

Ergonomics– rok 2019, ročník 62

Číslo 6



Songil Lee, Gyouhyung Kyung, Donghee Choi, Jihhyeon Yi, Minjoong Kim, Byeonghwa Choi & Seungbae Lee. *Where to put the creases? Interactions between hand length, task, screen size, and folding method on the suitability of hand-held foldable display devices.* Pages: 723-733.

Limited information is available regarding ergonomic foldable display device forms. This two-stage study involving young South Koreans (divided into three hand-length groups) was conducted to determine ergonomic forms for hand-held foldable display devices considering folding/unfolding comfort and preference. Stage I obtained the suitability of three screen sizes for five tasks. Stage II evaluated 14 different bi- and tri-folding methods considering screen size, folding direction, and folding time. The effects of hand length were all non-significant. Screen size preferences were task-dependent; small screens were preferred for making calls, and medium screens for web searching and gaming. Folding methods affected folding/unfolding comfort and preference; outward screen and Z-shape screen folding were the most preferred bi- and tri-fold concepts, respectively. Screen protection and access appeared to be competing factors in the user preference determination process. Foldable screen size and folding method should be determined by considering tasks, folding/unfolding comfort, and user preferences.

Practitioner summary: A 13.5 cm screen was preferred for making calls, whereas a 17.5 cm screen was best for web searching and gaming. An outward bi-fold screen concept with a 17.5 cm screen and Z-shape tri-fold screen concept with a 22.9 cm screen were preferred. Overall, the Z-shape concept was most preferred.

- **Keywords:** Foldable display, folding method, screen size, bi-fold screen, tri-fold screen

Tamar Ben-Bassat, David Shinar, Raquel Almqvist, Jeff K. Caird, Robert E. Dewar, Esko Lehtonen, Paul M. Salmon, Marion Sinclair, Heikki Summala, Lidia Zakowska & Gabriel Liberman. *Expert evaluation of traffic signs: conventional vs. alternative designs.* Pages: 734-747.

Traffic sign comprehension is significantly affected by their compliance with ergonomics design principles. Despite the UN Convention, designs vary among countries. The goal of

this study was to establish theoretical and methodological bases for evaluating the design of conventional and alternative signs. Thirty-one conventional signs and 1–3 alternatives for each conventional sign were evaluated for their compliance with three ergonomics guidelines for sign design: physical and conceptual compatibility, familiarity and standardisation. Twenty-seven human factors and ergonomics experts from 10 countries evaluated the signs relative to their compliance with the guidelines. Analysis of variance across alternatives revealed that for 19 of the 31 signs, an alternative design received a significantly higher rating in its ergonomics design than the conventional sign with the same meaning. We also found a very high correlation between the experts' ratings and comprehension from previous studies. In conclusion, many countries use signs for which better alternative designs exist, and therefore UN Convention signs should be re-examined, and ergonomics experts evaluation can serve as a good surrogate for road users' comprehension surveys. **Practitioner summary:** This study presents theoretical and methodological bases for evaluating the design of UN Conventional and alternative traffic signs. Human factors and ergonomics experts evaluated 31 conventional and 68 alternative road signs, based on ergonomics principles for sign design. Results indicated the need to re-examine poorly designed UN Convention signs.

- **Keywords:** Traffic sign design principles, compatibility, standardization, Vienna Convention, human factors and ergonomics experts

Ying-Yin Huang, Marino Menozzi, Guido Beldi & Yves Brand. *Training visual attention in a naturalistic visual environment.* Pages: 748-758.

The efficiency of training visual attention in the central and peripheral visual field was investigated by means of a visual detection task that was performed in a naturalistic visual environment including numerous, time-varying visual distractors. We investigated the minimum number of repetitions of the training required to obtain the top performance and whether intra-day training improved performance as efficiently as inter-day training. Additionally, our research aimed to find out whether exposure to a demanding task such as a microsurgical intervention may cancel out the effects of training. Results showed that performance in visual attention peaked within three (for tasks in the central visual field) to seven (for tasks in the periphery) days subsequent to training. Intra-day training had no significant effect on performance. When attention training was administered after exposure to stress, improvement of attentional performance was more pronounced than when training was completed before the exposure. Our findings support the implementation of training *in situ* at work for more efficient results. **Practitioner Summary:** Visual attention is important in an increasing number of workplaces, such as with surveillance, inspection, or driving. This study shows that it is possible to train visual attention efficiently within three to seven days. Because our study was executed in a naturalistic environment, training results are more likely to reflect the effects in the real workplace.

- **Keywords:** Attention and vigilance, training, visual complexity, dynamic information, demanding workload

Masakazu Hirota, Hiroyuki Kanda, Takao Endo, Tomomitsu Miyoshi, Suguru Miyagawa, Yoko Hirohara, Tatsuo Yamaguchi, Makoto Saika, Takeshi Morimoto & Takashi Fujikado. *Comparison of visual fatigue caused by head-mounted display for virtual reality and two-dimensional display using objective and subjective evaluation.* Pages: 759-766.

This study aimed to evaluate objective and subjective visual fatigue experienced before and after performing a visual task while using a head-mounted display for virtual reality (VR-HMD) and two-dimensional (2D) display. Binocular fusion maintenance (BFM) was measured using a binocular open-view Shack–Hartmann wavefront aberrometer

equipped with liquid crystal shutters. Twelve healthy subjects performed the BFM test and completed a questionnaire regarding subjective symptoms before and after performing a visual task that induces low visually induced motion sickness (VIMS). BFM ($p = .87$) and total subjective eye symptom scores ($p = .38$) were not significantly different between both groups, although these values were significantly lower after the visual task than before the task within both groups ($p < .05$). These findings suggest that visual fatigue after using a VR-HMD is not significantly different from that after using a 2D display in the presence of low-VIMS VR content. **Practitioner summary:** Objective and subjective evaluation of visual fatigue were not significantly different with the use of a head-mounted display for virtual reality (VR-HMD) and two-dimensional display. These results should be valuable not only to engineers developing VR content but also to researchers involved in the evaluation of visual fatigue using VR-HMD.

- **Keywords:** Virtual Reality, binocular fusion, visual fatigue, eye movement

Xiaopeng Yang, Amir Tjolleng, Wonsup Lee, Seokbong Park, Baekhee Lee, Jineun Jeong, Jinman Kim, Wongi Hong, Kihyo Jung, Heecheon You & Seikwon Park. *Analysis of natural finger-press motions for design of trackball buttons. Pages: 767-777.*

This study analysed natural press motions of the index, middle and ring fingers for ergonomic design of the positions and surface angles of the left, middle and right trackball buttons. Finger motions of 26 male participants for naturally pressing the trackball buttons were recorded after the participants adjusted the trackball buttons to their preferred locations for comfortable pressing. The natural positions of the finger pulps formed a symmetrically rainbow-shaped reach zone for the fingers. The natural press angles of the fingers' motion trajectories to the vertical reference line ranged from 14.2° to 20.5° , suggesting an 18-degree surface from the horizontal line for the trackball buttons. Regression formulas (adjusted $R^2 = 0.90 \pm 0.07$ and mean squared error = 8.55 ± 7.52 mm) were established to estimate the natural positions of finger pulps from hand segment lengths and joint angles for a population having different hand sizes from this study. **Relevance to Industry:** Trackball buttons designed based on the natural press motions of fingers can provide users with a low physical workload and a high comfort level. This study analysed the natural press motions of the index, middle and ring fingers for designing the positions and surface angles of trackball buttons.

- **Keywords:** Natural finger motion, natural motion trajectory, motion analysis, button position, button angle

Siao Hui Toh, Pieter Coenen, Erin K. Howie, Swarup Mukherjee, David A. Mackey & Leon M. Straker. *Mobile touch screen device use and associations with musculoskeletal symptoms and visual health in a nationally representative sample of Singaporean adolescents. Pages: 778-793.*

This study aimed to describe contemporary technology use, especially smartphones and tablets (mobile touch screen devices), and examine associations with musculoskeletal symptoms and visual health among adolescents in Singapore. A representative sample of 1884 adolescents (50.4% girls) from grades primary 5 to post-secondary (10–18 years old), recruited from 13 schools, completed an online questionnaire in class. Total technology use was high, with smartphone duration being highest (mean = 264 [SD = 243] min/day). Patterns of use, including multitasking and bout length, were influenced by gender, school level, type of device and activities. Musculoskeletal discomfort and visual symptoms were commonly reported. After adjusting for potential confounders, more hours/day of smartphone use was associated with increased risk of neck/shoulders, upper back, arms and wrist/hand discomfort (OR = 1.04[95%CI = 1.01–

1.07] to 1.07[1.03–1.10]) and visual symptoms (OR = 1.05[1.02–1.08]), but was associated with decreased odds of myopia (OR = 0.97[0.94–0.99]). No significant associations were found for tablet use. **Practitioner Summary:** 1884 adolescents in Singapore completed an in-depth questionnaire regarding their use of technology. The smartphone was the device with the highest usage, and greater smartphone use was associated with increased odds of musculoskeletal and visual symptoms. High use of smartphones has physical health implications for adolescents.

- **Keywords:** Mobile touch screen devices, smartphone, tablet, musculoskeletal symptoms, visual symptoms

Bernhard Schwartz, Jay M. Kapellusch, Arnold Baca & Barbara Wessner. [Medium-term effects of a two-desk sit/stand workstation on cognitive performance and workload for healthy people performing sedentary work: a secondary analysis of a randomised controlled trial](#). Pages: 794-810.

Implementing sit/stand workstations in sedentary work environments is a common way to reduce sedentary time, but their medium-term effect on cognitive performance is unclear. To address this circumstance, eighteen office workers participated in a two-arm, randomised controlled cross-over trial (ClinicalTrials.gov Identifier: NCT02825303), either working at a traditional (sit) or an interventional (sit/stand) workplace for 23 weeks. Cognitive performance (working speed, reaction time, concentration performance, accuracy), workload and relevant covariates (salivary cortisol level, heart rate, physical activity, sitting time) were measured pre- and post-intervention under laboratory conditions. MANOVA and RMANOVA results did not show differences in performance parameters and workload, respectively, between sit/stand and traditional workplace users. Differences in text editing accuracy and cortisol levels for sit/stand workstation users indicate potential connectivity to cognitive parameters which should be further examined with large-scale studies. **Practitioner summary:** Medium-term effects of working at sit/stand workstations on cognitive performance and workload are unexplored. This randomised controlled trial suggests that cognitive performance and workload are unaffected for sit/stand workstation users after 23 weeks of use. However, accuracy appeared to improve and physiological stress appeared to be altered.

- **Keywords:** Sit/stand workstation, cognitive performance, physiological stress, randomised controlled trial, workload

Mamiko Noguchi, Michal Glinka, Graham R. Mayberry, Kimihiro Noguchi & Jack P. Callaghan. *Are hybrid sit–stand postures a good compromise between sitting and standing?* Pages: 811-822.

Potential alternatives for conventional sitting and standing postures are hybrid sit-stand postures (i.e. perching). The purposes of this study were (i) to identify where lumbopelvic and pelvic angles deviate from sitting and standing and (ii) to use these breakpoints to define three distinct postural phases: sitting, perching, and standing, in order to examine differences in muscle activations and ground reaction forces between phases. Twenty-four participants completed 19 1-min static trials, from sitting (90°) to standing (180°), sequentially in 5°trunk–thigh angle increments. The perching phase was determined to be 145–175° for males and 160–175° for females. For both sexes, knee extensor activity was lower in standing compared to perching or sitting ($p < .01$). Anterior–posterior forces were the highest in perching ($p < .001$), requiring ~15% of body-weight. Chair designs aimed at reducing the lower limb demands within 115–170° trunk–thigh angle may improve the feasibility of sustaining the perched posture. **Practitioner summary:** Individuals who develop low back pain in sitting or standing may benefit from hybrid sit-stand postures (perching), yet kinematic and kinetic changes

associated with these postures have not been investigated. Perching can improve lumbar posture at a cost of increased lower limb demands, suggesting potential avenues for chair design improvement.

- **Keywords:** Ergonomics, low back pain, lumbopelvic angles, perching, chair design

Mohammad Iman Mokhlespour Esfahani, Maury A. Nussbaum & Zhenyu (James) Kong. *Using a smart textile system for classifying occupational manual material handling tasks: evidence from lab-based simulations.* Pages: 823-833.

Physical monitoring systems represent potentially powerful assessment devices to detect and describe occupational physical activities. A promising technology for such use is smart textile systems (STSs). Our goal in this exploratory study was to assess the feasibility and accuracy of using two STSs to classify several manual material handling (MMH) tasks. Specifically, commercially-available 'smart' socks and a custom 'smart' shirt were used individually and in combination. Eleven participants simulated nine separate MMH tasks while wearing the STSs, and task classification accuracy was quantified subsequently using several common models. The shirt and socks, both individually and in combination, could classify the simulated tasks with greater than 97% accuracy. Thus, using STSs appears to have potential utility for discriminating occupational physical tasks in the work environment. **Practitioner summary:** A smart textile system could classify diverse MMH tasks with high accuracy. This technology may help in developing future ergonomic exposure assessment systems, with the goal of preventing occupational injuries.

- **Keywords:** Smart shirt, smart socks, wearable sensor, exposure assessment, manual material handling

Femke Danckaers, Toon Huysmans, Ann Halleman, Guido De Bruyne, Steven Truijen & Jan Sijbers. *Posture normalisation of 3D body scans.* Pages: 834-848.

For product developers that design near-body products, virtual mannequins that represent realistic body shapes, are valuable tools. With statistical shape modelling, the variability of such body shapes can be described. Shape variation captured by statistical shape models (SSMs) is often polluted by posture variations, leading to less compact models. In this paper, we propose a framework that has low computational complexity to build a posture invariant SSM, by capturing and correcting the posture of an instance. The posture-normalised SSM is shown to be substantially more compact than the non-posture-normalised SSM. **Practitioner summary:** Statistical shape modelling is a technique to map out the variability of (body) shapes. This variability is often polluted by variations in posture. In this paper, we propose a framework to build a posture invariant statistical shape model.

- **Keywords:** Posture modelling, statistical shape model, 3D body scan, posture normalisation