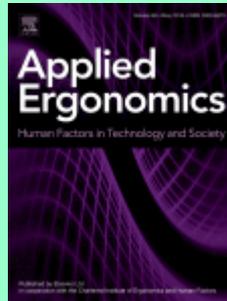


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Benoît Valéry, Nadine Matton, Sébastien Scannella, Frédéric Dehais.
Global difficulty modulates the prioritization strategy in multitasking situations. Pages 1-8.

There has been a considerable amount of research to conceptualize how cognition handle multitasking situations. Despite these efforts, it is still not clear how task parameters shape attentional resources allocation. For instance, many research have suggested that difficulty levels could explain these conflicting observations and very few have considered other factors such as task importance. In the present study, twenty participants had to carry out two N-Back tasks simultaneously, each subtask having distinct difficulty (0,1 or 2-Back) and importance (1 or 3 points) levels. Participants's cumulative dwell time were collected to assess their attentional strategies. Results showed that depending on the global level of difficulty (combination of the two levels of difficulty), attentional resources of people were driven either by the subtask difficulty (under low-global-difficulty) or the subtask importance (under high-global-difficulty), in a non-compensatory way. We discussed these results in terms of decision-making heuristics and metacognition.

- **Keywords:** Dual task; Attentional processes; Metacognition; Working memory; Decision-making

Sarah Kianfar, Pascale Carayon, Ann Schoofs Hundt, Peter Hoonakker.
Care coordination for chronically ill patients: Identifying coordination activities and interdependencies. Pages 9-16.

Care coordination is important for chronically ill patients who need assistance from a variety of healthcare professionals especially when they transition through different care settings. There has not been a clear definition of care coordination and its associated activities. This paper provides a two-dimension framework of care coordination for chronically ill patients: 1) coordination activities (i.e. communication and monitoring) and 2) interdependencies (i.e. flow, shared resources, simultaneity). We used this framework in a qualitative content analysis of 12 interviews with healthcare professionals involved in coordinating care of chronically ill patients. We identified a total of 258 care coordination activities and developed categories and sub-categories using the constant comparative method. The first category of care coordination activities involves communication with flow or shared resources interdependencies or both. This category includes arranging services and equipment for the patient, exchanging information about patient transition to different care settings, reporting errors and resolving them, and helping the patient with appointments and transportation. The second category involves monitoring, sometimes combined with communication, with flow or shared resources

interdependencies or both. This category includes reviewing medications and services and detecting errors, reviewing patient symptoms and following up if needed, and scheduling follow-up to review patient status. The last category involves communication with simultaneity interdependency. This category involves talking in the same location and developing a plan of care, people exchanging information at the same time, and scheduling delivery of medications/services to correspond with patient arrival home. Finally, we identified characteristics of health information technology that can support these various care coordination activities.

- **Keywords:** Care coordination; Coordination activity; Interdependency; Chronically ill patients; Patient journey; Health information technology

Aaron Rowen, Martha Grabowski, Jean-Philippe Rancy, Alyssa Crane. *Impacts of Wearable Augmented Reality Displays on operator performance, Situation Awareness, and communication in safety-critical systems. Pages 17-27.*

Wearable Augmented Reality Displays (WARDS) present situated, real-time information visually, providing immediate access to information to support decision making. The impacts of WARD use on operator performance, Situation Awareness (SA), and communication in one safety-critical system, marine transportation, were examined in a real-time physical simulator. WARD use improved operator trackkeeping performance, the practice of good seamanship, and SA, although operator responsiveness decreased. WARD users who used more closed-loop communication and information sharing showed improved threat avoidance, suggesting that operators can avoid accidents and failure through WARD use that promotes sharing and confirming information. WARD use also promoted information source diversity, a means of developing requisite variety. These operational impacts are important in safety-critical settings where failures can be catastrophic.

- **Keywords:** Augmented reality; Communication; Information displays

E. Orantes-Gonzalez, J. Heredia-Jimenez, M.A. Robinson. *A kinematic comparison of gait with a backpack versus a trolley for load carriage in children. Pages 28-34.*

The use of a school trolley is reaching and even surpassing the use of backpacks in many countries, although a recommended load has not been studied. To accomplish this, 3D gait kinematics of the lower limbs and thorax were analysed in 49 students walking unloaded, pulling a school trolley or carrying a backpack, all with either 10%, 15%, or 20% BW. The variables obtained were the degrees of flexion/extension, adduction/abduction and internal/external rotation of the thorax, pelvis, hip, knee and ankle. Statistical parametric mapping was used to evaluate differences between conditions and loads throughout the gait cycle. In the backpack conditions, the magnitudes of the differences decreased from proximal to distal joints compared to the unloaded condition. The use of a school trolley only required minor kinematic adaptations. Therefore, from kinematic analysis, it is recommended to avoid loads above 10% BW for children using a backpack and below 20% BW for children using a trolley.

- **Keywords:** SPM; Students; Rucksack; Wheeled backpack; Recommendations

Sarah L. Hemler, Danielle N. Charbonneau, Arian Iraqi, Mark S. Redfern, Joel M. Haight, Brian E. Moyer, Kurt E. Beschorner. *Changes in under-shoe traction and fluid drainage for progressively worn shoe tread. Pages 35-42.*

Shoe wear is known to increase slipping risk, but few studies have systematically studied this relationship. This study investigated the impact of progressive shoe wear on the available coefficient of friction (ACOF) and under-shoe fluid dynamics. Five different slip-resistant shoes were progressively worn using an accelerated, abrasive, wear protocol. The ACOF and fluid forces (the load supported by the fluid) were measured as shoes were slipped across a surface contaminated with a diluted glycerol solution. As the shoes became worn, an initial increase in ACOF was followed by a steady decrease. Low fluid forces were observed prior to wear followed by increased fluid forces as the worn region became larger. Results suggest that traction performance decreases particularly when the heel region without tread exceeds a size of 800mm². This study supports the concept of developing shoe replacement guidelines based upon the size of the worn region to reduce occupational slips.

- **Keywords:** Biomechanics; Slips and falls; Available coefficient of friction

Shu Ma, Changxu Wu, Jingyu Zhang, Xianzhong Zeng, Guozhen Zhao, Xianghong Sun. *Looking for an optimal pedal layout to improve the driving performance of patients with diabetic peripheral neuropathy.* Pages 43-49.

Diabetes can undermine people's ability to drive safely, but most previous studies have focused on its deterioration of the central nervous system. This study sought to investigate how diabetic peripheral neuropathy (DPN), a common complication of diabetes characterized by reduced sensitivity of the limbs, can influence people's braking behavior and other safety-related measures of driving. In addition, it also tested how such a deteriorating effect can be reduced by using certain pedal layout designs. In total, 29 healthy drivers and 31 drivers of type 2 diabetes matched in demographic variables were invited to participate in this study. The participants with type 2 diabetes (they are from here on out referred to as "patients") were then split into two subgroups based on the severity of DPN using the median of the Semmes-Weinstein monofilaments Examination (SWME) scores. All three groups of participants finished a series of vehicle-pedestrian conflict tasks in a driving simulator using nine different types of pedal layouts. These layouts varied in the lateral distance between the accelerator and the brake (45 mm, 60 mm, and 75 mm) and the width of brake pedals (50 mm, 70 mm, 90 mm). The results showed that patients with serious DPN had longer brake reaction times (BRT) and shorter minimum distance-to-collision (DTC) as compared to the other two groups. However, the effects of such a disadvantage varied across different pedal layouts. When the accelerator-brake distance was 45 mm, patients with serious DPN showed no compromised driving performance as compared to other two groups. In conclusion, we found the DPN could undermine driving performance of participants with type 2 diabetes, and a closer accelerator-brake lateral distance (45 mm) may be an optimal choice for them to counteract such a negative influence.

- **Keywords:** Drivers with type 2 diabetes; Braking behavior; Diabetic peripheral neuropathy; Pedal layout design

Caleb Teo, Phoebe Giffard, Venerina Johnston, Julia Treleaven. *Computer vision symptoms in people with and without neck pain.* Pages 50-56.

Background: Sixty-four to 90% of computer users experience symptoms of computer vision syndrome (CVS). People with CVS symptoms experience neck pain (NP), and people with NP can have visual symptoms. **Objectives:** (1) To examine differences in CVS symptoms in computer users with and without persistent NP. (2) To determine relationships between visual ergonomics, demographics, and CVS in those with and without persistent NP. **Design:** Comparative cross-sectional observational study. **Method:** An online survey consisting of multiple questionnaires including the Computer Vision Syndrome Questionnaire (CVS-Q), Visual Symptoms Survey (VSS), and

Convergence Insufficiency Symptoms Survey (CISS) was completed by 167 participants. **Results:** The persistent NP group had significantly higher CVS-Q, VSS, and CISS scores ($p < 0.01$) compared to controls. No relationships were found between visual ergonomics, demographics, and visual symptoms in both groups. **Conclusions:** People with persistent NP are more likely to present with CVS than controls. Clinicians should consider assessing visual symptoms in people presenting with persisting NP.

- **Keywords:** Computer vision syndrome; Persistent neck pain

Jessica R.I. Taylor, Michael S. Wogalter. *Specific egress directives enhance print and speech fire warnings. Pages 57-66.*

Despite its importance, research examining the effectiveness of different egress warnings in fire emergencies has been sparse. This research examines language-based warnings presented visually in Experiment 1 and spoken format in Experiment 2 on their rated suitability as fire egress warnings. Two types of phrases were manipulated: egress immediacy and egress directives. Phrase ordering was also varied. Both experiments demonstrated a minimal fire warning without egress information is perceived less acceptable than warnings with egress information. The warnings rated as most acceptable contained egress directives indicating how to evacuate safely and that it should be done quickly. Furthermore, analyses on warning length revealed longer, specific warnings were rated higher than shorter warnings. However, data in Experiment 2 suggested the longest statements were rated lower than ones that were somewhat shorter. Results are discussed in terms of application to fire emergency warnings and general warning issues in emergencies.

Emmanuelle Chaléat-Valayer, Camille Samuel, Stéphane Verdun, Rachel Bard-Pondarré, Jean-Claude Bernard, Grégoire Le Blay, Eric Berthonnaud. *Impact of an ergonomic seat on the stand-to-sit strategy in healthy subjects: Spinal and lower limbs kinematics. Pages 67-74.*

Purpose: To assess differences in spinal, pelvic and lower limb parameters in healthy individuals during a stand-to-sit task using three different seating conditions. **Methods:** Ten healthy adults carried out three stand-to-sit movements on different stools: a high ergonomic stool with the seat tilted 10° forward; a standard stool (adjusted to the same height as the ergonomic stool) and a standard stool at a lower level (so their thighs were horizontal). Movements were recorded by an optoelectronic Vicon system. **Results:** Hip flexion was altered by the height of the seat (significantly greater for the low standard stool in comparison to either the ergonomic stool or the high standard stool ($p < 0.0001$)). There was also significantly less knee flexion with the ergonomic stool in comparison to the low standard stool ($p < 0.0001$) and to the high standard stool ($p = 0.0017$). Lumbar lordosis was not significantly altered by seat height, although it was less pronounced with the ergonomic stool, with a significantly higher range of motion for the pelvis ($p = 0.015$). At the thoracic level, no differences were observed, except that the stand-to-sit movement on the lower stool produced greater flexion. **Conclusion:** Lumbar lordosis was not increased by the ergonomic stool and the range of lower limb motion was reduced by the high seat. These findings contrast with current opinion that ergonomic seats promote lumbar lordosis.

- **Keywords:** Ergonomic seat; Motion analysis; Lordosis

Ahmed Abobakr, Darius Nahavandi, Mohammed Hossny, Julie Iskander, Mohammed Attia, Saeid Nahavandi, Marty Smets. *RGB-D ergonomic assessment system of adopted working postures. Pages 75-88.*

Ensuring a healthier working environment is of utmost importance for companies and global health organizations. In manufacturing plants, the ergonomic assessment of adopted working postures is indispensable to avoid risk factors of work-related musculoskeletal disorders. This process receives high research interest and requires extracting plausible postural information as a preliminary step. This paper presents a semi-automated end-to-end ergonomic assessment system of adopted working postures. The proposed system analyzes the human posture holistically, does not rely on any attached markers, uses low cost depth technologies and leverages the state-of-the-art deep learning techniques. In particular, we train a deep convolutional neural network to analyze the articulated posture and predict body joint angles from a single depth image. The proposed method relies on learning from synthetic training images to allow simulating several physical tasks, different body shapes and rendering parameters and obtaining a highly generalizable model. The corresponding ground truth joint angles have been generated using a novel inverse kinematics modeling stage. We validated the proposed system in real environments and achieved a joint angle mean absolute error (MAE) of $3.19 \pm 1.57^\circ$ and a rapid upper limb assessment (RULA) grand score prediction accuracy of 89% with Kappa index of 0.71 which means substantial agreement with reference scores. This work facilitates evaluating several ergonomic assessment metrics as it provides direct access to necessary postural information overcoming the need for computationally expensive post-processing operations.

- **Keywords:** Ergonomics; MSDs; RULA; RGB-D; Deep learning; ConvNet; CNN; Posture analysis

Chloe J. Robbins, Harriet A. Allen, Peter Chapman. *Comparing drivers' visual attention at Junctions in Real and Simulated Environments*. Pages 89-101.

Driving simulation is widely used to answer important applied research questions, however, it is vital for specific driving tasks to undergo appropriate behavioural validation testing. Many previous validation studies have used simple driving tasks and measured relatively low-level vehicle control. The purpose of the current study was to investigate whether drivers' visual attention at intersections with different levels of demand, are similar in the simulator and on the road. Unlike simpler driving tasks, crossing intersections requires complex interactions with other vehicles governed by sequences of head and eye movements that may not be accurately captured in a simulated environment. In the current study we directly compare performance at simulated junctions with the same participants' behaviour in a real car. We compared drivers' visual attention in a high-fidelity driving simulator (instrumented car, 360-degree screen) and on-road in both low and medium demand driving situations. The low and medium demand driving situations involved the same motor movements, containing straight on, right turn and left turn manoeuvres. The low demand situations were controlled by the road environment and traffic lights, whereas medium demand situations required the driver to scan the environment and decide when it was safe to pull out into the junction. Natural junctions in Nottingham were used for the on-road phase and the same junctions were recreated in the simulator with traffic levels matched to those that were encountered on the real roads. The frequency and size of drivers' head movements were not significantly different between manoeuvres performed in the simulator and those conducted when driving on real roads. This suggests that drivers' broad search strategies in the simulator are representative of real-world driving. These strategies did change as a function of task demand - compared to low demand situations, behaviour at the medium demand junctions was characterised by longer junction crossing times, more head movements, shorter fixation durations and larger saccadic amplitudes. Although patterns of head movements were equivalent on road and in the simulator, there were differences in more fine-grained measures of eye-movements. Mean fixation durations were longer in the simulator compared to on-road, particularly in low-demand situations. We interpret this as evidence for lower levels of visual engagement with the simulated environment

compared to the real world, at least when the task demands are low. These results have important implications for driving research. They suggest that high fidelity driving simulators can be useful tools for investigating drivers' visual attention at junctions, particularly when the driving task is of at least moderate demand.

- **Keywords:** Simulator validity; Junctions; Eye movements; Demand

William Payre, Cyriel Diels. *Designing in-vehicle signs for connected vehicle features: Does appropriateness guarantee comprehension?* Pages 102-110.

This paper discusses the design and evaluation of connected and cooperative vehicle in-vehicle sign designs displayed on a mobile phone: Emergency Electronic Brake Lights (EEBL), Emergency Vehicle Warning (EVW), Traffic Condition Warning, and Road Works Warning. Appropriateness and comprehension of each design alternative were assessed using quantitative (i.e. Likert scales) and qualitative (i.e. open-ended questions) methods. Forty-four participants took part in the study and were shown twelve dashboard camera videos presenting a total of eleven designs alternatives, displayed with or without a legend. Despite their appropriateness, EEBL and EVW signs displayed with a legend were better comprehended and less ambiguous than those displayed without a legend. Moreover, displaying a legend below the signs to warn drivers of an emergency braking ahead was efficient in low visibility condition and could potentially increase safety in critical situations.

- **Keywords:** Warning signs; In-vehicle information; Emergency

Xingchen Zhou, Pei-Luen Patrick Rau. *Determining fidelity of mixed prototypes: Effect of media and physical interaction.* Pages 111-118.

Mixed prototyping, combining virtual and physical prototypes, is an emerging method used to aid in usability testing. This study aims to determine when to use a mixed prototype and how to choose its fidelity to validate the usability testing results and reduce the prototyping cost. A 2x2 between-subject experiment was designed to investigate the effects of the media (head-mounted display versus computer monitor) and physical interaction (using a tangible mock-up or not) on the usability evaluation results and other subjective measures. The experiment results showed that, when aesthetic and functional features are controlled, the non-functional mock-up facilitates users in finding problems regarding physical interaction and ergonomics. Media with high immersion positively influenced the users' subjective ratings. Based on the findings of this study, guidelines on how to choose the fidelity of the prototype during different stages of a usability test are suggested to help product developers find a cost-efficient way to conduct usability tests.

- **Keywords:** Usability test; Fidelity; Mixed prototype; Ergonomics

J.E. Anderson, A.J. Ross, R. Lim, N. Kodate, K. Thompson, H. Jensen, K. Cooney. *Nursing teamwork in the care of older people: A mixed methods study.* Pages 119-129.

Healthcare is increasingly complex and requires the ability to adapt to changing demands. Teamwork is essential to delivering high quality care and is central to nursing. The aims of this study were to identify the processes that underpin nursing teamwork and how these affect the care of older people, identify the relationship between perceived teamwork and perceived quality of care, and explore in depth the experience of working in nursing teams. The study was carried out in three older people's wards in a London teaching hospital. Nurses and healthcare assistants completed questionnaires (n = 65) on

known dynamics of teamwork (using the Nursing Teamwork Survey) together with ratings of organisational quality (using an adapted AHRQ HSPS scale). A sample (n = 22; 34%) was then interviewed about their perceptions of care, teamwork and how good outcomes are delivered in everyday work. Results showed that many care difficulties were routinely encountered, and confirmed the importance of teamwork (e.g. shared mental models of tasks and team roles and responsibilities, supported by leadership) in adapting to challenges. Perceived quality of teamwork was positively related to perceived quality of care. Work system variability and the external environment influenced teamwork, and confirmed the importance of team adaptive capacity. The CARE model shows the centrality of teamwork in adapting to variable demand and capacity to deliver care processes, and the influence of broader system factors on teamworking.

- **Keywords:** Teamwork; Quality of care; Nursing; Acute care; Care of older people

Tristan Tarrade, Fabrice Doucet, Nicolas Saint-Lô, Maxime Llari, Michel Behr. *Are custom-made foot orthoses of any interest on the treatment of foot pain for prolonged standing workers?* Pages 130-135.

Background: The prolonged standing position is an important factor in the onset of foot musculoskeletal disorders among workers. Safety shoes, designed to protect against the physical constraints of the work environment, do not address this issue to date.

Objectives: The goal of this study is to assess the possible benefits of custom-made foot orthoses among prolonged standing workers. Study design repeated measures without control group. **Methods:** Thirty-four standing workers who suffer from foot pain volunteered for the study. Custom-made foot orthoses, designed by a podiatrist, were 3D-printed and distributed to each volunteer. Static balance as well as static and dynamic plantar pressure measurements were carried out with sensors inserted in the safety shoes, before and after three weeks of wearing foot orthoses daily. A questionnaire on pain and comfort was also distributed before and after treatment.

Results: Feelings of pain, discomfort and heavy legs were found to be significantly reduced after wearing 3D-printed orthoses ($p < 0.05$). Additionally, in static and dynamic conditions, a significant decrease in mean peak pressure in the rearfoot area was observed along with a significant increase in mean peak pressure in the midfoot area ($p < 0.05$). There was also a significant improvement of balance in the medial-lateral direction. **Conclusion:** Custom-made orthoses significantly increase the well-being of standing workers in our experimental testing conditions. The custom-made shape allows for a better balanced distribution of foot peak pressure thanks to its support and stimulation of the foot arches particularly through a shift of pressure from the heel to the midfoot.

- **Keywords:** Foot orthoses; Standing work; Pain

Saad Alabdulkarim, Sunwook Kim, Maury A. Nussbaum. *Effects of exoskeleton design and precision requirements on physical demands and quality in a simulated overhead drilling task.* Pages 136-145.

We compared three passive exoskeleton designs in a mock drilling task under three precision requirements levels, defined by required hole sizes, in terms of physical demands (perceived exertion and muscular activation) and quality. The investigated designs were: 1) an upper-body exoskeleton mainly supporting the shoulder; and both 2) full-body, and 3) upper-body exoskeletons, each with connected supernumerary arms. At a fixed pace, participants (n = 12) repeated "drilling" two same-sized holes for 2 min. A fairly consistent result across exoskeleton designs was that higher precision demands increased some muscle activation levels and deteriorated quality. Designs with supernumerary arms led to the largest reductions in quality and increased physical demands overall, mainly in the low back. The shoulder-focused exoskeleton reduced shoulder demands but appeared to reduce quality with the highest precision requirement.

Although future work is needed under more diverse/realistic scenarios, these results might be useful to (re)design occupational exoskeletons.

- **Keywords:** Exoskeleton; Performance; Precision

Louise Bæk Larsen, Nerrolyn Ramstrand, Roy Tranberg. *Duty belt or load-bearing vest? Discomfort and pressure distribution for police driving standard fleet vehicles.* Pages 146-151.

Police working in active duty have a high prevalence of musculoskeletal pain, with lower back pain being the most frequently reported. As a part of uniform regulations, Swedish police are mandated to wear body armour and duty belts at all times during work. This study aimed to investigate the effect of different load carriage designs on invehicle sitting pressure and self-rated discomfort among police. Results showed less discomfort when wearing the alternate load carriage system incorporating a load-bearing vest and thigh holster compared to the standard load carriage system consisting of a duty belt. Pressures in the lower back were reduced when wearing the load-bearing vest whereas pressures in the upper back region increased. Relocating appointments away from the waist has the potential to improve sitting positions and the ergonomic situation for police when driving fleet vehicles.

- **Keywords:** Driving; Law enforcement; Lower back; Occupational health; Protective equipment

Tessy Luger, Robert Seibt, Timothy J. Cobb, Monika A. Rieger, Benjamin Steinhilber. *Influence of a passive lower-limb exoskeleton during simulated industrial work tasks on physical load, upper body posture, postural control and discomfort.* Pages 152-160.

Abstract: This study investigated the effect of wearing a passive lower-limb exoskeleton on physical load, kinematics, postural control, and discomfort. 45 healthy males participated and were exposed to three 21-min simulations, including screwing, cable-mounting, and clip-fitting. Each exposure comprised one of three exoskeleton statuses (standing, high and low sitting on exoskeleton) and three working distances (optimal, far, very far). The order of exoskeleton status and working distance were randomized across subjects. A force platform was used to calculate the mean center of pressure (COP) and absolute (SSABS) and relative static postural stability (SSREL) as measures of postural control as well as the weight transferred to the exoskeleton supports as indicator of physical load. Neck and back angles were recorded together with electrical activity of four bilateral muscles (trapezius, erector, vastus, gastrocnemius). Discomfort was recorded before and after each exposure on an 11-point numeric rating scale. Physical load decreased due to the exoskeleton carrying up to 64% of the subject's body mass. The COP remained within the base of support with the lowest values of static postural stability for high sitting (27%). During sitting, vastus activity increased (~95–135%) while gastrocnemius activity decreased (~25%) compared to standing. Trapezius and erector activity levels showed only minor differences between exposures. Larger working distances resulted in a more anterior COP and increased erector activity. Standing without exoskeleton was related to less discomfort (0.5) than sitting on the exoskeleton (~1.3). Working postures and distances changed SSREL and activity levels of the vastus, gastrocnemius, and erector, but not SSABS. However, postural stability did not approach a critical state in our simulations without external perturbations. Therefore, investigating exoskeletons in the field will provide useful information about their effectiveness and usability in dynamic working situations where external forces could occur.

- **Keywords:** Manual materials handling; Static postural stability; Industrial ergonomics

SangHoon Yoon, Thierry Lefrançois-Daignault, Julie N. Côté. *Effects of cycling while typing on upper limb and performance characteristics.* Pages 161-167.

Active computer workstations may help reduce workplace sedentarism. However, their impact on the upper limb musculoskeletal system is unknown. Subjects participated in two 60-min computer laptop-based Bike-and-Type sessions at different cycling intensities (LOW, HIGH). Upper trapezius and wrist extensor muscle blood flow, sensitivity and pain thresholds, and typing performance were measured intermittently. Neck/shoulder discomfort increased over time ($p < 0.001$), and was higher in the HIGH intensity ($p = 0.036$). Blood flow to the trapezius ($p = 0.041$) and wrist ($p = 0.021$) muscles were higher during HIGH, and wrist blood flow increased over time ($p = 0.01$). Trapezius sensitivity threshold significantly decreased over time ($p = 0.003$). There were no effects on pressure pain thresholds (interaction $p = 0.091$). Average typing speed was greater during HIGH ($p = 0.046$) and increased over time ($p < 0.001$). Time spent biking while typing effectively improved performance, which may facilitate muscle regeneration, although effects depend on biking intensity.

- **Keywords:** Computer work; Biking; Upper limbs

Svetlana Ognjanovic, Manfred Thüring, Ryan O. Murphy, Christoph Hölscher. *Display clutter and its effects on visual attention distribution and financial risk judgment.* Pages 168-174.

Display clutter is a widely studied phenomenon in ergonomics, where information density and other properties of task-relevant visualizations are related to effective user performance and visual attention. This paper examines the impact of clutter in the context of financial stock visualizations. Depending on their expertise, traders can use a variety of different cues to judge the current and future value of a stock and to assess its riskiness. In our study, two groups of participants (novices and experts) judge the riskiness of 28 pairs of stocks under two clutter conditions (low and high). Consistency of judgments and group concordance serve as measures for judgment performance, while mean fixation duration, fixation frequency, and transition matrix density are employed to capture visual attention. Our results reveal significant effects of display clutter and expertise on both the performance measures as well as the visual attention measures.

- **Keywords:** Display clutter; Expertise; Eye-tracking; Stocks

Shraddhaa Narasimha, Emma Dixon, Jeffrey W. Bertrand, Kapil Chalil Madathil. *An empirical study to investigate the efficacy of collaborative immersive virtual reality systems for designing information architecture of software systems.* Pages 175-186.

The ability of Immersive Virtual Reality (IVR) systems to mimic the real world has made it possible to use this technology to create environments for remote collaborative work. This study aimed to understand the feasibility of immersive virtual reality when conducting a collaborative Information Architecture (IA) design task-card sorting, with geographically dispersed participants. Using a between-subjects experimental design, thirty groups of two individuals each completed a card sorting activity using conventional in-person, video screen-sharing method or immersive virtual reality methods. The dependent measures included total time, percentage match with master card set, usability, presence and perceived workload. Overall usability was found to be significantly higher for the immersive virtual reality condition when compared to conventional in-person card sorting. In addition, the new immersive virtual reality technology performed as well as the other two conditions for other dependent variables. Qualitative data from the participants also indicated a positive reaction to the use of immersive virtual reality

for this task. Overall, the participants felt they were productive and enjoyed the IVR condition, indicating the potential of IVR-based approaches as an alternative to conventional approaches for IA design.

- **Keywords:** Computer-supported collaborative work; Virtual reality; Immersive systems; Information architecture design; Card sorting

Deanna Colburn, Lindsey Russo, Robert Burkard, David Hostler.
Firefighter protective clothing and self contained breathing apparatus does not alter balance testing using a standard sensory organization test or motor control test in healthy, rested individuals. Pages 187-192.

Background: There is a high rate of injury associated with firefighting: in 2016, 21% of all fireground injuries were attributed to falls, jumps and slips. Examining factors related to balance, including experience in wearing firefighter gear, may assist in reducing injury related to falls. **Objectives:** To assess the effects of wearing firefighter gear on postural balance in firefighters and non-firefighters in a rested condition. **Methods:** Each subject attended two sessions. In session 1, informed consent was obtained, a threshold audiogram was collected, and the sensory organization test (SOT) and motor control test (MCT) were administered with the subject dressed in street clothes. The second session was comprised of three different conditions with the order of testing randomized across subjects: street clothing, firefighter protective garments (coat, pants, helmet, hood) with breathing apparatus but no facemask, and firefighter protective garments with breathing apparatus and facemask. Twenty subjects participated: ten firefighters (8 males) and sex and age-matched non-firefighters (8 males) completed the study. **Results:** SOT scores were obtained for each sub-condition, including the overall performance score and sensory weightings. For the MCT, latency and amplitude data were obtained for the three forward and three reverse translation conditions. A significant difference was found for large forward surface translations in the MCT in firefighters. **Conclusion:** In spite of the altered center of balance created by breathing apparatus and the altered visual cues created by the facemask, wearing firefighter gear did not substantively affect anterior-posterior postural stability or motor response to linear translation in rested, healthy individuals. Firefighters and non-firefighters performed similarly across all except one of the experimental conditions.

- **Keywords:** Posturography; Firefighters; Thermal protective clothing; SCBA

Shabnam Pejhan, Sean K. Denroche, Geena J. Frew, Stacey M. Acker.
Effects of Knee Savers on the quadriceps muscle activation across deep knee bending postures. Pages 193-199.

Workers who kneel or squat frequently are at a high risk of developing knee pathologies. Knee Savers® are wedge-shaped pads, worn on the lower calf by baseball catchers that aim to reduce this risk. This study examined how Knee Savers® change the bilateral quadriceps muscle activity during dorsiflexed kneeling, and heels-up and flat-foot squatting. For twenty participants, integrated and peak electromyography (EMG) during descent and ascent phases, mean EMG during a 10-s static phase, and participants' subjective perception of muscle fatigue were compared between equipment conditions (with (W) and without (WO) Knee Savers®). Knee Savers® did not significantly reduce integrated or peak EMG during transitions into and out of the postures; however, they significantly reduced ($p < .03$) mean EMG in five of six muscles during the static phase. These findings indicate potential for Knee Savers® to reduce cumulative muscular effort and fatigue in applications where prolonged static kneeling or squatting are required.

- **Keywords:** Electromyography; Kneeling; Squatting; Ergonomics; Knee disorders

Ying Li, Fangzhou You, Xuqun You, Ming Ji. Smartphone text input: Effects of experience and phrase complexity on user performance, physiological reaction, and perceived usability. Pages 200-208.

Smartphones have become a common tool of daily communication, and a number of text input methods are extensively used. Qwerty and T9 are two universally used smartphone input methods that differ in user experience (UX) when entering phrases with different complexity. Phrase complexity is an indication of the number and type of characters used in a phrase. This study evaluated the impact of both experience and phrase complexity on the UX of Qwerty and T9. Thirty-two participants with different experience levels (high and low) used both Qwerty or T9 to input 40 phrases (both simple and complex phrases). Input time, speed, error rate, galvanic skin response, heart rate, and perceived usability were analyzed as dependent variables. The results indicated that Qwerty was more effective than T9 for entering complex phrases, while no obvious difference was found for simple phrases. Experience had a positive impact on the input method, and Qwerty was more helpful for participants with low experience level. Performance, physiological reaction, and perceived usability data showed similar results. These findings aid the optimal design of text input systems for smartphones.

- **Keywords:** Smartphone; Input method; Phrase complexity; User experience; Performance

Adam Hulme, Jason Thompson, Katherine L. Plant, Gemma J.M. Read, Scott Mclean, Amanda Clacy, Paul M. Salmon. Applying systems ergonomics methods in sport: A systematic review. Pages 214-225.

Introduction: As sports systems become increasingly more complex, competitive, and technology-centric, there is a greater need for systems ergonomics methods to consider the performance, health, and safety of athletes in context with the wider settings in which they operate. Therefore, the purpose of this systematic review was to identify and critically evaluate studies which have applied a systems ergonomics research approach in the context of sports performance and injury management. **Material and methods:** Five databases (PubMed, Scopus, ScienceDirect, Web of Science, and SPORTDiscus) were searched for the dates 01 January 1990 to 01 August 2017, inclusive, for original peer-reviewed journal articles and conference papers. Reported analyses were underpinned by a recognised systems ergonomics method, and study aims were related to the optimisation of sports performance (e.g. communication, playing style, technique, tactics, or equipment), and/or the management of sports injury (i.e. identification, prevention, or treatment). **Results:** A total of seven articles were identified. Two articles were focussed on understanding and optimising sports performance, whereas five examined sports injury management. The methods used were the Event Analysis of Systemic Teamwork, Cognitive Work Analysis (the Work Domain Analysis Abstraction Hierarchy), Rasmussen's Risk Management Framework, and the Systems Theoretic Accident Model and Processes method. The individual sport application was distance running, whereas the team sports contexts examined were cycling, football, Australian Football League, and rugby union. **Conclusions:** The included systems ergonomics applications were highly flexible, covering both amateur and elite sports contexts. The studies were rated as valuable, providing descriptions of injury controls and causation, the factors influencing injury management, the allocation of responsibilities for injury prevention, as well as the factors and their interactions underpinning sports performance. Implications and future directions for research are described.

Michel Récopé, Hélène Fache, Joffrey Beaujouan, Fabien Coutarel, Géraldine Rix-Lièvre. A study of the individual activity of professional volleyball players: Situation assessment and sensemaking under time pressure. Pages 226-237.

The aim of this study is to understand interindividual differences in defensive behaviour in elite volleyball players facing similar game situations. This recurrent observation leads us to adopt an activity-centred ergonomic approach. Two case studies are conducted in naturalistic contexts. In the first, thirty-one professional players are observed in order to account for typical forms of behaviour in relation to certain specific sets of game situations. Two characteristic populations are distinguished. The second study uses observations and self-confrontation interviews with twelve players representative of each population in order to characterise their situation assessment. Results highlight important contrasts between the two populations, both in behaviour and in situation assessment. They suggest that one norm of activity centred on the rally-ending issue and another on the roles to be assumed, guide the specific coherency of these populations under time pressure. The identification of these norms provides a hypothesis concerning the foundations of sensemaking. Implications for training development are discussed.

- **Keywords:** Activity; Time pressure; Situation assessment; Sensemaking; Norm; Defensive behaviour; Sport

Nadège Rochat, Denis Hauw, Ludovic Seifert. *Enactments and the design of trail running equipment: An example of carrying systems. Pages 238-247.*

Sports equipment brands have increasingly turned to experience-centered design, meaning the integration of users' activity into the design process. From an enactive perspective, this research investigated two entries of collecting and analyzing interactions between trail runners and their equipment. The paper articulates two studies. Study 1 analyzed traces of enactments on online forums and showed that trail runners reported the issues they enacted while running and reflexively posted the traces of their activity by highlighting the flaws in their carrying systems. Study 2 presents a field test protocol for assessing different carrying systems. The results showed four typical sequences of enactment that characterized the runners' activity. The outcomes of these two studies of runners' enactments while using equipment suggest a method that designers can appropriate to analyze experiential data, which can then be integrated into the conception process.

- **Keywords:** Enaction; Trail-running; Design

R. Varadaraju, J. Srinivasan. *Design of sports clothing for hot environments. Pages 248-255.*

The clothing design based on sweat distribution pattern is called as body mapping clothing. Comparisons of three designs of body mapped and one conventional design of T-shirt was done in a wearer testing at a controlled chamber of 33 °C and 60% relative humidity in a treadmill at 12 km/h for 40 min followed by 10 min resting. It is concluded that with the full body mapped T-shirt the increase in skin temperature is reduced in the chest area, shoulder, the body back by 47%,44% and 55% respectively; the increase in skin micro climate relative humidity is reduced in the chest area, shoulder, the body back by 54%,39.2% and 53% respectively; the increase in heart beat rate is reduced by 5.1%; the subjective perceptions of skin temperature, skin moisture and comfort are better; the wearer will be able to improve the running performance due better comfort level in terms lesser increase skin temperature, skin micro climate relative humidity and heart beat rate.

- **Keywords:** Comfort; Running; Fabric; Shirt; Wearer testing

Amanda Clacy, Natassia Goode, Rachael Sharman, Geoff P. Lovell, Paul Salmon. *A systems approach to understanding the identification and*

treatment of sport-related concussion in community rugby union. Pages 256-264.

Aim: The aim of the present study was to utilise a systems thinking approach to explore the perceived responsibilities for identifying and treating concussion held by different actors across the community rugby system (e.g., players, coaches, parents, medics, referees, and management), as well as their role-specific concussion management strategies. **Methods:** A systems approach was taken to assess what different stakeholders within rugby systems perceive their roles to be regarding concussion identification and treatment. Through an online survey, 118 members of the amateur (community) rugby union system were asked about their role-specific concussion management responsibilities and strategies. Respondents included players, parents, medics, coaches, club managers, administrators, and volunteers. **Results:** The majority of respondents indicated that they were able to identify the symptoms of rugby-related concussion, however, only medics stated their responsibility to use formal concussion assessments (e.g., SCAT2). A smaller number of the respondents indicated that they were involved in treating concussion within their current role/s (majority of which were medics). **Conclusions:** This study illustrated that the current challenges in the identification and treatment of rugby-related concussion in community sport may be due to role/responsibility confusion and possible overreliance on field-side medics. These findings offer insight into the possible limitations of the current concussion management guidelines and may offer empirically based direction for future revisions.

- **Keywords:** Systems thinking; Concussion; Injury management; Sport-related injury; Rugby union

Alexis Herbaut, Maxime Roux, Nils Guéguen, Pascale Chavet, Franck Barbier, Emilie Simoneau-Buessinger. Determination of optimal shoe fitting for children tennis players: Effects of inner-shoe volume and upper stiffness. Pages 265-271.

The purpose of this study was to determine the optimal inner-shoe volume for children tennis players. Sixteen participants, aged from 8 to 12 years old assessed comfort of 6 shoes, which were a combination of 3 lasts (thin, medium and wide) and 2 upper constructions (flexible and stiff), while a sock equipped with textile sensors was measuring the pressure applied on their foot. The thin last was based on the proportion of an adult last. The widest shoes produced the lowest pressure on the 1st and 5th metatarsal heads, the medial midfoot and the medial and lateral heel ($p < 0.05$), whilst they were perceived the most comfortable for the 3rd and 5th metatarsal heads, the 5th metatarsal base and the medial and lateral heel ($p < 0.05$). These outcomes indicated that footwear manufacturers should design wider shoes for children than for adults.

- **Keywords:** Footwear; Comfort; Pressure measurement

Tony Carden, Natassia Goode, Gemma J.M. Read, Paul M. Salmon. Sociotechnical systems as a framework for regulatory system design and evaluation: Using Work Domain Analysis to examine a new regulatory system. Pages 272-280.

Like most work systems, the domain of adventure activities has seen a series of serious incidents and subsequent calls to improve regulation. Safety regulation systems aim to promote safety and reduce accidents. However, there is scant evidence they have led to improved safety outcomes. In fact there is some evidence that the poor integration of regulatory system components has led to adverse safety outcomes in some contexts. Despite this, there is an absence of methods for evaluating regulatory and compliance systems. This article argues that sociotechnical systems theory and methods provide a

suitable framework for evaluating regulatory systems. This is demonstrated through an analysis of a recently introduced set of adventure activity regulations. Work Domain Analysis (WDA) was used to describe the regulatory system in terms of its functional purposes, values and priority measures, purpose-related functions, object-related processes and cognitive objects. This allowed judgement to be made on the nature of the new regulatory system and on the constraints that may impact its efficacy following implementation. Importantly, the analysis suggests that the new system's functional purpose of ensuring safe activities is not fully supported in terms of the functions and objects available to fulfil them. Potential improvements to the design of the system are discussed along with the implications for regulatory system design and evaluation across the safety critical domains generally.

- **Keywords:** Adventure activities; Adventure education; Cognitive work analysis; Outdoor activities; Outdoor education; Outdoor recreation; Regulation; Regulatory systems; Sociotechnical systems; Work Domain Analysis