

Ergonomics– rok 2019, ročník 62

Číslo 3



Alexander Kunze, Stephen J. Summerskill, Russell Marshall & Ashleigh J. Filtner. *Automation transparency: implications of uncertainty communication for human-automation interaction and interfaces*. Pages: 345-360.

Operators of highly automated driving systems may exhibit behaviour characteristic for overtrust issues due to an insufficient awareness of automation fallibility. Consequently, situation awareness in critical situations is reduced and safe driving performance following emergency takeovers is impeded. A driving simulator study was used to assess the impact of dynamically communicating system uncertainties on monitoring, trust, workload, takeovers, and physiological responses. The uncertainty information was conveyed visually using a stylised heart beat combined with a numerical display and users were engaged in a visual search task. Multilevel analysis results suggest that uncertainty communication helps operators calibrate their trust and gain situation awareness prior to critical situations, resulting in safer takeovers. In addition, eye tracking data indicate that operators can adjust their gaze behaviour in correspondence with the level of uncertainty. However, conveying uncertainties using a visual display significantly increases operator workload and impedes users in the execution of non-driving related tasks. **Practitioner Summary:** This article illustrates how the communication of system uncertainty information helps operators calibrate their trust in automation and, consequently, gain situation awareness. Multilevel analysis results of a driving simulator study affirm the benefits for trust calibration and highlight that operators adjust their behaviour according to multiple uncertainty levels.

- **Keywords:** Vehicle ergonomics, attitudes and behaviour, attention and vigilance, human-computer-interaction, information displays

Annette Kluge, Mike Silbert, Uta S. Wiemers, Barbara Frank & Oliver T. Wolf. *Retention of a standard operating procedure under the influence of social stress and refresher training in a simulated process control task*. Pages: 361-375

In a simulated process control task, we investigated the effects of refresher training and acute social stress on performing a standard operating procedure (SOP) containing a production and monitoring task and knowledge recall after a retention interval of two weeks. In a 2×2 between-group design (Factor 1: induced social stress, Factor 2: refresher training), 76 engineering students performed an SOP at t1 in week 1 and at t2 in week 3. A MANOVA in week three (t2) indicated a main effect of the refresher training for the SOP execution containing a production and a monitoring task and an impairing effect of stress on the monitoring task. That means that after a retention interval, stress mainly affects the SOP's monitoring task. An additional correlational analysis showed that knowledge test performance is negatively associated with cortisol level and that retentivity is a strong predictor for knowledge test performance and production task performance, too. **Practitioner Summary:** We investigated effects of social stress and refresher training on performing a standard operating procedure (SOP) after a retention interval of two weeks. The impact of social stress reduced the monitoring task performance as part of the SOP, but not the production outcome. Without refresher training, performance is significantly worse.

- **Keywords:** Stress hormones, cortisol, knowledge recall, start-up procedure

Jie Xu & Enid Montague. *An experimental study on individual and group affect in multi-tasking teams.* Pages: 376-390.

Research has shown that affect can influence human performance in various settings. This study aimed to explore the effects of individual and group affect on task perceptions and performance under different stress conditions (task demand and technology reliability) and team training methods in multi-tasking environments. Seventy-two participants participated in the experiment in two-person teams. The participants' affect was measured using facial expression recognition technology. Affect aggregated mean and affect similarity were used as indicators of group affect. Self-reports of workload, teamwork satisfaction, trust in team, and trust in technology were collected. The results demonstrated that different stress conditions and training methods altered individual and group affect. Individual affect did not significantly correlate with the task perception measures, while group affect was related to performance in the team-oriented task but not the individual-oriented tasks. These findings suggested that group affect may have an important role in both multi-tasking and team coordination.

Practitioner summary: Affect can influence human performance in various settings. This study explored how affect influences task perceptions and performance for teams in multi-tasking environments. The results demonstrated that individual affect was not correlated with self-reported task perceptions. Group affect was related to team performance in a team-oriented task.

- **Keywords:** Emotion, group affect, team performance, dynamic time warping, multi-tasking

Chia-Fen Chi, Chih-Chan Cheng, Yuh-Chuan Shih, I-Sheng Sun & Tin-Chang Chang. *Learning rate and subjective mental workload in five truck driving tasks.* Pages: 391-405.

Both learning curve models and subjective mental workload are useful tools for determining the length of training for new workers and predicting future task performance. An experiment was designed to collect the task completion times and subjective mental workload of five driving tasks including (a) reverse into garage, (b) 3-point turn, (c) parallel parking, (d) S-curve and (e) up-down-hill. The results indicated that task completion times of truck driving can be predicted with a learning curve. Practice significantly reduced the mental workload rating. However, the novice trainees tended to have a more significant reduction because, compared to experienced trainees,

they tended to give greater or lower workload scores than the experienced trainees before and after practice, respectively. The current study may not be complete enough to provide guidelines for a training programme, but it is adequate to suggest that learning rate and workload measure can serve as indexes for factoring in the individual differences. **Practitioner summary:** Learning curves can be used to determine the length of training for new workers and performance standards for a particular task. Learning rate and mental workload were found to be important measures for comparing individual differences in order to better design a training programme. However, mental workload must be evaluated by experienced participants.

- **Keywords:** Learning curves, NASA-TLX, subjective rating scale, experience effect

Lan-peng Li, Zhi-gang Liu, Hai-yan Zhu, Lin Zhu & Yuan-chun Huang. *Functional near-infrared spectroscopy in the evaluation of urban rail transit drivers' mental workload under simulated driving conditions.* Pages: 406-419.

The objective of this study is to investigate the potential of functional near-infrared spectroscopy (fNIRS) combined with heart rate variability indices, for the evaluation of the mental workload of urban rail transit drivers under simulated driving conditions, particularly during task engagement and disengagement. Experienced metro drivers wearing fNIRS monitoring systems were asked to drive for 90 min in a professional metro driving simulator. Workload stimulus tasks were added and an n -back task ($n = 3$) was implemented to induce workload in the simulated driving experiment. Experimental results indicate that fNIRS are sensitive to mental workload and reliable for discriminating the degree of mental workload. Research findings demonstrate the feasibility and reliability of fNIRS as a tool for real-time evaluating and monitoring driver mental workload along with task factors from a perspective of brain activations during simulated or actual driving. **Practitioner Summary:** This study provides evidence for the potential of functional near-infrared spectroscopy (fNIRS) for the evaluation of the mental workload of urban rail transit drivers under simulated driving conditions. The first fNIRS application to mental workload evaluation in the field of urban rail transportation helps companies develop reasonable shiftwork schedule and ensure operation safety.

- **Keywords:** Mental workload, urban rail transit driver, driving simulator, functional near-infrared spectroscopy (fNIRS), oxy-hemoglobin (oxy-Hb)

Yu Huang & Penglin Zhang. *Subjective discomfort caused by vertical whole-body vibration in the frequency range 2–100 Hz.* Pages: 420-430.

Current standards assume the same frequency weightings for discomfort at all magnitudes of vibration, whereas biodynamic and psychological studies show that the frequency-dependence of objective and subjective responses of the human body depends on the magnitude of vibration. This study investigated the discomfort of seated human body caused by vertical whole-body vibration over the frequency range 2–100 Hz at relatively high magnitudes from 1.0 to 2.5 ms⁻² r.m.s. Twenty-eight subjects (15 males and 13 females) judged the discomfort using the absolute magnitude estimation method. The rate of growth of discomfort with increasing vibration magnitude was highly dependent on the frequency, so the shapes of the equivalent comfort contours depended on the magnitude of vibration and no single frequency weighting would be appropriate for all magnitudes. The equivalent comfort contours indicated that the standards and previous relevant studies underestimated the vibration discomfort at frequencies greater than about 30 Hz. **Practitioner Summary:** The discomfort caused by vertical vibration at relatively high frequencies can be severe, particularly at relatively great magnitudes in transport. This study provides the frequency-dependence of vibration discomfort at 2–100 Hz, and shows how the frequency weightings in the current standards can be improved at relatively high frequencies.

- **Keywords:** Vibration discomfort, whole-body vibration, frequency weightings, vibration magnitude, vibration standards

Rachel L. Whittaker, Nicholas J. La Delfa & Clark R. Dickerson. *Algorithmically detectable directional changes in upper extremity motion indicate substantial myoelectric shoulder muscle fatigue during a repetitive manual task.* Pages: 431-443.

Repetitive workplace tasks are associated with fatigue-induced changes to shoulder muscular strategies, potentially altering kinematics and elevating susceptibility to tissue overexposures. Accessible and reliable methods to detect shoulder muscle fatigue in the workplace are therefore valuable. Detectable changes in joint motion may provide a plausible fatigue identification method. In this investigation, the onset of the first kinematic changes, as identified by a symbolic motion representation (SMSR) algorithm, and the onset of substantial surface electromyography (sEMG) mean power frequency (MPF) fatigue were not significantly different, both occurring around 10% of task duration. This highlights the potential utility of SMSR identified directional changes in joint motion during repetitive tasks as a cue of substantial muscle fatigue, enabling ergonomics responses that can mitigate shoulder muscular fatigue accumulation and its associated deleterious physical effects. **Practitioner Summary:** The onset of substantial muscle fatigue during a repetitive dynamic task was assessed using kinematics and myoelectric-based techniques. Algorithmically detectable directional changes in upper extremity joint motion occurred with the onset of substantial muscle fatigue, highlighting the potential of this as a useful approach for workplace fatigue identification.

- **Keywords:** Upper extremity kinematics, muscle fatigue, electromyography, symbolic motion structure representation

Hyeseon Han, Sojeong Lee & Gwanseob Shin. *Naturalistic data collection of head posture during smartphone use.* Pages: 444-448.

Association between smartphone use and head-down tilt posture has not yet been quantitatively evaluated in natural settings. This study aimed to objectively assess the angle and duration of head-down tilt posture of smartphone users during a typical working day via naturalistic data collection. Thirty-one college students conducted their typical school activities while their head posture and smartphone-app usage records were collected simultaneously for 8 hours. Participants spent 125.9 minutes (median usage duration) on their smartphones with significantly larger head-down tilt ($p < .05$) than when they were not using the phone. Head tilt angle greater than 30° was found to be more common when using the phone, while head tilt less than 20° was more common when they were not using the phone. Study findings provide empirical evidence that supports an association between the duration of smartphone use and the intensity of head-down tilt posture. **Practitioner Summary:** Head postures of young smartphone users were quantified for 8 hours continuously during a typical workday using a wearable sensor. Participants spent more time in larger head-down tilt postures (greater than 30°) when they were using their smartphones as compared to when they were not using them.

- **Keywords:** Text neck, mobile phone, looking down posture, texting

Benjamin Stone, Barry S. Mason, Andrea Bundon & Victoria L. Goosey-Tolfrey. *Elite handcycling: a qualitative analysis of recumbent handbike configuration for optimal sports performance.* Pages: 449-458.

Our understanding of handbike configuration is limited, yet it can be a key determinant of performance in handcycling. This study explored how 14 handcycling experts (elite

handcyclists, coaches, support staff, and manufacturers) perceived aspects of recumbent handbike configuration to impact upon endurance performance via semi-structured interviews. Optimising the handbike for comfort, stability, and power production was identified as key themes. Comfort and stability were identified to be the foundations of endurance performance and were primarily influenced by the seat, backrest, headrest, and their associated padding. Power production was determined by the relationship between the athletes' shoulder and abdomen and the trajectories of the handgrips, which were determined by the crank axis position, crank arm length, and handgrip width. Future studies should focus on quantifying the configuration of recumbent handbikes before determining the effects that crank arm length, handgrip width, and crank position have on endurance performance. **Practitioner Summary:** To gain a greater understanding of the impact of handbike configurations on endurance performance, the perceptions of expert handcyclists were explored qualitatively. Optimising the handbike for comfort and stability, primarily via backrest padding and power production, the position of the shoulders relative to handgrips and crank axis, were critical.

- **Keywords:** Recumbent handcycling, elite athletes, qualitative methods, disability ergonomics and sports ergonomics

H. I. Castellucci, C. A. Viviani, J. F. M. Molenbroek, P. M. Arezes, M. Martínez, V. Aparici & S. Bragança. *Anthropometric characteristics of Chilean workers for ergonomic and design purposes*. Pages: 459-474.

Obtaining an appropriate match between a product and its end-users requires anthropometric data, which are typically outdated and show variations among different countries. Chile had its anthropometric data taken nearly 20 years ago, thus they are probably outdated. The purpose of this article is to describe some anthropometric characteristics of Chilean workers. An anthropometric survey involving 27 measures and five calculated body dimensions was conducted in 2016. The measurements were based on ISO 7250 and ISO 15535 to ensure the highest standards possible, and a total of 2946 workers, aged from 18 to 76 years old, participated in the survey. The results showed that Chilean workers have smaller dimensions than Dutch and US workers but have larger dimensions than South Koreans. The data presented in this article constitute the most up-to-date anthropometric dataset describing the dimensions of Chilean workers. **Practitioner Summary:** In Chile, women are smaller and weigh less than men, and both of these populations have high body mass index (BMIs). In addition, the Chilean population exhibits substantial differences compared with other international adult populations. The data presented in this article should be used as a reference when designing for Chilean workers.

- **Keywords:** Anthropometry, Chile, design, ergonomics