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Gyuchan Thomas Jun; James Ward; P. John Clarkson. ***Systems modelling approaches to the design of safe healthcare delivery : ease of use and usefulness perceived by healthcare workers*****. Pages 829 – 847.**

The UK health service, which had been diagnosed to be seriously out of step with good design practice, has been recommended to obtain knowledge of design and risk management practice from other safety-critical industries. While these other industries have benefited from a broad range of systems modelling approaches, healthcare remains a long way behind. In order to investigate the healthcare-specific applicability of systems modelling approaches, this study identified 10 distinct methods through meta-model analysis. Healthcare workers' perception on 'ease of use' and 'usefulness' was then evaluated. The characterisation of the systems modelling methods showed that each method had particular capabilities to describe specific aspects of a complex system. However, the healthcare workers found that some of the methods, although potentially very useful, would be difficult to understand, particularly without prior experience. This study provides valuable insights into a better use of the systems modelling methods in healthcare. **Statement of Relevance:** The findings in this study provide insights into how to make a better use of various systems modelling approaches to the design and risk management of healthcare delivery systems, which have been a growing research interest among ergonomists and human factor professionals.

- **Keywords:** healthcare; patient safety; risk management; system design; systems modelling

Asit Dey; Danny D. Mann. ***Sensitivity and diagnosticity of NASA-TLX and simplified SWAT to assess the mental workload associated with operating an agricultural sprayer*****. Pages 848 – 857.**

The objectives of the present study were: a) to investigate three continuous variants of the NASA-Task Load Index (TLX) (standard NASA (CNASA), average NASA (C1NASA) and principal component NASA (PCNASA)) and five different variants of the simplified subjective workload assessment technique (SSWAT) (continuous standard SSWAT (CSSWAT), continuous average SSWAT (C1SSWAT), continuous principal component SSWAT (PCSSWAT), discrete event-based SSWAT (D1SSWAT) and discrete standard SSWAT (DSSWAT)) in terms of their sensitivity and diagnosticity to assess the mental workload associated with agricultural spraying; b) to compare and select the best

variants of NASA-TLX and SSWAT for future mental workload research in the agricultural domain. A total of 16 male university students (mean 30.4 ± 12.5 years) participated in this study. All the participants were trained to drive an agricultural spraying simulator. Sensitivity was assessed by the ability of the scales to report the maximum change in workload ratings due to the change in illumination and difficulty levels. In addition, the factor loading method was used to quantify sensitivity. The diagnosticity was assessed by the ability of the scale to diagnose the change in task levels from single to dual. Among all the variants of NASA-TLX and SSWAT, PCNASA and discrete variants of SSWAT showed the highest sensitivity and diagnosticity. Moreover, among all the variants of NASA and SSWAT, the discrete variants of SSWAT showed the highest sensitivity and diagnosticity but also high between-subject variability. The continuous variants of both scales had relatively low sensitivity and diagnosticity and also low between-subject variability. Hence, when selecting a scale for future mental workload research in the agricultural domain, a researcher should decide what to compromise: 1) between-subject variability or 2) sensitivity and diagnosticity. **Statement of Relevance:** The use of subjective workload scales is very popular in mental workload research. The present study investigated the different variants of two popular workload rating scales (i.e. NASA-TLX and SSWAT) in terms of their sensitivity and diagnositicity and selected the best variants of each scale for future mental workload research.

- **Keywords:** mental workload; NASA-TLX; SSWAT

W. Payne; J. Harvey. *A framework for the design and development of physical employment tests and standards*. Pages 858 – 871.

Because operational tasks in the uniformed services (military, police, fire and emergency services) are physically demanding and incur the risk of injury, employment policy in these services is usually competency based and predicated on objective physical employment standards (PESs) based on physical employment tests (PETs). In this paper, a comprehensive framework for the design of PETs and PESs is presented. Three broad approaches to physical employment testing are described and compared: generic predictive testing; task-related predictive testing; task simulation testing. Techniques for the selection of a set of tests with good coverage of job requirements, including job task analysis, physical demands analysis and correlation analysis, are discussed. Regarding individual PETs, theoretical considerations including measurability, discriminating power, reliability and validity, and practical considerations, including development of protocols, resource requirements, administrative issues and safety, are considered. With regard to the setting of PESs, criterion referencing and norm referencing are discussed. **Statement of Relevance:** This paper presents an integrated and coherent framework for the development of PESs and hence provides a much needed theoretically based but practically oriented guide for organisations seeking to establish valid and defensible PESs.

- **Keywords:** physical employment standards; physical test development; physical test reliability; physical test validity

Massimiliano Pau; Marco Pau. *Postural sway modifications induced by backpack carriage in primary school children : a case study in Italy*. Pages 872 – 881.

The aim of this investigation is to assess modifications in sway parameters introduced by backpack carriage in Italian primary school children (6-10 years old, n = 447). Two 30-s trials (without and with backpack) were performed directly at a school on a regular school day to collect data on sway area, centre of pressure path length and maximum displacement range in antero-posterior and medio-lateral directions. The results show a significant load-induced increase in all sway parameters and the existence of a linear relationship between sway area and backpack weight. Since postural sway represents an effective indicator of balance abilities, the alterations observed suggest that backpack

carriage originates balance impairment and thus may increase the risk of unintentional falls in children. **Statement of Relevance:** Loss of balance is among the primary causes of unintentional falls and postural sway represents an effective indicator of balance abilities. In this study, sway parameters were assessed in primary school children wearing backpacks. The differences that were observed show that backpack carriage potentially increases the risk of falls.

- **Keywords:** backpack; centre of pressure; children; postural sway; posturography

Kiwon Park; Pilwon Hur; Karl S. Rosengren; Gavin P. Horn; Elizabeth T. Hsiao-Wecksler. *Effect of load carriage on gait due to firefighting air bottle configuration*. Pages 882 – 891.

The air bottle configuration (mass and size) used with a firefighter's self-contained breathing apparatus may affect functional gait performance and slip/trip/fall risk, contributing to one of the most common and costly fire ground injuries to this population. To examine the potential effect of bottle mass and size on firefighter gait performance, four 30-min air bottle configurations were tested. To quantify biomechanical gait performance, kinetic and kinematic gait data were collected on 24 male firefighters while walking at normal and fast speeds during three conditions (no obstacle, 10 cm or 30 cm stationary obstacle). Bottle mass, obstacle height and walking speed - but not bottle size - were found to significantly impact gait parameters. Ten subjects (42%) contacted the taller obstacle while wearing heavier bottles, suggesting greater risk for tripping. Heavier bottles also resulted in larger forces by the trailing leg in both the anterior-posterior and vertical directions, suggesting greater risk for slipping. These results suggest that increased bottle weight may result in a decrease in gait performance and an increase in fall risk. **Statement of Relevance:** Occupations, such as firefighting, often require use of a self-contained breathing apparatus that includes a pressurised air bottle. No systematic assessment has investigated how modest changes in load carriage due to bottle configuration (mass and size) might affect gait behaviour, especially when crossing obstacles. Bottle mass, but not size, was found to decrease gait performance and increase fall risk.

- **Keywords:** firefighting; gait performance; ground reaction force; obstacle crossing; self-contained breathing apparatus

Thurmon E. Lockhart; Wen Shi. *Effects of age on dynamic accommodation*. Pages 892 – 903.

Visual accommodation plays a critical role in one's visual perception and activities of daily living. Age-related accommodation loss poses an increased risk to older adults' safety and independence. Although extensive effort has been made towards understanding the effect of age on steady-state accommodation, dynamic aspects of accommodation is still unknown. A study was therefore conducted to investigate age-related dynamic accommodative characteristics utilising a modified autorefractor. Ten individuals from each of three age groups (i.e. younger group: 20 to 29 years old; middle-aged group: 40 to 49 years old; older group: 60 to 69 years old) were recruited and their dynamic accommodation responses were examined. The laboratory experiment was designed to assess dynamic accommodation associated with an abrupt change from a constant far target (400 cm, 50 cd/m^2) to a near target (70 cm, 100 cd/m^2 or 20 cd/m^2), which aimed to simulate car dashboard reading behaviour while driving. The results of the study indicated that age and target intensity both had a significant impact on dynamic accommodation. These effects were attributed to both the age-related physiological limitation of the eye as well as to central neural processing delay. A method of measuring dynamic accommodation and the implications of the study are discussed. **Statement of Relevance:** The results of the study indicate that age and target intensity both have a significant impact on dynamic accommodation. These effects are attributed to age-

related physiological limitation of the eye as well as central neural processing delay and to decreased sensitivity of the cone photoreceptors. To enhance the visual performance of the ageing population involving dynamic accommodation, target distance and target light intensity should be carefully evaluated to facilitate effective viewing.

- **Keywords:** accommodation; ageing; autorefractor; dynamic accommodation; light intensity; vision

B. Mateo; R. Porcar-Seder; J. S. Solaz; J. C. Dürsteler. *Experimental procedure for measuring and comparing head–neck–trunk posture and movements caused by different progressive addition lens designs*. Pages 904 – 913.

This study demonstrates that appropriate measurement procedures can detect differences in head movement in a near reading task when using three different progressive addition lenses (PALs). The movements were measured using an anatomical reference system with a biomechanical rationale. This reference system was capable of representing rotations for comparing head flexion relative to trunk, head flexion relative to neck, head rotation relative to trunk and trunk flexion. The subject sample comprised 31 volunteers and three PAL designs with different viewing zones were selected. Significant differences were found between the lenses for three of the seven movement parameters examined. The differences occurred for both vertical and horizontal head movements and could be attributed to aspects of the PAL design. The measurement of the complete kinematic trunk-neck-head chain improved the number of differences that were found over those in previous studies. **Statement of Relevance:** The study proposes a methodology based on a biomechanical rationale able to differentiate head-neck-trunk posture and movements caused by different progressive addition lens designs with minimum invasiveness. This methodology could also be applied to analyse the ergonomics of other devices that restrict the user's field of view, such as helmets, personal protective equipment or helmet-mounted displays for pilots. This analysis will allow designers to optimise designs offering higher comfort and performance.

- **Keywords:** biomechanics; ergonomic tools and methods; health care ergonomics; user testing

Susanne Mayr; Axel Buchner. *After-effects of TFT-LCD display polarity and display colour on the detection of low-contrast objects*. Pages 914 – 925.

Participants performed a word-non-word discrimination task within a car control display emulated on a thin film transistor liquid-crystal display (TFT-LCD). The task simulated an information read-out from a TFT-LCD-based instrument panel. Subsequently, participants performed a low-contrast object detection task that simulated the detection of objects during night-time driving. In experiment 1, words/non-words were presented black-on-white (positive polarity) or white-on-black (negative polarity). In experiments 2 and 3, display colour was additionally manipulated. A positive polarity advantage in the discrimination task was consistently observed. In contrast, positive displays interfered more than negative displays with subsequent detection. The detrimental after-effect of positive polarity displays was strong with white and blue, reduced with amber and absent with red displays. Subjective measures showed a preference for blue over red, but a slight advantage for amber over blue. Implications for TFT-LCD design are derived from the results. **Statement of Relevance:** When using TFT-LCDs as car instrument panels, positive polarity red TFT-LCDs are very likely to lead to good instrument readability while at the same time minimising - relative to other colours - the negative effects of an illuminated display on low-contrast object detection during night-time driving.

- **Keywords:** display colour; display polarity; night-time driving; TFT-LCD