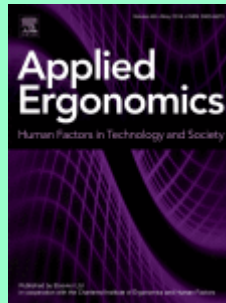


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Michael T. Picchiotti, Eric B. Weston, Gregory G. Knapik, Jonathan S. Dufour, William S. Marras. *Impact of two postural assist exoskeletons on biomechanical loading of the lumbar spine.* Pages 1-7.

This study evaluated loading on the low back while wearing two commercially available postural assist exoskeletons. Ten male subjects lifted a box from multiple lift origins (combinations of vertical height and asymmetry) to a common destination using a squatting lifting technique with and without the use of either exoskeleton. Dependent measures included subject kinematics, moment arms between the torso or weight being lifted and the lumbar spine, and spinal loads as predicted by an electromyography-driven spine model. One of the exoskeletons tested (StrongArm Technologies™ FLx) reduced peak torso flexion at the shin lift origin, but differences in moment arms or spinal loads attributable to either of the interventions were not observed. Thus, industrial exoskeletons designed to control posture may not be beneficial in reducing biomechanical loads on the lumbar spine. Interventions altering the external manual materials handling environment (lift origin, load weight) may be more appropriate when implementation is feasible.

- **Keywords:** Assistive device; Low back pain; Passive exoskeleton; Ergoskeleton

David Perlman, Aubrey Samost, August G. Domel, Bruce Mehler, Jonathan Dobres, Bryan Reimer. *The relative impact of smartwatch and smartphone use while driving on workload, attention, and driving performance.* Pages 8-16.

The impact of using a smartwatch to initiate phone calls on driver workload, attention, and performance was compared to smartphone visual-manual (VM) and auditory-vocal (AV) interfaces. In a driving simulator, 36 participants placed calls using each method. While task time and number of glances were greater for AV calling on the smartwatch vs. smartphone, remote detection task (R-DRT) responsiveness, mean single glance duration, percentage of long duration off-road glances, total off-road glance time, and percent time looking off-road were similar; the later metrics were all significantly higher for the VM interface vs. AV methods. Heart rate and skin conductance were higher during phone calling tasks than "just driving", but did not consistently differentiate calling method. Participants exhibited more erratic driving behavior (lane position and major steering wheel reversals) for smartphone VM calling compared to both AV methods. Workload ratings were lower for AV calling on both devices vs. VM calling.

- **Keywords:** Attention; Workload; Detection response task (DRT); Distraction; Age

A. Yu, K.L. Yick, S.P. Ng, J. Yip. *Case study on the effects of fit and material of sports gloves on hand performance. Pages 17-26.*

Active and sports fashion in the high-end market focuses on fit, superior comfort and functional performance for various end-uses. However, the engineering design of sports gloves in relation to hand anthropometry measurements remains unclear. In this study, two types of ready-to-wear sport gloves, namely, war-gaming glove and hiking glove were purchased from the market. The glove dimensions, fabrication properties and the effect of glove fit on hand and finger dexterity were investigated. Thirty female individuals (20–29 years old) participated a series of hand performance tests and subjective perception rating assessments towards the gloves. Results indicated that the active range of motion of fingers, finger tactile sensitivity, gripping strength and ability to handle pegs and marbles decreased with the use of gloves compared with bare hands. The perceptions of comfort and ease of hand motions decreased with the increased of wear time. The glove fit in terms of finger length dimensions was significantly correlated with hand grip force. The glove fit in hand, wrist and finger circumference dimensions had significant impact on the ability to handle small objects. It is suggested that hand length, hand circumference, finger circumference and the ratio of finger length to palm length should be considered in the design and development of gloves to improve hand performance and comfort.

- **Keywords:** Hand/glove dimensions; Material properties; Hand dexterity; Subjective perception; Wearing comfort

Wuyou Sui, Siobhan T. Smith, Matthew J. Fagan, Scott Rollo, Harry Prapavessis. *The effects of sedentary behaviour interventions on work-related productivity and performance outcomes in real and simulated office work: A systematic review. Pages 27-73.*

This review examined the impact of environmental, behavioral, and combined interventions to reduce occupational sedentary behaviour on work performance and productivity outcomes. Productivity outcomes were defined as variables assessing work-related tasks (e.g., typing, mouse), whereas performance outcomes were categorized as any variables assessing cognition that did not mimic work-related tasks. Nine databases were searched for articles published up to January 2018. Sixty-three studies were identified that met the inclusion criteria: 45 examined a productivity outcome (i.e., typing, mouse, work-related tasks, and absenteeism), 38 examined a performance outcome (i.e., memory, reading comprehension, mathematics, executive function, creativity, psychomotor function, and psychobiological factors), and 30 examined a self-reported productivity/performance outcome (i.e., presenteeism or other self-reported outcome). Overall, standing interventions do not appear to impact productivity/performance outcomes, whereas walking and cycling interventions demonstrate mixed null/negative associations for productivity outcomes. Hence, standing interventions to reduce occupational sedentary behaviour could be implemented without negatively impacting productivity/performance outcomes.

- **Keywords:** Sedentary behaviour; Work performance; Productivity

Joshua T. Kersten, Nathan B. Fethke. *Radio frequency identification to measure the duration of machine-paced assembly tasks: Agreement with self-reported task duration and application in variance components analyses of upper arm postures and movements recorded over multiple days. Pages 74-82.*

Technical advances in inertial measurement units (IMUs) with data logging functionality have enabled multi-day collection of fullshift upper arm postures and movements. Such data are useful for characterizing job-level exposures and, when coupled with task-level information, can inform interventions to mitigate high-exposure tasks. Previously reported methods for capturing task-level information, however, were limited primarily to self-report diaries or direct observation. In this study of machine-paced manufacturing workers (n=6), a low-cost radio frequency identification (RFID) system was used to collect information about when, and for how long, specific assembly tasks were performed during up to 14 consecutive work shifts (76 total work shifts across the six participants). The RFID data were compared to information collected with a self-report diary using Bland-Altman analyses. In addition, the RFID data were paired with IMU data to identify task-level exposures from within full-shift recordings of upper arm postures and movements. These data were then used to estimate the relative contributions of between- and within-worker sources of variance to overall variance in posture and movement summary measures using hierarchical random-effects analysis of variance (ANOVA) techniques. Average estimates of daily task duration based on RFID data were comparable to estimates obtained by self-report (mean bias < ±1 minute) but with substantial variability (limits of agreement > ±100 minutes). In addition, the ANOVA models containing task-level information suggested a substantial amount of the overall exposure variance was attributed to repeated observations of the same task within a work day. These findings (i) suggest that while the RFID system used in this study performed adequately, further refinement, validation, and/or alternative strategies may be needed and (ii) underscore the importance of repeated full-shift and task-based measurement approaches in characterizing physical exposures, even in machine-paced environments.

- **Keywords:** Exposure variability; Upper arm posture; RFID; Task-based measurement

Bauba S. Koma, Anne-Marie Bergh, Katia M. Costa-Black. *Barriers to and facilitators for implementing an office ergonomics programme in a South African research organisation. Pages 83-90.*

The focus of this study was on the possibility of implementing an office ergonomics programme as part of a broader workplace health initiative at a South African research organisation. We explored the perspectives of actors in the workplace regarding organisational barriers and facilitators to implementing ergonomic interventions. This qualitative study presents the perspectives of three workplace actor groups: operational managers (n = 4); health and safety representatives (n = 9); and office employees (n = 4) who were involved in a previous ergonomic assessments that proposed several corrective and preventive actions. Eight factors emerged as either barriers or as simultaneous barriers and facilitators to the implementation of proposed ergonomic interventions. These are: organisational culture; information and specialist support; funding; support from operational managers; attitude towards changes; general organisational awareness; individual knowledge of ergonomics; and support from colleagues. This study is one of the first in South Africa to investigate the perspectives of workplace actors in an office setting with regard to factors that influence implementation of ergonomics initiatives to reduce work-related musculoskeletal disorders.

- **Keywords:** Musculoskeletal disorders; Office ergonomics; Barriers and facilitators; Ergonomic intervention

Ehsan Garosi, Adel Mazloumi, Reza Kalantari, Zahra Vahedi, Zahra Shirzhiyan. *Design and ergonomic assessment of an infusion set connector tool used in nursing work. Pages 91-98.*

Nursing is a physically demanding job characterized by a high prevalence of fatigue and musculoskeletal disorders. One of the high-exertion and repetitive nursing tasks is the manual connection of an infusion set to a medical fluid bottle. Such physical work can be eased by the design of new hand tools. Correspondingly, this study designed and ergonomically assessed an infusion set connector tool (ISCT) and compared it with that of manual connection. First, a prototype of ISCT was designed to perform infusion set connecting task in the mechanical form. Subsequently, 12 nurses were asked to connect an infusion set to medical bottle in the form of manual and mechanical tasks and these tasks were evaluated using ergonomic indices including muscular activity level, force, posture, and subjective (Borg scale CR10) measures. Results showed that the activity levels (root mean square) of the extensor digitorum communis, flexor carpi radialis, biceps, triceps, and deltoid muscles remarkably decreased when the nurses used the ISCT. The postures of the wrist, arm, and shoulder regions were corrected from Rapid Upper Limb Assessment action level 3 to 2 when the designed tool was used. Additionally, the subjective perception of exertion was significantly lower with the use of the prototype.

- **Keywords:** Ergonomic design; Infusion set; Nursing

Per Bækgaard, Shahram Jalaliniya, John Paulin Hansen. *Pupillary measurement during an assembly task. Pages 99-107.*

We conducted an empirical study of 57 children using a printed Booklet and a digital Tablet instruction for LEGO® construction while they wore a head-mounted gaze tracker. Booklets caused a particularly strong pupil dilation when encountered as the first media. Subjective responses confirmed the booklet to be more difficult to use. The children who were least productive and asked for assistance more often had a significantly different pupil pattern than the rest. Our findings suggest that it is possible to collect pupil size data in unconstrained work scenarios, providing insight to task effort and difficulties.

- **Keywords:** Assembly manual; Eye tracking; Pupil dilation

Miguel Nobre Castro, John Rasmussen, Shaoping Bai, Michael Skipper Andersen. *The reachable 3-D workspace volume is a measure of payload and body-mass-index: A quasi-static kinetic assessment. Pages 108-119.*

An experimental protocol with five tasks is proposed for a low-cost empirical assessment of the reachable 3-D workspace (RWS), including both close-to-torso and far-from-torso regions. Ten participants repeated the protocol for four distinct hand payloads. The RWS expressed as a point cloud and its non-convex alpha-shape were obtained for each case. Moreover, individual strength surrogates for glenohumeral flexion and abduction, and elbow flexion were collected using a dynamometer. The RWS volume was statistically modelled using payload, body-mass-index and the strength surrogates as predictors. For increasing payload, a significant ($r = -0.736, p < 0.001$) decrease in RWS volume was found for distinct payload cases across all subjects. The only significant predictors found for the RWS volume were normalized payload ($F = 73.740, p < 0.001$) and body-mass-index ($F = 11.008, p = 0.003$). No significant interactions were found. The consequent regression model ($F(2,27) = 41.11, p < 0.001, \text{Radj}^2 = 0.7345$) explained around 73% of the variation in the data. The RWS volume is a function of payload and body-mass-index.

- **Keywords:** Reachable workspace; Strength measurements; Upper extremity kinematics; Statistical modelling

Dechristian França Barbieri, Divya Srinivasan, Svend Erik Mathiassen, Ana Beatriz Oliveira. *Variation in upper extremity, neck and trunk*

postures when performing computer work at a sit-stand station. Pages 120-128.

Sit-stand tables are introduced in offices to increase variation in gross body posture, but the extent to which upper body posture variation is also affected has not previously been addressed. Neck, trunk, and upper arm postures (means and minute-to-minute variances) were determined during periods of sitting and standing from 24 office workers using sit-stand tables to perform computer work. Posture variability resulting from different temporal compositions of sitting and standing computer work was then predicted for the neck, trunk and upper arm by simulations. Postural variability during computer work could be increased up to three-fold when 20–60% of the work was performed standing (i.e. 40–80% performed sitting), compared to performing computer work only sitting. The exact composition of sit-stand proportions leading to maximum variability, as well as the potential size of the increase in variability, differed considerably between workers. Guidelines for sit-stand table use should note these large inter-individual differences.

- **Keywords:** Office work; Adjustable table; Posture variation; Job variance ratio (JVR); Sedentary behaviors

Jia-Hua Lin, Xu Xu. Occupational cranking operations: The scapula perspective. Pages 129-133.

Cranking the landing gear is a common task performed by truck drivers to raise or lower trailers. This task poses a risk to the shoulder joint due to the required forceful exertion and the posture constrained to the hand-handle interface. As a potential occupational risk, there has been no definitive guideline for best practices among truck drivers. An operator can crank perpendicular (frontal) or parallel (sagittal) to the crank rotation. In this laboratory study, the effects of cranking method and resistance on scapular range of motion and shoulder muscle activity were observed in 12 participants. Scapular posture was measured using an optical motion tracking system. EMG was monitored on 16 muscles contributing to shoulder movement. The results show that during frontal cranking, the scapular range of protraction was $28 \pm 11.6^\circ$, which was more than the sagittal cranking ($23 \pm 10.4^\circ$), indicating a decreased subacromial space and elevated shoulder impingement risk. Seven muscles (all three deltoid muscles, middle trapezius, supraspinatus, infraspinatus, and teres minor) demonstrated that when the crank resistance was low, the front cranking method resulted in lower activity than the side cranking. When the crank resistance was 20 Nm, the muscle activity on these seven muscles was greater when cranking from the front than from the side. Based on these observations, we suggest that when the resistance is low (lowering the trailer) the driver should stand facing the trailer. On the contrary, it is advantageous to stand parallel to the trailer and crank while raising the trailer to apply the full body strength to reduce the shoulder load.

- **Keywords:** Shoulders; Trucking; Musculoskeletal disorders; Best practice

Scott P. Breloff, Chip Wade, Dwight E. Waddell. Lower extremity kinematics of cross-slope roof walking. Pages 134-142.

Working conditions of residential roofers expose them to a unique sloped environment. The purpose of this study is to determine in what way traversing across a sloped/roof surface alters lower extremity kinematics of the upslope and downslope legs compared to level walking. College aged males negotiated across a pitched (26 degrees) roof segment during which lower extremity three-dimensional kinematics were calculated. One foot was higher on the slope and one was lower for the duration of cross slope walking. Overall, cross-slope walking on a 26 degree roof significantly altered 77% of the measured lower extremity variables compared to level self-selected pace walking. The

data suggest that roof pitch incite significant differences in crossslope walking of the kinematics in the lower extremity between the upslope and down slope limbs when compared to level surface walking. These alterations could temporarily alter proprioception which may in turn lead to increased falls and musculoskeletal injury, though further study is needed.

- **Keywords:** Kinematics; Lower Extremity; Roof; Cross-Slope

Mirela Sant'Ana Rodrigues, Michael Sonne, David M. Andrews, Lavínia Freitas Tomazini, Tatiana de Oliveira Sato, Thaís Cristina Chaves. *Rapid office strain assessment (ROSA): Cross cultural validity, reliability and structural validity of the Brazilian-Portuguese version.* Pages 143-154.

Forty-three occupational health professionals (observers) and 90 workers were enrolled in this study to perform the cross-cultural adaptation of the Rapid Office Strain Assessment into Brazilian Portuguese (ROSA-Br) and evaluate its psychometric properties. After cross-cultural adaptation, the measurement properties were checked in three stages: study 1: pre-testing (27 observers rated 15 office worker videos), study 2: intra- and inter-observer reliability (26 observers rated 15 office worker videos), and study 3: validity and accuracy of ROSA-Br final scores (90 office workers). For the ROSA scores, acceptable intraclass correlation coefficients were found for 75% and 86% of the intra-observer reliability comparisons for non-trained and trained observers, respectively, and for 100% of the inter-observer reliability comparisons (0.43–0.86). For construct validity, moderate correlations were observed for 70% of the comparisons between ROSA final scores and other ergonomic instruments. Moderate accuracy was observed for a ROSA-Br final score of 6 (AUC [area under the curve] = 0.72, 0.89). Taken together, these results support the use of the ROSA-Br for ergonomic field assessments and research.

- **Keywords:** Office work; Rapid office strain assessment; Cross-cultural validity; Reliability; Construct validity; Accuracy; Ergonomic risk

Max Kinateder, William H. Warren, Karen B. Schloss. *What color are emergency exit signs? Egress behavior differs from verbal report.* Pages 155-160.

Illuminated emergency exit signs inform building occupants about safe egress routes in emergencies. These exit signs are often found in the presence of other colored signs, which may distract occupants when searching for safe exits. Such distractions can lead to confusing and even harmful outcomes, especially if occupants misinterpret the sign colors, mistaking non-exit signs for exit signs. We studied which colored signs people were most likely to infer were exit signs in a simulated emergency evacuation using virtual reality (VR). Participants were immersed in a virtual room with two doors (left and right), and an illuminated sign with different colored vertical bars above each door. They saw all pairwise combinations of six sign colors across trials. On each trial, a fire alarm sounded, and participants walked to the door that they thought was the exit. We tested two hypotheses: a local exposure hypothesis that color inferences are determined by exit sign colors in the local environment (i.e., red) and a semantic association hypothesis that color inferences are determined by color-concept associations (i.e. green associated with "go" and "safety"). The results challenged the local exposure hypothesis and supported the semantic association hypothesis. Participants predominantly walked toward green signs, even though the exit signs in the local environment—including the building where the experiment took place—were red. However, in a post-experiment survey, most participants reported that exit signs should be red. The results demonstrated a dissociation between the way observers thought they would behave in emergency situations (red=exit) and the way they did behave in simulated emergencies

(green = exit). These findings have implications for the design of evacuation systems. Observers, and perhaps designers, do not always anticipate how occupants will behave in emergency situations, which emphasizes the importance of behavioral evaluations for egress safety.

- **Keywords:** Emergency exit signs; Evacuation; Virtual reality; Color cognition; Visual reasoning

Junde Li, Qi Ma, Alan HS. Chan, S.S. Man. *Health monitoring through wearable technologies for older adults: Smart wearables acceptance model.* Pages 162-169.

In the context of a fast aging population, ubiquitous usage of smart wearable systems can alleviate the social burden caused by the increasing need of older adults for healthcare and assistance. To facilitate and encourage the use of smart wearable systems among older adults, this study investigated the factors that contribute to the acceptance of such systems, and smart wearables acceptance model for older adults was developed using structural equation modeling. The model was validated using 146 survey samples collected from adults aged 60 years and above. The results indicated that perceived usefulness, compatibility, facilitating conditions, and self-reported health status significantly and positively affect older adults' intention to use such technologies. Useful implications and insights were provided to future researchers and practitioners to enhance older adults' acceptance of smart wearable systems.

- **Keywords:** Smart wearable systems; Health monitoring; Telehealth; Older adults; Technology acceptance

René Germann, Björn Jahnke, Sven Matthiesen. *Objective usability evaluation of drywall screwdriver under consideration of the user experience.* Pages 170-177.

During validation of power tools, one objective is to determine the usability of the device for several applications. A common way to gain this user knowledge is to carry out tests under laboratory conditions with non-professional craftsmen, whereby a non-professional user does not work and evaluate a power tool similarly to a professional. Therefore an experimental study was conducted to investigate the possibility of training non-professionals in the professional working methods and evaluation of relevant key criteria for drywall screwdrivers. 39 subjects were divided into three groups and trained in the professional use of a drywall screwdriver. Results indicate that targeted training significantly improves the professional way of working (professional hand position $p = 0.000$, $\beta = -0.764$) and evaluation (testing of mass distribution $p = 0.000$, $\beta = -0.731$) of a drywall screwdriver. The gained knowledge can be used for the implementation of objective usability test-environments to derive specific and differentiated user-centered development potentials under laboratory conditions.

- **Keywords:** User-centered design; User experience; Usability testing; Power tool

Alexander R. MacIntosh, Geoffrey T. Desmoulin. *Police Officer performance and perception using light, medium and heavy weight tactical batons.* Pages 178-183.

Objective: Compare the effectiveness of light, medium and heavy weight Police expandable batons from a performance and a user perception perspective. **Rationale:** Police Officers are required to control combative individuals using less lethal tactics in proportion to the threat they face. Officers need to deliver sufficient force quickly and accurately. As such, it is important to select batons that are optimal for both

performance and user experience. **Methods:** Eleven active-duty New York Police Department Officers completed static and dynamic strike testing followed by a questionnaire. Six baton types were tested using different weights and lengths. **Results:** Peak force, dynamic task speed and accuracy were similar between baton types. Peak impulse, forearm muscle activity, and discomfort were higher with the heaviest baton. **Conclusions:** Lighter batons can deliver sufficient force to control assailants while imposing lower ergonomic costs and being preferable to the user with no impact on speed or accuracy.

- **Keywords:** Police; Baton; Less lethal

Jodi Oakman, Wendy Macdonald, Natasha Kinsman. *Barriers to more effective prevention of work-related musculoskeletal and mental health disorders.* Pages 184-192.

Work-related psychosocial hazards have substantial effects on risks of both musculoskeletal and mental health disorders (MSDs, MHDs). Recent Australian research on workplace risk management practices in 19 work organisations found that risks from work-related psychosocial hazards were poorly managed. This study identified factors impeding better management of MSD and MHD risks within those organisations. **Method:** Interviews were conducted with staff from residential aged care and logistics/transport organisations in Australia. Transcripts were analysed using a worker-centred systems framework. **Results and conclusions:** Many barriers to more effective risk management were identified. Most fundamentally, few people knew of the need to manage MSD risk arising from work-related psychosocial hazards, and OHS-related skills of key managers were often reported as inadequate, particularly concerning management of risk from psychosocial hazards. Also, funding and staffing levels were often reported as problematic, and OHS issues were seen as lower priority than accreditation and commercial requirements.

- **Keywords:** Musculoskeletal; Mental health; Occupational health and safety (OHS); Psychosocial hazards; Risk management

Cheng-Lung Lee. *An evaluation of tactile symbols in public environment for the visually impaired.* Pages 193-200.

Abstract: This study evaluated the identification performance of a set of tactile symbols used in public environments for the visually impaired. A questionnaire survey was carried out to investigate the public environment needs from 60 visually impaired associations. A two-stage experiment with a matching test was then conducted to explore the identification efficiency of graphic tactile public information symbols. Eighty-one students were recruited as participants from a school for the visually impaired. The survey results show that fourteen public buildings were frequently visited and ten architectural elements were mostly needed by the visually impaired. The experimental results showed the correct response of graphic symbols tested in both two-stage experiments could meet the identification criterion of 90% and even better except for the escalator/elevator with 87.0% in the second stage. Relevant confusion among the graphic symbols tested was found. Some suggestions were made in the study.

- **Keywords:** Tactile symbol; Visually impaired; Confusion matrix

M. Sanchiz, F. Amadiou, W.T. Fu, A. Chevalier. *Does pre-activating domain knowledge foster elaborated online information search strategies? Comparisons between young and old web user adults.* Pages 201-213.

The present study aimed at investigating how pre-activating prior topic knowledge before browsing the web can support information search performance and strategies of young and older users. The experiment focus on analyzing to what extent prior knowledge pre-activation might cope with older users' difficulties when interacting with a search engine. 26 older (age 60 to 77) and 22 young (age 18 to 32) adults performed 6 information search problems related to health and fantastic movies. Overall, results showed that pre-activating prior topic knowledge increased the time spent evaluating the search engine results pages, fostered deeper processing of the navigational paths elaborated (and thus reduced the exploration of different navigational paths) and improved the semantic specificity of queries. Pre-activating prior knowledge helped older adults produced semantically more specific queries when they had lower prior-knowledge than young adults. Moderation analyses indicated that the pre-activation supported older adults' search performance under the condition that participants generated semantically relevant keywords during this pre-activation task. Implications of these results show that prior topic knowledge pre-activation may be a good lead to support the beneficial role of prior knowledge in older users' search behavior and performance. Recommendations for design pre-activation support tool are provided.

- **Keywords:** Information search; Prior knowledge pre-activation; Aging; Search performance; Domain knowledge

Julian Keil, Dennis Edler, Frank Dickmann, Lars Kuchinke. *Meaningfulness of landmark pictograms reduces visual salience and recognition performance.* Pages 214-220.

Landmarks, objects in the environment used for orientation, navigation and the formation of cognitive maps are often represented in maps as pictograms. In order to support these tasks effectively and efficiently, landmark pictograms also need to be salient, as the map user needs to identify and process them quickly and easily. Two additional relevant characteristics for the usability of landmark pictograms are their meaningfulness and recognition performance. Meaningfulness is required to understand which categories of objects are represented by the pictograms. Ease of recognition prevents the necessity to consult a map repetitively and may support the formation of a cognitive map of the environment. In the present study, we investigated the relation between salience, meaningfulness and recognition performance of OpenStreetMap (OSM) pictograms and the potential effects of the visual complexity of pictograms on these usability characteristics. Salience was measured via eye fixations on specific pictograms, meaningfulness with an explicit continuous scale and recognition performance with a yes/no recognition memory paradigm. Statistical analyses showed that pictograms drew more visual attention if they were visually complex or if their meaning was inapprehensible or ambiguous. Less apprehensible pictograms were also recognized more often. Interestingly, the data indicated that longer fixations could lead to worse recognition performance. Long fixations on a pictogram may increase the likelihood of false recognition in subsequent situations where the pictogram is no longer valid or relevant. Based on the findings, we suggest balancing the meaningfulness and visual complexity of contiguous pictograms to enhance their recognition and to provide an optimal level of salience of single objects.

- **Keywords:** Cognitive cartography; Empirical cartography; Spatial cognition; Volunteered geographic information; Landmarks; Pictograms; Salience; Memory; Recognition; Meaningfulness; Cartosemiotics

Matthias G. Arend, Thomas Franke, Neville A. Stanton. *Know-how or know-why? The role of hybrid electric vehicle drivers' acquisition of eco-driving knowledge for eco-driving success.* Pages 221-229.

Hybrid electric vehicles (HEVs) can contribute to sustainable transport. Yet, their real-world energy efficiency depends on HEV drivers' eco-driving behaviour. Eco-driving knowledge is key for successful eco-driving. The present research focused on the role of perceived strategy knowledge (know-how) versus technical system knowledge (know-why) in a study with 121 HEV drivers. The relationship between knowledge components and knowledge acquisition processes, as well as fuel efficiency, were examined. Structural equation modelling results indicated that perceived strategy knowledge was related to acquisition by testing (i.e., interacting with the vehicle and its interfaces) and reading (i.e., manuals, books and websites) while technical system knowledge was only related to acquisition by reading. In contrast to technical system knowledge, perceived strategy knowledge was no significant predictor of fuel efficiency. The results indicated that emphasis should be put into promoting technical system knowledge (e.g., by tutoring systems) to support motivated drivers' in achieving higher fuel efficiency.

- **Keywords:** Eco-driving; Knowledge acquisition; User-energy interaction

Lillian Cornish, Andrew Hill, Mark S. Horswill, Stefanie I. Becker, Marcus O. Watson. *Eye-tracking reveals how observation chart design features affect the detection of patient deterioration: An experimental study.* Pages 230-242.

Particular design features intended to improve usability – including graphically displayed observations and integrated colour-based scoring-systems – have been shown to increase the speed and accuracy with which users of hospital observation charts detect abnormal patient observations. We used eye-tracking to evaluate two potential cognitive mechanisms underlying these effects. Novice chart-users completed a series of experimental trials in which they viewed patient data presented on one of three observation chart designs (varied within-subjects), and indicated which observation was abnormal (or that none were). A chart that incorporated both graphically displayed observations and an integrated colour-based scoring-system yielded faster, more accurate responses and fewer, shorter fixations than a graphical chart without a colour-based scoring-system. The latter, in turn, yielded the same advantages over a tabular chart (which incorporated neither design feature). These results suggest that both colour-based scoring-systems and graphically displayed observations improve search efficiency and reduce the cognitive resources required to process vital sign data.

- **Keywords:** Clinical deterioration; Patient safety; Human factors

Rodrigo Bini, Daniel Wundersitz, Michael Kingsley. *Biomechanical and physiological responses to electrically assisted cycling during simulated mail delivery.* Pages 243-249.

This study quantified the biomechanical (movements and forces) and physiological (energy expenditure) demands of postal delivery performed with electrically assisted bicycles (EABs). Ten postal workers and 10 recreational athletes performed three simulated postal tasks (simulated mail delivery circuit, delivery distance [close vs. far], and 3-min stationary cycling) while carrying 0, 16 and 32 kg. Physiological (energy expenditure) and biomechanical (internal and external forces and joint angles) responses were calculated. Energy expenditure (10–20%; $p < 0.05$) and power output (30–44%; $p < 0.05$) increased with increasing mail loads. Ground reaction force increased (~10%) for the far delivery distance, but joint reaction forces were unchanged. Lower hip flexion ($p < 0.01$), less hip abduction ($p < 0.01$) and larger spine anterior flexion ($p < 0.01$) were observed for the far delivery distance. Joint forces were not affected by the mail load transported (0–32 kg) or distance from the mailbox (close vs far). EABs can provide a suitable transportation method to assist mail delivery in terms of energy expenditure reduction.

- **Keywords:** Motion analysis; Ground reaction force; Joint forces; Postal workers

Alison C. McDonald, Daanish M. Mulla, Peter J. Keir. *Muscular and kinematic adaptations to fatiguing repetitive upper extremity work.* Pages 250-256.

Repetitive work is common in the modern workplace and the effects are often studied using fatigue protocols; however, there is evidence that the manner in which fatigue develops impacts the kinematic and muscular response to reduced physical capacity. The purpose of this study was to simultaneously evaluate muscular and kinematic adaptations during fatiguing, repetitive work until exhaustion. We measured muscle activity in 13 muscles in the shoulder and trunk, and captured full body kinematics while participants completed simulated, repetitive work tasks. Every 12 min, reference data were collected to quantify fatigue. This sequence continued until they reached the termination criteria. Participants displayed significant signs of muscle fatigue, loss of strength and increased perceived fatigue ($p < 0.05$). Analysis revealed a significant effect of time on posture and muscle activity that was both task and time dependent, and variable both between and within individuals. Participants were able to compensate for reduced physical capacity and maintain task performance through coordinated compensation strategies.

- **Keywords:** Dynamic work; Shoulder; Fatigue; Variability

Megan Romelfanger, Michael Kolich. *Comfortable automotive seat design and big data analytics: A study in thigh support.* Pages 257-262.

This study demonstrates how big data analytics can improve automotive seat design practices pertaining to thigh support and cushion length, a consistent customer complaint across the automotive seating industry. The method featured an analysis of survey feedback (complaint and self-reported anthropometry) obtained from 92,258 buyers of new vehicles in the North American market. Driver seat three dimensional scans from 139 vehicles (representing 12 manufacturers) provided metrics related to cushion length allowing for determination of the percentage of an average occupant's thigh supported by an automotive seat cushion in relation to customer complaints. The range determined to provide thigh support leading to minimal complaints for overall cushion length is 83.46%–88.49% and for cushion length to trim prominence is 73.63%–80.60%. A specific vehicle program was used to confirm the targets established using big data analytics were effective in minimizing customer issues related to thigh support and cushion length.

- **Keywords:** Cushion length; Big data; Comfort

Younguk Kim, Kunwoo Lee. *A novel approach to predict ingress/egress discomfort based on human motion and biomechanical analysis.* Pages 263-271.

This study proposes an ingress/egress discomfort prediction algorithm using an in-depth biomechanical method and motion capture database. The ingress/egress motion of the subject was captured using an optical motion capture system and physically adjustable vehicle mock-up. The subjective discomfort evaluation data were also recorded at the same time. The inverse kinematics and inverse dynamics were performed to analyze captured ingress/egress motion. These procedure provide motion and joint torque information on each subject. Based on the analysis results, this study proposes the following novel features: accumulated movement of joint and sum of rectified joint torque. This study conducted a feature selection procedure to identify a relevant feature subset. Recursive feature selection and optimal feature selection methods found the most relevant feature subset with collected subjective responses. Finally, we constructed the

prediction model using support vector machine. The prediction model was evaluated through prediction accuracy and statistical analysis. For comparison with the previous study, this study implemented two representative models and compare the result with those of the previous studies using the identical dataset. The effectiveness of proposed algorithm was demonstrated in comparison with previous studies.

- **Keywords:** Ingress/egress; Biomechanics; Discomfort; Motion analysis; Feature selection

Claudia Ackermann, Matthias Beggiato, Sarah Schubert, Josef F. Krems. *An experimental study to investigate design and assessment criteria: What is important for communication between pedestrians and automated vehicles?* Pages 272-282.

In the near future, more vehicles will have automated functions. The traffic system will be a shared space of automated and manually driven vehicles. In our study we focused on the perspective of vulnerable road users, namely pedestrians, in cooperative situations with automated vehicles. Established communication methods, such as eye-contact between pedestrians and drivers, may no longer work when automated vehicles represent the interaction partner. Therefore, we evaluated several human-machine-interfaces (HMI) in order to implement smooth and comfortable communication. We conducted a two-stage study consisting of an explorative focus group discussion with naïve pedestrians (n = 6), followed by an experimental video simulation study (n = 25) based on the results of the focus group discussion. From the focus group we sought member opinion about various HMI, upon presentation of acoustic and visual communication systems such as projections, displays and LED light strips, in addition to portable communication systems, specifically smart watches. On the basis of the focus group discussion, an evaluation criteria was derived. For the video simulation study, HMI designs were created with variations in position, type and coding of the message, and technology. These were assessed by 25 subjects according to the focus discussion derived evaluation criteria: recognizability, unambiguousness, interaction comfort and intuitive comprehensibility. The results show that direct instructions to cross the street are preferred over status information of the vehicle and that large-scale text-based messages from the vehicle to the pedestrian, deliver better results. Design recommendations for HMIs for communication between automated vehicles are derived, and the extent external HMIs may supplement informal communication strategies such as vehicle movement or braking maneuvers, is discussed.

- **Keywords:** Automated vehicles; Pedestrian-automation-interaction; HMI evaluation; HMI design recommendations

Reiko Mitsuya, Kazuhito Kato, Nei Kou, Takeshi Nakamura, Kohei Sugawara, Hiroki Dobashi, Takuro Sugita, Takashi Kawai. *Analysis of body pressure distribution on car seats by using deep learning.* Pages 283-287.

This study aimed to extract information from body pressure distribution, including comfort, participant body size, and seat characteristics by using supervised deep learning, and body pressure characteristics corresponding to sensory evaluation by using unsupervised deep learning. Body pressure data of 18 participants and 19 kinds of car seats were used for the analysis. Sensory evaluation of 9 items concerning cushion characteristics and seat comfort was conducted. From the analysis, we determined that body size and car seats could be classified with high precision by using body pressure distribution data. For the sensory evaluation items, the correct answer rate was high. By examining the importance of the cells of the mat, the features of the body pressure mat at the seat cushion and backrest, body size, car seat, and parts related to sensory

evaluation could be determined in detail. The study findings can be applied in the development of car seats.

- **Keywords:** Body pressure distribution; Car seat; Machine learning; Deep learning; Support vector machine; Characteristics extraction