Ergonomics– rok 2009, ročník 52

Číslo 2

J. C. F. de Winter; S. de Groot; M. Mulder; P. A. Wieringa; J. Dankelman; J. A. Mulder. *Relationships between driving simulator performance and driving test results*. **S. 137–153.**

This article is considered relevant because: 1) car driving is an everyday and safety-critical task; 2) simulators are used to an increasing extent for driver training (related topics: training, virtual reality, human - machine interaction); 3) the article addresses relationships between performance in the simulator and driving test results-a relevant topic for those involved in driver training and the virtual reality industries; 4) this article provides new insights about individual differences in young drivers' behaviour. Simulators are being used to an increasing extent for driver training, allowing for the possibility of collecting objective data on driver proficiency under standardised conditions. However, relatively little is known about how learner drivers' simulator measures relate to on-road driving. This study proposes a theoretical framework that quantifies driver proficiency in terms of speed of task execution, violations and errors. This study investigated the relationships between these three measures of learner drivers' (n = 804) proficiency during initial simulation-based training and the result of the driving test on the road, occurring an average of 6 months later. A higher chance of passing the driving test the first time was associated with making fewer steering errors on the simulator and could be predicted in regression analysis with a correlation of 0.18. Additionally, in accordance with the theoretical framework, a shorter duration of on-road training corresponded with faster task execution, fewer violations and fewer steering errors (predictive correlation 0.45). It is recommended that researchers conduct more large-scale studies into the reliability and validity of simulator measures and on-road driving tests.

- ▪ **Keywords:** driving simulator; driver training; performance assessment; driving test

Lyn Jackson; Peter Chapman; David Crundall. *What happens next? : predicting other road users' behaviour as a function of driving experience and processing time*. **S. 154–164.**

Hazard perception is one of the most important facets of driving and if the appropriate diagnostic tool is used it can discriminate between novice and experienced drivers. In this study video clips of actual driving scenarios were shown to novice and experienced drivers. The clips were stopped just prior to hazard onset and either the screen went black or the final still image stayed on the screen. Participants were then asked five questions about what happened next. This variant of the hazard perception test allowed

the influence of processing time to be included and the level of situation awareness to be measured. Experienced drivers significantly anticipated more correct hazardous outcomes than novice drivers when the screen went black. Novice drivers benefited from the extra processing time afforded by the image remaining on the screen and significantly anticipated more hazards when the image remained on the screen than when it went black. The findings indicate that when processing time is manipulated, hazard perception accuracy reveals experiential differences. These differences are discussed with reference to hazard perception and situation awareness. This research informs the current controversy over whether hazard perception is a good diagnostic tool for driving performance. It identifies potential confounds in previous work and demonstrates that experiential differences can be found if the appropriate tests are used. Further, it suggests improvements for new hazard perception tests.

▪ **Keywords:** hazard perception; situation awareness; experience; driving

Katja Kircher; Birgitta Thorslund. *Effects of road surface appearance and low friction warning systems on driver behaviour and confidence in the warning system*. S. 165–176.

Warning systems for slippery road conditions are a potential newcomer among driver support systems. A total of 75 participants drove in a high-fidelity driving simulator on roads with both visible and invisible ice, to investigate to which extent drivers rely on a low friction warning system. Three experimental groups with different versions of a low friction warning system and a control group without warning system were compared. All drivers ranked the systems according to trust. A system displaying recommended speed received the best ratings. Driving speed was analysed for three particular segments of the route. Generally, lowest speeds were achieved with the recommended speed system. The participants drove more slowly on a slippery segment that looked icy than on the segments that looked dry when they did not receive a low friction warning. When they received a warning for low friction they also lowered their speed for the segment looking like asphalt. The results provide guidelines for how to present low friction warnings to drivers. The design has substantial effects on the resulting behaviour and therefore it can have a high impact on traffic safety. So far, not much research on low friction warning systems has been reported.

▪ **Keywords:** IVIS; low friction warning; driving simulator; system trust

N. Brook-Carter; A. Stevens; N. Reed; S. Thompson. *Practical issues in the application of occlusion to measure visual demands imposed on drivers by in-vehicle tasks*. S. 177–186.

Occlusion is a practical technique to measure the visual demand imposed by in-vehicle tasks and to assess whether a task can be resumed having been interrupted. This study describes a number of important factors and variables that need to be controlled to ensure reliability of results. Training of participants on in-vehicle tasks is found to help consistency and five training sessions are required for complex tasks. No significant differences in training with and without occlusion goggles are reported. The required sample size is dependent on the variability of the task; for those investigated an appropriate sample size is found to be 14. For in-vehicle systems that exhibit a delay in response to the user, consistency is improved when these delays are excluded from timing measurements. In terms of calculating the occlusion parameter R, the within-participant basis is most consistent by taking the ratio of the respective median total shutter open time and total task times across trial repetitions completed by one participant on each task under evaluation and, for the purposes of identifying interface designs that exhibit poor resumability, the 85th percentile value is identified as most suitable. Findings from the study are discussed in terms of future application of the occlusion technique to assess in-vehicle information systems (IVIS).

K. S. Hale; K. M. Stanney; L. Malone. *Enhancing virtual environment spatial awareness training and transfer through tactile and vestibular cues*. S. 187–203.

Haptic interaction has been successfully incorporated into a variety of virtual environment (VE) systems, yet designing multimodal VE training systems remains challenging as each cue incorporated during training should maximise learning and training transfer. This study examined the impact of incorporating two independent, spatialised tactile cues and vestibular cues into a military VE training environment with the goal of empirically examining whether such cues could enhance performance within the training environment and also that knowledge and skills gained during training could transfer to another environment. The results showed that tactile cues enhanced spatial awareness and performance during both repeated training and within a transfer environment, yet there were costs associated when two independent tactile cues were presented during training. In addition, results suggest that spatial awareness benefits from a tactile point indicator may be impacted by vestibular cues, as performance benefits were seen when tactile cues were paired with head tracking. To fully realise training potential, it is essential to determine how best to leverage multimodal capacity of VE training systems by identifying how multimodal training cues may advance knowledge, skills and attitudes of trainees. Results from this study provide design guidelines for incorporating tactile cues in VE training environments to enhance spatial awareness.

Straker; R. Skoss; A. Burnett; R. Burgess-Limerick. *Effect of visual display height on modelled upper and lower cervical gravitational moment, muscle capacity and relative strain*. S. 204–221.

Head and neck posture is an important factor in neck pain related to computer use; however, the evidence for an optimal posture is unconvincing. This study measured the 3-D postures of 36 young adults during use of three different display heights. Cervical extensor muscle strain was estimated using modelled gravitational load moments and muscle capacities. The influence of more or less upper vs. lower cervical movement was also explored across a broad range of potential postures. Overall cervical extensor muscle capacity diminished away from a neutral posture whilst gravity moment increased with flexion. Overall cervical extensor muscle strain increased with head flexion but remained stable into head extension. Individual differences in the amount of upper and lower cervical movement had an important effect on strain, particularly for some muscles. Computer display height guidelines are an important component of ergonomics practice, yet the relative strain on neck extensor muscles as a function of display height has not been examined. The current findings provide more detailed biomechanical evidence that ergonomists can incorporate with usability and other evidence to determine appropriate display height recommendations.

J. Burgess; S. Hillier; D. Keogh; J. Kollmitzer; L. Oddsson. *Multi-segment trunk kinematics during a loaded lifting task for elderly and young subjects*. S. 222–231.

The trunk is frequently modelled as one fixed segment ignoring possible multi-segmental contributions during manual handling. This study compared segmental trunk motion in a

young and older population during a lifting task. Twelve elderly and 19 young subjects repeatedly lifted a 5 kg box from bench to shelf under two stance conditions. Displacement and angular trunk segment kinematics were recorded with an electromagnetic tracker system and then analysed. The elderly subjects displayed significantly increased pelvic and trunk displacement and significantly reduced pelvic and lower thorax (T10-L1) range of motion in both stance conditions. Upper thorax (C7-T10) motion was at times greater than lumbar motion and opposite to the lower segments and was related to the task while the lower segments contributed to both equilibrium and task requirements. Decreased segmental trunk angular kinematics may contribute to increased displacement kinematics and place the elderly at increased risk of injury and falling. The pelvis, lumbar spine, low thorax (T10-L1), upper thorax (C7-10) contributed uniquely and synchronously to trunk (C7-S2) mechanics during a lifting task. Reduced angular kinematics of the pelvis and low thorax contributed to increased displacement kinematics and hence increased the risk of falling in the elderly compared to the young. Investigations of trunk mechanics should include multi-segment analysis.

- **Keywords:** injury risks; health care ergonomics; manual handling; ageing

John D. Borstad; Blake Buetow; Emily Deppe; Jonas Kyllonen; Marie Liekhus; Cort J. Cieminski; Paula M. Ludewig. *A longitudinal analysis of the effects of a preventive exercise programme on the factors that predict shoulder pain in construction apprentices*. S. 232–244.

Construction apprentices are at risk for developing shoulder pain with increasing exposure to repetitive overhead work. Risk may decrease if shoulder biomechanics are optimised and if risk factors that contribute to shoulder pain onset are identified. This prospective cohort study examined demographic and work-related factors and shoulder pain onset over 2 years in a cohort of 240 construction apprentices. Approximately 50% of the sample (n = 117) performed a home exercise programme intended to have a protective effect, while the other 50% served as controls. The proportion of new-onset shoulder pain in the control group was higher than in the exercise group. Regression analysis identified four factors related to new-onset shoulder pain: previous neck pain; working in hot, cold or humid conditions; subject height; and bending and twisting the back. This information may assist employers and workers in preventing shoulder pain. By knowing factors predictive of shoulder pain development in construction workers, employers can take measures to protect workers and may secondarily decrease medical expenses and maintain productivity. Previous neck pain, working in extreme environmental conditions and being shorter all increased a worker's risk of developing shoulder pain. Exercises to optimise shoulder biomechanics have a small effect on preventing shoulder pain development.

Keywords: occupational exposure; ergonomics; prevention; overhead

T. Takken; A. Ribbink; H. Heneweer; H. Moolenaar; H. Wittink. *Workload demand in police officers during mountain bike patrols*. S. 245–250.

To the authors' knowledge this is the first paper that has used the training impulse (TRIMP) 'methodology' to calculate workload demand. It is believed that this is a promising method to calculate workload in a range of professions in order to understand the relationship between work demands and aerobic fitness. The aim of this study was to assess workload demand in police officers from the Utrecht police department in the Netherlands, during patrol by mountain bike. Maximum oxygen intake, maximum heart rate (HR_{max}), ventilatory threshold (VT)1 and VT2 were determined with a maximal exercise test on a bicycle ergometer. Heart rates were registered throughout three shifts in 20 subjects using a heart rate monitor. Exercise intensity was divided into three phases: phase I (between 40% of HR_{max} and VT1); phase II (between VT and the

respiratory compensation point (RCP)); and phase III (>RCP). The total TRIMP score was obtained by summating the results of the three phases. Average daily workload demands of 355 TRIMPs per day and 1777 TRIMPs per week were measured. Workload demand approached and in some cases exceeded the upper limit of 2000 TRIMPs per week threshold level for physiological stress demands in professional male cyclists.

- **Keywords:** physical workload; TRIMP; VO2max; HRmax

Jianwei Niu; Zhizhong Li; Gavriel Salvendy. *Multi-resolution shape description and clustering of three-dimensional head data*. S. 251–269.

The purpose of this study was to develop a 3-D anthropometric sizing method based on a clustering algorithm combined with a multi-resolution description and demonstrate the method with 3-D head data. Wavelet decomposition was adopted to provide flexible descriptions of 3-D shapes on different resolution levels. A block-division technique was then proposed to divide each decomposed 3-D surface into a predefined number of blocks. Afterwards, by using the block-distance metric, each decomposed surface was converted into a block-distance vector. Not only the size information but also the geometric information of the 3-D surfaces are contained in the vector. Finally, k-means clustering was performed on the vectors to segment the sample population into several groups. A total of 378 3-D upper head and face samples were analysed to illustrate the applicability of the method. Clustering was validated by using two measures, size-weighted variances and Clustering Validity Index. K-means clusterings of different variables were compared, including head length and head breadth, the top five principal components from principal component analysis (PCA) on the proposed block distance-based vectors and the block distance-based vectors directly. No obvious difference was found between clustering on the vectors with and without PCA. Lower values of the two measures when clustering on the block distance-based vectors indicated that the proposed block distance-based descriptor is superior to the traditional sizing dimensions of head length and head breadth. Unlike the traditional sizing methods based on key dimensions or derived variables, the method proposed in this study is based on the 3-D shape of the body surface. The proposed block-distance vector reflects not only the overall size but also the local spatial geometric features of a 3-D surface. The new method can be expected to improve the ergonomic design of those products requiring close fitting, such as face shields, goggles and helmets.

- **Keywords:** 3-D anthropometry; multi-resolution; clustering; sizing