

# Ergonomics – rok 2013, ročník 56

## Číslo 1



**Katherine L. Plant & Neville A. Stanton. *The explanatory power of Schema Theory: theoretical foundations and future applications in Ergonomics*. Pages 1-15.**

Schema Theory is intuitively appealing although it has not always received positive press; critics of the approach argue that the concept is too ambiguous and vague and there are inherent difficulties associated with measuring schemata. As such, the term schema can be met with scepticism and wariness. The purpose of this paper is to address the criticisms that have been levelled at Schema Theory by demonstrating how Schema Theory has been utilised in Ergonomics research, particularly in the key areas of situation awareness, naturalistic decision making and error. The future of Schema Theory is also discussed in light of its potential roles as a unifying theory in Ergonomics and in contributing to our understanding of distributed cognition. We conclude that Schema Theory has made a positive contribution to Ergonomics and with continued refinement of methods to infer and represent schemata it is likely that this trend will continue.

**Practitioner Summary:** This paper reviews the contribution that Schema Theory has made to Ergonomics research. The criticisms of the theory are addressed using examples from the areas of situation awareness, decision making and error.

- **Keywords:** Schema Theory, situation awareness, naturalistic decision making, error

**Catherine Harvey & Neville A. Stanton. *Modelling the hare and the tortoise: predicting the range of in-vehicle task times using critical path analysis*. Pages 16-33.**

Analytic models can enable predictions about important aspects of the usability of in-vehicle information systems (IVIS) to be made at an early stage of the product development process. Task times provide a quantitative measure of user performance and are therefore important in the evaluation of IVIS usability. In this study, critical path analysis (CPA) was used to model IVIS task times in a stationary vehicle, and the technique was extended to produce predictions for slowperson and fastperson performance, as well as average user (middleperson) performance. The CPA-predicted task times were compared to task times recorded in an empirical simulator study of IVIS interaction, and the predicted times were, on average, within acceptable precision limits. This work forms the foundation for extension of the CPA model to predict IVIS task times in a moving vehicle, to reflect the demands of the dual-task driving scenario.

**Practitioner Summary:** The CPA method was extended for the prediction of slowperson and fastperson IVIS task times. Comparison of the model predictions with empirical data demonstrated acceptable precision. The CPA model can be used in early IVIS evaluation; however, there is a need to extend it to represent the dual-task driving scenario.

- **Keywords:** in-vehicle information systems, interaction, modelling, task times

**Esko Lehtonen, Otto Lappi, Henri Kotkanen & Heikki Summala. *Look-ahead fixations in curve driving*. Pages 34-44.**

Two functionally distinct types of fixation, guiding fixations and look-ahead fixations, have been identified in naturalistic tasks based on their temporal relationship to the task execution. In car driving, steering through a curve is guided by fixations toward a region located 1–2 s in the future, but drivers also make fixations further along the road. We recorded drivers' eye movements while they drove an instrumented vehicle on curved rural roads and developed a method to quantify lead time and distance of look-ahead fixations. We also investigated the effect of cognitive load on look-ahead fixations. The look-ahead fixations appear to have a pattern which is connected to the sequential structure of a curve. This suggests that they have a role both in advance planning of the driving line and in the anticipation of oncoming vehicles. Cognitive load led to a shorter look-ahead lead time and distance.

**Practitioner Summary:** We developed a method to quantify lead time and distance of look-ahead fixations in curve driving from on-road eye movement data. The results are relevant for driver modelling and development of anticipation training programmes for novice drivers.

- **Keywords:** car driving, anticipation, look-ahead fixation, occlusion point, cognitive load

**Diane Gyi, Katherine Sang & Cheryl Haslam. *Participatory ergonomics: co-developing interventions to reduce the risk of musculoskeletal symptoms in business drivers*. Pages 45-58.**

The participatory process within four case study organisations with a target population of high mileage business drivers is described. The aim was to work with drivers and their managers to co-develop intervention activities to raise awareness of musculoskeletal health in drivers, including use of the car as a mobile office and manual handling from the car. Train-the-trainer sessions were delivered in each organisation, along with the co-production of training materials. The effectiveness of these activities were evaluated using three sources of data: post-intervention questionnaires, interviews with organisation 'champions' and observations from the research team's diaries. The approach raised management awareness of the risks to drivers and was successful in affecting change, and as such, participatory research should consider the early stages of a project as part of any intervention activities. The research team also reflect on conducting applied longitudinal research in the field.

**Practitioner Summary:** Raising awareness of the risks of musculoskeletal disorders in drivers who work from their vehicle is important. This paper reflects on research in the field and provides guidance on the participatory process and evaluating intervention activities. The participatory process was successful in affecting change at management level.

- **Keywords:** participatory ergonomics, musculoskeletal symptoms, occupational health, driving

**Trevor K. King, Colette N. Severin, Dwayne Van Eerd, Selahadin Ibrahim, Donald Cole, Ben Amick III & Ivan A. Steenstra. *A pilot randomised control trial of the effectiveness of a biofeedback mouse in reducing self-reported pain among office workers.* Pages 59-68.**

A pilot study examined the effectiveness of a biofeedback mouse in reducing upper extremity pain and discomfort in office workers; in addition, relative mouse use (RMU), satisfaction and the feasibility of running a randomised controlled trial (RCT) in a workplace setting were evaluated. The mouse would gently vibrate if the hand was idle for more than 12 s. The feedback reminded users to rest the arm in neutral, supported postures. Analysis showed a statistically significant reduction in shoulder pain and discomfort for the intervention group at T2 (38.7% lower than controls). Statistically significant differences in RMU time between groups were seen post intervention (-7% at T1 and +15% at T2 for the intervention group). Fifty-five percent of the intervention group was willing to continue using the mouse. It appears feasible to perform an RCT for this type of intervention in a workplace setting. Further study including more participants is suggested.

**Practitioner Summary:** The study findings support the feasibility of conducting randomised control trials in office settings to evaluate ergonomics interventions. The intervention resulted in reduced pain and discomfort in the shoulder. The intervention could be a relevant tool in the reduction of upper extremity musculoskeletal disorder. Further research will better explain the study's preliminary findings.

- **Keywords:** biofeedback mouse, randomised control trial (RCT), computer worker(s), pain and discomfort

**Steven Visser, Henk F. van der Molen, P. Paul F.M. Kuijer, Berry J. van Holland & Monique H.W. Frings-Dresen. *Evaluation of two working methods for screed floor layers on musculoskeletal complaints, work demands and workload.* Pages 69-78.**

Screed floors are bound by sand-cement (SF) or by anhydrite (AF). Sand-cement floors are levelled manually and anhydrite floors are self-levelling and therefore differences in work demands and prevalences of musculoskeletal complaints might occur. The objective was to assess among SF layers and AF layers (1) the prevalence of musculoskeletal complaints and (2) the physical work demands, energetic workload, perceived workload and discomfort. A questionnaire survey and an observational field study were performed. Compared with AF layers ( $n = 35$ ), SF layers ( $n = 203$ ) had higher, however, not statistically significant different, prevalences of neck (20% vs. 7%), shoulder (27% vs. 13%), low back (39% vs. 26%) and ankles/feet (9% vs. 0%) complaints. Sand-cement-bound screed floor layers ( $n = 18$ ) bent and kneeled significantly longer ( $\Delta 77$  min and  $\Delta 94$  min; respectively), whereas AF layers ( $n = 18$ ) stood significantly longer ( $\Delta 60$  min). The work demands of SF layers exceeded exposure criteria for low back and knee complaints and therefore new working measures should be developed and implemented.

**Practitioner Summary:** In comparison with anhydrite-bound screed floor layers, sand-cement-bound screed floor layers exceeded exposure criteria for work-related low back and knee complaints. New working methods and measures for sand-cement-bound screed floor layers should be developed and implemented to reduce the risk for work-related musculoskeletal complaints.

- **Keywords:** health complaints, work demands, floor layers, evaluation

**Iman Dianat, Zeynab Javadivala, Mohammad Asghari-Jafarabadi, Ahmad Asl Hashemi & Christine M. Haslegrave. *The use of schoolbags and***

***musculoskeletal symptoms among primary school children: are the recommended weight limits adequate? Pages 79-89.***

This cross-sectional study investigated the use of schoolbags and the prevalence of musculoskeletal symptoms among a sample of 307 Iranian primary school children aged 7–12 years. The average load carried by the children was 2.9 kg (representing on average 10.1% of the child's body weight). Most children chose to carry the schoolbag across two shoulders, although significant numbers also carried it on one shoulder or in the hand. Although the amount of load carried by school children was within the currently suggested load limit of 10% to 15% of the child's body weight, the prevalence of musculoskeletal problems was very high among the study population. Multiple logistic regression models indicated that the method of carrying the schoolbag was significantly associated with hand/wrist and shoulder symptoms, and that the time spent carrying a schoolbag was associated with hand/wrist and upper back symptoms. Schoolbag weight (expressed as a percentage of body weight) was only associated with hand/wrist symptoms. The results suggest that the current recommended weight limit may not be appropriate for school children in primary school, and that guidelines ought to consider factors other than relative schoolbag weight that influence the use of schoolbags among this age group.

**Practitioner Summary:** The carrying of schoolbags by primary school children and their musculoskeletal symptoms were investigated. The results provide evidence that the current weight limit may not be appropriate for younger school children, and that such guidelines should consider a broader combination of the factors that influence the use of schoolbags.

- **Keywords:** school bag, load carrying, musculoskeletal symptoms, load weight limit, children

***Seyyed Jalil Mirmohammadi, Rahmatollah Hafezi, Amir Houshang Mehrparvar, Raziye Soltani Gerdfarmarzi, Mehrdad Mostaghaci, Reza Jafari Nodoushan & Bibiseyede Rezaeian. An epidemiologic study on anthropometric dimensions of 7–11-year-old Iranian children: considering ethnic differences. Pages 90-102.***

Anthropometric data can be used to identify the physical dimensions of equipment, furniture, clothing and workstations. The use of poorly designed furniture that fails to fulfil the users' anthropometric dimensions, has a negative impact on human health. In this study, we measured some anthropometric dimensions of Iranian children from different ethnicities. A total of 12,731 Iranian primary school children aged 7–11 years were included in the study and their static anthropometric dimensions were measured. Descriptive statistics such as mean, standard deviation and key percentiles were calculated. All dimensions were compared among different ethnicities and different genders. This study showed significant differences in a set of 22 anthropometric dimensions with regard to gender, age and ethnicity. Turk boys and Arab girls were larger than their contemporaries in different ages. According to the results of this study, difference between genders and among different ethnicities should be taken into account by designers and manufacturers of school furniture.

**Practitioner Summary:** In this study, we measured 22 static anthropometric dimensions of 12,731 Iranian primary school children aged 7–11 years from different ethnicities. Descriptive statistics such as mean, standard deviation and key percentiles were measured for each dimension. This study showed significant differences in a set of 22 anthropometric dimensions in different genders, ages and ethnicities.

- **Keywords:** anthropometry, children, ethnicity, school furniture

**George F. Beard & Michael J. Griffin. *Discomfort caused by low-frequency lateral oscillation, roll oscillation and roll-compensated lateral oscillation. Pages 103-114.***

Roll compensation during cornering (aligning the feet-to-head axis of the body with the resultant force) reduces lateral acceleration, but how any improvement in comfort depends on the frequency of the acceleration has not previously been investigated. Seated subjects judged the discomfort caused by lateral oscillation, roll oscillation and fully roll-compensated lateral oscillation at each of seven frequencies (0.25–1.0 Hz). Irrespective of whether it was caused by pure lateral acceleration or gravitational acceleration due to pure roll, acceleration in the plane of the seat caused similar discomfort at frequencies less than 0.4 Hz. From 0.4 to 1.0 Hz, with the same lateral acceleration in the plane of the seat, there was greater discomfort from roll oscillation than from lateral acceleration. With fully roll-compensated lateral oscillation, discomfort was less than with either the lateral component or the roll component of the motion from 0.2 to 0.5 Hz, but discomfort increased with increasing frequency and caused similar discomfort to pure roll oscillation at 1.0 Hz.

**Practitioner summary:** Tilting can reduce passenger exposure to vehicle lateral acceleration when cornering, but how comfort depends on the frequency of motion was unknown. This study shows 'tilt-compensation' only improves comfort at frequencies less than 0.5 Hz. The findings affect tilting vehicles and the prediction of discomfort caused by low-frequency motions.

- **Keywords:** passenger comfort, tilting trains, low-frequency motion, tilt-compensation

**Elizabeth A. Thrailkill, Bethany R. Lowndes & M. Susan Hallbeck. *Vibration analysis of the sulky accessory for a commercial walk-behind lawn mower to determine operator comfort and health. Pages 115-125.***

A sulky is a single-wheeled platform attachment on which the operator of a commercial walk-behind lawn mower rides while standing. The effects of sulky vibration on operator comfort and health have not been investigated. In this study, tri-axial accelerometers measured sulky vibration during mower use by two commercial mowers on varied terrain and 12 volunteer mowers over a controlled course. The accelerometer data were processed according to methods established in ISO 2631. Results indicate the mean frequency-weighted root mean square (RMS) acceleration sums fall into the 'very uncomfortable' range for vibration of standing persons ( $1.9 \pm 0.48 \text{ m s}^{-2}$ ). Additionally, vibration dose values indicated that the mean vibration dosages exceeded the daily exposure limit values established in Directive [2002/44/EC](#) of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive [89/391/EEC](#))

[View all references](#)/44/EC (z-axis  $A(8)$  value of  $1.30 \pm 0.34 \text{ m s}^{-2}$ ;  $VDV_{\text{exp}}$  value of  $28.1 \pm 6.25 \text{ m s}^{-1.75}$ ). This information suggests that modifications including vibration damping should be added to the sulky to reduce rider discomfort and health risks.

**Practitioner Summary:** This study investigated the effects of vibration during use of a commercial lawn mowing sulky. Findings from accelerometer data suggest that the vibration experienced by sulky operators is significant enough to cause discomfort and health risks which may lead to personnel turnover or long-term effects for the operator.

- **Keywords:** whole-body vibration, standing, lawn mower, discomfort, health risk

**M.W.R. Holmes, C.D. McKinnon, C.R. Dickerson & J.P. Callaghan. *The effects of police duty belt and seat design changes on lumbar spine posture, driver contact pressure and discomfort.* Pages 126-136.**

Police officers spend large amounts of time performing duties within a police cruiser and report a high prevalence of musculoskeletal problems. This study evaluated the effects of driver seat and duty belt design on posture, pressure and discomfort. Ten male and 10 female university students attended two sessions involving simulated driving in a standard police seat (CV) and an active lumbar support (ALS) seat. Participants wore a full duty belt (FDB) or reduced duty belt (RDB) in each seat. Lumbar postures, driver-seat and driver-duty belt pressures and perceived discomfort were measured. Gender  $\times$  Seat interactions were found for pelvic ( $p = 0.0001$ ) and lumbar postures ( $p = 0.003$ ). Females had more lumbar flexion than males and were more extended in the ALS seat ( $-9.8 \pm 11.3^\circ$ ) than CV seat ( $-19.8 \pm 9.6^\circ$ ). The FDB had greater seat pressure than the RDB ( $p < 0.0001$ ), which corresponded to increased pelvis discomfort. This study supports the use of an ALS seat and RDB to reduce injury risk associated with prolonged sitting in police officers.

**Practitioner Summary:** Police officers report a high prevalence of musculoskeletal problems to the lower back, associated with prolonged driving and further investigation is needed to reduce injury risk. This simulated driving study investigated seat and duty belt configuration on biomechanical measures and discomfort. Seat design had the greatest impact, regardless of gender and males benefited more from a reduced belt configuration.

- **Keywords:** police officers, prolonged driving, lumbar posture, discomfort, seat pressure

**Sam D. Blacker, James M. Carter, David M. Wilkinson, Victoria L. Richmond, Mark P. Rayson & Malcolm Peattie. *Physiological responses of Police Officers during job simulations wearing chemical, biological, radiological and nuclear personal protective equipment.* Pages 137-147.**

The aim of this study was to quantify the physiological responses of Police Officers wearing chemical, biological, radiological and nuclear personal protective equipment (CBRN PPE) during firearms house entry (FE) unarmed house entry (UE) and crowd control (CC) simulations. Participants volunteered from the UK Police Force [FE ( $n = 6$ , age  $33 \pm 4$  years, body mass  $85.3 \pm 7.9$  kg,  $[\dot{V}O_2]_{max} 53 \pm 5$  ml  $\cdot$  kg $^{-1}$   $\cdot$  min $^{-1}$ ), UE and CC ( $n = 11$ , age  $34 \pm 5$  years, body mass  $88.5 \pm 13.8$  kg,  $[\dot{V}O_2]_{max} 51 \pm 5$  ml  $\cdot$  kg $^{-1}$   $\cdot$  min $^{-1}$ )]. Heart rate reserve (HRR) during FE was greater than UE ( $74 \pm 7$  vs.  $62 \pm 6\%$ HRR,  $p = 0.01$ ) but lower in CC ( $39 \pm 7\%$ HRR,  $p < 0.01$ ). Peak core body temperature was greater during FE ( $39.2 \pm 0.3^\circ\text{C}$ ) than UE ( $38.9 \pm 0.4^\circ\text{C}$ ,  $p < 0.01$ ) and CC ( $37.5 \pm 0.3^\circ\text{C}$ ,  $p < 0.01$ ), with similar trends in skin temperature. There were no differences in the volume of water consumed ( $1.13 \pm 0.44$  l,  $p = 0.51$ ) or change in body mass ( $-1.68 \pm 0.65$  kg,  $p = 0.74$ ) between simulations. The increase in body temperature was a primary physiological limitation to performance. Cooling strategies and revised operating procedures may improve Police Officers' physical performance while wearing CBRN PPE.

**Practitioner Summary.** In recent years, the likelihood of Police Officers having to respond to a chemical, biological, nuclear or radiological (CBRN) incident wearing personal protective equipment (PPE) has increased. Such apparel is likely to increase physiological strain and impair job performance; understanding these limitations may help improve Officer safety and operational effectiveness.

- **Keywords:** Police, thermoregulation, fatigue, personal protective equipment, heart rate