

## **Ergonomics– rok 2021, ročník 64**

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**Tim Bentley, Nicola Green, David Tappin & Roger Haslam. [State of science: the future of work – ergonomics and human factors contributions to the field](#). Pages: 427-439.**

This article is concerned with scholarly ergonomics and human factors (E/HF) contributions to date to the field of research inquiry known as the 'future of work'. The review considers E/HF perspectives on how the nature of work is changing and what this means for the practice of E/HF and for human performance and wellbeing at work. This field of research has attracted much attention from scholars from various disciplines as flexible working arrangements and casualised employment, in particular, have come under the microscope during the COVID-19 pandemic. The article begins by setting out the future of work field, focussing on the mega trends and future of work forces that are most relevant to the discipline. Next, E/HF contributions to this field are identified and discussed. Surprisingly, given the E/HF tradition as a system discipline fundamentally concerned with the study of human work, and as a contributor to transdisciplinary research related to the design of work systems, a search of the scholarly literature found few contributions outside of the automation systems field that addressed the future of work and E/HF directly. A research agenda is presented to address gaps in current knowledge in a number of key future of work domains. **Practitioner's Summary:** We reflect on E/HF contributions to the 'future of work' field and how the practice of E/HF needs to consider the changing nature of work. We outline future of work concerns and suggest research areas for further E/HF attention towards the design of decent and sustainable work for all.

- **Keywords:** Ergonomics and human factors, future of work, new ways of working, decent work

**Juergen Sauer, Amélie Jeanneret, Ondina Smargiassi & Simon Thuillard. *Human and machine-induced social stress and cognitive performance*. Pages: 440-454.**

The article examines the effects of social stress on work performance in a laboratory study using a battery of performance tests. Social stress was induced by a combination of negative feedback and ostracism. Participants received negative performance feedback

and were ostracised by two confederates of the experimenter. Using a one-way experimental design with three levels (machine-induced stress, human-induced stress, and no stress), 102 participants performed the following tasks: attention, divergent and convergent creativity. Participants also completed questionnaires measuring positive and negative affect, and state self-esteem. The manipulation check confirmed that social stress was successfully implemented. The results showed that social stress increased negative affect and reduced self-esteem. However, performance remained unaffected by social stress on any of the cognitive tasks, with no difference emerging between human-induced and machine-induced stress. The findings provide support for the 'blank-out'-mechanism, which assumes that humans can maintain performance levels even under difficult working conditions. **Practitioner summary:** Social stress in the form of negative performance feedback and social exclusion has a negative impact on the affect and self-esteem of humans. However, performance on subsequent tasks was not impaired.

- **Keywords:** Social stress, performance, negative feedback, ostracism, technological stress, social exclusion

**Sabina Hodzic, Bettina Kubicek, Lars Uhlig & Christian Korunka. [Activity-based flexible offices: effects on work-related outcomes in a longitudinal study](#). Pages: 455-473.**

A recent popular trend in office re-design is the activity-based flexible office (A-FO). Initially, assumptions about the effects of A-FOs were drawn from research into open-plan offices where lack of privacy, concentration opportunities, and an increase in distractions are identified as main downsides. These aspects have not been explored sufficiently in the context of A-FOs. Using a longitudinal within-subjects design with three measurement times, we focussed on analysing the change in distraction after moving to an A-FO, how distraction-affected important work-related outcomes, and what factors moderated these relationships. Results showed that moving to the A-FO had negative effects on distraction, work engagement, job satisfaction, and fatigue. The negative effects of distraction were more pronounced in situations of increased time pressure and unpredictability. The obtained results highlight the harmful effects of the interaction of work stressors for employees' motivation and well-being. **Practitioner summary:** The results of our research provide important insight into how moving to an activity-based flexible office impacts the employees. Besides having quiet zones for concentrated work to avoid distractions managers and leaders should also focus on taking care of work stressors to avoid fatigue and loss of motivation.

- **Keywords:** Activity-based flexible office, office type, distraction, time pressure, unpredictability

**Hanneke E. M. van der Hoek-Snieders, Rolph Houben & Wouter A. Dreschler. [Detectability of auditory warning signals in the ambient noise of Dutch train cabins](#). Pages: 474-484.**

Locomotive engineers need to detect auditory warning signals for safe and effective job performance. We measured the levels and spectra of the warning signals and noises present in Dutch train cabins to evaluate the effectiveness of these signals. Audio-recordings were made in six train types during normal operation. Signal detectability was estimated using the Detectsound software and compared against ISO 7731. Signal detectability was also measured in six normally-hearing individuals in a laboratory setting. Signal levels ranged between 68 and 84 dBA. Noise levels ranged between 53 and 77 dBA. The acoustical requirements for signal detectability were not met in multiple driving conditions, especially at higher speed. Sufficient signal-to-noise ratios were achieved in the laboratory measurements, but difficulties can be expected in unfavourable driving situations or when the engineer suffers from hearing loss. Acoustical, environmental, or work modifications might be required to prevent situations

with insufficient audibility in hearing-impaired engineers. **Practitioner summary:** The audibility of the warning signals in Dutch trains was evaluated by comparing signal and noise spectra. The results showed that sufficient audibility is not always guaranteed. Under laboratory conditions, normally-hearing individuals could compensate for the suboptimal acoustic circumstances, but acoustical, environmental, or work modifications might be required to prevent situations with insufficient audibility in hearing-impaired engineers.

- **Keywords:** Vehicle ergonomics, alarms and warnings, train drivers, ISO 7731, signal detection

**Steve Ngai Hung Tsang, Alan Hoi Shou Chan, Xing Pan & Siu Shing Man. *Auditory versus visual spatial stimulus-response mappings in tracking and discrete dual task performance: implications for human-machine interface design.* Pages: 485-501.**

A discrete four-choice response task with auditory signal presentation and a joystick-controlled visual tracking task was used to investigate how spatial compatibility influences the dual-task performance of different display-control settings. It was found that the more incompatible the stimulus-response mapping, the longer the delay for both tasks, presumably because of the longer stimulus encoding time required for the incompatible conditions. A comparison of the findings of this study with those of past experiments on visual visual setting shows that the dual-task performance in a cross-modality (auditory visual) setting was significantly better than that in an intra-modality (visual visual) setting because of visual scanning required in the intra-modal dual tasks. However, when the locations of visual visual tasks were close enough such that ambient and focal vision was concurrently used for information processing, the dual-task performance of intra-modality (visual visual) configuration was slightly better than that of the cross-modality (auditory visual) configuration. **Practitioner Summary:** The effect of spatial compatibility with auditory signal presentation in multiple display-control configurations was examined in a dual-task paradigm. The results provided important and useful ergonomics design implications and consequent recommendations for intra- and cross- modal interface design. The results should facilitate human-machine system design and improve overall system performance.

- **Keywords:** Spatial compatibility, multitask, intra- and cross-modality, multiple resources

**Colin D. McKinnon, Daniel R. Martel & Jack P. Callaghan. *The impact of a progressive sit-stand rotation exposure duration on low back posture, muscle activation, and pain development.* Pages: 502-511.**

This study evaluated early and frequent seated breaks from standing work to reduce low back pain (LBP) in known pain developers (PD). Twenty-four participants, classified as either PD or non-PD during a separate 2-hour standing session, performed 124 minutes of standing work with seated breaks at a 3:1 stand-sit ratio with increasing durations from 3:1 minute to 48:16 minutes. Back pain and spine posture measures showed no differences between PD and non-PD. Females had greater left gluteus medius activation (8.4%MVC) than males (4.5%MVC) and greater gluteus medius co-contraction. This protocol was successful at reducing LBP in PD to the level of non-PD, with mean pain scores (13 mm) only slightly exceeding the clinical LBP threshold of 10 mm. Early and frequent breaks within the first hour of standing work appear to be an effective solution to reduce the LBP that often occurs at the beginning of standing work. **Practitioner Summary:** Sit-stand workstations may be an effective solution to reduce static occupational low back postures. This experimental study demonstrated that early and

frequent seated breaks from standing work may be an effective solution to reduce tissue aggravation that often occurs within the first 45 minutes of a standing work exposure.

- **Keywords:** Sit-stand, low back pain, working posture, sitting, standing

**Dario Fontana & Angelo d'Errico. Agreement between observed and interview-based exposure to ergonomics factors for the upper extremities in employees of a package sorting plant. Pages: 512-520.**

Aim of the study was to estimate agreement between observational and interview-based exposure to ergonomic factors at work. Thirty-two male workers employed in a logistics hub were interviewed through the OCRA check-list on exposure to ergonomic factors in one of six work tasks. Observations of workers in each work task, based on the same OCRA check-list, were used to assess exposure in that task. Agreement between observed and interview-based scores of the check-list OCRA index, as well as of frequency and posture, was estimated both at individual and task group level through the Intraclass Correlation Coefficient (ICC). At work task level, high concordance was found between observed and interview-based scores for all the exposures examined, while at the individual level agreement was moderate. These results suggest that exposure assessment through interviews based on the OCRA check-list is a valid method, which could be used as a workstation screening tool. **Practitioner summary:** The study aimed to evaluate agreement between observational and interview-based exposure to ergonomic factors at work, assessed through the OCRA check-list on 32 male workers. Agreement was found at least moderate, suggesting that interview-based exposure assessed through the OCRA check-list could be used as a proxy of observations for workstation screening.

- **Keywords:** Agreement, interview-based exposure, observed exposure, ergonomics tools and methods, OCRA

**Danielle M. Vickery-Howe, Jace R. Drain, Anthea C. Clarke, Ben J. Dascombe, Joel T. McWilliam & Kane J. Middleton. Treadmill load carriage overestimates energy expenditure of overground load carriage. Pages: 521-531.**

This study compared physiological and biomechanical responses between treadmill and overground load carriage. Thirty adults completed six 10-minute walking trials across three loads (0, 20, and 40% body mass) and two surfaces (treadmill and overground). Relative oxygen consumption was significantly greater on the treadmill for 20% ( $1.54 \pm 0.20 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ) and 40% loads ( $1.08 \pm 0.20 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ). All other physiological and perceptual responses were significantly higher in the treadmill condition and with increases in load. Stance time was longer (0%: 0.05 s; 20%: 0.02 s, 40%: 0.05 s,  $p < 0.001$ ) and cadence was lower (0%: 1 step $\cdot\text{min}^{-1}$ ; 20%: 2 steps $\cdot\text{min}^{-1}$ ; 40%: 3 steps $\cdot\text{min}^{-1}$ ,  $p < 0.05$ ) on the treadmill. Peak lower limb joint angles were similar between surfaces except for ankle plantar flexion, which was  $8^\circ$  greater on the treadmill. The physiological responses to treadmill-based load carriage are generally not transferable to overground load carriage and caution must be taken when conducting treadmill-based load carriage research to inform operational-based scenarios. **Practitioner Summary:** Literature is limited when comparing the physiological and biomechanical responses to treadmill and overground load carriage. Using a repeated measures design, it was shown that although walking kinematics are generally similar between surfaces, there was a greater physiological demand while carrying a load on a treadmill when compared with overground.

- **Keywords:** Gait, physiological demand, biomechanics, kinematics, military ergonomics

**Cody Lindsay, Bradley Clark, Kahlee Adams & Wayne Spratford. *Shorter work boot shaft height improves ankle range of motion and decreases the oxygen cost of work.* Pages: 532-544.**

Work boots featuring design elements implemented to protect the foot and lower limb are common in many industries. However, boot design can have negative unintended consequences such as increases in work related fatigue and injury risk. This study compared joint kinematics and the physiological cost of two commercially available steel-toed work boots with different shaft designs worn throughout a simulated work task. A boot with a lower-cut and scalloped shaft allowed greater sagittal plane range of motion at the ankle joint compared to a boot with a higher-cut straight shaft, particularly in the late stance phase of the gait cycle. This was coupled with a decreased physiological cost of treadmill walking (2.6 and 3.1% improvement in oxygen consumption and walking economy, respectively), likely caused by a more efficient gait pattern. A lower-cut and scalloped shaft could lead to decreases in work-related fatigue and the subsequent risk of injuries in workers. **Practitioner summary:** Gait kinematics and the physiological cost of work boots with different shaft heights has not previously been investigated. A randomised cross-over study design found that a boot with a lower shaft height and scalloped collar improved ankle range of motion and reduced the physiological cost experienced by the wearers.

- **Keywords:** Work, boot, design, biomechanics, walking, work, task, oxygen consumption

**Antti Leinonen, Nikke Varis, Hannu Kokki & Tuomo K. Leino. [Normobaric hypoxia training in military aviation and subsequent hypoxia symptom recognition.](#) Pages: 545-552.**

Altitude hypoxia episodes are increasingly common in military aviation. Hypoxia training is mandatory for fighter pilots, but evidence-based data on the effects of training are scarce. The purpose of this study was to validate the normobaric hypoxia (NH) training effect. Data were collected from 89 pilots from the Finnish Air Force (FINAF). This survey was conducted in a tactical F/A-18C Hornet simulator in two sessions under normobaric conditions, in which the pilots performed flight missions and breathed 21% oxygen (O<sub>2</sub>) in nitrogen (N<sub>2</sub>), and blinded to the pilot, the breathing gas was changed to a hypoxic mixture containing either 8, 7 or 6% O<sub>2</sub> in N<sub>2</sub>. The time taken to notice hypoxia symptoms and peripheral capillary O<sub>2</sub> saturation was measured. A mean of 2.4 years after the initial training, pilots recognised their hypoxic symptoms 18 s quicker with 8% O<sub>2</sub> mixture, 20 s quicker with 7% O<sub>2</sub> and 10 s quicker with 6% O<sub>2</sub>. Our data indicate that NH training in a flight simulator helps pilots to recognise hypoxia symptoms earlier, and may, thus, enhance flight safety. **Practitioner Summary:** We show that hypoxia training enhances pilots' ability to recognise symptoms of acute normobaric hypoxic exposure up to 2.4 years after an initial NH training session. Based on these data, refreshment NH training is nowadays mandatory every 3 years in the FINAF as opposed to the North Atlantic Treaty Organisation (NATO) Standardisation Agreement (STANAG) requirement of 5-year intervals between hypoxia trainings.

- **Keywords:** Hypoxia, normobaric, aeromedical training, simulator, cognitive performance