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Ergonomics in a rapidly changing world

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Editorial

Sara Albolino, Elena Beleffi & Andrew Thatcher. *Ergonomics in a rapidly changing world*.

Jodi Oakman, Sue Hignett, Matthew Davis, Gemma Read, Michelle Aslanides, Bouhafs Mebarki & Stephen Legg. *Tertiary education in ergonomics and human factors: quo vadis?* Pages: 243-252.

In 2019, the Human Factors and Ergonomics (HFE) discipline turned 70; to celebrate, an international group of academics and educators have reflected on the status of HFE tertiary education across the globe. This paper draws on presentations and discussions from the 20th Triennial International Ergonomics Association (IEA) conference and considers the implications for HFE education programmes. Past, current, and future challenges are outlined and discussed with examples from different countries and programmes. This paper builds on 2012 strategy proposed by Dul and colleagues, to strengthen the demand, and application, of the HFE discipline and profession. It provides a considered set of reflections, noting the range of structural issues and financial pressures within the tertiary education system that create challenges for the viability of specialist programmes such as HFE. A need exists for the broader profession to collaborate and share innovations in HFE programme development, to ensure sustainable HFE education programmes. **Practitioner summary:** A range of structural issues and financial pressures exist within the tertiary education system that creates challenges for the viability of specialist programmes such as HFE. A need exists for the broader profession to collaborate and share innovations in HFE programme development, to ensure sustainable HFE education programmes.

- **Keywords:** Education, human factors, ergonomics, future of ergonomics

Cheryl Haslam, Aadil Kazi & Myanna Duncan. *Process evaluation of a tailored workplace intervention designed to promote sustainable working in a rapidly changing world*. Pages: 253-262.

Increasing numbers of people are employed in sedentary occupations, spending large amounts of time sitting at work which is detrimental to health and wellbeing. Evidence-based guidance is required to intervene to reduce sedentary behaviour, encourage physical activity and promote sustainable working. This article presents a process evaluation of a successful workplace intervention Walking Works Wonders, shown to be effective in improving health, job satisfaction and motivation (Haslam et al. 2018). In this qualitative process evaluation employees reported an increased awareness of their sedentary time and they particularly valued the monitoring of activity using pedometers. They described changes to their working and leisure time activity to accumulate more steps. Participants reported improved physiological and psychological health outcomes, improved working relations with colleagues, changes in dietary behaviour and involving their families in physical activity. The results highlight elements of the intervention that encouraged healthy and more sustainable working practices.Practitioner summary: This study provides the employees' perspective on the effective elements of a workplace intervention which encouraged physical activity and reduced sitting time. The results offer valuable insights for practitioners aiming to develop interventions to improve health and facilitate more sustainable working practices in a rapidly changing world of work.

- **Keywords:** Process evaluation, workplace intervention, physical activity, sedentary behaviour

Sofia Marchi, Niccolò Targi, Paul M. Liston & Oronzo Parlangeli. *The possible role of empathy and emotions in virtual negotiation*. Pages: 263-273.

The goal of the present study is to explore the role of empathic and emotional skills in virtual negotiation, and to try to verify their possible role in different contexts: monetary/non-monetary, in circumstances in which a counterparty is familiar or unknown, and with respect to polite or rude responses from the negotiating counterparty. To this end, 320 participants aged between 19 to 25 years old were involved in a simulated virtual negotiation. Participants were required to fill in a Basic Empathy Scale (BES) questionnaire, they were also asked to report the prevalent emotion they had felt during the interaction, and if they thought they were interacting with a real person. The results of this research confirm the tendency of participants to minimise losses. Although the capacity for empathy does not seem to have a role, the behaviour of participants appears more cooperative when they have to deal with a familiar negotiation counterparty. Emotions appear to play a positive role when negotiating with, what is perceived to be, a real person. **Practitioner summary:** We conducted this study as part of a Master's Degree programme which was specifically focussed on human-computer interaction. Results show that negotiation was affected by emotions experienced during the experiment, and by the perception of the negotiating counterparty as a familiar person more so than by empathy.

- **Keywords:** Negotiation, emotions, empathy, simulation, virtual environment

Michael Waechter, Danny Rueffert & Angelika C. Bullinger. *Get a grip: multi-method evaluation of handles for tablets on the shop floor*. Pages: 274-282.

Tablets on the shop floor need handles because user requirements for handling differ from tablet usage in leisure time. The ergonomics of such handles is under-researched, resulting in a lack of methods for their design and evaluation. In this paper, we present a multi-method evaluation of handles for a shop floor tablet. We combine and compare results of focus groups and the Comfort Questionnaire for Hand tools (CQH) with electromyography (EMG). With a field and a laboratory study, we evaluate four handles in order to identify (i) the most ergonomically rated handle and (ii) the most efficient evaluation method. Results consist of an evaluated prototype, and data that shows the comparability of results from focus groups and questionnaires to results from EMG measurements. Classifying handles as tangible human machine interfaces, we suggest that subjective evaluation with focus groups and CQH is efficient to evaluate their ergonomic quality. **Practitioner summary:** A handle for a tablet used in production environment is evaluated with different methods. Results show that data from focus groups and questionnaires can be used for evaluation of usability in the future, rendering complex EMG measurements unnecessary and making usability evaluation more efficient.

- **Keywords:** User-centred design, tangible human-machine-interface, electromyography, handle design

Xavier Robert-Lachaine, Christian Larue, Denys Denis, Alain Delisle, Hakim Mecheri, Philippe Corbeil & André Plamondon. *Feasibility of quantifying the physical exposure of materials handlers in the workplace with magnetic and inertial measurement units*. Pages: 283-292.

Handling tasks can expose workers to risk factors. The objective was to describe the feasibility of using magnetic and inertial measurement units (MIMUs) to quantify the physical exposure of materials handlers in the workplace. Full-body kinematics were obtained with MIMUs on 10 handlers gathering products ordered by retailers with a pallet truck. An observer classified the visual difference (VD) of segment orientation between a MIMUs avatar and video recordings in three categories (none, minor and major) for each product transfer. The feet, arms, shoulders and head were considered similar for ≥97% of observations. The trunk segment obtained the most differences with 9% of minor VD and 5% of major VD, which were related to the duration of the magnetic disturbances of the MIMUs. Estimating parameters of the physical exposure of handlers in the workplace is feasible with kinematics and an order list, but visual verification remains important for scientific rigour. **Practitioner Summary:** The feasibility of measuring physical exposure with magnetic and inertial measurement units was evaluated on materials handlers in the workplace. Visual observation of the postures indicated that most of the data is considered acceptable. Magnetic disturbances can increase the measurement error, so data must be verified to ensure validity.

- **Keywords:** Inertial measurement units, MIMU, physical exposure, manual materials handling, lifting

Leyde Briceno, Simone Lee Harrison, Clare Heal, Michael Kimlin & Gunther Paul. *Parametric human modelling to determine body surface area covered by sun-protective clothing*. Pages: 293-306.

Solar ultraviolet radiation (UVR) is the main environmental risk-factor for cancer of the skin. Sun-protective clothing provides a physical barrier that reduces the UVR dose reaching the skin and European and Australian standards for sun-protective clothing set minimum clothing coverage requirements. Body Surface Area Coverage by clothing (BSAC) is calculated by means of indirect or direct methods, which are laborious and do not support computer-based apparel design. To support the sun-safe specification and design of garments, parametric digital human models and protective clothing mesh covering the minimum Body Surface Area specified in AS/NZS 4399:2017, were created

making use of MakeHuman v1.1.1 and Blender software. The Whole Body Surface Area (WBSA) and the BSAC were calculated employing code developed in Blender. Thus, different groups of subjects were analysed to explore BSAC. The method assists in the evaluation of exposed body areas in a wider spectrum of different occupations. **Practitioner summary:** Sun-protective clothing provides a physical barrier that reduces the UVR dose reaching the skin's surface. Body Surface Area Coverage (BSAC) by clothing is an important determinant of the sun protective capabilities of a garment. In this study, BSAC is calculated using parametric digital human modelling.

- **Keywords:** Digital human modelling, body surface area coverage by clothing, whole body surface area, skin cancer, MakeHuman

Neville A. Stanton & Aaron P. J. Roberts. *Better together? Investigating new control room configurations and reduced crew size in submarine command and control*. Pages: 307-323.

The separation of the sound and control rooms in Royal Navy submarines seems to be artefactually reducing the effectiveness of information transition and the overall productivity of the team. A proposed integrated sound and control room was tested in three scenarios: Return to Periscope Depth (RTPD), Inshore Operations (INSO) and Dived Tracking (DT). The activities and communications of a team of serving submariners were recorded in a control room, in a single case study design, comparing co-location and reduced crewing with a baseline of the separate sound and control room configurations that is representative of current submarines. The Event Analysis of Systemic Teamwork (EAST) method was used to examine changes in social, information and task networks. In general terms, the co-location of the submariner team led to more efficient communication and completion of tasks. Reducing the crew was more challenging in the higher demand scenarios. **Practitioner Summary:** There are constraints acting on control rooms, both in terms of physical space and crew size. This study compared conventional control room with co-location and reduced crew in turn. Teamwork improved in the collocated control room but the reduced crew struggled most under conditions of high demand.

- **Keywords:** Submarine, control room, teamwork, communications, networks

Antonio Lanzotti, Amalia Vanacore, Andrea Tarallo, Dan Nathan-Roberts, Domenico Coccorese, Valerio Minopoli, Francesco Carbone, Raffaele d'Angelo, Corrado Grasso, Giuseppe Di Gironimo & Stefano Papa. *Interactive tools for safety 4.0: virtual ergonomics and serious games in real working contexts*. Pages: 324-333.

This paper presents an innovative safety training method based on digital ergonomics simulations and serious games, which are games that focus on education. Digital ergonomics is intended to disseminate the culture of safety among workers, while serious games are used to train the operators on specific safety procedures and verify their skills. The results of the experimentation in a real industrial environment showed that, compared to the traditional training methodology, multimedia contents and quantitative ergonomic analyses improve the level of attention and the awareness of the workers about their own safety. However, serious games turned out to be promising training tools with regard to standard operating procedures that are usually difficult or dangerous to simulate in a real working scenario without stopping production. **Practitioner summary:** Digital ergonomics and serious games are used to disseminate the culture of safety among the workers and for safety training. Our results show that the proposed methodology improves the level of attention and provides a better feedback about the actual skills of the workers than the standard educational strategies.

- **Keywords:** Digital humans, serious games, training methods, occupational safety

Steven C. Mallam, Salman Nazir & Amit Sharma. *The human element in future Maritime Operations – perceived impact of autonomous shipping*. Pages: 334-345.

The role of the human element within complex socio-technical systems is continually being transformed and redefined by technological advancement. Autonomous operations across varying transport domains are in differing stages of realisation and practical implementation, and specifically within maritime operations, is still in its infancy. This study explores the potential effects of autonomous technologies on future work organisation and roles of humans within maritime operations. Ten Subject-Matter Experts working within industry and academia were interviewed to elicit their perspectives on the current state and future implications of autonomous technologies. Four main themes emerged: (i) Trust, (ii) Awareness and Understanding, (iii) Control, (iv) Training and Organisation of Work. A fuzzier fifth theme also appeared in the data analysis: (v) Practical Implementation Considerations, which encompassed various sub-topics related to real-world implementation of autonomous ships. The results provide a framework of human element issues relevant for the organisation and implementation of autonomous maritime operations. **Practitioner summary:** As autonomous shipping rapidly moves closer to real-world implementation, it is critical to develop an understanding of future roles of humans in autonomous maritime operations. By eliciting expert knowledge from academics and practitioners, we establish a framework of relevant issues facing humans in emerging autonomous systems and operations at sea.

- **Keywords:** Autonomous systems, digitisation, work organisation, transport, training

Irem Sarbat & Seren Ozmehmet Tasan. *A structural framework for sustainable processes in ergonomics*. Pages: 346-366.

Considering today's globalised world, new concepts that assist ergonomics are needed to provide human well-being. Accordingly, the sustainability concept is used in this study to satisfy the needs of stakeholders, put environmentally-friendly and cost-effective interventions into practice and provide ergonomically well-designed and easily managed processes that are more flexible, adaptable and human-sensitive. To achieve this, a practical and easily adaptable framework, which integrates ergonomics and sustainability by presenting the relations between fundamental elements of ergonomics and sustainability dimensions (SDs), is proposed. Within this base framework, ergonomic indicators (EIs) and sub-dimensions proposed for the classification of EIs are structured for ergonomics under a sustainability point-of-view. The sub-dimensions proposed in this study, which have direct or indirect relations to humans, are 'Loss', 'Investment', 'Conditions', 'Contribution', 'Self-Development', and 'Satisfaction'. This structural framework, which can be easily used by ergonomists or managers, ensures a good starting point for providing sustainable processes in ergonomics. **Practitioner summary:** This study proposes a structural framework to present the relations between ergonomics and sustainability. In the context of ergonomics, fundamental elements of ergonomics are chosen, while three dimensions of sustainability and proposed sub-dimensions are used in the context of sustainability. The adapted ergonomic indicators are also classified within these sub-dimensions.

- **Keywords:** Sustainability indicators, ergonomic indicators, integration, relation, framework

Andrew Thatcher, Rounaq Nayak & Patrick Waterson. *Human factors and ergonomics systems-based tools for understanding and addressing global problems of the twenty-first century*. Pages: 367-387.

Sustainability is a systems problem with humans as integral elements of the system. However, sustainability problems usually have a broader scope than socio-technical systems and therefore, require additional considerations. This requires a fuller integration of complex systems understanding into the systems analysis toolset currently available to human factors and ergonomics. In this paper, we outline these complex systems requirements necessary to tackle global problems such as sustainability and then assess how three common systems analysis tools (i.e. Accimap, System Theoretic Accident Mapping and Processes, and Cognitive Work Analysis) stand up against these revised criteria. This assessment is then further explored through applying two of these tools (i.e. Accimap and System Theoretic Accident Mapping and Processes) to a transnational food integrity system problem. This case study shows that no single systems analysis method can be used in isolation to help identify key insights for intervention and that new methods may need to be developed or existing methods need to be adapted to understand these dynamic, adaptive systems. The implications for the further development of systems analysis tools are discussed. **Practitioner summary:** We assess the applicability of existing human factors and ergonomics systems-analysis tools for examining global problems and for identifying points to intervene in these systems. We comment on what extensions and further work will be required to enable human factors and ergonomics to intervene effectively.

- **Keywords:** Ergonomics tools and methods, human factors integration, complex systems, environmental change, system performance modelling