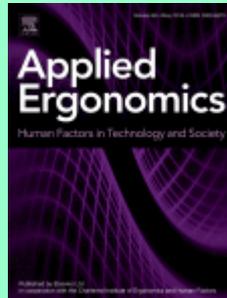


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Rita Wing Lam Yu, Alan Hoi Shou Chan. *Meta-analysis of the effects of game types and devices on older adults-video game interaction: Implications for video game training on cognition.* 103477.

Video game training can effectively improve the cognition of older adults. However, whether video game types and game devices influence the training effects of video games remains controversial. This meta-analysis aimed to access and evaluate the effects of video game types and game devices in video game training on the cognition of older adults. Interestingly, results indicated that mouse/keyboard was superior over other video game devices on perceptual-motor function. The effect size (Hedge's g) for perceptual-motor function decreased by 1.777 and 1.722 when the video game training device changed from mouse/keyboard to driving simulator and motion controller. The effects of cognitive training game and conventional video game were moderated by session length. More well-designed studies are required to clarify the unique efficacy of video game types and devices for older adults with video game training.

- **Keywords:** Aging; Cognition; Game device; Older adults; Video game training

Sebastian Skals, Rúni Bláfoss, Mark de Zee, Lars Louis Andersen, Michael Skipper Andersen. *Effects of load mass and position on the dynamic loading of the knees, shoulders and lumbar spine during lifting: a musculoskeletal modelling approach.* 103491.

Musculoskeletal models may enhance our understanding of the dynamic loading of the joints during manual material handling. This study used state-of-the-art musculoskeletal models to determine the effects of load mass, asymmetry angle, horizontal location and deposit height on the dynamic loading of the knees, shoulders and lumbar spine during lifting. Recommended weight limits and lifting indices were also calculated using the NIOSH lifting equation. Based on 1832 lifts from 22 subjects, we found that load mass had the most substantial effect on L5-S1 compression. Increments in asymmetry led to large increases in mediolateral shear, while load mass and asymmetry had significant effects on anteroposterior shear. Increased deposit height led to higher shoulder forces, while the horizontal location mostly affected the forces in the knees and shoulders. These results generally support the findings of previous research, but notable differences in the trends and magnitudes of the estimated forces were observed.

- **Keywords:** Computer simulation; Musculoskeletal system; Occupational injuries

Héctor Ignacio Castellucci, Carlos Viviani, Paulina Hernández, Gonzalo Bravo, Marta Martínez, Jaime Ibacache, Ángelo Bartsch. *Developing countries and the use of ISO Standard 11228-3 for risk management of Work-Related Musculoskeletal Disorders of the Upper Limbs (WRMSDs-ULs): The case of Chile.* 103483.

Work-Related Musculoskeletal Disorders of the Upper Limbs (WRMSDs-ULs) are one of the most common occupational diseases worldwide. Repetitive motion is one of the main risk factors associated with these conditions. Several efforts have been made within the scientific community in order to develop specific methods to assess the risk that repetitive work represents. Furthermore, internationally coordinated work has resulted in the generation of a series of ISO standards to address issues around ergonomics in the workplace. In 2012, Chile adopted the ISO11228-3 standard checklist in its regulatory process, creating the first technical standard of risk management for repetitive motion. The aim of this study is to present the results of a nation-wide online survey of Chilean Health and Safety Practitioners and Ergonomists, which was conducted in order to identify their level of application experience, most commonly adopted practices, and opinions on the first Chilean Standard for WRMSDs-ULs risk assessment. A second aim is to discuss common issues and possible improvements in public policies, and the adoption of international instruments by developing countries. A total of 331 respondents completed the survey (183 Ergonomists and 148 non-ergonomist). It was observed that a number of the participants consider that the adaptation of the ISO standard has several issues, ranging from simple ones as wording and format to more complex ones regarding overall structure, logic, and ease of use. One of the main issues expressed is the fact that during the adaptation process the instrument is applied in multitask jobs, without providing clear instructions or training. Furthermore, among the top three most used assessment methods were RULA and REBA, which are posture-driven, instead of methods validated for repetitive motion. The issues detected by the Chilean OHS practitioners are common in developing countries, where an intersection of lack of resources, public agency authoritarianism, and poor communication between public-private and public-public organizations contribute to poor consultation, validation, and adaptation processes. Suggestions to improve the current Chilean standard, as well as considerations for developing countries, are presented.

- **Keywords:** Upper-extremity; Risk assessment; Prevention; Repetitive strain injury

Zanyar Karimi, Adel Mazloumi, Ali Sharifnezhad, Amir Homayoun Jafari, Zeinab Kazemi, Ahmadsreza Keihani, Iraj Mohebbi. *Determining the interactions between postural variability structure and discomfort development using nonlinear analysis techniques during prolonged standing work.* 103489.

Purpose: Nonlinear analysis techniques provide a powerful approach to explore dynamics of posture-related time-varying signals. The aim of this study was to investigate the fundamental interactions between postural variability structure and discomfort development during prolonged standing. **Methods:** Twenty participants, with equal distribution for gender and standing work experience (SWE), completed a simulated long-term standing test. Low back and legs discomfort, center of pressure, lumbar curvature, and EMG activity of trunk and leg muscles were monitored. Nonlinear measures including largest Lyapunov exponent, multi-scale entropy, and detrended fluctuation analysis were applied to characterize the variability structure (i.e., complexity) in each signal. The size (i.e., amount) of variability was also computed using traditional linear metrics. **Results:** With progress of low back and legs discomfort over standing periods, significant lower levels were perceived by the participants having SWE. The amount of variability in all signals (except external oblique EMG activity) were

significantly increased with the time progress for all participants. The structure of variability in most signals demonstrated a lower complexity (more regularity) with fractal properties that deviated from 1/f noise. The SWE group showed a higher complexity levels. **Conclusions:** Overall, the findings verified variations in structure and amount of the postural variability. However, nonlinear analysis identified postural strategies according to the perceived discomfort in a different way. These results provide supports for future application of nonlinear tools in evaluating standing tasks and related ergonomics interventions as it allows further insight into how discomfort development impact the structure of postural changes.

- **Keywords:** Complexity; Standing work; Discomfort

Heikki Mansikka, Kai Virtanen, Ville Uggeldahl, Don Harris. *Team situation awareness accuracy measurement technique for simulated air combat - Curvilinear relationship between awareness and performance.* 103473.

A new technique for the assessment of Team Situation Awareness (TSA) accuracy based upon post task Critical Decision Method structured interviews was developed and tested using 39 combat-ready F/A-18 pilots. Pilots undertook a number of simulated air combat scenarios, flying in flights of four aircraft against a formation of enemy aircraft. Results showed a strong curvilinear relationship where high TSA accuracy resulted in higher performance in some areas of air combat, measured with friendly losses and kills. There were diminishing returns in performance as TSA accuracy increased. This may explain why previous studies on air combat have found relatively weak relationships between situation awareness and performance where the relationship has been assumed to be linear.

- **Keywords:** Critical decision method; Performance; Team situation awareness

Costas I. Karageorghis, Elias Mouchlianitis, William Payre, Garry Kuan, Luke W. Howard, Nick Reed, Andrew M. Parkes. *Psychological, psychophysiological and behavioural effects of participant-selected vs. researcher-selected music in simulated urban driving.* 103436.

We investigated the effect of participant-selected (PSel) and researcher-selected (RSel) music on urban driving behaviour in young men (N = 27; Mage = 20.6 years, SD = 1.9 years). A counterbalanced, within-subjects design was used with four simulated driving conditions: PSel fast-tempo music, PSel slow-tempo music, RSel music and an urban traffic-noise control. The between-subjects variable of personality (introverts vs. extroverts) was explored. The presence of PSel slow-tempo music and RSel music optimised affective valence and arousal for urban driving. NASA Task Load Index scores indicated that the urban traffic-noise control increased mental demand compared to PSel slow-tempo music. In the PSel slow-tempo condition, less use was made of the brake pedal. When compared to extroverts, introverts recorded lower mean speed and attracted lower risk ratings under PSel slow-tempo music. The utility of PSel slow-tempo and RSel music was demonstrated in terms of optimising affective state for simulated urban driving.

- **Keywords:** Affect; Distraction; Personality; Road safety; Young drivers; Simulation

M.A. Sinclair, M.J.deC. Henshaw, S.L. Henshaw. *On building sustainable communities: A perspective for HFE practitioners.* 103476.

This paper is aimed mainly at Human Factors and Ergonomics (HFE) practitioners. It addresses the sustainability of communities, since without them there is no real human future. It also fits current concerns about climate change and general sustainability. However, our understanding of the characteristics of sustainable communities is still insufficient, as is evidenced by the different perspectives extant in the HFE literature. This paper provides a further perspective based on systems ergonomics, intended both to extend our socio-technical understanding and to assist HFE practitioners in contributing to a broad approach by which to contribute to the never-ending renewal process for these communities. Without such an approach many communities will become unsustainable, with collapse as their end, as Tainter originally, icily, explained (Tainter 1988). The paper begins with a definition of a 'sustainable community', including its legal basis. Its sustainability goals are outlined, based mainly on principles of social justice, since without people there is no community. Then there is a discussion of the characteristics of sustainable communities, the classes of resources available to maintain sustainability, and some of the complexities and hindrances to this maintenance. The last sections link this conceptual landscape to HFE practice by outlining approaches and processes that move from the conceptual landscape in this paper to current practice.

Emad Alyan, Naufal M. Saad, Nidal Kamel, Mohammad Abdul Rahman. *Workplace design-related stress effects on prefrontal cortex connectivity and neurovascular coupling*. 103497.

This study aims to evaluate the effect of workstation type on the neural and vascular networks of the prefrontal cortex (PFC) underlying the cognitive activity involved during mental stress. Workstation design has been reported to affect the physical and mental health of employees. However, while the functional effects of ergonomic workstations have been documented, there is little research on the influence of workstation design on the executive function of the brain. In this study, 23 healthy volunteers in ergonomic and non-ergonomic workstations completed the Montreal imaging stress task, while their brain activity was recorded using the synchronized measurement of electroencephalography and functional near-infrared spectroscopy. The results revealed desynchronization in alpha rhythms and oxygenated hemoglobin, as well as decreased functional connectivity in the PFC networks at the non-ergonomic workstations. Additionally, a significant increase in salivary alpha-amylase activity was observed in all participants at the non-ergonomic workstations, confirming the presence of induced stress. These findings suggest that workstation design can significantly impact cognitive functioning and human capabilities at work. Therefore, the use of functional neuroimaging in workplace design can provide critical information on the causes of workplace-related stress.

- **Keywords:** EEG; Ergonomic; fNIRS; Oxygenated hemoglobin; Prefrontal cortex

B. Hu, S. Li, Y. Chen, R. Kavi, S. Coppola. *Applying deep neural networks and inertial measurement unit in recognizing irregular walking differences in the real world*. 103414.

Falling injuries pose serious health risks to people of all ages, and knowing the extent of exposure to irregular surfaces will increase the ability to measure fall risk. Current gait analysis methods require overly complicated instrumentation and have not been tested for external factors such as walking surfaces that are encountered in the real-world, thus the results are difficult to extrapolate to real-world situations. Artificial intelligence approaches (in particular deep learning networks of varied architectures) to analyze data collected from wearable sensors were used to identify irregular surface exposure in a real-world setting. Thirty young adults wore six Inertial Measurement Unit (IMU) sensors placed on their body (right wrist, trunks at the L5/S1 level, left and right thigh, left and right shank) while walking over eight different surfaces commonly encountered in the living community as well as occupational settings. Three variations of deep learning

models were trained to solve this walking surface recognition problem: 1) convolution neural network (CNN); 2) long short term memory (LSTM) network and 3) LSTM structure with an extra global pooling layer (Global-LSTM) which learns the coordination between different data streams (e.g. different channels of the same sensor as well as different sensors). Results indicated that all three deep learning models can recognize walking surfaces with above 0.90 accuracy, with the Global-LSTM yielding the best performance at 0.92 accuracy. In terms of individual sensors, the right thigh based Global-LSTM model reported the highest accuracy (0.90 accuracy). Results from this study provide further evidence that deep learning and wearable sensors can be utilized to recognize irregular walking surfaces induced motion alteration and applied to prevent falling injuries.

- **Keywords:** Uneven surface; Gait; Convolutional neural network; Inertial measurement units; Artificial intelligence

Marie-Lys F.A. Deschamps, Penelope Sanderson. *Nurses' use of auditory alarms and alerts in high dependency units: A field study.* 103475.

A fieldwork study conducted in six units of a major metropolitan Australian hospital revealed that nurses' attitudes towards alarms are influenced by each unit's physical layout and caseload. Additionally, nurses relied heavily on both non-actionable and actionable alarms to maintain their awareness of the status of their patients' wellbeing, and used auditory alarms beyond the scope of their intended design. Results suggest that before reducing or removing auditory alarms from the clinical environment to improve patient safety, it is important to understand how nurses in different clinical contexts use current alarm systems to extract meaningful information. Such an understanding could guide appropriate alarm reduction strategies and guide alternative design solutions to support nurses' situation awareness during monitoring.

- **Keywords:** Auditory alarms; Healthcare; Situation awareness

Liv De Raeymaekers, Nanna Martens Illemann, Tine Juul Als, Martin Glud Skjødt, Marie Steen Tvergaard, Lotte N.S. Andreasen Struijk. *Preliminary examination of the potential of robot-assisted sonography - An ergonomic tool for obstetric sonographers.* 103479.

The aim of this study was to explore the ergonomic challenges, the needs and reservations related to robot-assisted ultrasound for obstetric sonographers and thereby to provide information for the design of robotic solutions. A mixed-method design was used, where data from the obstetric sonographers and their immediate managers from 18 out of a Danish total of 20 obstetric departments was collected. The data was collected through a survey and interviews. 98.1% of the obstetric sonographers experienced ache, pain or discomfort related to scans. The most frequent cause for the sonographers' ergonomic challenges were the patients' physique (93,52%) and the need to obtain good image quality (83,33%). These reasons are non-controllable parameters for the obstetric sonographers and requires a solution, which ergonomically supports the sonographers in these situations. All of the interviewed obstetric sonographers (n = 8) and immediate managers (n = 3) claimed they were interested in testing a solution based on robot-assisted ultrasound.

- **Keywords:** Ultrasonography; Robotic; Ergonomic

Deborah Fels, Alethea Blackler, Kristina Niedderer. *Does bouncy equal happy? Comparing user's interpretations of emotions conveyed by one designed moving object based on the soma-semiotic Framework.* 103463.

When designing objects, designers attempt to communicate the purpose and meaning of that object to users using various factors such as visual appearance (aesthetic), practical interaction elements (product semantics) and meanings beyond the practical product interaction (semiotics). This study sought to confirm the previous deductively-developed soma-semiotic framework, whose purpose was to understand and ultimately predict the emotional impact of different design elements on users, using one specifically designed object, Fruit Bowl (FB). The purpose of the study reported in this paper was to compare the theoretically derived emotional responses to FB from the soma-semiotic framework with empirically derived data from users in order to improve the framework. Sixty participants evaluated the meaning and emotion conveyed by FB as well as self-reported their own experienced emotions under two scenarios. The framework predicted that FB would convey joy in a first scenario, and amusement in a second scenario based on different movements. Using a weighted vector analysis based on Russell's two-dimensional Circumplex of emotions, users identified that the overall emotion of the first scenario to be similar to the predicted emotion. This was attributed mostly to the bouncy movement of the bowl and its visual aesthetic. However, in the second scenario the overall rating was calm/impressed; rather than humour. The abstract design did not favour users making the same associations as the designer. We recommend that the soma-semiotic framework be revised to include aesthetic, in addition to semiotic and semantic, elements as determinants of user interpretations and reactions to designed objects.

- **Keywords:** Design and emotion; Artefact meaning; Design with movement; Soma semiotics

Nicole E. Werner, Rachel A. Rutkowski, Sheryl Krause, Hanna J. Barton, Kathryn Wust, Peter Hoonakker, Barbara King, Manish N. Shah, Michael S. Pulia, Maria Brenny-Fitzpatrick, Maureen Smith, Pascale Carayon. *Disparate perspectives: Exploring healthcare professionals' misaligned mental models of older adults' transitions of care between the emergency department and skilled nursing facility.* 103509.

Care transitions that occur across healthcare system boundaries represent a unique challenge for maintaining high quality care and patient safety, as these systems are typically not aligned to perform the care transition process. We explored healthcare professionals' mental models of older adults' transitions between the emergency department (ED) and skilled nursing facility (SNF). We conducted a thematic analysis of interviews with ED and SNF healthcare professionals and identified three themes: 1) ED and SNF healthcare professionals had misaligned mental models regarding communication processes and tools used during care transitions, 2) ED and SNF healthcare professionals had misaligned mental models regarding healthcare system capability, and 3) Misalignments led to individual and organizational consequences. Overall, we found that SNF and ED healthcare professionals are part of the same process but have different perceptions of the process. Future work must take steps to redesign and realign these distinct work systems such that those involved conceptualize themselves as part of a joint process.

- **Keywords:** Macroergonomics; Care transitions; Older adults; Mental models; Emergency department; Skilled nursing facility

Michelle R. Cardoso, Andrew K. Cardenas, Wayne J. Albert. *A biomechanical analysis of active vs static office chair designs.* 103481.

The objective of this study was to provide a biomechanical comparison of two different types of active chairs (AC1 & AC2) versus a static chair (NAC). Thirty healthy participants were recruited: fifteen healthy females and fifteen healthy males. Participants worked at

a computer workstation (1-h per chair). Equipment included: Pressure pads, Electromyography, Near-Infrared Spectroscopy, and Questionnaires (rate of perceived discomfort, seating discomfort questionnaire and exit survey). A significant increase in anterior-posterior postural sway was found on the seat pan with the use of the AC1. An increase in neuromuscular activity of the external obliques and an increase change in total oxygen index (%TOI) values in the gastrocnemius were also found using the AC1, however the difference was not much higher than the NAC and AC2. Lower discomfort scores in the gluteal area were found with the use of active chair AC1 compared to the NAC. Preliminary findings suggest that having an office chair with a split seat pan design shows potential to yield biomechanical and physiological benefits for the sitter, however further research is needed to better understand the ergonomic benefits of active sitting.

- **Keywords:** Active chairs; Chair design; Office ergonomics

Stephven Kolose, Tom Stewart, Patria Hume, Grant R. Tomkinson. *Cluster size prediction for military clothing using 3D body scan data.* 103487.

Aim: To determine how anthropometric characteristics cluster in the New Zealand Defence Force, and to describe the characteristics of each cluster. This information can inform the development of new uniform sizing systems for the New Zealand Defence Force. **Methods:** Anthropometric data (n = 84 variables) from 1,003 participants (212 females; 791 males) in the New Zealand Defence Force Anthropometry Survey (NZDFAS) were used. The dataset was stratified by gender and variables isolated based on their relevance to shirt and trouser sizing. Principal Component Analysis was used to identify the most important variables for clustering. A combination of two-step and k-means clustering was used to derive cluster characteristics. **Results:** The PCA identified optimal clothing (shirt = body height and waist girth; and trouser = inseam length and hip girth for females; inseam length and waist girth for males) variables. Two-step and k-means clustering identified optimal cluster numbers of 6 and 10 for female and male clothing, respectively. The female clothing clusters were more variable (intra-cluster) and further apart (inter-cluster) compared to males. **Conclusions:** Anthropometric measurements in combination with clustering techniques show promise for partitioning individuals into distinct groups. The anthropometry dimensions associated with each cluster can be used by the garment industry to develop specific sizing systems for the New Zealand Defence Force population.

- **Keywords:** Anthropometry; PCA; Cluster analysis; Clothing size; New Zealand Defence force

Jingyue Zheng, Tingru Zhang, Liang Ma, Yulun Wu, Wei Zhang. *Vibration warning design for reaction time reduction under the environment of intelligent connected vehicles.* 103490.

Scenario-based warnings for road safety can be provided in the environment of intelligent connected vehicles via Bluetooth earphones or smart wristbands; designing an optimal means of presentation to drivers is an important point of consideration. Vibration warnings have been widely studied owing to their unique benefits. This experimental study aims to identify suitable body parts for vibration warnings during driving. The independent variables were the vibration position (three levels of stimulus, i.e., wrist, shin, and upper jaw) and response effector (two levels, i.e., hand and foot). Experiment Tasks 1 and 2 measured participants' simple reaction time and choice reaction time, respectively, when providing vibration warnings in non-driving situations. The results demonstrate that the vibration on the upper jaw has the shortest simple reaction time and choice reaction time. The effect of stimulus-response consistency on choice reaction time was insignificant. Task 3 was similar to Task 2, with the exception of simulated driving. Compared to the result in Task 2, the choice reaction time in Task 3 was

approximately 200 ms longer. Vibration of the upper jaw was reported to have the highest perceived intensity and preference. Based on the study results, the design implications for wearable vibration warnings of collision avoidance systems are presented

- **Keywords:** Vibration warnings; Vibration positions; Response effector; Choice reaction time; Stimulus-response compatibility; Connected vehicles

Elizabeth A. Rapp van Roden, Juff George, Laurene T. Milan, Robert T. Bove. *Evaluation of injury patterns and accident modality in step ladder-related injuries.* 103492.

Step ladders are commonly found in homes and are used for a variety of tasks. While ladders are often associated with fall-related injuries, other accident modes that do not result in a fall can be observed in real-world data. In this study, the available data from the National Electronic Injury Surveillance System database involving step ladder-related injuries was supplemented by a biomechanical consideration of kinematics and injury mechanism to further understand accident modes and injury patterns. Results of this study demonstrated that the most common accident mode was falling (91%), followed by non-fall errors in execution of intended kinematics (non-fall execution errors) (4%) and pinching (1%). Falls were commonly associated with fractures, non-fall execution errors were commonly associated with a strain or sprain, while pinches were commonly associated with lacerations. The results of this study show that during step ladder use in a non-occupational setting, the accident mode is associated with an injury pattern.

- **Keywords:** Ladder; Injury; Epidemiology; Portable ladders

Natacha Métayer, Stéphanie Coeugnet. *Improving the experience in the pedestrian's interaction with an autonomous vehicle: An ergonomic comparison of external HMI.* 103478.

The number of studies on autonomous vehicles has increased over recent years. Many of these studies have indicated the importance of an external Human-Machine Interface of communication (eHMI) on autonomous vehicles to indicate their intentions to other road users. Using an experimental design, we compared three eHMIs coupled to three road infrastructures to observe pedestrians' crossing behavior and collect their feelings about different vehicle types. Our results showed that the eHMIs influence the pedestrians' decision to cross the street, confirming the importance of setting up eHMIs. The proportion of pedestrians who crossed in front of the autonomous vehicles was more significant for vehicles equipped with an eHMI than vehicles without an eHMI. In 10% of cases, pedestrians used circumvention strategies rather than crossing in front of a vehicle without an eHMI. This behavior was more often observed when there was no protected infrastructure. Finally, while our objective data failed to indicate whether a specific eHMI is better accepted than another, the subjective data on the participants' preferences provided some promising ideas for further studies and the eHMI final implementation.

- **Keywords:** Autonomous vehicle; Pedestrian; Communication system; Road infrastructure; Crossing behavior

Yong Min Kim, Ilsun Rhiu. *A comparative study of navigation interfaces in virtual reality environments: A mixed-method approach.* 103482.

Recently, motion-based navigation interfaces have been widely utilized in virtual reality (VR) environments. However, improper navigation interfaces can negatively impact the VR experience, and because different interfaces have different characteristics, the navigation experience may vary. Although comparative studies have been conducted with

various interfaces, information obtained by focusing on qualitative evaluation was limited. Thus, this study explores the effects from three navigation interfaces (walking-in-place (WIP), joystick, and teleportation) on user performance, sense of presence, workload, usability, and motion sickness through a mixed-method design. Twenty-one participants were asked to perform a navigation task using selected navigation interfaces. The results indicated different advantages and disadvantages in the navigation interfaces for each evaluation metric. In particular, it was found that more research on user safety is required for the WIP interface. The findings of this study are expected to contribute to the development of guidelines for applying navigation interfaces to specific VR environments.

- **Keywords:** Virtual reality; Navigation interface; User experience; Usability; Mixed-method analysis

Yusheng Yang, Hongpeng Zhou, Yu Song, Peter Vink. *Identify dominant dimensions of 3D hand shapes using statistical shape model and deep neural network.* 103462.

Hand anthropometry is one of the fundamentals of ergonomic research and product design. Many studies have been conducted to analyze the hand dimensions among different populations, however, the definitions and the numbers of those dimensions were usually selected based on the experience of the researchers and the available equipment. Few studies explored the importance of each hand dimension regarding the 3D shape of the hand. In this paper, we aim to identify the dominant dimensions that influence the hand shape variability while considering the stability of the measurements in practice. A novel four-step research method was proposed where in the first step, based on literature study, we defined 58 landmarks and 53 dimensions for the exploration. In the second step, 80,000 virtual hand models, each had the associated 53 dimensions, were augmented by changing the weights of Principle Components (PCs) of a statistical shape model (SSM). Deep neural networks (DNNs) were used to establish the inverse relationships from the dimensions to the weight of each PC of the hand SSM. Using the structured sparsity learning method, we identified 21 dominant dimensions that represent 90% of the variance of the hand shape. In the third step, two different manual measuring methods were used to evaluate the stability of the measurements in practice. Finally, we selected 16 dominant dimensions with lower measurement variance by synthesizing the findings in Step 2 and 3. It was concluded that the recognized 21 dominant dimensions can be treated as the reference dimensions for anthropometric study and using the selected 16 dominant dimensions with lower measurement variance, ergonomists are able to generate a 3D hand model based on simple measurement tools with an accuracy of 5.9 mm. Though the accuracy is limited, the efforts are minimum, and the results can be used as an indicator in the early stage of research/design.

- **Keywords:** Dominant hand dimensions; Measurement stability; Structured sparsity learning

P. Haraldsson, K. Areskoug-Josefsson, B. Rolander, E. Strengbom, D. Jonker. *Comparing the Structured Multidisciplinary work Evaluation Tool (SMET) questionnaire with technical measurements of physical workload in certified nursing assistants in a medical ward setting.* 103493.

The Certified Nursing Assistant (CNA) is an important part of the workforce in hospitals and nursing homes, whose work includes heavy and repetitive work tasks including patient manual handling. The Structured Multidisciplinary work Evaluation Tool (SMET) questionnaire is an Occupational Health Service method for evaluation of the work environment. The aim of this study is to compare the SMET questionnaire with technical measurements of physical workload in CNAs in a medical ward setting. 16 CNA's

participated voluntarily to 8 h of measurements during one workday. Physical workload was measured with surface electromyography and inclinometers, and the work environment was evaluated with the SMET questionnaire during the same working day. Spearman's rho was used in the statistical correlation analysis between measurements. This study shows strong, statistically significant correlations between the items in the SMET questionnaire and measured physical workload, n CNAs.

- **Keywords:** Questionnaire; Psychometrics; Measured physical workload

Sharmila Sreetharan, Joseph J. Schlesinger, Michael Schutz. *Decaying amplitude envelopes reduce alarm annoyance: Exploring new approaches to improving auditory interfaces.* 103432.

Auditory alarms offer great potential for facilitating human-computer interactions in complex, rapidly changing environments. They are particularly useful in medical settings, where in theory they should afford communication in emergency rooms, operating theatres, and hospitals around the world. Unfortunately, the sounds typically used in these devices are problematic, and researchers have documented numerous shortcomings. Their ubiquity means that even incremental improvements can have significant benefits for patient care. However, solutions have proven challenging for multiple reasons—including issues of backward compatibility inherent in changing any standard. Here we present a series of three experiments showing that manipulations to one specific, understudied property can significantly lower alarm annoyance without harming learning or memory—while preserving an alarm's melodic and rhythmic structure. These results suggest promising new directions for improving the hospital's soundscape, where evidence of problems related to sound are increasingly recognized as affecting medical outcomes as well as physician well-being.

- **Keywords:** Human-computer interface design; Alarm annoyance; Amplitude envelope; Modifiable risk factors

Yoshitaka Maeda, Kosuke Oiwa, Shiro Matsumoto, Akio Nozawa, Hiroshi Kawahira. *Years of experience is more effective in defining experts in the gaze analysis of laparoscopic suturing task than task duration.* 103474.

In this study, the relationship between gaze patterns, task duration, and years of experience, which are commonly used to define and evaluate expert surgeons in laparoscopic surgery, was identified. Ten surgeons with 1–28 years of experience and six inexperienced students were included. Subjects used forceps to repeat the task of suturing a suture pad. Each subject wore an eye-marking recorder, and gaze points were recorded and analyzed. No significant relationship between task duration and gaze pattern was observed. However, there was a significant relationship between a surgeon's years of experience and the percentage of time spent gazing at the forceps. Subjects with more years of experience operated without looking at the forceps and fixed their gaze on the operational target. Therefore, when analyzing laparoscopic gazing patterns, it may be more appropriate to define an “expert” based on the years of experience rather than task duration.

- **Keywords:** Laparoscopic surgery; Gaze patterns; Definition of expert

Donghyun Song, Eunjee Kim, Haerim Bak, Gwanseob Shin. *Effect of hand loads on upper extremity muscle activity during pushing and pulling motions.* 103504.

Manual pushing or pulling with a hand tool is a coordinated action by various upper extremity muscles. The objective of this experimental study was to examine the effects of horizontal and vertical hand loads on upper extremity muscle activity during concentric pushing and pulling exertions. Twenty young female participants conducted repetitive pushing and pulling trials with three horizontal loads (1 kg, 2 kg, 3 kg) and two vertical loads (0.6 kg, 1.3 kg) in a seated posture, while the myoelectric activity of seven upper extremity and shoulder muscles were quantified. Study results indicate that the shoulder flexor and extensor muscles were more strongly associated with horizontal load, and elbow flexors were more sensitive to vertical load. The empirical data from this systematic evaluation can offer initial insights for ergonomic design and evaluation of hand tools or occupational tasks that involve repetitive pushing or pulling.

- **Keywords:** Electromyography; Muscular load; Push and pull; Upper extremity muscles

Steven R. Clapp, Pamela R. McCauley, Waldemar Karwowski, P.A. Hancock. *The seat of happiness? The effect of seat comfort on the achievement of psychological flow during transactional work.* 103508.

Psychological flow is highly pleasurable, time-limited form of engagement in a task which has been shown to produce benefits in the workplace. Flow has historically been studied in the context of the interaction between the task and the performer. However, in work settings such as an office, many other factors may contribute to or hinder the achievement of flow. This present study broadens the research on flow to test the extent to which seating comfort while executing a challenging task influences an individual's ability to achieve flow. Fifty-four participants in this study were randomly assigned to one of two seat types and given a set of tasks to perform via a computer simulation. Seat comfort, coupled with participants' perceptions of their ability to concentrate on the simulation's set of tasks, was found to predict participants' flow experiences. Implications and future directions are discussed.

- **Keywords:** Psychological flow; Comfort; Concentration; Causal analysis; Scale comparison

Kiran Maini Gerhardsson, Thorbjörn Laike. *User acceptance of a personalised home lighting system based on wearable technology.* 103480.

Light/dark cycles play an essential role in people's performance, mood and daily rhythm. This study aimed to evaluate an early prototype of a personalised home lighting system including body-worn loggers. A convenience sample (N = 28) wore the devices for 23 h in the field and were given a demonstration of the lighting system components. Participants reported on questionnaires their acceptance of the lighting system and experience of physical comfort and visual appearance of the body-worn loggers. Semi-structured interviews were also held. In a hierarchical linear regression, physical comfort of the loggers explained 35.8% of the variance of 'the behavioural intention to use the system in the future', and 'performance expectancy' explained 50.6%. The interview data helped understand the reasons for the physical and psychological discomfort of wearing the devices. Many participants reported they were not comfortable about using a mobile phone for presence detection in the home.

- **Keywords:** Residential lighting technology; User acceptance; Wearable comfort; Mixed methods

Maria Vukovic, Lawrence Cavedon, John Thangarajah, Sebastian Rodriguez. *Performance degrades less under increased workload with the addition of speech control in a dynamic environment.* 103486.

This research empirically evaluates the introduction of speech to existing keyboard and mouse input modalities in an application used to control aircraft in a simulated, complex and dynamic environment. Task performance and task performance degradation are assessed for three levels of workload. Previous studies have evaluated task performance using these modalities however, only a couple have evaluated task performance under varying workload. Even though speech is a common addition to modern control interfaces, the effect of varying workload on this combination of control modalities has not yet been reported. Thirty-six participants commanded simulated aircraft through generated obstacle courses to reach a Combat Air Patrol (CAP) point while also responding to a secondary task. There were nine conditions that varied the control modality (Keyboard and Mouse (KM), Voice (V), and Keyboard, Mouse and Voice (KMV)), and workload by varying the number of aircraft being controlled (low, medium and high). Results showed that KM outperformed KMV and V for the low and medium workload levels. However, task performance with KMV was found to degrade the least as workload increased. KMV and KM were found to enable significantly more correct responses to the secondary task which was delivered aurally. Participants reported a preference for the combined modalities (KMV), self-assessing that KMV most reduced their workload. This research suggests that the addition of a speech interface to existing keyboard and mouse modalities, for control of aircraft in a simulation, may help manage cognitive load and may assist in controlling more aircraft under higher workloads.

- **Keywords:** Speech input; Keyboard; Mouse; Control modality; Varied workload conditions; Simulated aircraft control

J. Savin, C. Gaudez, M.A. Gilles, V. Padois, P. Bidaud. *Evidence of movement variability patterns during a repetitive pointing task until exhaustion.* 103464.

Human movement is characterized by its variability: the same task is never performed twice in exactly the same way. This variability is believed to play a functional role in movement performance and adaptability, as well as in preventing musculoskeletal damage. This article focuses on the time-evolution of movement variability throughout a repetitive pointing task until exhaustion. The kinematics of 13 subjects performing the pointing task is analyzed. Principal Component Analysis of joint angles identifies joint coordinations for each pointing cycle, and cycle-by-cycle comparison highlights movement variability. Non-supervised clustering reveals that subjects adopt successive coordination patterns at an intra-individual level. Inter-individual variability is characterized by the number and type of such patterns: from 3 to 5 patterns, mobilizing the trunk, the shoulder and the upper limbs differently. Movement variability exists even in a seemingly basic and constrained task. It appears in the very early stages of fatigue onset, and may correspond to adaptive coordination responses throughout task performance. This observation should encourage workstation designers to better account for movement variability in order to preserve operators' health and safety.

- **Keywords:** Movement variability; Muscle fatigue; Repetitive pointing task; Ergonomic assessment; Principal components analysis; Hierarchical ascending classification

Missie Smith, Joseph L. Gabbard, Gary Burnett, Chrisminder Hare, Harpreet Singh, Lee Skrypchuk. *Determining the impact of augmented reality graphic spatial location and motion on driver behaviors.* 103510.

While researchers have explored benefits of adding augmented reality graphics to vehicle displays, the impact of graphic characteristics have not been well researched. In this paper, we consider the impact of augmented reality graphic spatial location and motion, as well as turn direction, traffic presence, and gender, on participant driving and glance behavior and preferences. Twenty-two participants navigated through a simulated environment while using four different graphics. We employed a novel glance allocation analysis to differentiate information likely gathered with each glance with more granularity. Fixed graphics generally resulted in less visual attention and more time scanning for hazards than animated graphics. Finally, the screen-fixed graphic was preferred by participants over all world-relative graphics, suggesting that graphic spatially integration into the world may not always be necessary in visually complex urban environments like those considered in this study.

- **Keywords:** Augmented reality; Driving; Eye tracking; Graphics

J. Cort, L. Eaton, M. Smets, A. Stephens, G. Malone, R. Porto. *A comparison of the physical demands associated with various right-angle direct-current power tools.* 103488.

This work examined the physical demands associated with 4 commercially available direct current right-angle power tools along with their computer controlled fastening strategies. Physical demands were measured via an external instrumented handle that could also control the trigger of each tool. Data revealed that forces recorded by the external handle for each of the 4 tools differed. Independent of Joint-Hardness and Target Torque the Atlas Copco TurboTight® and Cleco Low Torque Reaction fastening strategies, both using a rapid spindle-head rotation strategy, produced the lowest peak and impulse force, respectively, when compared to the 2 tools that were designed to fasten with a longer duration. This work has shown that short duration fastening strategies provide an ergonomics benefit to the users as it requires less force to operate, such force reduction in previous research has been linked to reduced handle displacement and lower muscle effort.

- **Keywords:** Right-angle power tool; Manufacturing ergonomics; Physical demands; Power tool comparison

Yibo Zhu, Eric B. Weston, Ranjana K. Mehta, William S. Marras. *Neural and biomechanical tradeoffs associated with human-exoskeleton interactions.* 103494.

Industrial passive low-back exoskeletons have gained recent attention as ergonomic interventions to manual handling tasks. This research utilized a two-armed experimental approach (single vs dual-task paradigms) to quantify neural and biomechanical tradeoffs associated with short-term human-exoskeleton interaction (HEI) during asymmetrical lifting in twelve healthy adults balanced by gender. A dynamic, electromyography-assisted spine model was employed that indicated statistical, but marginal, biomechanical benefits of the tested exoskeleton, which diminished with the introduction of the cognitive dual-task. Using Near Infrared Spectroscopy (fNIRS)-based brain connectivity analyses, we found that the tested exoskeleton imposed greater neurocognitive and motor adaptation efforts by engaging action monitoring and error processing brain networks. Collectively, these findings indicate that a wearer's biomechanical response to increased cognitive demands in the workplace may offset the mechanical advantages of exoskeletons. We also demonstrate the utility of ambulatory fNIRS to capture the neural cost of HEI without the need for elaborate dual-task manipulations.

- **Keywords:** Spinal load; Brain activity; Human-robot interaction; Neuroergonomics; Manual handling