

## **Ergonomics– rok 2019, ročník 62**

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**Tony Carden, Natassia Goode & Paul M. Salmon. *Accounting for memes in sociotechnical systems: extending the abstraction hierarchy to consider cognitive objects*. Pages: 849-863.**

Work domain analysis (WDA) is used to model the functional structure of sociotechnical systems (STS) through the abstraction hierarchy (AH). By identifying objects, processes, functions and measures that support system purposes, WDA reveals constraints within the system. Traditionally, the AH describes system elements at the lowest level of abstraction as physical objects. Multiple analyses of complex systems reveal that many include objects that exist only at a conceptual level. This paper argues that, by extending the AH to include cognitive objects, the analytical power of WDA is extended, and novel areas of application are enabled. Three case studies are used to demonstrate the role that cognitive objects play within STS. It is concluded that cognitive objects are a valid construct that offer a significant enhancement of WDA and enable its application to some of the world's most pressing problems. Implications for future applications of WDA and the AH are discussed. **Practitioner summary:** Some sociotechnical systems include memes as part of their functional structure. Three case studies were used to evaluate the utility of introducing cognitive objects alongside physical ones in work domain analysis, the first phase of cognitive work analysis. Including cognitive objects increases the scope and accuracy of work domain analysis.

- **Keywords:** Cognitive object, work domain analysis, abstraction hierarchy, meme, cognitive work analysis

**Megan E. Salwei, Pascale Carayon, Ann S. Hundt, Peter Hoonakker, Vaibhav Agrawal, Peter Kleinschmidt, Jason Stamm, Douglas Wiegmann & Brian W. Patterson. *Role network measures to assess healthcare team adaptation to complex situations: the case of venous thromboembolism prophylaxis*. Pages: 864-879.**

Hospitals are complex environments that rely on clinicians working together to provide appropriate care to patients. These clinical teams adapt their interactions to meet changing situational needs. Venous thromboembolism (VTE) prophylaxis is a complex

process that occurs throughout a patient's hospitalisation, presenting five stages with different levels of complexity: admission, interruption, re-initiation, initiation, and transfer. The objective of our study is to understand how the VTE prophylaxis team adapts as the complexity in the process changes; we do this by using social network analysis (SNA) measures. We interviewed 45 clinicians representing 9 different cases, creating 43 role networks. The role networks were analysed using SNA measures to understand team changes between low and high complexity stages. When comparing low and high complexity stages, we found two team adaptation mechanisms: (1) relative increase in the number of people, team activities, and interactions within the team, or (2) relative increase in discussion among the team, reflected by an increase in reciprocity. **Practitioner Summary:** The reason for this study was to quantify team adaptation to complexity in a process using social network analysis (SNA). The VTE prophylaxis team adapted to complexity by two different mechanisms, by increasing the roles, activities, and interactions among the team or by increasing the two-way communication and discussion throughout the team. We demonstrated the ability for SNA to identify adaptation within a team.

- **Keywords:** Team adaptation, social network analysis, complexity, patient safety

**Ulrika Ohlander, Jens Alfredson, Maria Riveiro & Göran Falkman. [Fighter pilots' teamwork: a descriptive study](#). Pages: 880-890.**

The execution of teamwork varies widely depending on the domain and task in question. Despite the considerable diversity of teams and their operation, researchers tend to aim for unified theories and models regardless of field. However, we argue that there is a need for translation and adaptation of the theoretical models to each specific domain. To this end, a case study was carried out on fighter pilots and it was investigated how teamwork is performed in this specialised and challenging environment, with a specific focus on the dependence on technology for these teams. The collaboration between the fighter pilots is described and analysed using a generic theoretical model for effective teamwork from the literature. The results show that domain-specific application and modification is needed in order for the model to capture fighter pilot's teamwork. The study provides deeper understanding of the working conditions for teams of pilots and gives design implications for how tactical support systems can enhance teamwork in the domain. **Practitioner summary:** This article presents a qualitative interview study with fighter pilots based on a generic theoretical teamwork model applied to the fighter domain. The purpose is to understand the conditions under which teams of fighter pilots work and to provide guidance for the design of future technological aids.

- **Keywords:** Teamwork, team effectiveness, fighter pilot, fighter aircraft

**Xuguang Wang, Michelle Cardoso, Ilias Theodorakos & Georges Beurier. [A parametric investigation on seat/occupant contact forces and their relationship with initially perceived discomfort using a configurable seat](#). Pages: 891-902.**

The present work investigates the contact forces between sitters and seat as well as their correlations with perceived discomfort. Twelve different economy class aeroplane seat configurations were simulated using a multi-adjustable experimental seat by varying seat pan and backrest angles, as well as seat pan compressed surface. Eighteen males and 18 females, selected by their body mass index and stature, tested these configurations for two sitting postures. Perceived discomfort was significantly affected by seat parameters and posture and correlated both with normal force distribution on the seat-pan surface and with normal forces at the lumbar and head supports. Lower discomfort ratings were obtained for more evenly distributed normal forces on the seat pan. Shear force at the seat pan surface was at its lowest when sitters were allowed to self-select their seat-pan angle, supporting that a shear force should be reduced but not zeroed to improve seating

comfort. **Practitioner Summary:** The effects of seat-pan and backrest angle, anthropometric dimensions and sitting posture on contact forces and perceived discomfort were investigated using a multi-adjustable experimental seat. In addition to preferred seat profile parameters, the present work provides quantitative guidelines on contact force requirement for improving seating comfort.

- **Keywords:** Seat, comfort, discomfort, contact force distribution, aeroplane

**S. J. Baltrusch, J. H. van Dieën, S. M. Bruijn, A. S. Koopman, C. A. M. van Bennekom & H. Houdijk. *The effect of a passive trunk exoskeleton on metabolic costs during lifting and walking.* Pages: 903-916.**

The objective of this study was to assess how wearing a passive trunk exoskeleton affects metabolic costs, movement strategy and muscle activation during repetitive lifting and walking. We measured energy expenditure, kinematics and muscle activity in 11 healthy men during 5 min of repetitive lifting and 5 min of walking with and without exoskeleton. Wearing the exoskeleton during lifting, metabolic costs decreased as much as 17%. In conjunction, participants tended to move through a smaller range of motion, reducing mechanical work generation. Walking with the exoskeleton, metabolic costs increased up to 17%. Participants walked somewhat slower with shortened steps while abdominal muscle activity slightly increased when wearing the exoskeleton. Wearing an exoskeleton during lifting decreased metabolic costs and hence may reduce the development of fatigue and low back pain risk. During walking metabolic costs increased, stressing the need for a device that allows disengagement of support depending on activities performed. **Practitioner summary:** Physiological strain is an important risk factor for low back pain. We observed that an exoskeleton reduced metabolic costs during lifting, but had an opposite effect while walking. Therefore, exoskeletons may be of benefit for lifting by decreasing physiological strain but should allow disengagement of support when switching between tasks.

- **Keywords:** Assistive device, low back pain, oxygen consumption, movement behaviour, EMG

**Kristina M. Gruevski & Jack P. Callaghan. *The effect of age on in-vivo spine stiffness, postures and discomfort responses during prolonged sitting exposures.* Pages: 917-927.**

Many industrialised working populations are ageing and prolonged sitting exposures are prevalent across occupational sectors. The purpose of this work was to determine the effect of age and sex on passive spine stiffness, postures and discomfort in response to seated work. A total of 34 participants were recruited, with 17 older adults with an average age of (standard deviation) 63.7 ( $\pm 3.9$ ) years and 17 younger adults aged 23.8 ( $\pm 5.0$ ) years. Participants were asked to sit continuously for 90 min while typing. Baseline passive spine stiffness was higher in older adults at 40% flexion compared to younger adults ( $p = .0233$ ). Older adults sat in less normalised flexion, at 33.4% ( $\pm 16.4$ ) compared to 60.9% ( $\pm 20.2$ ) in the younger group ( $p = .0003$ ). Discomfort was higher among older adults in the neck, right shoulder and middle back regions ( $p < .0086$ ). An understanding of age-specific responses to workplace exposures is essential to determine whether age-specific interventions are warranted. **Practitioner summary:** Older adults had higher passive spine stiffness and sat with less flexion during prolonged sitting. Discomfort was higher among older adults and occurred earlier in the simulation compared to younger participants, indicating that interventions, such as walking breaks may need to be implemented earlier during sitting for aged workers.

- **Keywords:** Aging, ergonomics, spine stiffness, prolonged sitting, low back pain

**Udayraj, Faming Wang, Wenfang Song, Ying Ke, Pengjun Xu, Cathy Sin Wei Chow & Nuruzzaman Noor. *Performance enhancement of hybrid personal cooling clothing in a hot environment: PCM cooling energy management with additional insulation*. Pages: 928-939.**

A novel design of personal cooling clothing incorporating additional insulation sandwiched between phase change materials (PCMs) and clothing outer layer is proposed. Performance of four personal cooling systems including clothing with only PCMs, clothing with PCMs and insulation (PCM + INS), clothing with PCMs and ventilation fans (HYB), and clothing with PCMs, ventilation fans and insulation (HYB + INS) was investigated. Effect of additional insulation on clothing cooling performance in terms of human physiological and perceptual responses was also examined. Human trials were carried out in a hot environment (i.e. 36 °C, RH = 59%). Results showed that significantly lower mean skin/torso temperatures were registered in HYB + INS as compared to HYB. In contrast, no significant effect of the use of insulation on both skin and body temperatures between PCM and PCM + INS was observed. Also, no significant difference in thermal sensations, thermal comfort, and skin wetness sensation was registered between cooling systems with and without additional insulation. **Practitioner Summary:** Hybrid personal cooling clothing has shown the ability to provide a relatively cool microclimate around the wearer's body while working in hot environments. The present work addresses the importance of cooling energy saving for PCMs in a hot environment. This work contributes to optimising cooling performance of hybrid personal cooling systems.

- **Keywords:** Heat stress, personal cooling, phase change materials, energy management, air ventilation, physiological responses

**Jorge Sierra-Pérez, Jesús Boschmonart-Rives & Jordi Oliver-Solà. *Introducing ergonomics requirements in the eco-design of energy-related products from users' behaviour approach*. Pages: 940-953.**

Ergonomics has been a very important activity in the design process. However, ergonomics rarely includes the environmental requirements into the design of products. The article proposes and presents the Eco-Ergo model through its application to a real-world product, a washing machine, to allow designers and ergonomists to establish product design requirements in order to minimise environmental impacts related to user-product interaction during the use stage. This model uses a visual language of representation, Blueprinting-based, that helps designers explore problems they have not previously considered during the market research when a wide variety of products with different interaction elements is analysed. The application of this model allows direct efforts and attention on the user analysis phase in the most influential user's actions on the environmental performance of energy-related products during use, establishing ergonomics requirements related to users behaviour at the initial design phase. **Practitioner summary:** This study provides a proposal to incorporate ergonomics into the practice of eco-design through the use of human factors in the establishment of initial eco-design requirements. This blueprint-based model combines an empirical and theoretical approach, based on the product test developed by designers, ergonomists and environmentalists.

- **Keywords:** Ergonomics, user-centred design, product design, energy-related products, user behavior

**Wei Xu, Dov Furie, Manjunath Mahabhaleshwar, Bala Suresh & Hardev Chouhan. *Applications of an interaction, process, integration and intelligence (IPII) design approach for ergonomics solutions*. Pages: 954-980.**

This paper first reviews current ergonomics design approaches in delivering digital solutions to achieve a unified experience from interaction and business process design perspectives. Then, it analyses the opportunities that new technologies may bring in for enhancing current ergonomics design approaches from integration and intelligence design perspectives. To address the challenges in today's ergonomics practices in delivering digital solutions, an interaction, process, integration and intelligence (IPII) design approach is proposed. A case study is presented that implemented the IPII approach. The quantitative data gathered from the case study demonstrates that the IPII approach has achieved significant advantages in reaching the goal of a unified experience and operational benefits for delivering digital solutions. The IPII approach also demonstrates improvements compared to today's ergonomics design approaches, such as user-centred design, for digital solutions. Finally, the paper highlights the contributions of the IPII approach for future ergonomics practices in delivering digital solutions. **Practitioner Summary:** In addition to the interaction design for the UI of digital solutions, as is the case in current typical ergonomics practice, the IPII adds three additional design components: process, integration and intelligence design. The case study demonstrates the advantages of the IPII, providing an enhanced approach for designing digital solutions.

- **Keywords:** Product design, human-computer interaction, user experience, intelligence design, ergonomics design approach