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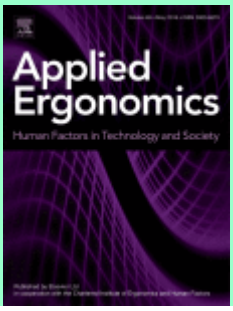

Jianwei Niu, He Geng, Yijing Zhang, Xiaoping Du. *Relationship between automation trust and operator performance for the novice and expert in spacecraft rendezvous and docking (RVD)*. Pages 1-8.

Operator trust in automation is a crucial factor influencing its use and operational performance. However, the relationship between automation trust and performance remains poorly understood and requires further investigation. The objective of this paper is to explore the difference in trust and performance on automation-aided spacecraft rendezvous and docking (RVD) between the novice and the expert and to investigate the relationship between automation trust and performance as well. We employed a two-factor mixed design, with training skill (novice and expert) and automation mode (manual RVD and automation aided RVD) serving as the two factors. Twenty participants, 10 novices and 10 experts, were recruited to conduct six RVD tasks for two automation levels. After the tasks, operator performance was recorded by the desktop hand-held docking training equipment. Operator trust was also measured by a 12-items questionnaire at the beginning and end of each trial. As a result, automation narrowed the performance gap significantly between the novice and the expert, and the automation trust showed a marginally significant difference between the novice and the expert. Furthermore, the result demonstrated that the attitude angle control error of the expert was related to the total trust score, whereas other automation performance indicators were not related to the total score of trust. However, automation performance was related to the dimensions of trust, such as entrust, harmful, and dependable.

- **Keywords:** Automation aided; Automation trust; Automation performance; Spacecraft rendezvous and docking (RVD)

Mark Dennison, Michael D'Zmura. *Effects of unexpected visual motion on postural sway and motion sickness*. Pages 9-16.

Motion sickness is thought to occur when the brain's assumptions about incoming sensory information do not match the actual signals received. These signals must involve the vestibular system for motion sickness to occur. In this paper, we describe an experiment in which subjects experienced unexpected visual motions, or perturbations, as they navigated a virtual environment (VE) while standing and wearing a head mounted display (HMD) or while viewing a monitor. We found that postural instability, as measured by a balance board, increased with time only when perturbations were present. HMD users exhibited greater sway when exposed to visual perturbations than did monitor users. Yet motion sickness increased only when an HMD was used and occurred with or without participants undergoing perturbations. These results suggest

that the postural instability which is generated by unexpected visual perturbation does not necessarily increase the likelihood of motion sickness in a virtual environment.

- **Keywords:** Virtual reality; Motion sickness; Postural instability

Barys Shyrokau, Joost De Winter, Olaf Stroosma, Chris Dijksterhuis, Jan Loof, Rene van Paassen, Riender Happee. *The effect of steering-system linearity, simulator motion, and truck driving experience on steering of an articulated tractor-semitrailer combination*. Pages 17-28.

Steering systems of trucks consist of many linkages, which introduce nonlinearities that may negatively affect steering performance. Nowadays, it is possible to equip steering systems with actuators that provide artificial steering characteristics. However, before new steering systems are deployed in real vehicles, evaluation in a safe and controlled simulator environment is recommended. A much-debated question is whether experiments need to be performed in a motion-base simulator or whether a fixed-base simulator suffices. Furthermore, it is unknown whether simulator-based tests can be validly conducted with a convenience sample of university participants who have not driven a truck before. We investigated the effect of steering characteristic (i.e., nonlinear vs. linear) on drivers' subjective opinions about the ride and the steering system, and on their objective driving performance in an articulated tractor-semitrailer combination. Thirty-two participants (12 truck drivers and 20 university drivers) each completed eight 5.5-min drives in which the simulator's motion system was either turned on or off and the steering model either resembled a linear (i.e., artificial) or nonlinear (i.e., realistic) system. Per drive, participants performed a lane-keeping task, merged onto the highway, and completed four overtaking manoeuvers. Results showed that the linear steering system yielded less subjective and objective steering effort, and better lane-keeping performance, than the nonlinear system. Consistent with prior research, participants drove a wider path through curves when motion was on compared to when motion was off. Truck drivers exhibited higher steering activity than university drivers, but there were no significant differences between the two groups in lane keeping performance and steering effort. We conclude that for future truck steering systems, a linear system may be valuable for improving performance. Furthermore, the results suggest that on-centre evaluations of steering systems do not require a motion base, and should not be performed using a convenience sample of university students.

Peter Cocron, Isabel Neumann, Maria Kreußlein, Daniel Wanner, Maxim Bierbach, Josef F. Krems. *Regenerative braking failures in battery electric vehicles and their impact on the driver*. Pages 29-37.

A unique feature of battery electric vehicles (BEV) is their regenerative braking system (RBS) to recapture kinetic energy in deceleration maneuvers. If such a system is triggered via gas pedal, most deceleration maneuvers can be executed by just using this pedal. This impacts the driving task as different deceleration strategies can be applied. Previous research has indicated that a RBS failure leading to a sudden reduced deceleration represents an adverse event for BEV drivers. In the present study, we investigated such a failure's impact on the driver's evaluation and behavior. We conducted an experiment on a closed-off test track using a modified BEV that could temporarily switch off the RBS. One half of the 44 participants in the study received information about an upcoming RBS failure whereas the other half did not. While 91% of the drivers receiving prior information noticed the RBS failure, only 48% recognized it in the "uniformed" group. In general, the failure and the perception of its occurrence influenced the driver's evaluation and behavior more than receiving prior information. Nevertheless, under the tested conditions, drivers kept control and were able to compensate for the RBS failure. As the participants drove quite simple maneuvers in our experiment, further studies are needed to validate our findings using more complex

driving settings. Given that RBS failures could have severe consequences, appropriate information and warning strategies for drivers are necessary.

- **Keywords:** Battery electric vehicles; Regenerative braking; Controllability; Failures; Traffic safety

Sonja de Groot, Femke Bos, Jorine Koopman, Aldo E. Hoekstra, Riemer J.K. Vegter. *The effect of a novel square-profile hand rim on propulsion technique of wheelchair tennis players*. Pages 38-44.

The purpose of this study was to investigate the effect of a square-profile hand rim (SPR) on propulsion technique of wheelchair tennis players. Eight experienced wheelchair tennis players performed two sets of three submaximal exercise tests and six sprint tests on a wheelchair ergometer, once with a regular rim (RR) and once with a SPR. Torque and velocity were measured continuously and power output and timing variables were calculated. No significant differences were found in propulsion technique between the RR and SPR during the submaximal tests. When sprinting with the racket, the SPR showed a significantly lower overall speed (9.1 vs. 9.8 m s−1), maximal speed (10.5 vs. 11.4 m s−1), and maximal acceleration (18.6 vs. 10.9 m s−2). The SPR does not seem to improve the propulsion technique when propelling a wheelchair with a tennis racket in the hand. However, the results gave input for new hand rim designs for wheelchair tennis.

- **Keywords:** Wheelchair tennis; Task performance and analysis; Torque; Design; Wheelchair ergonomics

Caroline Brum Rosso, Tarcisio Abreu Saurin. *The joint use of resilience engineering and lean production for work system design: A study in healthcare*. Pages 45-56.

Although lean production (LP) has been increasingly adopted in healthcare systems, its benefits often fall short of expectations. This might be partially due to the failure of lean to account for the complexity of healthcare. This paper discusses the joint use of principles of LP and resilience engineering (RE), which is an approach for system design inspired by complexity science. Thus, a framework for supporting the design of socio-technical systems, which combines insights from LP and RE, was developed and tested in a system involving a patient flow from an emergency department to an intensive care unit. Based on this empirical study, as well as on extant theory, eight design propositions that support the framework application were developed. Both the framework and its corresponding propositions can contribute to the design of socio-technical systems that are at the same time safe and efficient.

- **Keywords:** Resilience engineering; Lean production; Healthcare; Emergency department; Design science research

Vera Schellewald, Jens Kleinert, Rolf Ellegast. *Use and physiological responses of portable dynamic office workstations in an occupational setting – A field study*. Pages 57-64.

Objective: The aim of this study was to investigate the use of two types of dynamic workstations (Deskbike, activeLife Trainer) and their effects on physiological activation in an occupational setting. **Methods:** 30 employees were given access to the devices for 28 days. Frequency and duration of borrowing and use was recorded by a Chipcard-system. Physiological activation (energy expenditure, heart rate) while working in a seated position and using the workstations was measured with the activity tracker Fitbit Charge HR. **Results:** Participants used dynamic workstations on 40% of their working days for

an average of 54.3 ± 23.9 min per day. Energy expenditure and heart rate increased significantly while using the workstations compared to working seated. The Deskbike was used more frequently and resulted in greater heart rate elevation. **Conclusion:** Both types of dynamic workstations were used by the employees and had positive effects on physiological activation. The implementation of either type can be recommended.

- **Keywords:** Dynamic workstations; Physiological activation; Occupational setting

Shenghui Liu, Yunxia Qu, Shujun Hou, Kai Li, Xinye Li, Yang Zhai, Yunxiao Ji. *Comfort evaluation of a subject-specific seating interface formed by vibrating grains*. Pages 65-72.

Sitting is the most common posture for work in offices, and spinal cord injury (SCI) patients who are wheelchair dependent spend 10.6 h per day seated in wheelchairs. Thus, the comfort of subject-specific interfaces is increasingly important for the well-being of patients and office workers. This paper introduces a new method of forming a subject-specific interface, based on vibrating grains. Twenty subjects (10 females and 10 males) participated in the sitting test. Interface comfort was evaluated using the pressure distribution and subjective rating methods. Five seating interface types were compared. The results showed that compared with a flat interface, the interfaces formed by vibrating grains had a significantly reduced peak contact pressure (PeakCP) (by more than 58.03%), and that PeakCP was highly correlated with the comfort rating ($R = -0.533$) and discomfort rating($R = -0.603$). This new method shows promise for guiding the future development of customized seating interfaces.

- **Keywords:** Subject-specific interface; Pressure distribution; Subjective rating

Amanda Waleh Åström, Marina Heiden, Svend Erik Mathiassen, Annika Strömberg. *Uncertainty in monetary cost estimates for assessing working postures using inclinometry, observation or self-report*. Pages 73-77.

Objective: To assess uncertainty in cost estimates for collecting posture data by inclinometry, observations and self-report. **Method:** In a study addressing physical workloads at a paper mill, costs were calculated for measuring postures of twenty-eight workers during three shifts. Uncertainty in costs was assessed for all three methods as the range between an assumed best case (lowest cost) and worst case (highest cost) using scenario analysis. **Results:** The cost for observation was larger, but also more uncertain (€16506 and €89552 in the best and worst case, respectively) than that of inclinometry (€7613 - €45896). Self-report costs were both lower and less uncertain (€3743 - €23368). **Conclusions:** The extent of uncertainty in cost estimates implies that observation could be less expensive than inclinometry, e.g., in a scenario where experienced observers could use existing software, while inclinometers would have to be purchased. We propose adding uncertainty assessments to cost estimates when selecting a method for measuring working postures, and offer guidance in how to proceed in a specific setting.

- **Keywords:** Cost components; Scenario analysis; Exposure assessment

Jeong Ho Kim, Luz S. Marin, Jack T. Dennerlein. *Evaluation of commercially available seat suspensions to reduce whole body vibration exposures in mining heavy equipment vehicle operators*. Pages 78-86.

As mining vehicle operators are exposed to high level of Whole body vibration (WBV) for prolonged periods of time, approaches to reduce this exposure are needed for the specific types of exposures in mining. Although various engineering controls (i.e. seat suspension

systems) have been developed to address WBV, there has been lack of research to systematically evaluate these systems in reducing WBV exposures in mining heavy equipment vehicle settings. Therefore, this laboratory-based study evaluated the efficacy of different combinations of fore-aft (x-axis), lateral (y-axis), and vertical (z-axis) suspensions in reducing WBV exposures. The results showed that the active vertical suspension more effectively reduced the vertical vibration (~50%; p's < 0.0001) as compared to the passive vertical suspension (10%; p's < 0.11). The passive fore-aft (x-axis) and lateral (y-axis) suspension systems did not attenuate the corresponding axis vibration (p's > 0.06) and sometimes amplified the floor vibration, especially when the non-vertical vibration was predominant (p's < 0.02). These results indicate that there is a critical need to develop more effective engineering controls including better seat suspensions to address non-vertical WBV exposures, especially because these non-vertical WBV exposures can increase risks for adverse health effects including musculoskeletal loading, discomfort, and impaired visual acuity.

- **Keywords:** Engineering control; Lateral vibration; Musculoskeletal disorders; Mining vehicles; Seat suspension; Professional drivers; Low back pain

Vanessa Riethmeister, Ute Bültmann, Marijke Gordijn, Sandra Brouwer, Michiel de Boer. *Investigating daily fatigue scores during two-week offshore day shifts*. Pages 87-94.

Objectives: This study examined daily scores of fatigue and circadian rhythm markers over two-week offshore day shift periods. **Methods:** A prospective cohort study among N = 60 offshore day-shift workers working two-week offshore shifts was conducted. Offshore day shifts lasted from 07:00 – 19:00 h. Fatigue was measured objectively with pre- and post-shift scores of the 3-minute psychomotor vigilance tasks (PVT-B) parameters (reaction times, number of lapses, errors and false starts) and subjectively with pre- and post-shift Karolinska Sleepiness Scale (KSS) ratings. Evening saliva samples were collected on offshore days 2,7 and 13 to measure circadian rhythm markers such as dim-light melatonin onset times and cortisol. Generalized and linear mixed model analyses were used to examine daily fatigue scores over time. **Results:** Complete data from N = 42 offshore day shift workers was analyzed. Daily parameters of objective fatigue, PVT-B scores (reaction times, average number of lapses, errors and false starts), remained stable over the course of the two-week offshore day shifts. Daily subjective post-shift fatigue scores significantly increased over the course of the two-week offshore shifts. Each day offshore was associated with an increased post-shift subjective fatigue score of 0.06 points (95%CI: .03 - .09 p < .001). No significant statistical differences in subjective pre-shift fatigue scores were found. Neither a circadian rhythm phase shift of melatonin nor an effect on the pattern and levels of evening cortisol was found. **Conclusion:** Daily parameters of objective fatigue scores remained stable over the course of the two-week offshore day shifts. Daily subjective post-shift fatigue scores significantly increased over the course of the two-week offshore shifts. No significant changes in circadian rhythm markers were found. Increased post-shift fatigue scores, especially during the last days of an offshore shift, should be considered and managed in (offshore) fatigue risk management programs and fatigue risk prediction models.

- **Keywords:** Cortisol; Fatigue risk management; Melatonin; Occupational health; Safety; Sleepiness

Chantelle C. Lachance, Alexandra M.B. Korall, Colin M. Russell, Fabio Feldman, Stephen N. Robinovitch, Dawn C. Mackey. *Hand forces exerted by long-term care staff when pushing wheelchairs on compliant and non-compliant flooring*. Pages 95-101.

Purpose-designed compliant flooring and carpeting have been promoted as a means for reducing fall-related injuries in high-risk environments, such as long-term care. However, it is not known whether these surfaces influence the forces that long-term care staff exert when pushing residents in wheelchairs. We studied 14 direct-care staff who pushed a loaded wheelchair instrumented with a triaxial load cell to test the effects on hand force of flooring overlay (vinyl versus carpet) and flooring subfloor (concrete versus compliant rubber [brand: SmartCells]). During straight-line pushing, carpet overlay increased initial and sustained hand forces compared to vinyl overlay by 22–49% over a concrete subfloor and by 8–20% over a compliant subfloor. Compliant subflooring increased initial and sustained hand forces compared to concrete subflooring by 18–31% when under a vinyl overlay. In contrast, compliant flooring caused no change in initial or sustained hand forces compared to concrete subflooring when under a carpet overlay.

- **Keywords:** Compliant flooring; Push forces; Manual materials handling; Nursing and nursing systems; Wheelchair; Usability testing and evaluation