

Ergonomics– rok 2014, ročník 57

Číslo 1



Lutz Schega, Daniel Hamacher, Sandra Erfuth, Wolfgang Behrens-Baumann, Juliane Reupsch & Michael B. Hoffmann. *Differential effects of head-mounted displays on visual performance.* pages 1-11.

Head-mounted displays (HMDs) virtually augment the visual world to aid visual task completion. Three types of HMDs were compared [look around (LA); optical see-through with organic light emitting diodes and virtual retinal display] to determine whether LA, leaving the observer functionally monocular, is inferior. Response times and error rates were determined for a combined visual search and Go-NoGo task. The costs of switching between displays were assessed separately. Finally, HMD effects on basic visual functions were quantified. Effects of HMDs on visual search and Go-NoGo task were small, but for LA display-switching costs for the Go-NoGo-task the effects were pronounced. Basic visual functions were most affected for LA (reduced visual acuity and visual field sensitivity, inaccurate vergence movements and absent stereo-vision). LA involved comparatively high switching costs for the Go-NoGo task, which might indicate reduced processing of external control cues. Reduced basic visual functions are a likely cause of this effect. **Practitioner Summary:** We assessed how basic visual functions are affected in different head-mounted displays (HMDs) and how this relates to their efficiency in reality augmentation. In conclusion, look-around HMDs are an economical alternative to optical-see-through HMDs, if unpredictable external events are kept to a minimum.

- **Keywords:** consumer ergonomics, user needs analysis, human factors integration, risk assessment and management, vision and lighting

Jessie Y.C. Chen, Razia V.N. Oden & John O. Merritt. *Utility of stereoscopic displays for indirect-vision driving and robot teleoperation.* pages 12-22.

The effectiveness of an active shutter-glasses stereoscopic display (SD) and a passive polarised SD was evaluated in a live robot-teleoperation task and a simulated indirect-vision driving task in various terrains. Overall, participants completed their tasks significantly faster with the SDs in three-dimensional (3D) mode than with the SDs in the baseline 2D mode. They also navigated more accurately with the SDs in 3D mode. When the effectiveness of the two types of SDs was examined separately, results showed that the active shutter-glasses SD resulted in faster responses and task completion times than the passive polarised SD, though most of the differences failed to reach statistical

significance. Perceived workload when interacting with the two SD systems did not differ significantly between the active versus passive display types or between the 3D and 2D modes of operation; however, participants reported more severe discomfort after interacting with the passive polarised SD. **Practitioner Summary:** This study demonstrated the utility of SDs for enhancing operators' navigation-related performance. The results furthered the understanding of the differential effectiveness of an active stereoscopic system versus a passive system. The findings will facilitate the implementation of stereoscopic systems for robotics control and indirect-vision driving in military settings.

- **Keywords:** stereoscopic display, human–robot interaction, indirect-vision driving, simulation, military, visual discomfort

Jan Alexander Häusser, Stefan Schulz-Hardt & Andreas Mojzisch. *The active learning hypothesis of the job–demand–control model : an experimental examination.* pages 23-33.

The active learning hypothesis of the job–demand–control model [Karasek, R. A. 1979. "Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign." *Administration Science Quarterly* 24: 285–307] proposes positive effects of high job demands and high job control on performance. We conducted a 2 (demands: high vs. low) × 2 (control: high vs. low) experimental office workplace simulation to examine this hypothesis. Since performance during a work simulation is confounded by the boundaries of the demands and control manipulations (e.g. time limits), we used a post-test, in which participants continued working at their task, but without any manipulation of demands and control. This post-test allowed for examining active learning (transfer) effects in an unconfounded fashion. Our results revealed that high demands had a positive effect on quantitative performance, without affecting task accuracy. In contrast, high control resulted in a speed–accuracy tradeoff, that is participants in the high control conditions worked slower but with greater accuracy than participants in the low control conditions. **Practitioner Summary:** The job–demand–control model proposes positive effects of high job demands–high job control combinations on active learning and performance. In an experimental workplace simulation, we found positive effects of high demands on quantitative performance, whereas high control resulted in a speed–accuracy trade-off (participants worked slower but were more accurate).

- **Keywords:** job–demand–control model, active learning hypothesis, speed–accuracy tradeoff, work performance

Wei Xu. *Enhanced ergonomics approaches for product design : a user experience ecosystem perspective and case studies.* pages 34-51.

This paper first discusses the major inefficiencies faced in current human factors and ergonomics (HFE) approaches: (1) delivering an optimal end-to-end user experience (UX) to users of a solution across its solution lifecycle stages; (2) strategically influencing the product business and technology capability roadmaps from a UX perspective and (3) proactively identifying new market opportunities and influencing the platform architecture capabilities on which the UX of end products relies. In response to these challenges, three case studies are presented to demonstrate how enhanced ergonomics design approaches have effectively addressed the challenges faced in current HFE approaches. Then, the enhanced ergonomics design approaches are conceptualised by a user-experience ecosystem (UXE) framework, from a UX ecosystem perspective. Finally, evidence supporting the UXE, the advantage and the formalised process for executing UXE and methodological considerations are discussed. **Practitioner Summary:** This paper presents enhanced ergonomics approaches to product design via three case studies to effectively address current HFE challenges by leveraging a systematic end-to-

end UX approach, UX roadmaps and emerging UX associated with prioritised user needs and usages. Thus, HFE professionals can be more strategic, creative and influential.

- **Keywords:** human factors and ergonomics, ergonomic product, user-experience ecosystem, end-to-end user experience, user experience roadmap, emerging user experience

Charlotte de Vries & Matthew B. Parkinson. *Limiting disproportionate disaccommodation in design for human variability.* pages 52-65.

In the design of artefacts, tasks and environments for human use, the body dimensions of the target population are a critical element in spatial optimisation of the design. This study examines how the choices designers make affect the ability of different user groups to safely and effectively interact with a designed artefact. Due to the variability in body size and shape across different demographic groups, heterogeneous user populations are unlikely to experience uniform levels of performance. The associated variability in the rate of unacceptable user conditions is referred to here as disproportionate disaccommodation. This is both an ethical and a performance concern that can partially be addressed through improved design practice. Three methods for incorporating the consideration of user demographics and the corresponding variability in body size and shape are presented. They are compared with a baseline strategy in terms of accommodation and cost. **Practitioner Summary:** Many common design strategies will unintentionally disaccommodate some user demographics at disproportionate rates. Minorities are at greater risk for disaccommodation, and consequently, disproportionate injury rates. This study presents evidence of disproportionate injury rates, discusses three methods of designing for demographics and evaluates and compares these methods with a baseline.

- **Keywords:** anthropometry, design methods, demographics, injury rates

Chip Wade, John C. Garner, Mark S. Redfern & Robert O. Andres. *Walking on ballast impacts balance.* pages 66-73.

Railroad workers often perform daily work activities on irregular surfaces, specifically on ballast rock. Previous research and injury epidemiology have suggested a relationship between working on irregular surfaces and postural instability. The purpose of this study was to examine the impact of walking on ballast for an extended duration on standing balance. A total of 16 healthy adult males walked on a 7.62 m × 4.57 m (25 ft × 15 ft) walking surface of no ballast (NB) or covered with ballast (B) of an average rock size of about 1 inch for 4 h. Balance was evaluated using dynamic posturography with the NeuroCom® Equitest System™ prior to experiencing the NB or B surface and again every 30 min during the 4 h of ballast exposure. Dependent variables were the sway velocity and root-mean-square (RMS) sway components in the medial-lateral and anterior-posterior directions. Repeated measures ANOVA revealed statistically significant differences in RMS and sway velocity between ballast surface conditions and across exposure times. Overall, the ballast surface condition induced greater sway in all of the dynamic posturography conditions. Walking on irregular surfaces for extended durations has a deleterious effect on balance compared to walking on a surface without ballast. These findings of changes in balance during ballast exposure suggest that working on an irregular surface may impact postural control. **Practitioner Summary:** Epidemiology and scientific literature indicate a conceivable connection between walking surface characteristics and injury. These potential links are particularly evident in the railroad industry given the ballast surfaces widely encountered. The current findings provide data in which to enhance current work practices focusing on postural instability.

- **Keywords:** kinetics, gait analysis, railroad, ballast, irregular terrain

Hui-Lien Chien, Ming-Wei Liu, Tung-Wu Lu, Chien-Chung Kuo & Pei-Chen Chung. *Inter-joint sharing of total support moments in the lower extremities during gait in narrow-heeled shoes of different heights.* pages 74-85.

The study aimed to investigate the influence of the base and height of shoe heels on the total support moment (Ms) and individual joint contributions during gait. Fifteen healthy females walked barefoot and with narrow-heeled shoes (heel heights: 3.9, 6.3 and 7.3 cm) while kinematic and kinetic data were measured. Compared with the barefoot condition, the subjects maintained unaltered Ms in the sagittal plane in shod conditions. This was achieved by increasing the knee extensor moment to compensate for the diminished ankle plantarflexor moments in medium and high heel conditions. In the frontal plane, subjects in shod conditions had to sustain an increased Ms for balance control during late single-leg stance with increased knee abductor and ankle pronator moments as a result of the reduced base of the heels. The results will be helpful for future shoe designs to reduce fall risks and prevent relevant musculoskeletal problems. **Practitioner Summary:** Knowledge of the influence of narrow-heeled shoes on lower limb support moments helps in shoe design to address fall risks. Gait analysis showed that females in narrow-heeled shoes maintained unaltered sagittal total support moments but sustained an increased demand in the frontal plane during late single-leg stance.

- **Keywords:** gait, high heels, biomechanics, total support moment

Daniel Neesham-Smith, Brad Aisbett & Kevin Netto. *Trunk postures and upper-body muscle activations during physically demanding wildfire suppression tasks.* pages 86-92.

This study examined the trunk postures and upper-body muscle activations during four physically demanding wildfire suppression tasks. Bilateral, wireless surface electromyography was recorded from the trapezius and erector spinae muscles of nine experienced, wildfire fighters. Synchronised video captured two retroreflective markers to allow for quantification of two-dimensional sagittal trunk flexion. In all tasks, significantly longer time was spent in the mild and severe trunk flexion ($p \leq 0.002$) compared to the time spent in a neutral posture. Mean and peak muscle activation in all tasks exceeded previously established safe limits. These activation levels also significantly increased through the performance of each task ($p < 0.001$). The results suggest that the wildfire suppression tasks analysed impose significant musculoskeletal demand on firefighters. Fire agencies should consider developing interventions to reduce the exposure of their personnel to these potentially injurious musculoskeletal demands. **Practitioner Summary:** Wildfire fighters adopt high-risk trunk postures and utilise high levels of upper-body muscle activity to perform wildfire suppression tasks. This combination places these workers at elevated risk of musculoskeletal injury. Interventions should be developed to manage the injury exposure risk of this vital workforce.

- **Keywords:** wildfire, electromyography, posture

Dervla A.M. Hogan, Birgit A. Greiner & Leonard O'Sullivan. *The effect of manual handling training on achieving training transfer, employee's behaviour change and subsequent reduction of work-related musculoskeletal disorders : a systematic review.* pages 93-107.

This systematic review investigated the effectiveness of manual handling training on achieving training transfer, leading to a positive change in employee's manual handling behaviour and a reduction of work-related musculoskeletal disorders (WRMSDs) following training. Six electronic databases were searched for randomised controlled trials, non-

randomised controlled trials or cohort studies with a control and/or comparison group that investigated the effectiveness of manual handling training. Thirteen articles met the inclusion and exclusion criteria. Following quality assessment, nine of the included articles were found to be of high quality. This systematic review suggests that there has been very little research focusing on the effectiveness of manual handling training on training transfer to employees and the associated behavioural change. This review indicates that whilst employees report understanding and awareness following training, this does not always lead to the expected behavioural change. This review also suggests it cannot be demonstrated that training transfer will lead to a reduction of WRMSDs. **Practitioner Summary:** This systematic review investigated the effect of manual handling training on behavioural change and WRMSDs. Thirteen articles met the inclusion and exclusion criteria. Overall, the evidence suggests manual handling training is not effective at causing a change in employee's manual handling behaviour following training or at reducing WRMSDs.

- **Keywords:** training transfer, behavioural change, occupational low back pain, manual handling training, systematic review

Yong-Ku Kong, Min-Tae Seo & Hyun-Sung Kang. *Evaluation of total grip strength and individual finger forces on opposing (A-type) handles among Koreans.* pages 108-115.

The present study evaluated the effect of grip span on finger forces and defined the best grip span for maximising total grip strength based on the finger forces and subjective discomfort in a static exertion. Five grip spans (45, 50, 55, 60 and 65 mm) of the opposing (A-type) handle shape were tested in this study to measure total grip strength and individual finger force among Korean population. A total of 30 males who participated in this study were asked to exert a maximum grip force with two repetitions, and to report the subjective discomfort experienced between exertions using the Borg's CR-10 scale. The highest grip strength was obtained at 45 mm and 50 mm grip spans. Results also showed that forces of all fingers, except for the middle finger force, significantly differed over the grip spans. The lowest subjective discomfort was observed in the 50 mm grip span. The results might be used as development guidelines for ergonomic opposing (A-type) hand tools for Korean population. **Practitioner Summary:** This research evaluated the effects of opposing (A-type) handle grip spans on finger forces and subjective ratings. The findings of this study would be valuable and applicable information for designing handles in opposing (A-type) hand tools, which have relatively been less focused upon.

- **Keywords:** total grip strength, individual finger force, grip spans, subjective discomfort, opposing (A-type) hand tool

Peter Mylon, Roger Lewis, Matt J. Carré & Nicolas Martin. *A critical review of glove and hand research with regard to medical glove design.* pages 116-129.

Research from a number of areas was surveyed, including hand function; skin friction; manual performance testing; glove comfort, fit and durability; and user perception. The relevance of the research to medical glove design was discussed. It was concluded that, while an understanding has been gained of the factors that affect glove performance in general, specific application to thin rubber gloves has not been well explored. The focus in glove performance testing has also been on simple tasks such as pegboards, which do not necessarily assess the fine dexterity required in many surgical tasks. Recommendations were made for the development of a new battery of tests specific to medical gloves that would simulate real medical tasks and could produce repeatable results and have sufficient resolution to differentiate between glove types. **Practitioner Summary:** In this paper, glove and hand research to-date was reviewed, for the purpose

of laying out the current state of scientific knowledge with regard to medical glove design and identifying key areas for further research. Recommendations were made for the development of tests that better simulate medical tasks.

- **Keywords:** gloves, dexterity, tactile sensation, medical, friction

Coskun Dizmen, Errol R. Hoffmann & Alan H.S. Chan. *Movement time to edge and non-edge targets. pages 130-135.*

Time to capture a target at the edge of a screen is expected to be less than when the target is slightly away from the screen edge. This is due to the effective target width, in the direction of cursor movement, being large when the target is at the screen edge, allowing a user to control the movement only in a direction perpendicular to the direction of movement. An experiment with 71 participants and a range of Fitts' Index of Difficulty (ID) showed a strong difference in the capture times of targets at the screen edge and targets placed one pixel from the screen edge. This advantage is typically 100 ms, independent of the ID of the movement. **Practitioner Summary:** Movement time to icons placed at the screen edge (no space between icon and screen edge) is faster than when they are placed a short distance from the edge (as in Microsoft Windows).

- **Keywords:** icon capture, screen design, icon location