

Applied Ergonomics - rok 2011, ročník 42

Číslo 6 (November 2011)



J.B. Rousek, M.S. Hallbeck. *Improving and analyzing signage within a healthcare setting.* Pages 771-784.

Healthcare facilities are increasingly utilizing pictograms rather than text signs to help direct people. The purpose of this study was to analyze a wide variety of standardized healthcare pictograms and the effects of color contrasts and complexity for participants with both normal and impaired vision. Fifty (25 males, 25 females) participants completed a signage recognition questionnaire and identified pictograms while wearing vision simulators to represent specific visual impairment. The study showed that certain color contrasts, complexities and orientations can help or hinder comprehension of signage for people with and without visual impairment. High contrast signage with consistent pictograms involving human figures (not too detailed or too abstract) is most identifiable. Standardization of healthcare signage is recommended to speed up and aid the cognitive thought process in detecting signage and determining meaning. These fundamental signage principles are critical in producing an efficient, universal wayfinding system for healthcare facilities.

- **Keywords:** Signage; Pictograms; Healthcare; Visual impairment; Color contrast

Frédéric Dehais, Emrah Akin Sisbot, Rachid Alami, Mickaël Causse. *Physiological and subjective evaluation of a human-robot object hand-over task.* Pages 785-791.

In the context of task sharing between a robot companion and its human partners, the notions of safe and compliant hardware are not enough. It is necessary to guarantee ergonomic robot motions. Therefore, we have developed Human Aware Manipulation Planner (Sisbot et al., 2010), a motion planner specifically designed for human-robot object transfer by explicitly taking into account the legibility, the safety and the physical comfort of robot motions. The main objective of this research was to define precise subjective metrics to assess our planner when a human interacts with a robot in an object hand-over task. A second objective was to obtain quantitative data to evaluate the effect of this interaction. Given the short duration, the "relative ease" of the object hand-over task and its qualitative component, classical behavioral measures based on accuracy or reaction time were unsuitable to compare our gestures. In this perspective, we selected three measurements based on the galvanic skin conductance response, the deltoid muscle activity and the ocular activity. To test our assumptions and validate our planner, an experimental set-up involving Jido, a mobile manipulator robot, and a seated human was proposed. For the purpose of the experiment, we have defined three motions

that combine different levels of legibility, safety and physical comfort values. After each robot gesture the participants were asked to rate them on a three dimensional subjective scale. It has appeared that the subjective data were in favor of our reference motion. Eventually the three motions elicited different physiological and ocular responses that could be used to partially discriminate them.

- **Keywords:** Human–Robot interaction; Robot companion; Physiology; Eye tracking; Human aware planning; Subjective evaluation

Gauthier Bedek, Fabien Salaün, Zuzana Martinkovska, Eric Devaux, Daniel Dupont. *Evaluation of thermal and moisture management properties on nitted fabrics and comparison with a physiological model in warm conditions.* Pages 792-800.

This study reports on an experimental investigation of physical properties on the textile thermal comfort. Textile properties, such as thickness, relative porosity, air permeability, moisture regain, thermal conductivity, drying time and water-vapour transmission rate have been considered and correlated to the thermal and vapour resistance, permeability index, thermal effusivity and moisture management capability in order to determine the overall comfort performance of underwear fabrics. The results suggested that the fibre type, together with moisture regain and knitted structure characteristics appeared to affect some comfort-related properties of the fabrics. Additionally, thermal sensations, temperature and skin wetness predicted by Caseto[®] software for three distinct activity levels were investigated. Results show that the data obtained from this model in transient state are correlated to the thermal conductivity for the temperature and to Ret, moisture regain and drying time for the skin wetness. This provides potential information to determine the end uses of these fabrics according to the selected activity level.

- **Keywords:** Thermal comfort; Heat and mass transfer; Underwear physical characteristics

Stephan Milosavljevic, Diane E. Gregory, Poonam Pal, Allan B. Carman, Peter D. Milburn, Jack P. Callaghan. *The interaction between skill, postures, forces and back pain in wool handling.* Pages 801-806.

Wool handling is an important rural occupation where workers process 200 or more fleeces daily, separating them into various quality components. Loads and postures they experience carry substantial risk of low back pain (LBP). Although a formal skill training structure exists, interaction with loads and LBP is unknown. We examined whether skill and LBP influenced trunk postures and loads of 60 wool handlers representing 3 skill levels. LBP prevalence ranged from 20% for junior (lowest skill) to 45% for open class (highest skill) wool handlers. Open class wool handlers demonstrated increased lateral bend and more axially twisted postures, generating greater medio-lateral shear forces and lateral bend and axial twist moments. LBP was associated with open class wool handlers spending more time in severe axially twisted postures. These findings suggest that skill-based training needs to be reviewed to reduce the quantity of axially twisted posture which may help reduce the prevalence of LBP in this workforce.

- **Keywords:** Wool handling; Skill; Cumulative loading; Work posture; Low back pain

Leandro Luigi Di Stasi, Adoración Antolí, José Juan Cañas. *Main semence : an index for detecting mental workload variation in complex tasks.* Pages 807-813.

The primary aim of this study was to validate the saccadic main sequence, in particular the peak velocity [PV], as an alternative psychophysiological measure of Mental Workload [MW]. Taking the Wickens' multiple resource model as the theoretical framework of reference, an experiment was conducted using the Firechief[®] microworld. MW was manipulated by changing the task complexity (between groups) and the amount of training (within groups). There were significant effects on PV from both factors. These results provide additional empirical support for the sensitivity of PV to discriminate MW variation on visual-dynamic complex tasks. These findings and other recent results on PV could provide important information for the development of a new vigilance screening tool for the prevention of accidents in several fields of applied ergonomics.

- **Keywords:** Eye movements; Microworlds; Fatigue

Peter J. Keir, Kia Sanei, Michael W.R. Holmes. *Task rotation effects on upper extremity and back muscle activity.* Pages 814-819.

Job rotation is an intuitive approach to distributing work to minimize muscular fatigue. The purpose of the current study was to evaluate rotation between lifting and gripping on muscle activity and effort. Ten male participants performed all 4 combinations of two 15 min tasks in 30 min trials split between separate days to prevent fatigue. The tasks of lifting a 12 kg box and gripping at 20% of maximum were performed 6 times per minute (5 s work: 5 s rest). Muscle activity (percentiles, gaps) and perceived effort were significantly affected by the task combinations. The forearm and upper erector spinae muscles did not benefit as greatly from rotating between lifting and gripping tasks as the lower erector spinae, deltoid or trapezius. In addition to gross task differences, overlaps in muscle activity between "low back" and "upper extremity" tasks must be considered when creating effective job rotation schemes.

- **Keywords:** Electromyography; Task rotation; Lifting

Ami Eliav, Talia Lavie, Yisrael Parmet, Helman Stern, Yael Edan. *Advanced methods for displays and remote control of robots.* Pages 820-829.

An in-depth evaluation of the usability and situation awareness performance of different displays and destination controls of robots are presented. In two experiments we evaluate the way information is presented to the operator and assess different means for controlling the robot. Our study compares three types of displays: a "blocks" display, a HUD (head-up display), and a radar display, and two types of controls: touch screen and hand gestures. The HUD demonstrated better performance when compared to the blocks display and was perceived to have greater usability compared to the radar display. The HUD was also found to be more useful when the operation of the robot was more difficult, i.e., when using the hand-gesture method. The experiments also pointed to the importance of using a wide viewing angle to minimize distortion and for easier coping with the difficulties of locating objects in the field of view margins. The touch screen was found to be superior in terms of both objective performance and its perceived usability. No differences were found between the displays and the controllers in terms of situation awareness. This research sheds light on the preferred display type and controlling method for operating robots from a distance, making it easier to cope with the challenges of operating such systems.

- **Keywords:** Human-robot interaction; Displays; Directional controllers

Arja Uusitalo, Terhi Mets, Kaisu Martinmäki, Saija Mauno, Ulla Kinnunen, Heikki Rusko. *Heart rate variability related to effort at work.* Pages 830-838.

Changes in autonomic nervous system function have been related to work stress induced increases in cardiovascular morbidity and mortality. Our purpose was to examine whether various heart rate variability (HRV) measures and new HRV-based relaxation measures are related to self-reported chronic work stress and daily emotions. The relaxation measures are based on neural network modelling of individual baseline heart rate and HRV information. Nineteen healthy hospital workers were studied during two work days during the same work period. Daytime, work time and night time heart rate, as well as physical activity were recorded. An effort-reward imbalance (ERI) questionnaire was used to assess chronic work stress. The emotions of stress, irritation and satisfaction were assessed six times during both days. Seventeen subjects had an ERI ratio over 1, indicating imbalance between effort and reward, that is, chronic work stress. Of the daily emotions, satisfaction was the predominant emotion. The daytime relaxation percentage was higher on Day 2 than on Day 1 ($4 \pm 6\%$ vs. $2 \pm 3\%$, $p < 0.05$) and the night time relaxation ($43 \pm 30\%$) was significantly higher than daytime or work time relaxation on the both Days. Chronic work stress correlated with the vagal activity index of HRV. However, effort at work had many HRV correlates: the higher the work effort the lower daytime HRV and relaxation time. Emotions at work were also correlated with work time (stress and satisfaction) and night time (irritation) HRV. These results indicate that daily emotions at work and chronic work stress, especially effort, is associated with cardiac autonomic function. Neural network modelling of individual heart rate and HRV information may provide additional information in stress research in field conditions.

- **Keywords:** Autonomic nervous system; Ambulatory measurement; Effort-Reward imbalance; Hospital worker; Recovery; Stress

Magne Helland, Gunnar Horgen, Tor Martin Kvikstad, Tore Garthus, Arne Aarås. *Will musculoskeletal and visual stress change when Visual Display Unit (VDU) operators move from small offices to an ergonomically optimized office landscape? Pages 839-845.*

This study investigated the effect of moving from small offices to a landscape environment for 19 Visual Display Unit (VDU) operators at Alcatel Denmark AS. The operators reported significantly improved lighting condition and glare situation. Further, visual discomfort was also significantly reduced on a Visual Analogue Scale (VAS). There was no significant correlation between lighting condition and visual discomfort neither in the small offices nor in the office landscape. However, visual discomfort correlated significantly with glare in small offices i.e. more glare is related to more visual discomfort. This correlation disappeared after the lighting system in the office landscape had been improved. There was also a significant correlation between glare and itching of the eyes as well as blurred vision in the small offices, i.e. more glare more visual symptoms. Experience of pain was found to reduce the subjective assessment of work capacity during VDU tasks. There was a significant correlation between visual discomfort and reduced work capacity in small offices and in the office landscape. When moving from the small offices to the office landscape, there was a significant reduction in headache as well as back pain. No significant changes in pain intensity in the neck, shoulder, forearm, and wrist/hand were observed. The pain levels in different body areas were significantly correlated with subjective assessment of reduced work capacity in small offices and in the office landscape. By careful design and construction of an office landscape with regard to lighting and visual conditions, transfer from small offices may be acceptable from a visual-ergonomic point of view.

- **Keywords:** VDU workplaces; Lighting conditions; Office landscape; Visual discomfort; Musculoskeletal disorders

A.M. Dale, A.E. Rohn, A. Patton, J. Standeven, B. Evanoff. *Variability and misclassification of worker estimated hand force. Pages 846-851.*

Ergonomic studies often use worker estimated hand force reproduced on a dynamometer to quantify force exposures but this method has not been well-studied in real work settings. This study evaluated the validity of worker estimates of hand force in a field study and determined the misclassification of worker estimated hand force exposures compared to directly measured forces. Eight experienced sheet metal assemblers completed ¼-inch diameter fastener installations using 6 different pneumatic tools. Grip forces were recorded by a pressure mat and were compared to worker estimated forces demonstrated on a dynamometer. Directly measured and worker estimated readings showed moderate correlations (0.53–0.67) for four installation tools and fair to moderate for two tools. The coefficient for variation of force estimates was 65% within repeated subject trials and 78% between averaged subject trials but 69% between subject trials during actual tool installations. Misclassification of worker estimated exposures varied by two cut-points: 29% using 4.0 kg and 49% using 6.0 kg. The force match procedure may provide adequate differentiation of high and low exposures in some settings, but is likely to result in substantial misclassification in other settings.

- **Keywords:** Force measurement; Hand force; Exposure rating

Melissa T. Baysari, Carlo Caponecchia, Andrew S. McIntosh. *A reliability and usability study of TRACER-RAV : the technique for the retrospective analysis of cognitive errors : for rail, Australian vision. Pages 852-859.*

The aim of this study was to compare the usability and reliability of two human error identification tools: TRACER-Rail (developed by the Rail Safety and Standards Board in the UK) and TRACER-RAV (an Australian specific version of the tool). Following an attempt to modify TRACER-Rail to more appropriately suit the Australian rail context, it was predicted that TRACER-RAV would be rated as more usable and be applied more consistently by Australian users than TRACER-Rail. In Experiment 1, twenty-five rail employees used either TRACER-Rail or TRACER-RAV1 to extract and classify errors from six Australian rail incident reports. In Experiment 2, eleven university students used both TRACER-Rail and TRACER-RAV2 to extract and classify errors from three incident summaries. The results revealed that although modification of TRACER-Rail to become TRACER-RAV1 and TRACER-RAV2 did not result in improved inter-rater reliability, modification resulted in improved ratings of usability in Experiment 2. Most participants in Experiment 2 preferred TRACER-RAV2 to TRACER-Rail. The poor inter-rater reliability observed was most likely the result of inadequate training, limited practice in using the tools, and insufficient human factors knowledge.

- **Keywords:** Human error; TRACER; Rail

Darja Rugelj, France Sevšek. *The effect of load mass and its placement on postural sway. Pages 860-866.*

The purpose of this study was to investigate the effects of increasing load on postural sway in two different carrying positions: backpack and waist jacket. Potential differences between males and females were additionally evaluated. 60 young college students participated in this study, and were assigned to backpack and waist jacket groups. The loads in both groups were 12, 21 and 30 kg. Stabilometry was used to assess the amount of postural sway. The medio-lateral and antero-posterior mean sway, mean velocity, medio-lateral and antero-posterior path length and sway area of the centre of pressure position were calculated. In the backpack group all analyzed sway parameters linearly increased with additional load, the differences were significant at $p < 0.001$. However no significant change of the analyzed parameters was found when the subjects carried additional load in the waist jacket. Our results indicate that postural sway depends on the amount of the load carried in a backpack. Additionally, the position of the load is of significant importance. Carrying weight in a backpack increases postural sway with increasing weight whereas carrying weight in a waist jacket does not influence

the amount of postural sway. There are no significant differences in the response to the amount and configuration of the load between male and female subjects.

- **Keywords:** Stabilometry; Postural sway; Load position; Load configuration

Sangeun Jin, Gary A. Mirka. *The effect of a lower extremity kinematic constraint on lifting biomechanics. Pages 867-872.*

Leaning against a stationary barrier during manual materials handling tasks is observed in many industrial environments, but the effects of this kinematic constraint on low back mechanics are unknown. Thirteen participants performed two-handed lifting tasks using both a leaning posture and no leaning posture while trunk kinematics, muscle activity and ground reaction force were monitored. Results revealed that lifting with the leaning posture required significantly less activity in erector spinae (26% vs. 36% MVC) and latissimus dorsi (8% vs. 14% MVC), and less passive tissue moment compared with the no leaning posture. Peak sagittal accelerations were lower when leaning, but the leaning posture also had significantly higher slip potential as measured by required coefficient of friction (0.05 vs. 0.36). The results suggested that the leaning lifting strategy provides reduced low back stress, but does so at the cost of increased slip potential.

- **Keywords:** Manual materials handling; Kinematic constraints; Low back

Hyuk Choi, Man Sik Park, Bonghyun Nam, Jungbok Lee, Eunhi Kim, Heung-Man Lee. *Palm surface area database and estimation formula in Korean children using the alginate method. Pages 873-882.*

Studies of palm surface area (PSA) have been investigated as an important reference area unit in physiology and medicine today. Most previous PSA studies have been limited to adults. The purpose of this study was to archive Korean children's PSA data and to calculate an optimized formula for estimating PSA. A total of 305 people, 186 boys and 119 girls all aged between 7 and 18 years, were recruited for this study and their PSA was directly measured by a useful, accurate, and quick method – the alginate method. Mean PSA for males and females was found and the optimized formula for estimating PSA was computed. It would be meaningful to note that this trial was the first to generate data from Korean children, which could be widely available for utilization in anthropometry, toxicology research, thermal physiology and in skin burn studies for Asian children.

- **Keywords:** Anthropometry; Palm surface area; Asian children; Formula

Michael J. Taber, Natalie F. Dies, Stephen S. Cheung. *The effect of transportation suit induced heat stress on helicopter underwater escape preparation and task performance. Pages 883-889.*

Although essential in an emergency such as a helicopter ditching, mandatory survival suits worn by civilian personnel may lead to heat strain during a normal flight. To explore the possibility that wearing a helicopter transportation suit impairs emergency performance, 11 individuals completed underwater escape procedures immediately following a pre-recorded emergency announcement (randomly played between 50 and 90 min) in two ambient temperature conditions (Thermoneutral = 21 °C and Hot = 34 °C). Mean skin and rectal temperatures were recorded throughout the trials, while situation awareness and thermal sensation/comfort were recorded on completion of trials. Results indicate that although mean skin and rectal temperatures were significantly higher at the end of both trials, escape procedures were not impaired. It can therefore be concluded that although conditions inside an offshore transport helicopter

are perceived as being hot and uncomfortable, no deficits in escape performance should be expected in the first 90 min of flight.

- **Keywords:** Heat stress; Situation awareness; Underwater escape procedures; Human performance

A. Virgílio M. Oliveira, Adélio R. Gaspar, Divo A. Quintela. *Dynamic clothing insulation : measurements with a thermal manikin operating under the thermal comfort regulation mode.* Pages 890-899.

The main objective of the present work is the assessment of the thermal insulation of clothing ensembles, both in static conditions and considering the effect of body movements. The different equations used to calculate the equivalent thermal resistance of the whole body, namely the *serial*, the *global* and the *parallel* methods, are considered and the results are presented and discussed for the basic, the effective and the total clothing insulations. The results show that the dynamic thermal insulation values are always lower than the corresponding static ones. The highest mean relative difference $[(\text{static-dynamic})/\text{static}]$ was obtained with the *parallel* method and the lowest with the *serial*. For I_{cl} the mean relative differences varied from 0.5 to 13.4% with the *serial* method, from 5.6 to 14.6% with the *global* and from 7.2 to 17.7% with the *parallel* method. In addition, the dynamic tests presents the higher mean relative differences between the calculation methods. The results also show that the *serial* method always presents the higher values and the *parallel* method the lowest ones. The relative differences between the calculation methods $\{[(\text{serial-global})/\text{global}] \text{ and } [(\text{parallel-global})/\text{global}]\}$ were sometimes significant and associated to the non-uniform distribution of the clothing insulation. In fact, the ensembles with the highest thermal insulation values present the highest differences between the calculation methods.

- **Keywords:** Thermal insulation of clothing; Calculation methods; Movable thermal manikin; Cold protective clothing

Y.J. Wang, P.Y. Mok, Y. Li, Y.L. Kwok. *Body measurements of Chinese males in dynamic postures and application.* Pages 900-912.

It is generally accepted that there is a relationship between body dimensions, body movement and clothing wearing ease design, and yet previous research in this area has been neither sufficient nor systematic. This paper proposes a method to measure the human body in the static state and in 17 dynamic postures, so as to understand dimensional changes of different body parts during dynamic movements. Experimental work is carried out to collect 30 measurements of 10 male Chinese subjects in both static and dynamic states. Factor analysis is used to analyse body measurement data in a static state, and such key measurements describe the characteristics of different body figures. Moreover, one-way ANOVA is used to analyse how dynamic postures affect these key body measurements. Finally, an application of the research results is suggested: A *dynamic block patternmaking* method for high-performance clothing design.

- **Keywords:** Body measurements; Wearing ease; Dynamic block pattern

Venkatesh Balasubramanian, Ashwani Dutt, Shobhit Rai. *Analysis of muscle fatigue in helicopter pilots.* Pages 913-918.

Helicopter pilots espouse ergonomically unfavourable postures and endure vibration which result in low back pain. The objective of this study was to investigate the effects of a helicopter flight on pilots back and shoulder muscles using surface Electromyography (sEMG) analysis. This study also correlates low back pain symptoms from Rehabilitation Bioengineering Group Pain Scale (RBGPS) questionnaire with muscle fatigue rates obtained. RBGPS was administered on 20 Coast Guard helicopter pilots. sEMG was

acquired before and after flight from erector spinae and trapezius muscles in 8 of these 20 pilots. Statistical analysis of time and frequency domain parameters indicated significant fatigue in right trapezius muscle due to flying. Muscle fatigue correlated with average duration of flight ($r^2 = 0.913$), total service as pilot ($r^2 = 0.825$), pain ($r^2 = 0.463$) and total flying hours ($r^2 = 0.507$). However, muscle fatigue weakly correlated with Body Mass Index (BMI) ($r^2 = 0.000144$) and age ($r^2 = 0.033$).

- **Keywords:** Helicopter pilots; Low back pain; sEMG study; RBGPS

Scarlett R. Herring, Pamela Castillejos, M. Susan Hallbeck. *User-centered evaluation of handle shape and size and input controls for a neutron detektor. Pages 919-928.*

Current neutron detectors are big, heavy, difficult to use and are not ergonomically designed. Good handle design and easy to use control mechanisms are imperative for comfort, usability and accuracy for hand-held tools. Two studies were performed to assess these factors; Study I explored handle design (shape and size) preference and Study II evaluated the effects of control mechanisms, device orientations and word orientation on performance time. According to research findings, the recommended handle perimeter is 11 cm with a diameter range of 3.5–4.0 cm. These results demonstrated that as the handle perimeter decreased the handle becomes less preferred by first responders when using layered gloves. For control type, the fastest performance time was found with vertical push buttons and a vertical word orientation. These objective results matched the subjective results, which showed that the most preferred controller was a vertical push button control.

- **Keywords:** Handle; Controls; First responders; Hand-held tools; Gloves

Kai Way Li, Ruifeng Yu. *Assessment of grip force and subjective hand force exertion under handedness and postural conditions. Pages 929-933.*

The Borg CR-10 scale has been used to quantify the perception of physical exertion. An experiment was conducted to test the grip force of males on four levels of the CR-10 scale under experimental conditions. It was found that the subjects applied higher grip forces than they perceived at levels 2, 5, and 7 on the scale. The grip forces between dominant and non-dominant hands at low CR-10 levels were negligible. The grip forces were significantly different between the two hands at level 10. Similar results were found for the postural conditions. A follow-up experiment was conducted to estimate the subjective rating when applying a pre-determined grip force under the same conditions. Regression models were established to link the relationship between the subjective rating and hand force. The estimated ratings were lower than those actual values under all the tested conditions, even though the models have high R^2 values.

- **Keywords:** Borg CR-10; Grip force; Hand exertion; Subjective rating

Russell J. Branaghan, Christine M. Covas-Smith, Kenneth D. Jackson, Craig Eidman. *Using knowledge structures to redesign an instructor-operator station. Pages 934-940.*

Frequently, user interface (UI) designers must choose between modifying an established, but suboptimal and familiar, UI or to avoid such changes. Changing the UI's, organization may frustrate users who have become familiar with the original design, whereas failing to make changes may force users to perform at an unsatisfactory level. This paper presents two studies that investigate whether users familiar with a poorly designed UI would find items faster, and prefer a reorganized UI that conformed to domain expert knowledge, or

would their familiarity with the original UI yield faster performance and higher satisfaction. This paper describes activities to redesign a menu structure in a simulator instructor-operator station (IOS) using hierarchical card sorting and cluster analysis (Romesburg, 2004). This analysis was used to reorganize the menu structure to reflect the knowledge representations of domain experts in accordance with the principle of proximity compatibility. The new design was validated with a separate set of users by a reaction time experiment and preference selection.

- **Keywords:** Mental models; Menu design; Simulation training