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Guy H. Walker, Paul M. Salmon, Melissa Bedinger & Neville A. Stanton.
Quantum ergonomics: shifting the paradigm of the systems agenda.
Pages: 157-166.

A paradigm is an accepted world view. If we do not continually question our paradigm then wider trends and movements will overtake the discipline leaving it ill adapted to future challenges. This Special Issue is an opportunity to keep systems thinking at the forefront of ergonomics theory and practice. Systems thinking prompts us to ask whether ergonomics, as a discipline, has been too timid? Too preoccupied with the resolution of immediate problems with industrial-age methods when, approaching fast, are developments which could render these operating assumptions an irrelevance. Practical case studies are presented to show how abstract systems problems can be tackled head-on to deliver highly innovative and cost-effective insights. The strategic direction of the discipline foregrounds high-quality systems problems. These are something the discipline is well able to respond to provided that the appropriate operating paradigms are selected. **Practitioner Summary:** High-quality systems problems are the future of the discipline. How do we convert obtuse sounding systems concepts into practical interventions? In this paper, the essence of systems thinking is distilled and practical case studies used to demonstrate the benefits of this new paradigm.

- **Keywords:** Paradigms, systems thinking, big data, internet of things

Stephen J. Guastello. ***Nonlinear dynamical systems for theory and research in ergonomics.*** **Pages: 167-193.**

Nonlinear dynamical systems (NDS) theory offers new constructs, methods and explanations for phenomena that have in turn produced new paradigms of thinking within several disciplines of the behavioural sciences. This article explores the recent developments of NDS as a paradigm in ergonomics. The exposition includes its basic axioms, the primary constructs from elementary dynamics and so-called complexity theory, an overview of its methods, and growing areas of application within ergonomics. The applications considered here include: psychophysics, iconic displays, control theory, cognitive workload and fatigue, occupational accidents, resilience of systems, team coordination and synchronisation in systems. Although these applications make use of

different subsets of NDS constructs, several of them share the general principles of the complex adaptive system. **Practitioner Summary:** Nonlinear dynamical systems theory reframes problems in ergonomics that involve complex systems as they change over time. The leading applications to date include psychophysics, control theory, cognitive workload and fatigue, biomechanics, occupational accidents, resilience of systems, team coordination and synchronisation of system components.

- **Keywords:** General ergonomics, application domains, team working, organisational ergonomics, mental fatigue, psychological aspects, learning and skill acquisition, psychological aspects, operator workload, system performance

Paul M. Salmon, Guy H. Walker, Gemma J. M. Read, Natassia Goode & Neville A. Stanton. *Fitting methods to paradigms: are ergonomics methods fit for systems thinking?* Pages: 194-205.

The issues being tackled within ergonomics problem spaces are shifting. Although existing paradigms appear relevant for modern day systems, it is worth questioning whether our methods are. This paper asks whether the complexities of systems thinking, a currently ubiquitous ergonomics paradigm, are outpacing the capabilities of our methodological toolkit. This is achieved through examining the contemporary ergonomics problem space and the extent to which ergonomics methods can meet the challenges posed. Specifically, five key areas within the ergonomics paradigm of systems thinking are focused on: normal performance as a cause of accidents, accident prediction, system migration, systems concepts and ergonomics in design. The methods available for pursuing each line of inquiry are discussed, along with their ability to respond to key requirements. In doing so, a series of new methodological requirements and capabilities are identified. It is argued that further methodological development is required to provide researchers and practitioners with appropriate tools to explore both contemporary and future problems. **Practitioner Summary:** Ergonomics methods are the cornerstone of our discipline. This paper examines whether our current methodological toolkit is fit for purpose given the changing nature of ergonomics problems. The findings provide key research and practice requirements for methodological development.

- **Keywords:** Ergonomics tools and methods, methods and approaches, system performance, complex systems, system performance modelling, sociotechnical systems, organisational ergonomics, systems thinking

Neville Moray, John Groeger & Neville Stanton. *Quantitative modelling in cognitive ergonomics: predicting signals passed at danger.* Pages: 206-220.

This paper shows how to combine field observations, experimental data and mathematical modelling to produce quantitative explanations and predictions of complex events in human-machine interaction. As an example, we consider a major railway accident. In 1999, a commuter train passed a red signal near Ladbroke Grove, UK, into the path of an express. We use the Public Inquiry Report, 'black box' data, and accident and engineering reports to construct a case history of the accident. We show how to combine field data with mathematical modelling to estimate the probability that the driver observed and identified the state of the signals, and checked their status. Our methodology can explain the SPAD ('Signal Passed At Danger'), generate recommendations about signal design and placement and provide quantitative guidance for the design of safer railway systems' speed limits and the location of signals. **Practitioner Summary:** Detailed ergonomic analysis of railway signals and rail infrastructure reveals problems of signal identification at this location. A record of driver eye movements measures attention, from which a quantitative model for our signal placement and permitted speeds can be derived. The paper is an example of how to

combine field data, basic research and mathematical modelling to solve ergonomic design problems.

- **Keywords:** Railway ergonomics, cognitive ergonomics, accidents, attention dynamics, mental models, eye movements, mathematical models

Neville A. Stanton & Catherine Harvey. *Beyond human error taxonomies in assessment of risk in sociotechnical systems: a new paradigm with the EAST 'broken-links' approach.* Pages: 221-233.

Risk assessments in Sociotechnical Systems (STS) tend to be based on error taxonomies, yet the term 'human error' does not sit easily with STS theories and concepts. A new break-link approach was proposed as an alternative risk assessment paradigm to reveal the effect of information communication failures between agents and tasks on the entire STS. A case study of the training of a Royal Navy crew detecting a low flying Hawk (simulating a sea-skimming missile) is presented using EAST to model the Hawk-Frigate STS in terms of social, information and task networks. By breaking 19 social links and 12 task links, 137 potential risks were identified. Discoveries included revealing the effect of risk moving around the system; reducing the risks to the Hawk increased the risks to the Frigate. Future research should examine the effects of compounded information communication failures on STS performance. **Practitioner Summary:** The paper presents a step-by-step walk-through of EAST to show how it can be used for risk assessment in sociotechnical systems. The 'broken-links' method takes a systemic, rather than taxonomic, approach to identify information communication failures in social and task networks.

- **Keywords:** Sociotechnical systems, analytical models, risk, EAST

Ben D. Sawyer, Waldemar Karwowski, Petros Xanthopoulos & P. A. Hancock. *Detection of error-related negativity in complex visual stimuli: a new neuroergonomic arrow in the practitioner's quiver.* Pages: 234-240.

Brain processes responsible for the error-related negativity (ERN) evoked response potential (ERP) have historically been studied in highly controlled laboratory experiments through presentation of simple visual stimuli. The present work describes the first time the ERN has been evoked and successfully detected in visual search of complex stimuli. A letter flanker task and a motorcycle conspicuity task were presented to participants during electroencephalographic (EEG) recording. Direct visual inspection and subsequent statistical analysis of the resultant time-locked ERP data clearly indicated that the ERN was detectable in both groups. Further, the ERN pattern did not differ between groups. Such results show that the ERN can be successfully elicited and detected in visual search of complex static images, opening the door to applied neuroergonomic use. Harnessing the brain's error detection system presents significant opportunities and complex challenges, and implication of such are discussed in the context of human-machine systems. **Practitioner Summary:** For the first time, error-related negativity (ERN) has been successfully elicited and detected in a visually complex applied search task. Brain-process-based error detection in human-machine systems presents unique challenges, but promises broad neuroergonomic applications.

- **Keywords:** Error negativity, applied electroencephalography, visual search, human-machine systems, motorcycle conspicuity

Pavle Mijović, Vanja Ković, Maarten De Vos, Ivan Mačužić, Petar Todorović, Branislav Jeremić & Ivan Gligorijević. *Towards continuous*

and real-time attention monitoring at work: reaction time versus brain response. Pages: 241-254.

Continuous and objective measurement of the user attention state still represents a major challenge in the ergonomics research. Recently available wearable electroencephalography (EEG) opens new opportunities for objective and continuous evaluation of operators' attention, which may provide a new paradigm in ergonomics. In this study, wearable EEG was recorded during simulated assembly operation, with the aim to analyse P300 event-related potential component, which provides reliable information on attention processing. In parallel, reaction times (RTs) were recorded and the correlation between these two attention-related modalities was investigated. Negative correlation between P300 amplitudes and RTs has been observed on the group level ($p < .001$). However, on the individual level, the obtained correlations were not consistent. As a result, we propose the P300 amplitude for accurate attention monitoring in ergonomics research. On the other hand, no significant correlation between RTs and P300 latency was found on group, neither on individual level. **Practitioner Summary:** Ergonomic studies of assembly operations mainly investigated physical aspects, while mental states of the assemblers were not sufficiently addressed. Presented study aims at attention tracking, using realistic workplace replica. It is shown that drops in attention could be successfully traced only by direct brainwave observation, using wireless electroencephalographic measurements.

- **Keywords:** Attention, wireless EEG, event-related potentials, P300, reaction times

Sean Gallagher & Mark C. Schall Jr. Musculoskeletal disorders as a fatigue failure process: evidence, implications and research needs. Pages: 255-269.

Mounting evidence suggests that musculoskeletal disorders (MSDs) may be the result of a fatigue failure process in musculoskeletal tissues. Evaluations of MSD risk in epidemiological studies and current MSD risk assessment tools, however, have not yet incorporated important principles of fatigue failure analysis in their appraisals of MSD risk. This article examines the evidence suggesting that fatigue failure may play an important role in the aetiology of MSDs, assesses important implications with respect to MSD risk assessment and discusses research needs that may be required to advance the scientific community's ability to more effectively prevent the development of MSDs. **Practitioner Summary:** Evidence suggests that musculoskeletal disorders (MSDs) may result from a fatigue failure process. This article proposes a unifying framework that aims to explain why exposure to physical risk factors contributes to the development of work-related MSDs. Implications of that framework are discussed.

- **Keywords:** Musculoskeletal disorders, fatigue failure, cumulative trauma, rest, risk assessment

Sarah Sharples & Robert J. Houghton. The field becomes the laboratory? The impact of the contextual digital footprint on the discipline of E/HF. Pages: 270-283.

The increasing prevalence of affordable digital sensors, ubiquitous networking and computation puts us at what is only the start of a new era in terms of the volume, coverage and granularity of data that we can access about individuals and workplaces. This paper examines the consequences of harnessing this data deluge for the practice of E/HF. Focusing on what we term the 'contextual digital footprint', the trail of data we produce through interactions with many different digital systems over the course of even a single day, we describe three example scenarios (drawn from health care, distributed

work and transportation) and examine how access to data directly drawn in considerable volume from the field will potentially change our application of design and evaluation methods. We conclude with a discussion of issues relevant to ethical and professional practice within this new environment including the increased challenges of respecting anonymity, working with $n = \text{all data-sets}$ and the central role of ergonomists in promulgating positive uses of data while retaining a systems-based humanistic approach to work design. **Practitioner summary:** The paper envisions the impact of new and emerging sources of data about people and workplaces upon future practice in E/HF. We identify practical consequences for ergonomics practice, highlight new areas of professional competence likely to be required and flag both the risks and benefits of adopting a more data-driven approach.

- **Keywords:** Ethics, future of ergonomics, human factors/ergonomics discipline, methods personal data, work design
- **Plný text**
<http://www.tandfonline.com/doi/pdf/10.1080/00140139.2016.1151946?needAccess=true>

P. A. Hancock. *Imposing limits on autonomous systems*. Pages: 284-291.

Our present era is witnessing the genesis of a sea-change in the way that advanced technologies operate. Amongst this burgeoning wave of untrammelled automation there is now beginning to arise a cadre of ever-more independent, autonomous systems. The degree of interaction between these latter systems with any form of human controller is becoming progressively more diminished and remote; and this perhaps necessarily so. Here, I advocate for human-centred and human favouring constraints to be designed, programmed, promulgated and imposed upon these nascent forms of independent entity. I am not sanguine about the collective response of modern society to this call. Nevertheless, the warning must be voiced and the issue debated, especially among those who most look to mediate between people and technology. **Practitioner Summary:** Practitioners are witnessing the penetration of progressively more independent technical orthotics into virtually all systems' operations. This work enjoins them to advocate for sentient, rational and mindful human-centred approaches towards such innovations. Practitioners need to place user-centred concerns above either the technical or the financial imperatives which motivate this line of progress.

- **Keywords:** Autonomy, constraints and limitations, human-centred design

Miles Richardson, Marta Maspero, David Golightly, David Sheffield, Vicki Staples & Ryan Lumber. *Nature: a new paradigm for well-being and ergonomics*. Pages: 292-305.

Nature is presented as a new paradigm for ergonomics. As a discipline concerned with well-being, the importance of natural environments for wellness should be part of ergonomics knowledge and practice. This position is supported by providing a concise summary of the evidence of the value of the natural environment to well-being. Further, an emerging body of research has found relationships between well-being and a connection to nature, a concept that reveals the integrative character of human experience which can inform wider practice and epistemology in ergonomics. Practitioners are encouraged to bring nature into the workplace, so that ergonomics keeps pace with the move to nature-based solutions, but also as a necessity in the current ecological and social context. **Practitioner Summary:** Nature-based solutions are coming to the fore to address societal challenges such as well-being. As ergonomics is concerned with well-being, there is a need for a paradigm shift in the discipline. This position is supported by providing a concise summary of the evidence of the value of the natural environment to well-being.

- **Keywords:** Nature, health, well-being, ergonomics