Rail Ergonomics Questionnaire (REQUEST). Appl. Ergon., in press. doi:10.1016/j.apergo.2008.04.010].

- **Keywords:** Questionnaire design; Rail human factors; Reliability

Brendan Ryan, John R. Wilson, Sarah Sharples, Theresa Clarke. *Attitudes and opinions of railway signallers and related staff, using the Rail Ergonomics Questionnaire (REQUEST)*. S. 230-238.

Abstract: REQUEST, the Rail Ergonomics Questionnaire, has been designed to survey attitudes and opinions of railway signallers and those in associated roles on a range of human factors such as job satisfaction, the workplace, culture or stress. The development of the survey instrument has been described in Ryan et al. [2008. Developing a rail ergonomics questionnaire (REQUEST). Appl. Ergon., doi:10.1016/j.apergo.2008.04.006.]. The present paper presents an overview of findings from this national survey which achieved a sample size of 3889 and a response rate of 83%. Findings are compared by different roles (e.g. signaller, controller) on a range of main scales and responses to additional questions in the survey. Ratings from the largest of the occupational groups, the signaller at 83.1% of the overall population, have been compared according to different types of signalling system used, identifying different characteristics in the use of lever, panel and VDU signalling systems. Comparisons of signallers' ratings by geographical location have produced findings of interest at different layers of management of the organisation, identifying locations with high or low ratings on a range of scales. The findings provide valuable information for the client organisation, using direct input from frontline staff on a range of human factors issues. This was a large survey, one of the largest ever civilian human factors surveys, involving lengthy, often repetitive and frequently complex analyses. Lessons learned within the administration of the survey, the analysis of the data and dissemination of the findings will be of interest to researchers. An overview of the scope of analyses of the database is introduced, in addition to proposals for further development of the survey instrument.

- **Keywords:** Rail human factors; Survey administration and analysis; Comparisons of roles

Francesco Calvino, Maria La Gennusa, Gianfranco Rizzo, Gianluca Scaccianoce, Angela Simone. *Measurements of projected areas of seated and standing people of southern Italy based on a statistical analysis*. S. 239-250.

Abstract: One of the most important components affecting the human thermal balance is represented by its radiative exchange with the surrounding surfaces. The projected area of the human body is an important parameter of these thermal exchanges. Unfortunately, although the anthropometric measures of people are characterized by significant differences among various populations, the experimental data currently available in the literature refers to a small group of people. Moreover, measurements are generally performed regardless of the statistical significance of the involved subjects with respect to the population to which they belong. In this study, a statistical study is introduced that is based on a large analysis of the anthropometric characteristics of the analysed population. Moreover, a new experimental procedure is applied to evaluate the projected area factor and the effective radiating area of a sample of people belonging to the population of southern Italy. The calculated projected area factors are fairly in

accordance with those originally proposed by Fanger for standing people. For seated people, however, the experimental values of the present study show some differences from those of the literature. This study provided a tentative explanation for these discrepancies.

- **Keywords:** Angle factors; Projected area factors; Effective radiating area; Thermal comfort

Ali Kitis, Erdal Celik, Ummuhan B. Aslan, Mehmet Zencir. *DASH questionnaire for the analysis of musculoskeletal symptoms in industry workers : a validity and reliability study. S. 251-255.*

Abstract: Purpose: The disabilities of the arm, shoulder and hand (DASH) questionnaire is a self-administered region-specific outcome instrument developed as a measure of self-rated upper-extremity disability and symptoms. The aim of this study was to evaluate the reliability and the construct validity of the DASH questionnaire by establishing its correlation to the Medical Outcomes Study Short Form-36 (SF-36) in industry workers. Also we aimed to investigate whether the DASH can be used as a standardized questionnaire to evaluate the work-related musculoskeletal disorders (WMSDs) in upper extremity in industrial settings and epidemiological studies. **Material and methods:** The Turkish version's reliability and construct validity were evaluated in 240 industry workers with upper-extremity musculoskeletal complaints. Workers were asked to complete a packet that included the DASH and the SF-36. Test-retest reliability was assessed in all workers who filled in the DASH questionnaire 15 days later. Construct validity was evaluated by comparing the overall and work component DASH scores with SF-36 summary and subscales. **Results:** The mean DASH score for the textile workers whose duties were confection, dyeing, sewing, quality control and packaging was calculated as 65, 55, 68, 54 and 67, respectively. As a result of this study, pain intensity in shoulder, wrist and hand was significantly associated with the DASH score ($p < 0.05$). Internal consistency of the DASH was high (Cronbach alpha 0.91). Test-retest reliability was excellent for the overall DASH (intraclass correlation coefficient (ICC) 0.92). Moderate correlations ($p < 0.05$) were found between the overall and work component DASH and the SF-36 summary scales. Pearson correlation coefficients of the overall and work component DASH to the SF-36 subscales ranged from -0.33 to -0.82 . **Conclusion:** These results support that DASH is a reliable and valid instrument to measure functional disability and investigate the ergonomic risk factors in textile workers with upper-extremity musculoskeletal complaints.

- **Keywords:** DASH; Upper extremity; Musculoskeletal disorders; Textile industry; Ergonomics

John G. Cherng, Mahmut Eksioğlu, Kemal Kızılaslan. *Vibration reduction of pneumatic percussive rivet tools : mechanical and ergonomic re-design approaches. S. 256-266.*

Abstract: This paper presents a systematic design approach, which is the result of years of research effort, to ergonomic re-design of rivet tools, i.e. rivet hammers and bucking bars. The investigation was carried out using both ergonomic approach and mechanical analysis of the rivet tools dynamic behavior. The optimal mechanical design parameters of the re-designed rivet tools were determined by Taguchi method. Two ergonomically re-designed rivet tools with vibration damping/isolation mechanisms were tested against two conventional rivet tools in both laboratory and field tests. Vibration characteristics of both types of tools were measured by laboratory tests using a custom-made test fixture. The subjective field evaluations of the tools were performed by six experienced riveters at an aircraft repair shop. Results indicate that the isolation spring and polymer damper are very effective in reducing the overall level of vibration under both unweighted and weighted acceleration conditions. The mass of the dolly head and the housing played a

significant role in the vibration absorption of the bucking bars. Another important result was that the duct iron has better vibration reducing capability compared to steel and aluminum for bucking bars. Mathematical simulation results were also consistent with the experimental results. Overall conclusion obtained from the study was that by applying the design principles of ergonomics and by adding vibration damping/isolation mechanisms to the rivet tools, the vibration level can significantly be reduced and the tools become safer and user friendly. The details of the experience learned, design modifications, test methods, mathematical models and the results are included in the paper.

- **Keywords:** Hand tool; Rivet hammer; Bucking bar; Ergonomic design; Vibration

Channa P. Witana, Ravindra S. Goonetilleke, Shuping Xiong, Emily Y.L. Au. *Effects of surface characteristics on the plantar shape of feet and subjects' perceived sensations.* S. 267-279.

Abstract: Orthotics and other types of shoe inserts are primarily designed to reduce injury and improve comfort. The interaction between the plantar surface of the foot and the load-bearing surface contributes to foot and surface deformations and hence to perceived comfort, discomfort or pain. The plantar shapes of 16 participants' feet were captured when standing on three support surfaces that had different cushioning properties in the mid-foot region. Foot shape deformations were quantified using 3D laser scans. A questionnaire was used to evaluate the participant's perceptions of perceived shape and perceived feeling. The results showed that the structure in the mid-foot could change shape, independent of the rear-foot and forefoot regions. Participants were capable of identifying the shape changes with distinct preferences towards certain shapes. The cushioning properties of the mid-foot materials also have a direct influence on perceived feelings. This research has strong implications for the design and material selection of orthotics, insoles and footwear.

- **Keywords:** Plantar shape; Custom-made orthotics; Footwear; Cushioning; Foot shape; Perception

Chin-Bong Choi, Peom Park, Young-Ho Kim, M. Susan Hallbeck, Myung-Chul Jung. *Comparison of visibility measurement techniques for forklift truck design factors.* S. 280-285.

Abstract: This study applied the light bulb shadow test, a manikin vision assessment test, and an individual test to a forklift truck to identify forklift truck design factors influencing visibility. The light bulb shadow test followed the standard of ISO/DIS 13564-1 for traveling and maneuvering tests with four test paths (Test Nos. 1, 3, 4, and 6). Digital human and forklift truck models were developed for the manikin vision assessment test with CATIA V5R13 human modeling solutions. Six participants performed the individual tests. Both employed similar parameters to the light bulb shadow test. The individual test had better visibility with fewer numbers and a greater distribution of the shadowed grids than the other two tests due to eye movement and anthropometric differences. The design factors of load backrest extension, lift chain, hose, dashboard, and steering wheel should be the first factors considered to improve visibility, especially when a forklift truck mainly performs a forward traveling task in an open area.

- **Keywords:** Forklift truck visibility; Light bulb shadow test; Manikin vision assessment test

P.K. Nag, S. Pal, A. Nag, H. Vyas. *Influence of arm and wrist support on forearm and back muscle activity in computer keyboard operation.* S. 286-291.

Abstract: The effects of forearm and wrist supports on the upper extremity postures in computer keying tasks and associated EMG activity of arm and back muscles were examined ($N=8$). Four positions were forearms unsupported (floating) and supported, wrists supported by bead packed (WR1) and gel-filled (WR2) wrist rest. The right and left elbow extensions were 65° and 68° , respectively, in unsupported forearms. Bilateral elbow extension increased with the forearm/wrist supports and mostly, the elbow was maintained at around 90° or greater. The wrist extension decreased with forearm/wrist supports over the unsupported condition. The forearm support significantly reduced the activity of forearm extensor digitorum, i.e., right ($F_{(1, 47)}=12.19, p<0.01$) and left ($F_{(1, 47)}=5.38, p<0.05$) and upper trapezius muscles over the floating posture. Wrist rests, however, increased load on the upper trapezius; the activities of flexor digitorum superficialis and erector spinae were close to the resting EMG activity for both forearm and/or wrist support. The type of wrist rests was a concern and this study indicated that the gel filled wrist rest was advantageous in reducing the forearm muscle load, in comparison to the bead packed cushions.

- **Keywords:** Computer keyboard; Electromyogram; 3D motion analysis; Forearm support; Wrist rests; Elbow and wrist extensions

Ravindra S. Goonetilleke, Errol R. Hoffmann, Ameersing Luximon. *Effects of pen design on drawing and writing performance.* S. 292-301.

Abstract: Two experiments are reported with the aim of determining the effect of pen shape and size on two different types of task: drawing and writing. Experiment 1 attempted to determine the optimum shape and size of shank for ball-point pens used to perform an accurate drawing task. Twenty-seven participants used a total of nine different pens. Drawing performance was measured by having the subjects follow mazes of different size. The dependent variables were drawing movement time and drawing accuracy. The results indicate that the pen with an equivalent diameter of 8 mm had the best accuracy during drawing, even though it had the lowest speed. The results confirm the applicability and validity of the Drury tracking model for such a task. Even though users tended to prefer larger pens, their accuracy with such pens tended to be low. In a second experiment, subjects performed a writing task (with no accuracy constraints) and rated their preference for types of pen. An attempt was made to determine the preferred dimensions of ball-point pens for writing in Chinese and English. A total of 36 'bare-bodied' pens and 20 Chinese subjects were used to evaluate the effects of shape, size and weight on time to write a sentence. The Writing Ability, Comfort and an Overall Rating were given by the subjects. The results indicate that the Chinese subjects preferred a circular shaped pen for writing in both languages. A factor analysis showed that speed, comfort and writing ability are independent parameters in pen evaluations.

- **Keywords:** Pen; Pen size; Pen cross-section; Design; Shank design; Human-performance; Writing; Implements