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Colin G. Drury. *Human factors/ergonomics implications of big data analytics: Chartered Institute of Ergonomics and Human Factors annual lecture.* Pages 659-673.

In recent years, advances in sensor technology, connectedness and computational power have come together to produce huge data-sets. The treatment and analysis of these data-sets is known as big data analytics (BDA), and the somewhat related term data mining. Fields allied to human factors/ergonomics (HFE), e.g. statistics, have developed computational methods to derive meaningful, actionable conclusions from these data bases. This paper examines BDA, often characterised by volume, velocity and variety, giving examples of successful BDA use. This examination provides context by considering examples of using BDA on human data, using BDA in HFE studies, and studies of how people perform BDA. Significant issues for HFE are the reliance of BDA on correlation rather than hypotheses and theory, the ethics of BDA and the use of HFE in data visualisation. **Practitioner Summary:** Human factors/ergonomics practitioners are increasingly likely to work with the large data bases and novel software associated with big data analytics (BDA) and similar fields such as data mining. This paper shows the characteristics of BDA and details methodological and ethical issues that arise in BDA.

- **Keywords:** big data, data mining, correlation, ethics

Gabriel A. Koepp, Bradley J. Snedden & James A. Levine. *Workplace slip, trip and fall injuries and obesity.* Pages 674-679.

The objective of this study was to examine the relationship between slip, trip and fall injuries and obesity in a population of workers at the Idaho National Laboratory (INL) in Idaho Falls, Idaho. INL is an applied engineering facility dedicated to supporting the US Department of Energy's mission. An analysis was performed on injuries reported to the INL Medical Clinic to determine whether obesity was related to an increase in slip, trip and fall injuries. Records were analysed that spanned a 6-year period (2005–2010), and included 8581 employees (mean age, 47 ± 11 years and body mass index [BMI], $29 \pm 5 \text{ kg/m}^2$; 34% obesity rate). Of the 189 people who reported slip, trip and fall injuries (mean age, 48 ± 11 years), 51% were obese ($P < 0.001$ compared with uninjured employees), and their mean BMI was $31 \pm 6 \text{ kg/m}^2$ ($P < 0.001$). Obesity in

this population was associated with a greater rate of slip, trip and fall injuries. **Practitioner Summary:** Slip, trip and fall injuries are a major contributor of workplace-related injuries and a great financial burden to employers. This study examines the impact of obesity in slip, trip and fall injuries. The investigation found that obesity was associated with a greater rate of slip, trip and fall injuries.

- **Keywords:** ergonomics, falls, injury, obesity, workplace

Jamie C. Gorman & Michael J. Crites. *Learning to tie well with others: bimanual versus intermanual performance of a highly practised skill.* Pages 680-697.

Studies indicate that novices are faster in manual tasks when performing with a partner ('intermanual') than with their own two hands ('bimanual'). The generality of this 'mode effect' was examined using a highly practised bimanual task, shoe tying, at which participants were experts. Speed-variability correlations confirmed participants were bimanually skilled but not intermanually skilled. Contrary to results using novices, intermanual was slower, such that prior skill reverses the effect. Analyses incorporating the similarity of shoe-tying strategies across dyads implicated a perceptual rather than shared knowledge/representation basis for intermanual performance. Practice effects indicated that intermanual performance built upon prior bimanual skill, such that novel relative timings between dyads' hands must be acquired. Motor transfer effects provided support for this conclusion. During shoe tying, hands were tightly coupled in the intermanual mode due to the perceptual coupling constraints of intermanual performance. Increased coupling was correlated with slower performance. Implications for real-world tasks (e.g. surgical knot tying) are described. **Practitioner Summary:** Novice participants perform manual tasks faster with a partner ('intermanual') than on their own ('bimanual'). The generality of this 'mode effect' was investigated using a highly practised bimanual task, shoe tying. The mode effect was reversed and mechanisms underlying intermanual skill acquisition were identified. Practical implications extend to tasks such as surgical knot tying.

- **Keywords:** coordination, coupling, interpersonal, practice effects, motor transfer, recurrence

Evgueni Douissembekov, George A. Michael, Joceline Rogé, Patrick Bonhoure, Catherine Gabaude & Jordan Navarro. *Effects of shrinkage of the visual field through ageing on parking performance: a parametric manipulation of salience and relevance of contextual components.* Pages 698-711.

The Master Activation model of attention (Michael, Vairot, and Fernandez, Capture attentionnelle en vision: La saillance, la pertinence, et la balance cortico-sous-corticale. In: G. A. Michael (ed),*Neuroscience cognitive de l'attention visuelle* [Cognitive Neuroscience of Visual Attention], Solal, Marseille, pp. 165–201, 2007; Michael, Lété, and Ducrot, Trajectories of Attentional Development: An Exploration with the Master Activation Map Model, *Developmental Psychology*, 49:615–631, 2013) was used to study visual attention and driving behaviours of younger and older drivers while parking a car. The salience and the relevance of elements present in the parking environment were manipulated during parking manoeuvres. Different effects on manoeuvring were observed depending on driver characteristics such as age and the extent of the field of view (FV). It was found that the presence of a relevant element, such as a pedestrian, impaired parking performance only among older drivers with a narrower FV. The distinct effects of salience and relevance suggest that they had different statuses in attentional processing of manoeuvring drivers. **Practitioner Summary:** The study investigated parking behaviour with different levels of salience and relevance of the parking

environment. Younger and older drivers made parallel and perpendicular manoeuvres with high or low salience obstacles and in the absence or presence of a pedestrian on the adjacent pavement. Salience and relevance had distinct effects on manoeuvring, depending on the driver's age and FV.

- **Keywords:** older drivers, parking manoeuvres, visual attention, salience, relevance

Pieter Vansteenkiste, Greet Cardon, Renaat Philippaerts & Matthieu Lenoir. Measuring dwell time percentage from head-mounted eye-tracking data – comparison of a frame-by-frame and a fixation-by-fixation analysis. Pages 712-721.

Although analysing software for eye-tracking data has significantly improved in the past decades, the analysis of gaze behaviour recorded with head-mounted devices is still challenging and time-consuming. Therefore, new methods have to be tested to reduce the analysis workload while maintaining accuracy and reliability. In this article, dwell time percentages to six areas of interest (AOIs), of six participants cycling on four different roads, were analysed both frame-by-frame and in a 'fixation-by-fixation' manner. The fixation-based method is similar to the classic frame-by-frame method but instead of assigning frames, fixations are assigned to one of the AOIs. Although some considerable differences were found between the two methods, a Pearson correlation of 0.930 points out a good validity of the fixation-by-fixation method. For the analysis of gaze behaviour over an extended period of time, the fixation-based approach is a valuable and time-saving alternative for the classic frame-by-frame analysis. **Practitioner Summary:** A fixation-by-fixation analysis is compared with a frame-by-frame method to analyse dwell time percentage. Although some considerable differences were found between the two methods, a high correlation indicates that the results are very similar. Therefore the fixation-by-fixation method could be a valuable and time-saving alternative for the frame-by-frame analysis.

- **Keywords:** head-mounted eye tracking, gaze behaviour, eye-tracking methodology, frame-by-frame analysis, dwell time

Michael A. Rupp, Paul Oppold & Daniel S. McConnell. Evaluating input device usability as a function of task difficulty in a tracking task. Pages 722-735.

Game controllers are emerging as a preferred choice for the manual control of unmanned vehicles, but an understanding of their usability characteristics has yet to emerge. We compared the usability of an Xbox 360 game controller in a dual task situation using MATB II to the traditional joystick and keyboard interface in two experiments. In the first experiment, performance with the game controller was associated with fewer tracking errors. In a second experiment, we trained users on the devices, and found that even after training the game controller was still associated with fewer tracking errors as well as higher usability and lower workload ratings. These results are consistent with the idea that game controllers are highly usable input devices and do not require high mental workload to operate, thus making them suitable for complex control tasks. **Practitioner Summary:** Game controllers are being used more often for non-gaming purposes include teleoperation of unmanned vehicles. This research investigates the utility of such devices for complex tasks, especially following extensive practice. The game controller was associated with lower workload and fewer errors, indicating its suitability for complex control tasks.

- **Keywords:** input devices, game controllers, compensatory tracking, joysticks, human-computer interaction

Y. Blache, L. Desmoulins, P. Allard, A. Plamondon & M. Begon. Effects of height and load weight on shoulder muscle work during overhead lifting task. Pages 748-761.

Few musculoskeletal models are available to assess shoulder deeper muscle demand during overhead lifting tasks. Our objective was to implement a musculoskeletal model to assess the effect of lifting height and load on shoulder muscle work. A musculoskeletal model scaled from 15 male subjects was used to calculate shoulder muscle work during six lifting tasks. Boxes containing three different loads (6, 12 and 18 kg) were lifted by the subjects from the waist to shoulder or eye level. After optimisation of the maximal isometric force of the model's muscles, the bio-fidelity of the model was improved by 19%. The latter was able to reproduce the subjects' lifting movements. Mechanical work of the rotator cuff muscles, upper trapezius and anterior deltoid was increased with lifting load and height augmentation. In conclusion, the use of a musculoskeletal model validated by electromyography enabled to evaluate the muscle demand of deep muscles during lifting tasks. **Practitioner Summary:** This study aimed to assess the effect of lifting height and weight lifted on shoulder muscle load. A musculoskeletal model was implemented to calculate the work of shoulder muscles during lifting tasks. The overhead lifting task with the use of a heavy box was the most demanding for the rotator cuff muscles, anterior deltoid and upper trapezius.

- **Keywords:** biomechanics, musculoskeletal model, handling movement, rotator cuff muscles

Robert J. Savage, Mark A. Jaffrey, Daniel C. Billing & Daniel J. Ham. Maximal and sub-maximal functional lifting performance at different platform heights. Pages 762-769.

Introducing valid physical employment tests requires identifying and developing a small number of practical tests that provide broad coverage of physical performance across the full range of job tasks. This study investigated discrete lifting performance across various platform heights reflective of common military lifting tasks. Sixteen Australian Army personnel performed a discrete lifting assessment to maximal lifting capacity (MLC) and maximal acceptable weight of lift (MAWL) at four platform heights between 1.30 and 1.70 m. There were strong correlations between platform height and normalised lifting performance for MLC ($R^2 = 0.76 \pm 0.18, p < 0.05$) and MAWL ($R^2 = 0.73 \pm 0.21, p < 0.05$). The developed relationship allowed prediction of lifting capacity at one platform height based on lifting capacity at any of the three other heights, with a standard error of < 4.5 kg and < 2.0 kg for MLC and MAWL, respectively. **Practitioner Summary:** Physical employment tests must be both practical and reflective of job task demands. This study illustrates the potential for the implementation of a single discrete lifting assessment to predict performance across numerous occupational lifting heights.

- **Keywords:** lifting capacity, maximal acceptable weight of lift, validity, physical employment testing

Alexandra K. Mullins, Liam E. Annett, Jace R. Drain, Justin G. Kemp, Ross A. Clark & Douglas G. Whyte. Lower limb kinematics and physiological responses to prolonged load carriage in untrained individuals. Pages 770-780.

The aim of this study was to simultaneously assess the changes in physiology, and kinematic and spatiotemporal features of gait, during prolonged load carriage in individuals without load carriage experience. Eleven males, representative of new military recruits, walked for 120 min at 5.5 km h^{-1} , 0% grade, on a motorised treadmill while

carrying a 22 kg load. The load ($\leq 30\%$ body mass) was distributed over a weighted vest, combat webbing and replica model firearm, to reflect a patrol order load. Oxygen consumption and heart rate increased throughout the trial; however, apart from a minor increase in step length, there were no changes in the kinematic or spatiotemporal parameters, despite an increase in perceived exertion and discomfort. These data suggest that individuals with no experience in load carriage are able to maintain normal gait during 2 h of fixed speed walking, while carrying a patrol order load $\leq 30\%$ body mass. **Practitioner Summary:** It is presumed that lower limb injury is associated with prolonged load carriage, especially in new military recruits. Our results suggest that prolonged carriage of a 22 kg load does not cause any functionally relevant gross biomechanical changes despite an increase in the physiological demands and perceived intensity of the task.

- **Keywords:** oxygen consumption, cardiovascular drift, kinematics, spatiotemporal, gait analysis, military, 3D motion analysis

Raffaele Spinelli, Giovanna Ottaviani Aalmo & Natascia Magagnotti. The effect of a slack-pulling device in reducing operator physiological workload during log winching operations. Pages 781-790.

The authors conducted a comparative test to determine whether the introduction of a hydraulic slack puller allowed reducing the physiological workload of operators assigned to log winching tasks. The tests were conducted in northern Italy, on the mountains near Como. The study involved five volunteer subjects, considered representatives of the regional logging workforce. Physiological workload was determined by measuring the operators' heart rate upon completion of specific tasks. The slack puller improved the efficiency of downhill winching, since it allowed a single operator to pull out the cable on his own, without requiring the assistance of a colleague. However, introduction of the slack puller did not result in any reductions of operator physiological workload. The main stressor when working on a steep slope is moving up and down the slope: pulling a cable is only a secondary stressor. Any measures targeting secondary stressors are unlikely to produce dramatic reductions of operator workload. **Practitioner Summary:** Five operators were tasked with operating the same winch, with and without a slack puller. Heart-rate measurements showed that introduction of the slack puller did not result in any significant reductions of operator physiological workload, because the main stressor when working on a steep slope is moving up the slope.

- **Keywords:** agriculture ergonomics, equipment design, operator physiological workload, industrial ergonomics

Merav Golebowicz, Yafa Levanon, Ram Palti & Navah Z. Ratzon. Efficacy of a telerehabilitation intervention programme using biofeedback among computer operators. Pages 791-802.

Computer operators spend long periods of time sitting in a static posture at computer workstations and therefore have an increased exposure to work-related musculoskeletal disorders (WRMSD). The present study is aimed at investigating the feasibility and effectiveness of a tele-biofeedback ergonomic intervention programme among computer operators suffering from WRMSD. Twelve subjects with WRMSD were assigned an ergonomic intervention accompanied by remote tele-biofeedback training, which was practised at their workstations. Evaluations of pain symptoms and locations, body posture and psychosocial characteristics were carried out before and after the intervention in the workplace. The hypothesis was partially verified as it showed improved body position at the workstation and decreased pain in some body parts. Tele-biofeedback, as part of an intervention, appears to be feasible and efficient for computer operators who suffer from WRMSD. This study encourages further research on tele-health within the scope of occupational therapy practice. **Practitioner Summary:** Research

concerning tele-health using biofeedback is scarce. The present study analyses the feasibility and partial effectiveness of a tele-biofeedback ergonomic intervention programme for computer operators suffering from WRMSD. The uniqueness and singularity of this study is the usage of remote communication between participants and practitioners through the Internet.

- **Keywords:** tele-health, ergonomic intervention, computer workstation, work-related MSD

Hongchae Baek & Byoung-Kyong Min. *Blue light aids in coping with the post-lunch dip: an EEG study. Pages 803-810.*

The 'post-lunch dip' is a commonly experienced period of drowsiness in the afternoon hours. If this inevitable period can be disrupted by an environmental cue, the result will be enhanced workplace performance. Because blue light is known to be a critical cue for entraining biological rhythms, we investigated whether blue light illumination can be a practical strategy for coping with the post-lunch dip. Twenty healthy participants underwent a continuous performance test, during which the electroencephalogram (EEG) was recorded under four different illumination conditions: dark ($< 0.3 \text{ lx}$), 33% blue-enriched light, 66% blue-enriched light and white polychromatic light. As a result, exposure to blue-enriched light during the post-lunch dip period significantly reduced the EEG alpha activity, and increased task performance. Since desynchronisation of alpha activity reflects enhancement of vigilance, our findings imply that blue light might disrupt the post-lunch dip. Subsequent exploration of illumination parameters will be beneficial for possible chronobiological and ergonomic applications. **Practitioner Summary:** As blue light is a crucial cue to entrain human circadian rhythms, we investigated whether blue light can cope with the post-lunch dip. As a result, blue light significantly improved cognitive performance, and reduced the EEG alpha activity, reflecting enhancement of vigilance. Therefore, blue light helps in avoiding the post-lunch dip.

- **Keywords:** blue light, EEG alpha activity, illumination, post-lunch dip, work efficacy

Tanja Becker, Thomas Penzel & Ingo Fietze. *A new German Charité Jet Lag Scale for jet lag symptoms and application. Pages 811-821.*

Travelling across multiple time zones provokes adaptation of endogenous circadian rhythm to the new time zone. Within the context of previous studies, an English-language state-of-health questionnaire, the Columbia Jet Lag Scale, is the only sufficiently validated scale for jet lag and its symptoms. This study presents a new state-of-health questionnaire in German, one intended to achieve standardisation of surveys on jet lag. The questionnaire was applied to define the baseline for the prevalence of jet lag symptoms based on a reference group ($n = 36$). The jet lag score ascertained was subsequently applied to determine the frequency of jet lag in a group of 53 subjects. Systematic investigation of the frequency of jet lag symptoms had not been previously presented. Among the group of 53 travelling test subjects, 60% demonstrated moderate jet lag symptoms. **Practitioner Summary:** This introduction of the Charité Jet Lag Scale, the first German jet lag questionnaire, calls attention to this topic for the first time since a 2000 publication in *Ergonomics*. Our systematic investigation of jet lag frequency, with the new scale, determined moderate jet lag symptoms among 60% of subjects.

- **Keywords:** circadian rhythm, jet lag, frequency, state-of-health questionnaire, time zone transitions

Gemma J.M. Read, Paul M. Salmon, Michael G. Lenné & Neville A. Stanton. *Designing sociotechnical systems with cognitive work analysis: putting theory back into practice. Pages 822-851.*

Cognitive work analysis (CWA) is a framework of methods for analysing complex sociotechnical systems. However, the translation from the outputs of CWA to design is not straightforward. Sociotechnical systems theory provides values and principles for the design of sociotechnical systems which may offer a theoretically consistent basis for a design approach for use with CWA. This article explores the extent to which CWA and sociotechnical systems theory offer complementary perspectives and presents an abstraction hierarchy (AH), based on a review of literature, that describes an 'optimal' CWA and sociotechnical systems theory design system. The optimal AH is used to assess the extent to which current CWA-based design practices, uncovered through a survey of CWA practitioners, aligns with sociotechnical systems theory. Recommendations for a design approach that would support the integration of CWA and sociotechnical systems theory design values and principles are also derived. **Practitioner Summary:** Cognitive work analysis (CWA) is commonly used by ergonomics practitioners for evaluating complex systems and informing the development of design improvements. Despite this, translation from analysis to design is not straightforward. Building upon synergies between CWA and sociotechnical systems design principles, recommendations for a design toolkit are specified.

- **Keywords:** cognitive work analysis, sociotechnical systems theory, system design, complex systems

Michael A. Nees & Anjali Fortna. *A comparison of human versus virtual interruptions. Pages 852-856.*

Although a wealth of research has examined the effects of virtual interruptions, human-initiated interruptions are common in many work settings. An experiment compared performance on a primary data-entry task during human-initiated (human) versus computer-initiated (virtual) interruptions. Participants completed blocks of trials that featured either an interruption from a computer or an interruption from a human experimenter. The timing of the onset of the interruptions was also varied across trials. Human interruptions resulted in much shorter interruption lags. No significant differences were observed for the number of correct responses on the primary task for human versus virtual interruptions, but interruptions that occurred later in the task sequence resulted in fewer mistakes. The social aspect of human interruptions may have attenuated interruption lags in that condition, and it is possible that virtual interruptions may permit people greater temporal flexibility in managing their engagement with interruptions. **Practitioner Summary:** An experiment compared human- and computer-initiated interruptions of a verbal data-entry task. Human-initiated interruptions resulted in much shorter interruption lags. Virtual interruptions may permit people greater temporal flexibility in managing their engagement with interruptions.

- **Keywords:** interruptions, interruption lag, resumption lag, human-computer interaction, multitasking