

Ergonomics – rok 2013, ročník 56

Číslo 3



Special Issue: Ergonomics and Sustainability

Klaus J. Zink & Klaus Fischer. *Do we need sustainability as a new approach in human factors and ergonomics?* Pages 348-356.

The International Ergonomics Association Technical Committee 'Human Factors and Sustainable Development' was established to contribute to a broad discourse about opportunities and risks resulting from current societal 'mega-trends' and their impacts on the interactions among humans and other elements of a system, e.g. in work systems. This paper focuses on the underlying key issues: how do the sustainability paradigm and human factors/ergonomics interplay and interact, and is sustainability necessary as a new approach for our discipline? Based on a discussion of the sustainability concept, some general principles for designing new and enhancing existent approaches of human factors and ergonomics regarding their orientation towards sustainability are proposed.

Practitioner summary: The increasing profile of sustainability on the international stage presents new opportunities for human factors/ergonomics. Positioning of the sustainability paradigm within human factors/ergonomics is discussed. Approaches to incorporating sustainability in the design of work systems are considered.

- **Keywords:** ergonomics, human factors, sustainable development, sustainability, sustainable work systems

Sidney W.A. Dekker, Peter A. Hancock & Peter Wilkin. *Ergonomics and sustainability: towards an embrace of complexity and emergence.* Pages 357-364.

Technology offers a promising route to a sustainable future, and ergonomics can serve a vital role. The argument of this article is that the lasting success of sustainability initiatives in ergonomics hinges on an examination of ergonomics' own epistemology and ethics. The epistemology of ergonomics is fundamentally empiricist and positivist. This places practical constraints on its ability to address important issues such as sustainability, emergence and complexity. The implicit ethical position of ergonomics is one of neutrality, and its positivist epistemology generally puts value-laden questions outside the parameters of what it sees as scientific practice. We argue, by contrast, that a discipline that deals with both technology and human beings cannot avoid engaging with questions of complexity and emergence and seeking innovative ways of addressing these issues.

Practitioner Summary: Ergonomics has largely modelled its research on a reductive science, studying parts and problems to fix. In sustainability efforts, this can lead to mere local adaptations with a negative effect on global sustainability. Ergonomics must consider quality of life globally, appreciating complexity and emergent effects of local relationships.

- **Keywords:** sustainability, ergonomics, epistemology, ethics, complexity, emergence

K. Martin, S. Legg & C. Brown. *Designing for sustainability: ergonomics – carpe diem*. Pages 365-388.

Sustainability is a global issue that has worldwide attention but the role of ergonomics in designing for sustainability is poorly understood and seldom considered. An analysis of the literature on ergonomics, design and sustainability was conducted via a search of electronic databases: Scopus, Business Source Complete, Google Scholar, Emerald Publishing, Academic Search Premiere, Web of Science, Discover and Ergonomics Abstracts, for the years 1995–2012. A total of 1934 articles fulfilled the search criteria, but content analysis of the abstracts indicated that only 14 refereed articles addressed the main search criteria. Of those seven were in ergonomics journals and seven were in other journals (and were not written by ergonomists). It is concluded that the contribution of ergonomics to sustainability and sustainable design has been limited, even though the goals of sustainability and ergonomics are congruent. Ergonomists have not been at the forefront of research contributing to sustainability – and it is time for them to 'seize the day' – '*carpe diem*'.

Practitioner Summary: This literature review shows that ergonomics contribution to sustainability is limited but since there is congruence between the disciplines it calls for ergonomists to become more involved and to seize the day – *carpe diem*.

- **Keywords:** human factors, green design, conservation, environment, review

Andrew Thatcher. *Green ergonomics: definition and scope*. Pages 389-398.

This paper demonstrates that the goals of ergonomics (i.e. effectiveness, efficiency, health, safety and usability) are closely aligned with the goals of design for environmental sustainability. In this paper, the term 'green ergonomics' is conceptualised to specifically describe ergonomics interventions with a pro-nature emphasis. Green ergonomics is focused on the bi-directional connections between human systems and nature. This involves looking at (1) how ergonomics design and evaluation might be used to conserve, preserve, and restore nature and (2) how ecosystem services might be harnessed to facilitate the improved wellbeing and effectiveness of human systems. The paper proposes the scope of green ergonomics based on these bi-directional relationships in the areas of the design of low resource systems and products, the design of green jobs, and the design for behaviour change. Suggestions for further work in the green ergonomics domain are also made.

Practitioner Summary: Given the enormous environmental challenges facing modern industrial society, this paper encourages ergonomics science to embrace a pro-nature understanding of work design and research. This paper sets out the role for green ergonomics based on an appreciation of the human–nature connections that have been integrated with our understanding of ergonomics science and practice.

- **Keywords:** green ergonomics, environment, pro-nature, sustainability

Margaret A. Hanson. *Green ergonomics: challenges and opportunities.* Pages 399-408.

Addressing the causes and consequences of environmental degradation presents significant challenges for humankind. This paper considers what ergonomics/human factors (E/HF) professionals can contribute to understanding and tackling some of the issues that arise through the movement towards a more environmentally sustainable economy. These issues are considered in relation to work in green industries (specifically, sustainable energy production, recycling and organic food production), and there is a need to ensure that these jobs are safe and healthy; the design of products and systems that are 'environmentally friendly' to facilitate their acceptability and use and how E/HF professionals can contribute to understanding and promoting behavioural change relating to environmental choices. The activities of some international organisations in this area are identified and the potential for E/HF involvement is considered. The implications for the E/HF profession are discussed.

Practitioner summary: This paper considers how ergonomics/human factors professionals can contribute to the movement towards more sustainable and 'environmentally friendly' design and work. Potential challenges and opportunities are discussed in relation to jobs in green industries, products and systems and behaviour change.

- **Keywords:** green ergonomics, green industries, green jobs, sustainable design

Christopher Durugbo. *Improving information recognition and performance of recycling chimneys.* Pages 409-421.

The aim of this study was to assess and improve how recyclers (individuals carrying out the task of recycling) make use of visual cues to carry out recycling tasks in relation to 'recycling chimneys' (repositories for recycled waste). An initial task analysis was conducted through an activity sampling study and an eye tracking experiment using a mobile eye tracker to capture fixations of recyclers during recycling tasks. Following data collection using the eye tracker, a set of recommendations for improving information representation were then identified using the widely researched skills, rules, knowledge framework, and for a comparative study to assess the performance of improved interfaces for recycling chimneys based on Ecological Interface Design principles.

Practitioner Summary: Information representation on recycling chimneys determines how we recycle waste. This study describes an eco-ergonomics-based approach to improve the design of interfaces for recycling chimneys. The results are valuable for improving the performance of waste collection processes in terms of minimising contamination and increasing the quantity of recyclables.

- **Keywords:** recycling, sustainability, waste, eye movement, task analysis

Gopal Nadadur & Matthew B. Parkinson. *The role of anthropometry in designing for sustainability.* Pages 422-439.

An understanding of human factors and ergonomics facilitates the design of artefacts, tasks and environments that fulfil their users' physical and cognitive requirements. Research in these fields furthers the goal of efficiently *accommodating* the desired percentage of user populations through enhanced awareness and modelling of human variability. Design for sustainability (DfS) allows for these concepts to be leveraged in the broader context of designing to minimise negative impacts on the environment. This paper focuses on anthropometry and proposes three ways in which its consideration is relevant to DfS: reducing raw material consumption, increasing usage lifetimes and ethical human resource considerations. This is demonstrated through the application of

anthropometry synthesis, virtual fitting, and sizing and adjustability allocation methods in the design of an industrial workstation seat for use in five distinct global populations. This work highlights the importance of and opportunities for using ergonomic design principles in DfS efforts.

Practitioner Summary: This research demonstrates the relevance of some anthropometry-based ergonomics concepts to the field of design for sustainability. A global design case study leverages human variability considerations in furthering three sustainable design goals: reducing raw material consumption, increasing usage lifetimes and incorporating ethical human resource considerations in design.

- **Keywords:** design for sustainability, human variability, global product development, anthropometry, user populations, sizing and adjustability allocation

Alex W. Stedmon, Robin Winslow & Alyson Langley. *Micro-generation schemes: user behaviours and attitudes towards energy consumption.* Pages 440-450.

In the last decade, there has been increasing pressure on developed nations to reduce their carbon emissions. Distributed micro-generation (MG) initiatives provide incentives for small-scale renewable energy generation, particularly by residential home-owners. This paper investigates the existing knowledge base to consider if living in a property with on-site renewable electricity generation may affect user attitudes and behaviours. This knowledge is interpreted from a human factors perspective by focussing on individual behaviour and social learning as well as identifying underlying user requirements and user needs. Suggestions are then made with regard to the effects that MG schemes may have on public attitudes and where further research efforts should be focused. There is evidence that renewable energy initiatives are likely to result in a shift in public behaviour, particularly towards reduced energy consumption where mechanisms for increased feedback can act as a facilitator to learning and motivator to change.

Practitioner Summary: The role of human factors/ergonomics in supporting renewable energy initiatives has not been fully exploited. A range of case studies explore user needs and awareness of renewable energy, presenting mixed evidence for reduced consumption. However, individual behaviour and social learning can be influenced through increased feedback that acts as a facilitator to change.

- **Keywords:** user attitudes, user behaviour, energy consumption, micro-generation

Charlotte B.A. Kobus, Ruth Mugge & Jan P.L. Schoormans. *Washing when the sun is shining! How users interact with a household energy management system.* Pages 451-462.

To make optimal use of sustainable energy, domestic electricity consumption should shift to match local supply conditions. Energy management systems (EMS) are a new sustainable technology that can help to disrupt consumers' habits concerning electricity consumption, whilst reinforcing desired behaviours. This research examined the factors that influence the likelihood that people will shift their electricity consumption to match sustainable supply. Twenty-one interviews were conducted with households who had used the EMS 'Smart Wash' for several months. The findings showed that the likelihood of behaviour change is influenced by a combination of the user's motivation, specific contextual factors and the design of the EMS. Based on these results, several recommendations are given for the future design of EMSs.

Practitioner Summary: Energy management systems (EMS) are a new technology that encourages people to shift electricity consumption to match local solar supply. Interviews

among users of an EMS showed that the likelihood of behaviour change is influenced by the combination of the user's motivation, contextual factors and the EMS design.

- **Keywords:** energy management system, electricity consumption

Therese Peffer, Daniel Perry, Marco Pritoni, Cecilia Aragon & Alan Meier. *Facilitating energy savings with programmable thermostats: evaluation and guidelines for the thermostat user interface. Pages 463-479.*

Thermostats control heating and cooling in homes – representing a major part of domestic energy use – yet, poor ergonomics of these devices has thwarted efforts to reduce energy consumption. Theoretically, programmable thermostats can reduce energy by 5–15%, but in practice little to no savings compared to manual thermostats are found. Several studies have found that programmable thermostats are not installed properly, are generally misunderstood and have poor usability. After conducting a usability study of programmable thermostats, we reviewed several guidelines from ergonomics, general device usability, computer–human interfaces and building control sources. We analysed the characteristics of thermostats that enabled or hindered successfully completing tasks and in a timely manner. Subjects had higher success rates with thermostat displays with positive examples of guidelines, such as visibility of possible actions, consistency and standards, and feedback. We suggested other guidelines that seemed missing, such as navigation cues, clear hierarchy and simple decision paths.

Practitioner Summary: Our evaluation of a usability test of five residential programmable thermostats led to the development of a comprehensive set of specific guidelines for thermostat design including visibility of possible actions, consistency, standards, simple decision paths and clear hierarchy. Improving the usability of thermostats may facilitate energy savings.

- **Keywords:** thermostat, user interface, energy, usability, heuristic evaluation, residential

So Young Lee & Mihyun Kang. *Innovation characteristics and intention to adopt sustainable facilities management practices. Pages 480-491.*

Sustainable facilities management (SFM) is important because typical buildings consume more resources and energy than necessary, negatively impact the environment and generate lots of waste (US Department of Energy, 2003, *Green Buildings*). This study examined innovation characteristics that relate to facility managers' intention to adopt SFM practices. Based on the diffusion of innovations theory (Rogers 1962, 1995, *Diffusion of Innovations*. 4th ed. New York: The Free Press), an SFM innovation and adoption model was proposed. A survey was conducted with a convenience sample of 240 public facilities managers in 25 facilities management divisions in Seoul, Korea, and its metropolitan areas. Structural equation modelling was employed to analyse the data. The results showed that economic advantage and human comfort aspects are predictors for the intention of SFM adoption. Observability is positively relevant to the intention of SFM adoption. Complexity, however, is not a significant predictor for the intention of SFM adoption. Practical implications for sustainable products and systems and the built environment are suggested.

Practitioner summary: To incorporate an innovation like sustainable practices, it is required to meet the needs of potential adopters. Innovation characteristics that influence facility managers' intention to adopt sustainable facilities management were examined. A survey was conducted. Economic advantage, human comfort and observability are predictors for the intention of adoption of sustainable practice.

- **Keywords:** sustainability, adoption, facilities management, public buildings

A. Hedge & J.A. Dorsey. *Green buildings need good ergonomics. Pages 492-506.*

A retrospective post-occupancy evaluation survey of 44 occupants in two Leadership in Energy and Environmental Design (LEED) Platinum buildings on a US college campus is reported. The Internet survey covered a range of indoor environment and ergonomics issues. Results show that working in these buildings were a generally positive experience for their health, performance and satisfaction. However, in one building there were persistent issues of variability in air temperature, air freshness, air quality and noise that affected the perceived health and performance of the occupants. Although the buildings were energy-efficient and sustainable structures, ergonomics design issues were identified. Implications for the role of ergonomics in green buildings and in the US LEED rating system are discussed.

Practitioner Summary: This survey identified a number of ergonomics design issues present in the LEED Platinum energy-efficient and sustainable buildings that were studied. These results highlight the importance of integrating ergonomics design into green buildings as a component in the US LEED rating system.

- **Keywords:** green buildings, office ergonomics, indoor environmental conditions, occupant health and comfort

Joan Harvey, Neil Thorpe & Richard Fairchild. *Attitudes towards and perceptions of eco-driving and the role of feedback systems. Pages 507-521.*

This paper addresses whether eco-driving may be encouraged by providing drivers with feedback, and how eco-driving attitudes fit with other environmental attitudes. Eight focus groups, including fleet drivers, discussed how feedback and other motives might affect driving behaviour. A survey of 350 respondents investigated attitudes towards saving fuel, the role of incentives and use of eco-friendly products. The focus groups' findings show that the environment is a lower priority than comfort and convenience, that feedback might provide a stimulus to eco-driving and that saving money was less important than saving time. The attitude survey showed that price, convenience, attitudes and eco-driving are not conceptually linked together, that convenience is rated as more important than saving money from fuel efficiency and that although the environment is of concern, it is not a high enough priority to increase fuel efficiency. The findings are discussed in relation to the low level of priority given to environmental concerns and the inability of financial incentives presenting significant challenges in terms of changing the subjective norms of the majority of drivers.

Practitioner summary: This paper, using focus groups and a questionnaire, aims to understand how feedback devices, attitudes and motivation can improve eco-driving behaviours. The incentive to save money by better fuel economy was found to be insufficient, and roles for feedback devices and how information is presented are identified.

- **Keywords:** driver feedback, telematics, eco-driving, attitudes

Neville A. Stanton, Rich C. McIlroy, Catherine Harvey, Simon Blainey, Adrian Hickford, John M. Preston & Brendan Ryan. *Following the cognitive work analysis train of thought: exploring the constraints of modal shift to rail transport. Pages 522-540.*

Environmental concerns show that transport is responsible for almost a quarter of all greenhouse gas emissions, and it is also the fastest growing sector. Modal shift towards public transport could help slow down, or even reverse, this trend. There appear to be a number of constraints that are preventing this from happening. This paper explores the constraints to modal shift to rail transport from the perspective of cognitive work analysis, specifically the abstraction hierarchy, the contextual activity template and social organisational and cooperation analyses. Whilst these analyses may not present any new barriers, they do show how the constraints are interlinked in an explicit manner. These interrelations are important for two reasons. First, in consideration of constraint removal, one must anticipate the likely effects on the remainder of the system. Second, by linking functions and situations, new concepts of travel may be identified and explored.

Practitioner Summary: The purpose of this study was to use a semi-structured approach to identifying constraints to modal shift from a variety of perspectives. It is argued that cognitive work analysis offers a new way of thinking about the modal shift problem and helps to generate new insights into potential solutions.

- **Keywords:** modal shift, cognitive work analysis, constraints

Brendan Ryan & John R. Wilson. *Ergonomics in the development and implementation of organisational strategy for sustainability. Pages 541-555.*

This is the first phase of an ergonomics study of sustainability in a rail organisation, particularly environmental sustainability. The main emphasis has been on the use of a qualitative approach to carry out in-depth consultation with those in influential and policy setting roles in the organisation, collecting and analysing perceptions on sustainability policy and related business processes. The study identified factors affecting implementation of policy on sustainability and these have been developed to produce a list of requirements for implementing the policy. The findings are valuable in understanding the range of attitudes, aspirations and perceived constraints, from the perspective of those in senior roles in the company, and development of a sustainability strategy for a rail infrastructure owner. There is need for wider consultation, both within the organisation and externally, to validate and refine the understanding of barriers to the implementation of the policy. The role of ergonomics in supporting the work on sustainability is discussed.

Practitioner Summary: The study collects in-depth views from senior managers on the challenges of implementing a policy on sustainability in a rail organisation. Outputs include a list of factors affecting implementation of policy and requirements for better implementation of policy in this area. Potential contributions of ergonomics to sustainability in organisational contexts are discussed.

- **Keywords:** transport ergonomics, environmental sustainability, systems ergonomics, ergonomics tools and methods, organisational change

Tim Horberry, Robin Burgess-Limerick & Ruth Fuller. *The contributions of human factors and ergonomics to a sustainable minerals industry. Pages 556-564.*

This article describes examples of the application of human factors research and development work to a sustainable minerals industry. It begins by outlining human-related aspects of the minerals industry and the key human factors work previously undertaken in this domain. The focus then switches to sustainability in the minerals industry. Sustainability principles are introduced and illustrations provided of how human factors research and development work fits within such a framework. Three case studies of human factors in the minerals industry research are presented and the sustainability

implications in each case study are highlighted. Finally, future trends related to human factors work in a sustainable minerals industry are addressed, in particular the opportunities and possible adverse consequences that increasing deployment of mining automation might bring.

Practitioner Summary: Minerals industries are a major global activity with significant sustainability implications. Aspects of sustainability in mining are examined using three case studies. These illustrate the contribution of human factors/ergonomics in reducing risks; developing emergency response management systems; and the value of participatory ergonomics in improving the design of mining equipment.

- **Keywords:** minerals industry, mining, ergonomics, human factors, sustainability

R.S. Bridger, K. Brasher & A. Bennett. *Sustaining person-environment fit with a changing workforce.* Pages 565-577.

Data on health and lifestyle from the Naval service cohort study of occupational stress form the background to a discussion of employee health and the sustainability of a healthy workforce in relation to secular changes – in particular, the increasing prevalence of obesity. One thousand two hundred and forty-one Naval personnel returned questionnaires in 2007 and 2011 and reported their body mass index (BMI), alcohol consumption and smoking, general health and health conditions such as back pain and high blood pressure on both occasions. Health risk due to high BMI and waist circumference in 2011 was predicted by low participation in exercise in 2007. Those performing physically demanding work in 2007 were more likely to be in the 'no risk' category in 2011. High BMI in 2007 was associated with the development of back pain, musculoskeletal conditions and high blood pressure in 2011. The findings are discussed in relation to two aspects of sustainability: the sustainability of current ergonomics practice in relation to health and safety; and the role of ergonomics in sustaining a healthy and productive workforce.

Practitioner Summary: Evidence is presented for the benefits of exercise in sustaining employee health and for an association between a high BMI and a number of common health complaints that have traditionally been tackled through workplace ergonomics. This evidence can be used to support the development of workplace design concepts that promote physical activity.

- **Keywords:** body mass index, lifestyle, musculoskeletal disorders, back pain, psychological strain, exercise