

## **Ergonomics- rok 2015, ročník 58**

### **Číslo 6**



**Rui-feng Yu & Xin Wu. Working alone or in the presence of others: exploring social facilitation in baggage X-ray security screening tasks. Pages 857-865.**

This study investigated whether the mere presence of a human audience would evoke a social facilitation effect in baggage X-ray security screening tasks. A 2 (target presence: present vs. absent) × 2 (task complexity: simple vs. complex) × 2 (social presence: alone vs. human audience) within-subject experiment simulating a real baggage screening task was conducted. This experiment included 20 male participants. The participants' search performance in this task was recorded. The results showed that the presence of a human audience speeded up responses in simple tasks and slowed down responses in complex tasks. However, the social facilitation effect produced by the presence of a human audience had no effect on response accuracy. These findings suggested that the complexity of screening tasks should be considered when designing work organisation modes for security screening tasks. **Practitioner summary:** This study investigated whether the presence of a human audience could evoke a social facilitation effect in baggage X-ray security screening tasks. An experimental simulation was conducted. The results showed that the presence of a human audience facilitated the search performance of simple tasks and inhibited the performance of complex tasks.

- **Keywords:** visual search, social facilitation, work organisation, threat detection

**Rich C. McIlroy & Neville A. Stanton. A decision ladder analysis of eco-driving: the first step towards fuel-efficient driving behaviour. Pages 866-882.**

This paper provides a decision ladder analysis of eco-driving, and a discussion of the resultant models in terms of the skills, rules and knowledge taxonomy of human behaviour and how this can inform the design of an in-vehicle, eco-driving support system. In order to understand the types of behaviours that characterise fuel-efficient driving, a review was conducted of the academic literature and of more publicly available resources, such as governmental, car manufacturers' and specific eco-driving organisations' websites. The review identified four largely distinct driving activities that play a central role in the use of fuel in the private road vehicle. A focus group involving

four researchers in the transport ergonomics field, followed by a series of five interviews with eco-driving experts, served to validate, supplement and further specify the models. **Practitioner Summary:** This paper presents a decision ladder analysis of eco-driving. A four-member focus group and five interviews with eco-driving experts were conducted; the resultant models are discussed in terms of supporting fuel-efficient driving behaviours in the novice eco-driver through their potential to inform the design of an in-vehicle eco-driving support system.

- **Keywords:** eco-driving, decision ladders, skills, rules, and knowledge, driver feedback, energy consumption

**Anjum Naweed, Sophia Rainbird & Janine Chapman. *Investigating the formal countermeasures and informal strategies used to mitigate SPAD risk in train driving. Pages 883-896.***

Various countermeasures are used to mitigate signal passed at danger (SPAD) events on railways, yet they continue. While risk factors that destabilise cognitive processes have been identified, less has been published on the relationship between these factors and the informal strategies that drivers themselves adopt to reduce individual SPAD risk. This study aimed to address this gap and used a participative approach to collect and thematically analyse data from 28 drivers across eight rail organisations in Australia and New Zealand. The results showed not all formal countermeasures were considered effective, and identified several informal strategies. These aimed to reduce task disruption, service distortion and maintain connectedness to signals. While some evidenced redundancies in the task and cab, others did not reduce baseline risk. This paper explores the relationship between the established risks and identified strategies towards evaluating the utility of formal and informal mitigations. The research has application to the investigation of collision risk in all transport domains. **Practitioner Summary:** A participative approach was used to investigate SPAD mitigation techniques in train driving, and to explore risk-strategy relationship dynamics. Several informal strategies designed to reduce task disruption, service distortion and maintain signal connectedness were identified. While some evidenced redundancies in the task and cab, others did not reduce baseline risk.

- **Keywords:** human factors risk, cognitive ergonomics, rail, train driving, SPADs, distraction

**Fitri Trapsilawati, Xingda Qu, Chris D. Wickens & Chun-Hsien Chen. *Human factors assessment of conflict resolution aid reliability and time pressure in future air traffic control. Pages 897-908.***

Though it has been reported that air traffic controllers' (ATCos') performance improves with the aid of a conflict resolution aid (CRA), the effects of imperfect automation on CRA are so far unknown. The main objective of this study was to examine the effects of imperfect automation on conflict resolution. Twelve students with ATC knowledge were instructed to complete ATC tasks in four CRA conditions including reliable, unreliable and high time pressure, unreliable and low time pressure, and manual conditions. Participants were able to resolve the designated conflicts more accurately and faster in the reliable versus unreliable CRA conditions. When comparing the unreliable CRA and manual conditions, unreliable CRA led to better conflict resolution performance and higher situation awareness. Surprisingly, high time pressure triggered better conflict resolution performance as compared to the low time pressure condition. The findings from the present study highlight the importance of CRA in future ATC operations. **Practitioner Summary:** Conflict resolution aid (CRA) is a proposed automation decision aid in air traffic control (ATC). It was found in the present study that CRA was able to promote air traffic controllers' performance even when it was not perfectly reliable. These findings highlight the importance of CRA in future ATC operations.

- **Keywords:** air traffic control, conflict resolution aid, automation reliability, time pressure, human factors assessment

**Katherine L. Plant & Neville A. Stanton.** *The process of processing: exploring the validity of Neisser's perceptual cycle model with accounts from critical decision-making in the cockpit.* Pages 909-923.

The perceptual cycle model (PCM) has been widely applied in ergonomics research in domains including road, rail and aviation. The PCM assumes that information processing occurs in a cyclical manner drawing on top-down and bottom-up influences to produce perceptual exploration and actions. However, the validity of the model has not been addressed. This paper explores the construct validity of the PCM in the context of aeronautical decision-making. The critical decision method was used to interview 20 helicopter pilots about critical decision-making. The data were qualitatively analysed using an established coding scheme, and composite PCMs for incident phases were constructed. It was found that the PCM provided a mutually exclusive and exhaustive classification of the information-processing cycles for dealing with critical incidents. However, a counter-cycle was also discovered which has been attributed to skill-based behaviour, characteristic of experts. The practical applications and future research questions are discussed. **Practitioner Summary:** This paper explores whether information processing, when dealing with critical incidents, occurs in the manner anticipated by the perceptual cycle model. In addition to the traditional processing cycle, a reciprocal counter-cycle was found. This research can be utilised by those who use the model as an accident analysis framework.

- **Keywords:** critical decision method, perceptual cycle model, schema theory, aeronautical decision-making, qualitative analysis, validity

**Kejin Chen & Zhizhong Li.** *How does information congruence influence diagnosis performance?* Pages 924-934.

Diagnosis performance is critical for the safety of high-consequence industrial systems. It depends highly on the information provided, perceived, interpreted and integrated by operators. This article examines the influence of information congruence (congruent information vs. conflicting information vs. missing information) and its interaction with time pressure (high vs. low) on diagnosis performance on a simulated platform. The experimental results reveal that the participants confronted with conflicting information spent significantly more time generating correct hypotheses and rated the results with lower probability values than when confronted with the other two levels of information congruence and were more prone to arrive at a wrong diagnosis result than when they were provided with congruent information. This finding stresses the importance of the proper processing of non-congruent information in safety-critical systems. Time pressure significantly influenced display switching frequency and completion time. This result indicates the decisive role of time pressure. **Practitioner Summary:** This article examines the influence of information congruence and its interaction with time pressure on human diagnosis performance on a simulated platform. For complex systems in the process control industry, the results stress the importance of the proper processing of non-congruent information in safety-critical systems.

- **Keywords:** complex systems, diagnosis performance, information congruence, time pressure

**Richard Clewley & Edward J.N. Stupple.** *The vulnerability of rules in complex work environments: dynamism and uncertainty pose problems for cognition.* Pages 935-941.

Many complex work environments rely heavily on cognitive operators using rules. Operators sometimes fail to implement rules, with catastrophic human, social and economic costs. Rule-based error is widely reported, yet the mechanisms of rule vulnerability have received less attention. This paper examines rule vulnerability in the complex setting of airline transport operations. We examined 'the stable approach criteria rule', which acts as a system defence during the approach to land. The study experimentally tested whether system state complexity influenced rule failure. The results showed increased uncertainty and dynamism led to increased likelihood of rule failure. There was also an interaction effect, indicating complexity from different sources can combine to further constrain rule-based response. We discuss the results in relation to recent aircraft accidents and suggest that 'rule-based error' could be progressed to embrace rule vulnerability, fragility and failure. This better reflects the influence that system behaviour and cognitive variety have on rule-based response. **Practitioner Summary:** In this study, we examined mechanisms of rule vulnerability in the complex setting of airline transport operations. The results suggest work scenarios featuring high uncertainty and dynamism constrain rule-based response, leading to rules becoming vulnerable, fragile or failing completely. This has significant implications for rule-intensive, safety critical work environments.

- **Keywords:** rules, rule-based cognitive control, complexity, flight safety

**Victoria Smy, Helen Seeby & John Patrick. *The nature of complexity facing novice designers in a constraint satisfaction task. Pages 942-952.***

This paper examines the effects of different types of complexity facing novice designers in constraint satisfaction tasks. The nature of the complexity in a design task was varied by manipulating different aspects of the extrinsic constraints, which refer to restrictions concerning how design components can be assembled. We investigated the effect of the number of constraints (Study 1) and the number of different types of constraint (Study 2) in a simulated office design task. Results indicated that tackling a design task with a greater number of constraints, or more types of constraint, resulted in decrements in performance. Study 3 examined the effect of reasoning about constraints that involved a fixed location in the office layout and those that did not. It was found that having a higher proportion of constraints that referenced a fixed location led to better design performance. The theoretical and practical aspects of these results are discussed. **Practitioner summary:** This paper identifies sources of constraint complexity facing the novice designer in an office design task. Three features of constraints proved problematic: the number of constraints, the number of types of constraint and whether the constraint involved a specific location. Training and decision support solutions are discussed.

- **Keywords:** design, constraint satisfaction, constraints, office design

**Ingunn Stemland, Jørgen Ingebrigtsen, Caroline S. Christiansen, Bente R. Jensen, Christiana Hanisch, Jørgen Skotte & Andreas Holtermann. *Validity of the Acti4 method for detection of physical activity types in free-living settings: comparison with video analysis. Pages 953-965.***

This study examined the ability of the Acti4 software for identifying physical activity types from accelerometers during free-living with different levels of movement complexity compared with video observations. Nineteen aircraft cabin cleaners with ActiGraph GT3X+ accelerometer at the thigh and hip performed one semi-standardised and two non-standardised sessions (outside and inside aircraft) with different levels of movement complexity during working hours. The sensitivity for identifying different activity types was 75.4–99.4% for the semi-standardised session, 54.6–98.5% outside the aircraft and 49.9–90.2% inside the aircraft. The specificity was above 90% for all activities, except 'moving' inside the aircraft. These findings indicate that Acti4 provides

good estimates of time spent in different activity types during semi-standardised conditions, and for sitting, standing and walking during non-standardised conditions with normal level of movement complexity. The Acti4 software may be a useful tool for researchers and practitioners in the field of ergonomics, occupational and public health.

**Practitioner Summary:** Being inexpensive, small, water-resistant and without wires, the ActiGraph GT3X+ by applying the Acti4 software may be a useful tool for long-term field measurements of physical activity types for researchers and practitioners in the field of ergonomics, occupational and public health.

- **Keywords:** occupational, accelerometry, validation, ActiGraph, Acti4

**Alberto Ranavolo, Silvia Mari, Carmela Conte, Mariano Serrao, Alessio Silvetti, Sergio Iavicoli & Francesco Draicchio. A new muscle co-activation index for biomechanical load evaluation in work activities. Pages 966-979.**

Low-back disorders (LBDs) are the most common and costly musculoskeletal problem. Muscle co-activation, a mechanism that stabilises the spine, is adopted by the central nervous system to provide added protection and avoid LBDs. However, during high-risk lifting tasks, the compressive load on the spine grows owing to increased co-activation. The aim of this study was to develop a method for the sample-by-sample monitoring of the co-activation of more than two muscles, and to compare this method with agonist-antagonist methods. We propose a time-varying multi-muscle co-activation function that considers electromyographic (EMG) signals as input. EMG data of 10 healthy subjects were recorded while they manually lifted loads at three progressively heavier conditions. The repeated measures ANOVA revealed a significant effect of lifting condition on our co-activation index. Heavier conditions resulted in higher muscle co-activation values. Significant correlations were found between the time-varying multi-muscle co-activation index and other agonist-antagonist methods. **Practitioner Summary:** We have developed a method to quantify muscle co-activation during the execution of a lifting task. To do this we used surface electromyography. Our algorithm provides a measure of time-varying co-activation between more than two muscles.

- **Keywords:** muscle co-activation, musculoskeletal disorders, EMG, biomechanical load

**Ramakrishnan Mani, Stephan Milosavljevic & S. John Sullivan. Control of posture during tasks representing common work-related postures – a reliability study. Pages 980-989.**

Assessment of control of posture using a task battery that represents work-related postural conditions is highly recommended for providing a comprehensive understanding of collective postural demands. However, dearth of evidence exists on the reliability of a task battery, thus precluding its use as an outcome measure in field research. This study investigated the intrasession reliability and systematic variation of force plate derived centre of pressure (COP) measures obtained during repeated performance of a task battery (lifting task, limits of stability and bipedal and unipedal stance). COP signals obtained during each task performance were processed to derive various time-domain COP measures. Statistical analyses revealed that 13 of the 19 COP measures displayed excellent relative ( $ICC_{(2,3)} \geq 0.75$ ) and acceptable absolute reliability ( $SEM\%: \leq 10$ ). Although COP measures displayed systematic variation, the differences were less or equal to the measurement error, except COP measures of unipedal stance and limits of stability. The chosen task battery is reliable and can be used for comprehensive evaluation of control of posture, in both field and laboratory research. **Practitioner Summary:** Repeated evaluation of multiple tasks together sequentially could introduce measurement variability. This study investigated intrasession reliability of a task battery

representing common work-related postures. The chosen task battery was found to be reliable with acceptable measurement error and can be used in field research settings for evaluation of control of posture.

- **Keywords:** task battery, postural control, reliability, standard error of measurement, centre of pressure

**Anita N. Vasavada, Derek D. Nevins, Steven M. Monda, Ellis Hughes & David C. Lin. *Gravitational demand on the neck musculature during tablet computer use. Pages 990-1004.***

Tablet computer use requires substantial head and neck flexion, which is a risk factor for neck pain. The goal of this study was to evaluate the biomechanics of the head-neck system during seated tablet computer use under a variety of conditions. A physiologically relevant variable, gravitational demand (the ratio of gravitational moment due to the weight of the head to maximal muscle moment capacity), was estimated using a musculoskeletal model incorporating subject-specific size and intervertebral postures from radiographs. Gravitational demand in postures adopted during tablet computer use was 3–5 times that of the neutral posture, with the lowest demand when the tablet was in a high propped position. Moreover, the estimated gravitational demand could be correlated to head and neck postural measures ( $0.48 < R^2 < 0.64$ ,  $p < 0.001$ ). These findings provide quantitative data about mechanical requirements on the neck musculature during tablet computer use and are important for developing ergonomics guidelines. **Practitioner Summary:** Flexed head and neck postures occur during tablet computer use and are implicated in neck pain. The mechanical demand on the neck muscles was estimated to increase 3–5 times during seated tablet computer use versus seated neutral posture, with the lowest demand in a high propped tablet position but few differences in other conditions.

- **Keywords:** tablet computer, biomechanics, neck muscles, posture

**Ana Christina Vieira & Fernando Ribeiro. *Impact of backpack type on respiratory muscle strength and lung function in children. Pages 1005-1011.***

We examine the influence of backpack type on lung function and respiratory muscle strength in children. Thirty-seven children were assessed for lung function and inspiratory and expiratory muscle strength under four randomly determined conditions: unloaded erect standing and three conditions carrying 15% of the child's body weight. In these three conditions, children carried the weight on a backpack with bilateral shoulder straps carried over both shoulders, on a backpack with bilateral shoulder straps carried over one shoulder and on a backpack with a mono shoulder strap. Significantly lower forced vital capacity, forced expiratory volume in one second and maximal expiratory pressure were observed when children carried a backpack with a mono shoulder strap compared to the unloaded standing position. In conclusion, the restrictive effect and the decrease in expiratory muscle strength were more pronounced for the backpack with a mono shoulder strap, suggesting that a double strap backpack is preferable to a mono shoulder strap backpack. **Practitioner summary:** There is little known about the effect of schoolbags on respiratory muscle function. We investigated the influence of backpack type on lung function and respiratory muscle strength. A backpack with a mono shoulder strap created a restrictive effect and a decrease in strength, suggesting that a double strap backpack is preferable to a mono shoulder strap backpack.

- **Keywords:** child, maximal inspiratory pressure, maximal expiratory pressure, pulmonary function, schoolbag type

**Gavin P. Horn, Richard M. Kesler, Robert W. Motl, Elizabeth T. Hsiao-Wecksler, Rachel E. Klaren, Ipek Ensari, Matthew N. Petrucci, Bo Fernhall & Karl S. Rosengren.** *Physiological responses to simulated firefighter exercise protocols in varying environments.* Pages 1012-1021.

For decades, research to quantify the effects of firefighting activities and personal protective equipment on physiology and biomechanics has been conducted in a variety of testing environments. It is unknown if these different environments provide similar information and comparable responses. A novel Firefighting Activities Station, which simulates four common fireground tasks, is presented for use with an environmental chamber in a controlled laboratory setting. Nineteen firefighters completed three different exercise protocols following common research practices. Simulated firefighting activities conducted in an environmental chamber or live-fire structures elicited similar physiological responses (max heart rate: 190.1 vs 188.0 bpm, core temperature response: 0.047°C/min vs 0.043°C/min) and accelerometry counts. However, the response to a treadmill protocol commonly used in laboratory settings resulted in significantly lower heart rate (178.4 vs 188.0 bpm), core temperature response (0.037°C/min vs 0.043°C/min) and physical activity counts compared with firefighting activities in the burn building. **Practitioner Summary:** We introduce a new approach for simulating realistic firefighting activities in a controlled laboratory environment for ergonomics assessment of fire service equipment and personnel. Physiological responses to this proposed protocol more closely replicate those from live-fire activities than a traditional treadmill protocol and are simple to replicate and standardise.

- **Keywords:** firefighting, test protocol, core temperature, heart rate, heat stress

**Sandra Sanok, Franco Mendolia, Martin Wittkowski, Daniel Rooney, Matthias Putzke & Daniel Aeschbach.** *Passenger comfort on high-speed trains: effect of tunnel noise on the subjective assessment of pressure variations.* Pages 1022-1031.

When passing through a tunnel, aerodynamic effects on high-speed trains may impair passenger comfort. These variations in atmospheric pressure are accompanied by transient increases in sound pressure level. To date, it is unclear whether the latter influences the perceived discomfort associated with the variations in atmospheric pressure. In a pressure chamber of the DLR-Institute of Aerospace Medicine, 71 participants ( $M = 28.3$  years  $\pm 8.1$  SD) rated randomised pressure changes during two conditions according to a crossover design. The pressure changes were presented together with tunnel noise such that the sound pressure level was transiently elevated by either +6 dB (low noise condition) or +12 dB (high noise condition) above background noise level (65 dB(A)). Data were combined with those of a recent study, in which identical pressure changes were presented without tunnel noise (Schwanitz et al., 2013, 'Pressure Variations on a Train - Where is the Threshold to Railway Passenger Discomfort?' *Applied Ergonomics* 44 (2): 200-209). Exposure-response relationships for the combined data set comprising all three noise conditions show that pressure discomfort increases with the magnitude and speed of the pressure changes but decreases with increasing tunnel noise. **Practitioner Summary:** In a pressure chamber, we systematically examined how pressure discomfort, as it may be experienced by railway passengers, is affected by the presence of tunnel noise during pressure changes. It is shown that across three conditions (no noise, low noise (+6 dB), high noise (+12 dB)) pressure discomfort decreases with increasing tunnel noise.

- **Keywords:** passenger comfort, high-speed train, tunnel, pressure variations, sound pressure level

**Okey Francis Obi, Boniface O. Ugwuishiwu & Busayo S. Adeboye. A survey of anthropometry of rural agricultural workers in Enugu State, south-eastern Nigeria. Pages 1032-1044.**

In developed countries, large amount of anthropometric data are available for reference purposes; however, anthropometric data of Nigerian populace are lacking. As a result, most agricultural machines and equipment used are designed using anthropometric data from other populations of the world. A total of 377 rural agricultural workers within the age limit of 18–45 years, who are involved in different agricultural activities, were selected from six rural agriculture-based communities in Enugu state. Thirty-six anthropometric body dimensions were measured including age and body weight. A comparison between the male and female data indicated that data obtained from male agricultural workers were higher than that obtained from their female counterparts in all body dimensions except chest (bust) depth, abdominal breadth and hip breadth (sitting). In terms of design parameters, it was observed that the data from Nigerian agricultural workers were different from that obtained from agricultural workers in north-eastern India. **Practitioner Summary.** Anthropometric data of Nigeria populace are lacking. As a result, most agricultural machines and equipment used are designed using anthropometric data from other populations of the world. It was observed that the data from Nigerian agricultural workers were different from that obtained from agricultural workers in north-eastern India.

- **Keywords:** anthropometric data, equipment design, rural agricultural workers, Nigeria

**Brian T. Pagano, Matthew B. Parkinson & Matthew P. Reed. An updated estimate of the body dimensions of US children. Pages 1045-1057.**

Anthropometric data from children are important for product design and the promulgation of safety standards. The last major detailed study of child anthropometry in the USA was conducted more than 30 years ago. Subsequent demographic changes and the increased prevalence of overweight and obesity render those data increasingly obsolete. A new, large-scale anthropometric survey is needed. As an interim step, a new anthropometric synthesis technique was used to create a virtual population of modern children, each described by 84 anthropometric measures. A subset of these data was validated against limited modern data. Comparisons with data from the 1970s showed significant changes in measures of width and circumference of the torso, arms and legs. Measures of length and measurements of the head, face, hands and feet exhibited little change. The new virtual population provides guidance for a comprehensive child anthropometry survey and could improve safety and accommodation in product design. **Practitioner Summary:** This research reviews the inadequacies of available sources of US child anthropometry as a result of the rise in the rates of overweight and obesity. A new synthesised database of detailed modern child anthropometry was created and validated. The results quantify changes in US child body dimensions since the 1970s.

- **Keywords:** child anthropometry, anthropometry synthesis, human variability, child obesity, child growth, product design