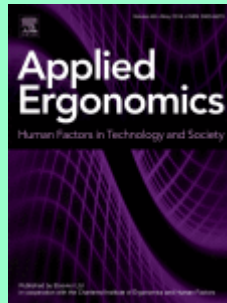


## **Applied Ergonomics - rok 2020, Volume 89**

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### **Michael Weiner, April Savoy, Barry C. Barker. *Gains, losses, and uncertainties from computerizing referrals and consultations.***

Consultations entail transitions in care between referrers and consultants, as patients visit different clinicians and care sites. This complex process has been consistently prone to communication breakdowns. Despite expectations and benefits of electronic health records (EHRs), incomplete, vague, or inappropriate referrals continue to hinder consultations; referrals can be sent to the wrong specialty service; and consultation findings frequently fail to reach referrers. Due to the inadequate support of interpersonal communication afforded by EHRs, these issues persist. Important aspects of ergonomics and human factors engineering frequently appear overlooked during the design and implementation of EHRs. Usability issues have contributed to delays in medical diagnosis, treatment, and follow-up. Some of these delays contribute to patient harms. Our multidisciplinary team of clinicians and ergonomics professionals reflects on referral and consultation. We describe how computerization in healthcare should benefit from approaches informed and developed through applied ergonomics and human factors.

- **Keywords:** Referral and consultation; Human factors and ergonomics; Electronic health records

### **Celeste E. Coltman, Julie R. Steele, Wayne A. Spratford, Richard H. Molloy. *Are female soldiers satisfied with the fit and function of body armour?***

Design and development of contemporary military body armour has traditionally focused primarily on male soldiers. As the anthropometric body dimensions of male and female soldiers differ, we aimed to determine whether current body armour was meeting fit and functional requirements of female soldiers. One-hundred and forty-seven female Australian Defence Force soldiers completed a 59-item questionnaire regarding the fit and function of current body armour. Most (68%) participants reported wearing ill-fitting body armour, which was associated with increased total musculoskeletal pain and discomfort, as well as pain at the shoulders, abdomen, and hips. Body armour that was too large was more likely to interfere with task performance when it was integrated with a combat belt, as well as when female soldiers performed operationally representative tasks. Modifying body armour design and sizing to cater to the anthropometric dimensions of female soldiers is recommended.

- **Keywords:** Body armour; Female soldiers; Fit; Musculoskeletal pain and discomfort; Integration; Movement interference

**Howard Chen, Mark C. Schall, Nathan B. Fethke. *Measuring upper arm elevation using an inertial measurement unit: An exploration of sensor fusion algorithms and gyroscope models.***

Many sensor fusion algorithms for analyzing human motion information collected with inertial measurement units have been reported in the scientific literature. Selecting which algorithm to use can be a challenge for ergonomists that may be unfamiliar with the strengths and limitations of the various options. In this paper, we describe fundamental differences among several algorithms, including differences in sensor fusion approach (e.g., complementary filter vs. Kalman Filter) and gyroscope error modeling (i.e., inclusion or exclusion of gyroscope bias). We then compare different sensor fusion algorithms considering the fundamentals discussed using laboratory-based measurements of upper arm elevation collected under three motion speeds. Results indicate peak displacement errors of  $<4.5^\circ$  with a computationally efficient, non-proprietary complementary filter that did not account for gyroscope bias during each of the one-minute trials. Controlling for gyroscope bias reduced peak displacement errors to  $<3.0^\circ$ . The complementary filters were comparable ( $<1^\circ$  peak displacement difference) to the more complex Kalman filters.

- **Keywords:** Inclinometer; Kalman filter; Complementary filter; Inertial measurement units; Inertial-based motion capture

**Danellie Lynas, Robin Burgess-Limerick. *Whole-body vibration associated with underground coal mining equipment in Australia.***

Environmental and logistical difficulties associated with obtaining whole-body vibration measurements from mobile equipment during operation in underground coal mines have hampered attempts to assess the potential vibration exposures associated with the use of such equipment. An alternative measurement technique was used to gather data from mobile equipment during normal operation at three low-methane coal mines and to estimate the possible magnitude of benefit of three control measures. 188 long duration measurements were obtained from shuttle cars (N = 142, median measurement duration = 3.2 h); personnel transport (N = 24, median measurement duration = 2.4 h); and materials transport vehicles (N = 22, median measurement duration = 1.8 h). Whole-body vibration amplitudes either within or exceeding the ISO health guidance caution zone were consistently measured. In particular, shuttle cars demonstrated whole-body vibration amplitudes which frequently exceeded the health guidance caution zone. The potential effects of roadway maintenance, decreased vehicle speed, and shuttle car seat replacement were found to be practically meaningful.

- **Keywords:** Whole-body vibration; Underground coal mine; Shuttle car

**Adedoyin A. Adeleye, Saad A. Alabdulkarim, Maury A. Nussbaum. *Impacts of different fabric scissor designs on physical demands and performance in simulated fabric cutting tasks.***

While there is wide evidence that the occupational use of hand tools increases the risk of musculoskeletal disorder, evidence is limited regarding manual scissors, commonly used by custom tailors for bespoke garment production. We assessed whether scissor design impacts physical demands (muscle activity, perceived discomfort, and wrist posture) and task performance (quality and perceived efficiency). Twenty-four novice volunteers each completed simulated cutting tasks in 24 conditions involving the factorial combinations of four scissor designs (SD), three workstation heights, and two fabric types. SD significantly affected all outcome measures, and differences between SDs were consistent across workstation heights and fabric types. Two wide-handled scissors appeared superior overall, which may be related to the distinct grip type employed with this type of

design. These results suggest that careful scissor selection has the potential to both reduce injury risk and enhance performance during fabric cutting tasks, though future testing is needed under more realistic conditions.

- **Keywords:** Scissor design; Hand injury; Physical demands; Custom tailors; Muscle activity; Task performance

**Pooriput Waongengarm, Allard J. van der Beek, Nipaporn Akkarakittichoke, Prawit Janwantanakul. *Perceived musculoskeletal discomfort and its association with postural shifts during 4-h prolonged sitting in office workers.***

This study examined the characteristics of perceived discomfort and postural shifts at different magnitudes during a 4-h sitting period and the association between perceived discomfort and number of postural shifts. Forty healthy participants continuously typed a standardized text passage at a computer work station for 4 h. Subjects rated perceived body discomfort using Borg's CR-10 scale in 10 body regions (i.e. neck, shoulder, elbow, wrist/hand, upper back, lower back, buttock, thigh, knee, and ankle/foot). A seat pressure mat device was used to gather seat pressure data during sitting. Postural shifts were determined by analysis of the dispersion index of both ischial tuberosities from seat pressure data. The threshold for a postural shift was set at  $\pm 10\%$  and  $\pm 20\%$ . Perceived discomfort in all body regions increased continuously during a 4-h sitting period. The body regions with the highest perceived discomfort were the low back, buttocks, upper back, thigh, and neck. The average ( $\pm$ SD) numbers of postural shifts during the 1st, 2nd, 3rd, and 4th hour of sitting were  $14.8 \pm 9.5$ ,  $17.8 \pm 9.4$ ,  $18.2 \pm 11.1$ , and  $18.1 \pm 9.8$  shifts per hour for the 10% threshold, and were  $4.8 \pm 4.4$ ,  $6.0 \pm 5.6$ ,  $7.4 \pm 6.7$ , and  $7.7 \pm 6.6$  shifts per hour for the 20% threshold, respectively. Prolonged sitting led to an increase in perceived musculoskeletal discomfort over time. The number of postural shifts at both magnitudes increased in the first 2 h of sitting and, in the second 2-h period of sitting, only the number of larger postural shifts (with 20% threshold) increased. The findings extend our understanding of sitting behaviors.

- **Keywords:** Musculoskeletal disorders; Low back pain; Computers; Office workers

**Claudio M. Brunoro, Ivan Bolis, Tiago F.A.C. Sigahi, Bruno C. Kawasaki, Laerte I. Sznclwar. *Defining the meaning of "sustainable work" from activity-centered ergonomics and psychodynamics of Work's perspectives.***

**Introduction:** Work-related issues are already part of the theoretical framework and the historical rationale that underpin corporate sustainability. However, the relationship between work and sustainability is still little known in company practices. Based on the concepts of activity-centered ergonomics (ACE) and psychodynamics of work (PDW), this paper investigates the meaning of "sustainable work" in Brazilian companies. Thus, two research questions guided this study: How the concept of "sustainable work" can be defined in the perception of companies based on the perspective of ACE and PDW? How the concepts provided by these approaches can help companies in developing practices towards sustainable work? **Method:** Case studies conducted in ten Brazilian companies engaged in corporate sustainability practices involving document analysis, interviews, and content analysis. **Results:** Companies recognize the importance of human action in organizational processes, by considering people as the cornerstone for ensuring corporate sustainability, and seeking to build a work with meaning and significance. However, i) Improvement actions are usually mitigatory or compensatory, acting on the effects while the root causes remain untouched; ii) Sustainability initiatives focus on individual issues, in most cases on the leader (individual), narrowing its scope and neglecting broader, important topics such as work organization and work content; iii)

Both work overload and work for sustainability agenda are usually disregarded; iv) A comprehensive view of health should not be limited to the workplace. **Conclusions:** According to companies' perceptions, sustainable work includes but is not limited to integrating work to corporate sustainability guidelines, respecting labor laws and human rights, developing synergy between areas/departments towards sustainability, providing possibilities for constructing health in its multidimensionality with the worker as protagonist, and creating work that is meaningful, pleasurable and leads to happiness and recognition. ACE and PDW offer valuable concepts to support companies in bridging the gap between their corporate sustainability vision and practices, i.e., transforming guidelines into actions towards sustainable work. In this sense, sustainable work is believed to be that which improves the organization's performance and promotes professional development as well as workers' health broadly and positively (not limited to the absence of illness, but in the sense of building health) and well-being. Thus, it fosters respect for and the development of intelligence and creativity (as opposed to alienating work) by performing work that has meaning and significance, understanding the profound importance of physical, cognitive and organizational issues, and above all, the importance of work to the development of culture (Bolis et al., 2014).

- **Keywords:** Corporate sustainability; Work; Activity-centered ergonomics; Psychodynamic of work; Corporate social responsibility

**Sunwook Kim, Saman Madinei, Mohammad Mehdi Alemi, Divya Srinivasan, Maury A. Nussbaum. *Assessing the potential for "undesired" effects of passive back-support exoskeleton use during a simulated manual assembly task: Muscle activity, posture, balance, discomfort, and usability.***

Back-support exoskeletons (BSEs) are wearable systems designed to reduce physical demands on the back, but which could have undesired effects beyond this design intention. Participants ( $n = 18$ ) used two commercial BSEs to complete a brief ( $\sim 15$ – $20$  s) simulated manual assembly task in varying conditions, with outcome measures that included: working posture, activity levels in "secondary" muscle groups (shoulders and thighs), perceived balance, discomfort, and usability. Using a BSE led to small and inconsistent changes in working postures (e.g.,  $< \sim 14^\circ$  change in lumbar flexion), muscular activity in the secondary muscle groups ( $< \pm 2\%$  of maximum voluntary isometric contractions), or perceived balance. Limitations in movement were reported for both BSEs, however, along with moderate levels of discomfort. Task-specific responses were evident for all outcome measures, though these depended on the specific BSE used and differed between genders in many cases. Future work should focus on interactions between a given user, BSE design, and task conditions.

- **Keywords:** Exoskeleton design; Intervention; Quasi-static task; Working posture

**Takanori Chihara, Fumihiko Kobayashi, Jiro Sakamoto. *Evaluation of mental workload during automobile driving using one-class support vector machine with eye movement data.***

The aim of this study is to investigate the usefulness of the anomaly detection method by one-class support vector machine (OCSVM) for the evaluation of mental workload (MWL) during automobile driving. Twelve students (six males and six females) participated. The participants performed driving tasks with a driving simulator (DS) and the N-back task that was used to control their MWL. The N-back task had five difficulty levels from "none" to "3-back." Eye and head movements were measured during the DS driving. Results showed that the standard deviation (SD) of the gaze angle, SD of eyeball rotation angle, share rate of head movement, and blink frequency had significant correlations with the task difficulty. The decision boundary of OCSVM could detect 95% of high MWL state

(i.e., "3-back" state). In addition, the absolute value of the distance from the decision boundary increased with the task difficulty from "0-back" to "3-back."

- **Keywords:** Distracted driving; Cognitive capacity; Machine learning

**Ben R. Lane, Paul M. Salmon, Dennis Desmond, Adrian Cherney, Adam Carley, Adam Hulme, Neville A. Stanton. *Out of control? Using STAMP to model the control and feedback mechanisms surrounding identity crime in darknet marketplaces.***

Darknet marketplaces have emerged as a facilitator of identity crime and trading. This study aimed to (1) understand the entities and control and feedback mechanisms that influence identity crime prevention and occurrence on the darknet in the Australian system and to (2) comprehensively identify the implications of control failures across all system levels. The Systems-Theoretic Accident Model and Processes (STAMP) was used to develop an identity crime control structure in consultation with subject matter experts and then the Systems-Theoretic Process Analysis (STPA) was applied. The STPA identified 310 risk states, resulting from control failures and which were associated with the range of agencies, organisations, and individuals present across system levels. As darknet marketplaces rapidly evolve, alignment between these entities is necessary to enable agile system responses. STAMP and STPA have promise in understanding the potential for intervention across all system levels in preventing societal issues such as identity crime.

- **Keywords:** Darknet; Identity crime; Systems theoretic process analysis

**Denys Denis, Maud Gonella, Marie Comeau, Martin Lauzier. *Questioning the value of manual material handling training: a scoping and critical literature review.***

Manual material handling training (MMHT) is of questionable value according to five meta-analyses. However, little is known about why this is so. The aim of this study is to take a closer look at how MMHT are evaluated in order to identify what could explain judgement about their (lack of) effectiveness. Seventy-seven studies were included in a scoping review, and were analyzed using an inductive grid comprising numerous criteria. Workplace training programs, being the most frequent, were described in these papers in greater detail. Given the broad range of contexts it was found that MMHT differed greatly from one study to the other. All the while, contents presented through these programs were surprisingly uniform, with an emphasis on adopting the safe handling technique commonly known as "straight back, bent knees", although such training approach principally focuses on the trainee's behaviours, while paying little (to no) attention to the work conditions that might condition correct behavioral display. Limitations of current MMHT are discussed and explanations are given in order to better explain why they are reported to be so ineffective. Concrete recommendations on how to improve them close the paper.

- **Keywords:** Manual material handling training; Training programs; Training effectiveness; Scoping review

**Ramon Sancibrian, Carlos Redondo-Figuero, Maria C. Gutierrez-Diez, Esther Gonzalez-Sarabia, Jose C. Manuel-Palazuelos. *Ergonomic evaluation and performance of a new handle for laparoscopic tools in surgery.***

This paper presents a new handle for instruments used in laparoscopic surgery. This new handle has been designed to provide the best ergonomic and usability features required

in this kind of surgical interventions. The main novelty of this handle is that the opening and closing motion of the end-effector is operated with the thumb using a lever located on the top of the handle. This enables the surgeon to reach the patient's organs without adopting extremely awkward postures. In order to demonstrate its advantages, the handle has been tested and compared with another commercial handle in terms of efficiency, effectiveness, and satisfaction. To this end, volunteers have been selected for participation in the experimental evaluation, which comprised two types of surveys: objective and subjective. Electromyography and goniometric studies provide objective parameters for evaluation. Questionnaires are used for the subjective assessment. Outstanding results include the lower level of pain reported by the individuals working with the new handle, as well as the reduction in the hyperflexion of the wrist. Compared with the conventional handle, electromyography reveals that no muscle load is increased when working with the new handle. The results of the subjective survey show that volunteers expressed a significant preference for the new handle, demonstrating an improvement in the ergonomic characteristics.

- **Keywords:** Laparoscopic surgery; Handle design; Biomechanics

***Esra Bas. STPA methodology in a socio-technical system of monitoring and tracking diabetes mellitus.***

In this paper, an adaptation of the system-theoretic process analysis (STPA) approach to a sociotechnical system of monitoring and tracking diabetes mellitus (DM) is proposed. Several human controllers such as the patient, physicians, other healthcare providers, and people in the social environment were considered in the hierarchical safety control structure. During the identification of the causal factors (causal scenarios) for the unsafe control actions of the human controllers, the three-phase approach proposed by France (2017) as well as the interaction problems between the subsystems in the hierarchical safety control structure were considered, and the implementation of the basic safety design procedure was included in the methodology for the improvement of system. A dynamic STPA methodology is also proposed as an extension to the basic methodology.

- **Keywords:** STPA; System-theoretic process analysis; STAMP; Human controller; Healthcare; Diabetes mellitus

***Chiuhsiang Joe Lin, Sui-Hua Ho. The development of a mobile user interface ability evaluation system for the elderly.***

This research aimed to develop a comprehensive evaluation of the mobile user interface abilities of the elderly so that technology can be designed to meet individualized needs. A total of 135 older adults were evaluated with the developed system, the Elderly Mobile User Interface Ability Evaluation System (EMUIAES). The prediction of age and the use of technology on elderly mobile interface usage were investigated based on the findings of the evaluation. The relationship between performance on Fitts' task and elderly mobile user interface ability (EMUIA) was also examined. The findings showed a strong effect of age on the elderly's use of mobile user interfaces. Previous experience with personal and tablet computers also contributed to the use of mobile user interfaces. In addition, this research demonstrated the application of Fitts' law to describe the elderly mobile user interface behaviors, particularly for tasks involving fast tapping and pointing. The EMUIAES can provide future researchers and designers a comprehensive tool to describe the elderly's diverse behaviors and changes in their ability to use mobile interfaces. Individualized interface designs for elderly users can be developed based on these findings to improve the elderly users' experiences of using technology.

- **Keywords:** Human computer interaction; User interface; Aging; Evaluation

**Ornwipa Thamsuwan, Kit Galvin, Maria Tchong-French, Lovenoor Aulck, Linda Ng Boyle, Randal P. Ching, Kevin J. McQuade, Peter W. Johnson. *Comparisons of physical exposure between workers harvesting apples on mobile orchard platforms and ladders, part 2: Repetitive upper arm motions.***

Farmworkers are exposed to physical risk factors including repetitive motions. Existing ergonomic assessment methods are primarily laboratory-based and, thus, inappropriate for use in the field. This study presents an approach to characterize the repetitive motions of the upper arms based on direct measurement using accelerometers. Repetition rates were derived from upper arm inclination data and with video recordings in the field. This method was used to investigate whether harvesting with mobile platforms (teams harvesting apples from the platform and the ground) increased the farmworkers' exposure to upper arm repetitive motions compared to traditional harvesting using ladders. The ladder workers had higher repetitive motions (13.7 cycles per minute) compared to the platform and ground workers (11.7 and 12.2 cycles per minutes). The higher repetitions in the ladder workers were likely due to their ability to work independently and the additional arm movements associated with ladder climbing and walking.

- **Keywords:** Accelerometer; Agriculture; Productivity; Repetition

**Tianna H. Beharriell, Matthew P. Mavor, Wantuir Ramos, Jean-François Mauger, Pascal Imbeault, Ryan B. Graham. *Beyond the mechanical lens: Systemic inflammatory responses to repetitive lifting under varying loads and frequencies.***

**Objective:** Currently, low back disorder (LBD) research focuses primarily on mechanical variables to assess whether task demands exceed tissue capacity; however, it is important to assess how other nonmechanical variables affect tissue capacity in a time-dependent manner. The current investigation sought to explore physiological responses to an acute lifting task, as lifting has been implicated as a risk factor in the development of LBDs. **Methods:** Twelve participants completed two sessions of 2 h of repetitive symmetrical lifting from floor to knuckle height under two conditions, matched for total external work (Low Force High Repetition (LFHR) and High Force Low Repetition (HFLR)). Full-body kinematics and ground reaction forces were measured throughout. Interleukin 6 (IL-6) and interleukin 8 (IL-8), markers of systemic inflammation, were assessed from blood sampling at Baseline, 0, 4 and 24 h post-lifting on both days. Dual x-ray absorptiometry (DEXA) scans were also performed on participants to quantify body composition. **Results:** Significant load (HFLR and LFHR) \* time (Baseline, 0, 4, 24 h) interaction effects were found for both IL-6 and IL-8, where the LFHR condition resulted in greater responses at 0 and 4 h post-lifting. **Conclusions:** This was the first study of its kind to concurrently measure peak and cumulative spinal moments and their relationship to systemic inflammation in both sexes, while strictly controlling for confounding variables (e.g. physical activity, caloric intake, body composition, etc.). Greater levels of IL-6 and IL-8 were seen in the LFHR condition, likely due to the greater cumulative spinal moments in this condition.

- **Keywords:** Spine; Lifting; Inflammation; Cumulative/Peak Spinal Moments; Cytokines

**Peter Dam, Malthe Bilgram, August Brandi, Mogens Frederiksen, Thomas H. Langer, Afshin Samani. *Evaluation of the effect of a newly developed steering unit with enhanced self-alignment and deadband on mental workload during driving of agricultural tractors.***

The aim of present study was to investigate the effect of a newly developed steering unit with enhanced self-alignment and deadband on mental workload (MW) during heavy vehicle operation. Fourteen participants performed two tasks consisting of a lane keeping and a double lane shift with two tractors equipped with 1) a conventional and 2) an enhanced steering system. Physiological measurements, i.e., electromyography, electrodermal activity and heart rate were recorded during the tasks. Furthermore, performance measurements and subjective perception of MW were collected. Present study demonstrated that participants perceived the enhanced steering system requiring less mental demands to operate. Participants improved their performance during the lane keeping task and tended to improve in the double lane shift task with the enhanced system. Physiological measurements did not reveal differences between the steering systems. This study highlighted the dissociation of subjective indices of mental workload from physiological indices in driving of heavy vehicles.

- **Keywords:** Physiological indices; Heavy vehicles; Steering systems

**Firdaous Sekkay, Daniel Imbeau, Philippe-Antoine Dubé, Yuvin Chinniah, Nathalie de Marcellis-Warin, Nancy Beauregard, Martin Trépanier. *Assessment of physical work demand of short distance industrial gas delivery truck drivers.***

**Aim:** This study assessed the work-related physical demands of short-distance truck drivers employed by a large gas delivery company in Canada. **Methods:** A total of 19 truck drivers participated in the data collection, which included a combination of self-reports, field observations and direct measurements to report on the work shift task composition, postures, physical workload, and force exertions. **Results:** Driving (mean of 43% of daily work shift) and delivering gas cylinders to customers (28%) were the main tasks of the truck drivers. Delivering gas cylinders measured as moderate level work and daily work duration was not excessive with respect to mean cardiac strain for most drivers. However, manual handling and force exertion activities were frequent and deemed unsafe most of the time with respect to existing guidelines on manual materials handling. **Conclusion:** This study documents physical risk factors that are consistent with musculoskeletal pain prevalence reported for short-distance truck drivers.

- **Keywords:** Short-distance truck drivers; Industrial gas cylinders; Manual materials handling; Physical workload; MSD

**Daniela Raccanello, Rob Hall, Roberto Burro. *Can emojis mean "Earthquake"?***

With the increase in digital communications systems and social media, there is a need for simple graphics-based ways to signal the occurrence of major disasters. We describe the development and initial usability testing of a sign to indicate that an earthquake has occurred. We involved 264 Italian adults, who completed an online survey to evaluate the evocativeness, simplicity, and universality of 16 emojis depicting earthquakes. Through a Self-Organising Map analysis we identified four similar response profiles to the evocativeness scale, differing in their mean strength. A non-metric Multidimensional Scaling suggested that evocativeness was higher for the emojis featuring a damaged building. Linear Mixed Models indicated that emojis with fabricated vs. natural structures were judged as more evocative, simpler, and more universal when characterized by danger from falling objects. In some cases, adding behavioral elements increased evocativeness. Practical implications for informing the development of a new emoji for earthquakes are discussed.

- **Keywords:** Earthquake; Emoji; Communication; Emotion



**A. Armougum, A. Gaston-Bellegarde, C. Joie-La Marle, P. Piolino. *Physiological investigation of cognitive load in real-life train travelers during information processing.***

Management of travelers' cognitive load is crucial for efficient information processing for optimal railway operations. We investigated variations in travelers' cognitive load with different expertise levels, in a field study. We aimed to assess the use of three eye metrics: pupil diameter, saccade amplitude and gaze of fixation duration for cognitive load analysis between expert and novice travelers in a Mass Transit train station: Saint-Michel Notre Dame. Physiological measures of emotional activity through skin conductance responses were also investigated, together with subjective measures of mental load using NASA-Task Load Index. Our results followed our expectations, where novice travelers expressed higher cognitive load than expert travelers, characterized by wider pupil diameter, larger amplitude of saccade and longer gaze duration, as well as higher electrodermal activity and NASA-TLX. Additional observations showed that experts used hierarchical and symmetrical scan paths, with more intense exposure on relevant information, characterized by brighter heat maps. This difference in behavior showed a clear difference in strategies for information retrieval at different expertise levels. Metrics of eye tracking device, together with electrodermal activity, proved to be potent in cognitive load analysis of train travelers, and helped to provide insights for real-life information processing.

- **Keywords:** Eye tracking; Cognitive load; Train travelers; Expertise; Eye metrics; Electrodermal activity

**Ornwipa Thamsuwan, Kit Galvin, Maria Tchong-French, Lovenoor Aulck, Linda Ng Boyle, Randal P. Ching, Kevin J. McQuade, Peter W. Johnson. *Comparisons of physical exposure between workers harvesting apples on mobile orchard platforms and ladders, part 1: Back and upper arm postures.***

This study compared farmworkers' exposure to non-neutral postures using a new mobile platform apple harvesting method and the traditional method using ladders. Twenty-four workers were recruited and assigned into three groups: ladder workers ( $n = 8$ ) picking apples from full trees using a ladder, mobile platform workers ( $n = 8$ ) picking apples from upper part of the trees while standing on a moving platform, and ground-based mobile platform workers ( $n = 8$ ) picking apples from lower part of the trees which the mobile platform workers left out. Upper arm and back inclinations were continuously monitored during harvesting using tri-axial accelerometers over full work shifts ( $\sim 8$  h). Upper arm posture was characterized as the percentage of time that upper arm flexion and abduction exceeded  $30^\circ$ ,  $60^\circ$ , and  $90^\circ$ . Back posture was characterized as the percentage of time that torso angles (sagittal flexion or lateral bending) exceeded  $10^\circ$ ,  $20^\circ$ , and  $30^\circ$ . The 10th, 50th, and 90th postural percentiles were also calculated. The platform workers had lower exposures to upper arm flexion and abduction than the ground and ladder workers. There were no differences in torso angles between the ladder and mobile platform workers; however, the ground workers were exposed to more and greater percentages of time in torso flexions.

**Kyle A. Pettijohn, Chad Peltier, Jamie R. Lukos, Jacob N. Norris, Adam T. Biggs. *Virtual and augmented reality in a simulated naval engagement: Preliminary comparisons of simulator sickness and human performance.***

The aim of this study was to compare simulator sickness symptoms while participants wore either a virtual reality (VR) or augmented reality (AR) headset. A secondary aim involved comparing how physical motion affects symptoms. During a simulation, participants wore VR and AR headsets while standing on a motion platform and firing at

hostile ships under three motion conditions: No Physical Motion; Synchronous Motion, in which the physical and displayed motion were coupled; and Asynchronous Motion, in which the physical motion did not match the display. Symptoms increased over time but were not different with respect to headset or motion. The VR condition had higher accuracy and faster response time to the commence fire instruction. Further research is necessary to determine if this holds under more extreme motion. The use of VR or AR headsets for training under gentle motion conditions is practicable and should be permissible under normal conditions during deployment.

- **Keywords:** Virtual environments; Motion sickness; Simulation and training; Attentional processes; Perceptual-motor performance

**Anthony D. Joffe, Mark W. Wiggins. *Cross-task cue utilisation and situational awareness in learning to manage a simulated rail control task.***

Cue utilisation and situational awareness share similar properties since both constructs are dependent upon the application of feature-event associations in memory. The aim of this study was to investigate the extent to which cue utilisation and situational awareness contribute to learning a simplified, simulated rail control task incorporating an implicit pattern of train movements. Fifty-five undergraduate students completed an assessment of cue utilisation prior to completing the rail control task during periods of lower and higher task demands. Situational awareness was assessed using Situation Awareness Global Assessment Technique (SAGAT) queries. The results indicated that, while both cue utilisation and situational awareness were related to the detection of the implicit pattern of train movements, they contributed separately to performance on the simulated rail control task. The outcomes suggest that cue utilisation and situational awareness may be separate constructs, where cue utilisation constitutes a capacity variable that is associated with changes in response to task demand and situational awareness constitutes an outcome variable that emerges through task exposure.

- **Keywords:** Situational awareness; SAGAT; Cue utilisation; Learning; Rail control; Simulation

**Sarvesh Kolekar, Joost de Winter, David Abbink. *Which parts of the road guide obstacle avoidance? Quantifying the driver's risk field.***

Gibson and Crooks (1938) argued that a 'field of safe travel' could qualitatively explain drivers' steering behavior on straights, curved roads, and while avoiding obstacles. This study aims to quantitatively explain driver behavior while avoiding obstacles on a straight road, and quantify the 'Driver's Risk Field' (DRF). In a fixed-based driving simulator, 77 (7 longitudinal and 11 lateral) positions of the obstacles were used to quantify the subjectively perceived and objectively (maximum absolute steering angle) measured DRF for eight participants. The subjective response was a numerical answer to the question "How much steering do you think you need at this moment in time?" The results show that the propagation of the width of the DRF, along the longitudinal distance, resembled an hourglass shape, and all participants responded to obstacles that were placed beyond the width of the car. This implies that the Driver's Risk Field is wider than the car width.

- **Keywords:** Field of safe travel; Risk; Obstacle avoidance; Potential field; Driving

**Carl Mikael Lind, Liyun Yang, Farhad Abtahi, Lars Hanson, Kaj Lindecrantz, Ke Lu, Mikael Forsman, Jörgen Eklund. *Reducing postural load in order picking through a smart workwear system using real-time vibrotactile feedback.***

Vibrotactile feedback training may be one possible method for interventions that target at learning better work techniques and improving postures in manual handling. This study aimed to evaluate the short term effect of real-time vibrotactile feedback on postural exposure using a smart workwear system for work postures intervention in simulated industrial order picking. Fifteen workers at an industrial manufacturing plant performed order-picking tasks, in which the vibrotactile feedback was used for postural training at work. The system recorded the trunk and upper arm postures. Questionnaires and semi-structured interviews were conducted about the users' experience of the system. The results showed reduced time in trunk inclination  $\geq 20^\circ$ ,  $\geq 30^\circ$  and  $\geq 45^\circ$  and dominant upper arm elevation  $\geq 30^\circ$  and  $\geq 45^\circ$  when the workers received feedback, and for trunk inclination  $\geq 20^\circ$ ,  $\geq 30^\circ$  and  $\geq 45^\circ$  and dominant upper arm elevation  $\geq 30^\circ$ , after feedback withdrawal. The workers perceived the system as useable, comfortable, and supportive for learning. The system has the potential of contributing to improved postures in order picking through an automated short-term training program.

- **Keywords:** Work technique training; The smart workwear consortium; Intervention

**Karina Aase, Justin Waring. *Crossing boundaries: Establishing a framework for researching quality and safety in care transitions.***

**Background:** Despite the breadth and diversity of research and policies on care transitions, research studies often report similar components that affect the quality and safety of care, including communication across professional groups and care settings, transfer of information, coordination of resources or training of healthcare personnel. In this article, we aim to deepen our understanding of care transitions by proposing a heuristic research framework that takes into account the components and factors influencing the quality and safety of care transitions in diverse settings. **Methodology:** Using a pragmatic qualitative narrative meta-synthesis of empirically grounded research studies (N = 13) involving 31 researchers from seven countries (Australia, Canada, Denmark, Germany, the Netherlands, Norway and the UK), we conducted a thematic analysis to identify the components analysed in the included studies. We then used these components to create a framework for researching care transitions. **Results:** Our narrative synthesis found that the quality and safety of care transitions are influenced by a range of patient-centred, communicative, collaborative, cultural, competency-based, accountability-based and spatial components. These components are encompassed within a broader set of dimensions that require careful consideration: (1) the conceptualising of the care transition notion, (2) the methodology for researching care transitions, (3) the role of patients and carers in care transitions, (4) the complexity surrounding care transitions, (5) the boundaries intertwined in care transitions and (6) care transition improvement interventions. These six dimensions constitute an analytical framework for planning and conducting research on care transitions in diverse settings. **Conclusion:** The proposed six-dimensional framework for researching quality and safety in care transitions offers a roadmap for future practice and policy interventions and provides a starting point for planning and designing future research.

- **Keywords:** Healthcare; Care transitions; Quality and safety

**Dario Babić, Helena Dijanić, Lea Jakob, Darko Babić, Eduardo Garcia-Garzon. *Driver eye movements in relation to unfamiliar traffic signs: An eye tracking study.***

Traffic signs are an integral part of the traffic control plan and they provide road users with necessary information on the upcoming situation. This paper aims to examine the level of understanding of traffic sign imagery used in different countries and to track participants' eye movement when they encounter unfamiliar signs. Tobii eye tracking glasses were used to track gaze differences between familiar and unfamiliar traffic signs.

Our findings show that sign characteristics (such as the amount of information on the sign) and the observer's knowledge of the sign meaning have a significant impact on eye behaviour. Signs containing more information (loaded with more content) and unfamiliar to the participant systematically produced the longest overall and average fixations and gazing duration. Given that longer gaze time for unfamiliar traffic signs presents a potential traffic hazard, we evaluated the need for standardization of traffic signs.

- **Keywords:** Cross-cultural; Eye tracking; Traffic safety; Traffic sign

**Kristina M. Gruevski, Jack P. Callaghan. *The effect of age, prolonged seated work and sex on posture and perceived effort during a lifting task.***

The purpose of this investigation was to determine the effect of prolonged seated work, lift task, age and sex on normalized lumbar angles, thoracic angles, perceived effort and duration of lifts. A total of 17 young and 17 mature participants were recruited with an average (standard deviation) age of 23.8 (5.0) years and 63.7 (3.9) years, respectively. Participants completed 3 different floor to knuckle lifts before and following 90 min of seated work. The lifts included; (i) 7 kg symmetrical, (ii) 4.5 kg symmetrical and (iii) 4.5 kg asymmetrical. Prolonged seated work and age interacted to affect normalized peak lumbar angles ( $p = 0.0469$ ) where older adults adopted 56(15)% flexion after seated work compared to 67(16)% among younger adults. Older adults took significantly longer to complete the lifting tasks compared to younger adults while age did not affect perceived effort across lifting tasks. Older workers may require age specific interventions given age specific responses.

- **Keywords:** Aging; Manual material handling; Prolonged sitting