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**Special Section: Keynote Addresses From the 18th
Triennial Congress of the International Ergonomics
Association**



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**Andrew S. Imada. *Preface to the Special Section: A Context for the
Keynote Addresses at the 18th IEA Triennial Congress. S 879-880.***

This special edition contains several of the keynote addresses presented at IEA2012, the 18th Triennial Congress of the International Ergonomics Association (IEA). This was a truly international event with attendees from more than 49 countries. Those of us who attended IEA2012 witnessed an important point in history. This was the first IEA Congress to be held in Latin America, which drew more than 300 attendees from the region. The decision to hold this IEA Congress in this part of the world showed the foresight of the IEA officers and council who made that decision and the courage of the Associação Brasileira de Ergonomia (ABERGO) for taking on this groundbreaking challenge. The location, representation, and diverse content reflected the current global realities, growth potential, and composition of the IEA.

**William S. Marras. *The Complex Spine: The Multidimensional System of
Causal Pathways for Low-Back Disorders. S. 881-889.***

Objective: The aim of this study was to examine the logic behind the knowledge of low-back problem causal pathways. **Background:** Low-back pain and low-back disorders (LBDs) continue to represent the major musculoskeletal risk problem in the workplace, with the prevalence and costs of such disorders increasing over time. In recent years, there has been much criticism of the ability of ergonomics methods to control the risk of LBDs. **Method:** Logical assessment of the systems logic associated with our understanding and prevention of LBDs. **Results:** Current spine loading as well as spine tolerance research efforts are bringing the field to the point where there is a better systems understanding of the inextricable link between the musculoskeletal system and the cognitive system. Loading is influenced by both the physical environment factors as well as mental demands, whereas tolerances are defined by both physical tissue tolerance and biochemically based tissue sensitivities to pain. However, the logic used in many low-back risk assessment tools may be overly simplistic, given what is understood about causal pathways. Current tools typically assess only load or position in a very cursory manner. **Conclusion:** Efforts must work toward satisfying both the physical environment and the cognitive environment for the worker if one is to reliably lower the

risk of low-back problems. **Application:** This systems representation of LBD development may serve as a guide to identify gaps in our understanding of LBDs.

- **Keywords:** health and medical systems, biomechanics, anthropometry, work physiology, aging and individual differences, attentional processes

Kazutaka Kogi. *Practical Ways to Facilitate Ergonomics Improvements in Occupational Health Practice.* S. 890-900.

Objective: Recent advances in participatory pro-grams for improving workplace conditions are discussed to examine practical ways to facilitate ergonomics improvements. **Background:** Participatory training programs are gaining importance, particularly in promoting occupational health and safety in small-scale workplaces. These pro-grams have led to many improvements that can reduce work-related risks in varied situations. **Materials:** Recent experiences in participatory action-oriented training programs in small workplaces and agriculture are reviewed. The emphasis of the review is on training steps, types of improvements achieved, and the use of action tools by trainers and training participants. **Results:** Immediate improvements in multiple technical areas are targeted, including materials handling, workstation design, physical environment, welfare facilities, and work organization. In facilitating ergonomics improvements in each local situation, it is important to focus on (a) building on local good practices; (b) applying practical, simple improvements that apply the basic principles of ergonomics; and (c) developing action-oriented toolkits for direct use by workers and managers. This facilitation process is effective when locally designed action toolkits are used by trainers, including local good examples, action checklists, and illustrated how-to guides. Intervention studies demonstrate the effectiveness of participatory steps that use these toolkits in promoting good practices and reducing work-related risks. **Conclusion:** In facilitating ergonomics improvements in small-scale workplaces, it is important to focus on practical, low-cost improvements that build on local good practices. The use of action-oriented toolkits reflecting basic ergonomics principles is helpful. The promotion of the intercountry networking of positive experiences in participatory training is suggested.

- **Keywords:** ergonomics improvements, occupational health practice, work-related risks, small-scale workplaces, action-oriented toolkits

Elías Apud. *Ergonomics in Mining: The Chilean Experience.* S. 901-907.

Objective: The objective of this article is to analyze the current state of knowledge regarding ergonomics in Chilean mining. **Background:** Information has been gathered during the past 15 years from studies of Chilean miners.

Method: This article is based on a compilation of information of 700 workplaces where physical, mental, environmental, and organizational loads were evaluated with a systemic approach. **Results:** The results of the Chilean experience reveal that it is important to overcome the concept of "static" ergonomics focused on workplaces that may be valid for offices and machine operation but not for a significant number of miners who will be moving around workstations located in systems of different complexity. The consequence of these complex and dynamic work situations is that more than 50% of absenteeism for health reasons is attributed to musculoskeletal disorders, and there are no standard recommendations that universally apply. The results showed that these problems can be tackled by implementing participatory programs. **Conclusion:** The main conclusion of the Chilean experience is that there is a need to continue advancing from diagnostic studies to participatory interventions. At the same time, it is imperative that all new investments in plants, small or large, include considerations of relevant ergonomic concepts from the early planning stages. It is also important to increase ergonomic training within companies, including not only the managers who make major

decisions but also the workers who are directly affected by the lack of ergonomics. **Application:** It is expected that this description of the Chilean experience may be useful for other countries where mining is also a source of income and employment.

- **Keywords:** participatory ergonomics, training, self-care, innovation, savings

Kapila Jayaratne. *Inculcating the Ergonomic Culture in Developing Countries: National Healthy Schoolbag Initiative in Sri Lanka.* S. 908-924.

Objective: The aim of this article is to describe a survey on ergonomic factors of classroom environments of school children, their influence on health, and use of research outcomes to launch a healthy schoolbag initiative. **Background:** Ergonomics have not yet well penetrated relevant fields in industrially developing countries, such as Sri Lanka. One of the crucial parameters of the school environment is ergonomics. Available evidence suggests ergonomic mismatches in classroom settings. Good practice examples in child ergonomic interventions are few in resource-poor contexts. **Method:** A school-based cross-sectional study was conducted in a district in Sri Lanka with a sample of 1,607 children in Grades 6 to 8 with the use of a stratified multistage cluster sampling method. **Results:** Many children did experience discomfort related to substandard seating arrangements in the classroom. A significant proportion had to turn their necks to see the blackboard. For many children, seating locations were not changed. There were widespread incompatibilities of classroom furniture with anthropometric dimensions of children. A majority of children perceived discomfort contributed by mismatched classroom furniture. Carriage of school materials was not healthy. Deficiencies were noted in weight, model, ergonomic features, and carrying behavior of bags. Children experienced several negative effects, in part attributable to mismatched ergonomic factors. **Application:** The schoolbag was considered a priority issue. Findings were disseminated to stakeholders and to media. Solutions were contemplated on bag weight reduction, healthy schoolbag introduction, and behavior change in a collaborative initiative with the Education Ministry. Political, administrative, and business stakeholders were successfully engaged to inculcate an ergonomic culture in an industrially developing country.

- **Keywords:** backpack, school environment, school ergonomics, ergonomics for children, school health promotion

Barbara A. Silverstein, Stephen S. Bao, Steven Russell, and Kate Stewart. *Water and Coffee: A Systems Approach to Improving Coffee Harvesting Work in Nicaragua.* S. 925-939.

Objective: The aim of this study was to reduce the physical load on coffee-harvesting workers while maintaining productivity. **Background:** Coffee is second to oil in commodity trading. Water is becoming scarce worldwide. The global virtual water footprint for one cup of coffee is 140 liters. Shade-grown coffee is one approach to reducing the water footprint. **Method:** A participatory ergonomics approach was used during two Nicaraguan shade-grown coffee harvesting seasons to reduce the physical load on harvesters with the use of a newly designed bag instead of a basket strapped around the waist. **Results:** Productivity in the mountainous, shade-grown coffee farms was maintained while physical load on the worker was improved somewhat. Among basket users, 84.2% reported pain in at least one body area compared with 78.9% of bag users (*ns*). Nonetheless, 74% of participants liked the bag "much better" than the basket. Workers identified ways the bag could be improved further with the use of local materials. These suggestions included (a) reducing the horizontal distance of the bag to reduce reach and (b) having waterproof material on the bag between the worker and the bag to reduce moisture and damage to the berries. There was no difference in productivity between using the bag and using the small basket. **Conclusions:** Workers

are extending this participatory approach to how to get the harvested coffee cherries down the mountain other than carrying 40-kg bags on their backs. The ultimate goal is to make the coffee-harvesting bag design available to harvesters around the world.

- **Keywords:** coffee farming, participatory ergonomics, musculoskeletal disorders

Dave Moore and Tim Barnard. *With Eloquence and Humanity? Human Factors/Ergonomics in Sustainable Human Development*. S. 940-951.

This article is based on a keynote presentation given at the 18th Congress of the International Ergonomics Association in Recife, Brazil, February 2012. It considers new, and not so new, approaches and practical roles for the emerging field of human factors/ergonomics (HFE) in sustainable development (SD). The material for this article was largely drawn from the literature in the fields of human development, sustainability, climate change mitigation and adaptation, and social/environmental impact assessment. Identifying the role of HFE in SD is not a simple one and from the outset is complicated by the widely differing ideas in the sustainability literature about what exactly it is we are hoping to sustain. Is it individual companies, business models, cultures, or the carrying capacity of our planet? Or combinations of these? For the purposes of this article, certain assumptions are made, and various emerging opportunities and responsibilities associated with our changing world of work are introduced. First, there are new versions of traditional tasks for us, such as working with the people and companies in the renewable energy sectors. Beyond this, however, it is suggested that there are emerging roles for HFE professionals in transdisciplinary work where we might play our part, for example, in tackling the twinned issues of climate change and human development in areas of significant poverty. In particular we have the tools and capabilities to help define and measure what groups have reason to value, and wish to sustain. It is suggested, that to do this effectively, however, will require a philosophical shift, or perhaps just a philosophical restatement at a collective level, regarding who and what we ultimately serve.

- **Keywords:** sustainability, sustainable human development, HFE in sustainable development, future of HFE

Andréa Aparecida da Luz, Miryam Cristina Mazieiro Vergueiro da Silva, Samantha Lemos Turte, Marildo de Oliveira Lopes, and Frida Marina Fischer. *Effects of Working Full-Time and Studying in the Evening Hours Among Young Apprentices and Trainees*. S. 952-963.

Objective: This research aims to assess apprentices' and trainees' work conditions, psychosocial factors at work, as well as health symptoms after joining the labor force. **Background:** Despite the fact that there are over 3.5 million young working students in Brazil, this increasing rate brings with it difficult working conditions such as work pressure, heavy workloads, and lack of safety training. **Method:** This study was carried out in a nongovernmental organization (NGO) with 40 young members of a first job program in the city of São Paulo, Brazil. They filled out a comprehensive questionnaire focused on sociodemographic variables, working conditions, and health symptoms. Individual and collective semi-structured interviews were conducted. Empirical data analysis was performed using analysis of content. **Results:** The majority of participants mentioned difficulties in dealing with the pressure and their share of responsibilities at work. Body pains, headaches, sleep deprivation during the workweek, and frequent colds were mentioned. Lack of appropriate task and safety training contributed to the occurrence of work injuries. **Conclusion:** Having a full-time job during the day coupled with evening high school attendance may jeopardize these people's health and future. **Application:** This study can make a contribution to the revision and implementation of

work training programs for adolescents. It can also help in the creation of more sensible policies regarding youth employment.

- **Keywords:** teenage working students, employment, decent work, health symptoms

Francisco Rebelo, Paulo Noriega, Emília Duarte, and Marcelo Soares. *Using Virtual Reality to Assess User Experience*. S. 964-982.

Objective: The aim of this article is to discuss how user experience (UX) evaluation can benefit from the use of virtual reality (VR). **Background:** UX is usually evaluated in laboratory settings. However, considering that UX occurs as a consequence of the interaction between the product, the user, and the context of use, the assessment of UX can benefit from a more ecological test setting. VR provides the means to develop realistic-looking virtual environments with the advantage of allowing greater control of the experimental conditions while granting good ecological validity. **Method:** The methods used to evaluate UX, as well as their main limitations, are identified. The current VR equipment and its potential applications (as well as its limitations and drawbacks) to overcome some of the limitations in the assessment of UX are highlighted. **Results:** The relevance of VR for UX studies is discussed, and a VR-based framework for evaluating UX is presented. **Conclusion:** UX research may benefit from a VR-based methodology in the scopes of user research (e.g., assessment of users' expectations derived from their lifestyles) and human-product interaction (e.g., assessment of users' emotions since the first moment of contact with the product and then during the interaction). **Application:** This article provides knowledge to researchers and professionals engaged in the design of technological interfaces about the usefulness of VR in the evaluation of UX.

- **Keywords:** user experience, virtual reality, virtual environments, technological interfaces, context of use

Waldemar Karwowski. *A Review of Human Factors Challenges of Complex Adaptive Systems: Discovering and Understanding Chaos in Human Performance*. S. 983-995.

Objective: In this paper, the author explores a need for a greater understanding of the true nature of human-system interactions from the perspective of the theory of complex adaptive systems, including the essence of complexity, emergent properties of system behavior, nonlinear systems dynamics, and deterministic chaos. **Background:** Human performance, more often than not, constitutes complex adaptive phenomena with emergent properties that exhibit nonlinear dynamical (chaotic) behaviors. **Methods:** The complexity challenges in the design and management of contemporary work systems, including service systems, are explored. Examples of selected applications of the concepts of nonlinear dynamics to the study of human physical performance are provided. **Results:** Understanding and applications of the concepts of theory of complex adaptive and dynamical systems should significantly improve the effectiveness of human-centered design efforts of a large system of systems. **Conclusion:** Performance of many contemporary work systems and environments may be sensitive to the initial conditions and may exhibit dynamic nonlinear properties and chaotic system behaviors. Human-centered design of emergent human-system interactions requires application of the theories of nonlinear dynamics and complex adaptive system. **Application:** The success of future human-systems integration efforts requires the fusion of paradigms, knowledge, design principles, and methodologies of human factors and ergonomics with those of the science of complex adaptive systems as well as modern systems engineering.

- **Keywords:** complex adaptive systems, human–systems interactions, system of systems, nonlinear dynamics, deterministic chaos, emergent behaviors, human– systems integration

Attentional Processes

François Vachon, Benoît R. Vallières, Dylan M. Jones, and Sébastien Tremblay. *Nonexplicit Change Detection in Complex Dynamic Settings: What Eye Movements Reveal*. S. 996-1007.

Objective: We employed a computer-controlled command-and-control (C2) simulation and recorded eye movements to examine the extent and nature of the inability to detect critical changes in dynamic displays when change detection is implicit (i.e., requires no explicit report) to the operator's task. **Background:** Change blindness—the failure to notice significant changes to a visual scene—may have dire consequences on performance in C2 and surveillance operations. **Method:** Participants performed a radar-based risk-assessment task involving multiple subtasks. Although participants were not required to explicitly report critical changes to the operational display, change detection was critical in informing decision making. Participants' eye movements were used as an index of visual attention across the display. **Results:** Nonfixated (i.e., unattended) changes were more likely to be missed than were fixated (i.e., attended) changes, supporting the idea that focused attention is necessary for conscious change detection. The finding of significant pupil dilation for changes undetected but fixated suggests that attended changes can nonetheless be missed because of a failure of attentional processes. **Conclusion:** Change blindness in complex dynamic displays takes the form of failures in establishing task-appropriate patterns of attentional allocation. **Application:** These findings have implications in the design of change-detection support tools for dynamic displays and work procedure in C2 and surveillance.

- **Keywords:** change detection, focused attention, dynamic displays, command and control, eye tracking, pupillometry, microworld

Automation, Expert Systems

Karen M. Feigh, Michael C. Dorneich, and Caroline C. Hayes. *Toward a Characterization of Adaptive Systems: A Framework for Researchers and System Designers*. S.1008-1024.

Objective: This article presents a systematic framework characterizing adaptive systems. **Background:** Adaptive systems are those that can appropriately modify their behavior to fit the current context. This concept is appealing because it offers the possibility of creating computer assistants that behave like good human assistants who can provide what is needed without being asked. However, the majority of adaptive systems have been experimental rather than practical because of the technical challenges in accurately perceiving and interpreting users' current cognitive state; integrating cognitive state, environment, and task information; and using it to predict users' current needs. The authors anticipate that recent developments in neurological and physiological sensors to identify users' cognitive state will increase interest in adaptive systems research and practice over the next few years. **Method:** To inform future efforts in adaptive systems, this work provides an organizing framework for characterizing adaptive systems, identifying considerations and implications, and suggesting future research issues. **Results:** A two-part framework is presented that (a) categorizes ways in which adaptive systems can modify their behavior and (b) characterizes trigger mechanisms through which adaptive systems can sense the current situation and decide how to adapt. **Conclusion:** The framework provided in this article

provides a tool for organizing and informing past, present, and future research and development efforts in adaptive systems.

- **Keywords:** adaptive systems, adaptive automation, adaptable automation, dynamic function allocation

Cognitive Processes

Curtis Craig, Martina I. Klein, John Griswold, Krishnanath Gaitonde, Thomas McGill, and Ari Halldorsson. *Using Cognitive Task Analysis to Identify Critical Decisions in the Laparoscopic Environment*. S.1025-1039.

Objective: The aim of this study was to identify the critical decisions surgeons need to make regarding laparoscopic surgery, the information these decisions are based on, the strategies employed by surgeons to reach their objectives, and the difficulties experienced by novices. **Background:** Laparoscopic training focuses on the development of technical skills. However, successful surgical outcomes are also dependent on appropriate decisions made during surgery, which are influenced by critical cues and the use of appropriate strategies. Novices might not be as adept at cue detection and strategy use. **Method:** Participants were eight attending surgeons. The authors employed task-analytic techniques to identify critical decisions inherent in laparoscopy and the cues, strategies, and novice traps associated with these decisions. **Results:** The authors used decision requirements tables to organize the data into the key decisions made during the preoperative, operative, and postoperative phases as well as the cues, strategies, and novice traps associated with these decisions. Key decisions identified for the preoperative phase included but were not limited to the decision of performing a laparoscopic versus open surgery, necessity to review the literature, practicing the procedure, and trocar placement. Some key decisions identified for the operative phase included converting to open surgery, performing angiograms, cutting tissue or organs, and reevaluation of the approach. Only one key decision was identified for the postoperative phase: whether the surgeon's technique needs to be evaluated and revised. **Conclusion:** The laparoscopic environment requires complex decision making, and novices are prone to errors in their decisions. **Application:** The information elicited in this study is applicable to laparoscopic training.

- **Keywords:** minimally invasive surgery, surgical training, strategies, novice traps

Colin Ware and Roland Arsenault. *Target Finding With a Spatially Aware Handheld Chart Display*. S. 1040-1052.

Objective: The objective was to evaluate the use of a spatially aware handheld chart display in a comparison with a track-up fixed display configuration and to investigate how cognitive strategies vary when performing the task of matching chart symbols with environmental features under different display geometries and task constraints. **Background:** Small-screen devices containing both accelerometers and magnetometers support the development of spatially aware handheld maps. These can be designed so that symbols representing targets in the external world appear in a perspective view determined by the orientation of the device. **Method:** A panoramic display was used to simulate a marine environment. The task involved matching targets in the scene to symbols on simulated chart displays. In Experiment 1, a spatially aware handheld chart display was compared to a fixed track-up chart display. In Experiment 2, a gaze monitoring system was added and the distance between the chart display and the scene viewpoint was varied. **Results:** All respondents were faster with the handheld device. Novices were much more accurate with the handheld device. People allocated their gaze very differently if they had to move between a map display and a view of the

environment. **Conclusion:** There may be important benefits to spatially aware handheld displays in reducing errors relating to common navigation tasks. **Application:** Both the difficulty of spatial transformations and the allocation of attention should be considered in the design of chart displays.

- **Keywords:** handheld chart, spatially aware display, attention, map reading

Communication Systems

Xu Xu, Chien-Chi Chang, Gert S. Faber, Idsart Kingma, and Jack T. Dennerlein. *Estimating 3-D L5/S1 Moments During Manual Lifting Using a Video Coding System: Validity and Interrater Reliability.* S. 1053-1065.

Objective: The aim of the study was to investigate the validity and interrater reliability of using a proposed video coding system to estimate the dynamical 3-D L5/S1 joint moment on the basis of four key frames from video clips of asymmetric lifting tasks. **Background:** L5/S1 joint loading has been widely adopted to quantify low-back loading during lifting tasks. However, the measurement of L5/S1 joint loading usually requires a laboratory environment, which cannot be applied during field surveys. **Method:** The validity of this system was investigated by comparing the estimated L5/S1 joint moments of various simulated lifting tasks with motion tracking system-based reference L5/S1 joint moments. **Results:** The comparison showed that the video coding system yielded good estimates on peak moment ($r = .91$, average absolute error [AAE] = 20.3 Nm) and cumulative moment ($r = .88$, AAE = 22.5 Nm·sec) of the sagittal plane. The interrater reliability of this system was assessed among 10 raters who used this system. The intraclass correlation ranged between .51 and .89 for the moments of different planes. **Conclusion:** The results of the validity and interrater reliability analyses showed that the proposed video coding system could provide a good estimate of total L5/S1 joint loading on the basis of side-view video clips of the simulated lifting tasks. **Application:** Although it was not as accurate as a motion tracking system for L5/S1 joint loading calculations, this approach can be an alternative for back load estimation for some lifting configurations when the use of motion tracking systems is not possible.

- **Keywords:** video coding, lifting, L5/S1 moment

Consumer Products, Tools

Mohsen Makhsous, Fang Lin, David Hanawalt, Shannon Lynn Kruger, and Angie LaMantia. *The Effect of Chair Designs on Sitting Pressure Distribution and Tissue Perfusion.* S. 1066-1074.

Objective: The aim of this study was to investigate the effect of five chair designs on interface pressure distribution and tissue perfusion in the buttock-thigh region. **Background:** Prolonged sitting has been found to contribute to the symptoms of work-related low back pain. Studies have found that chair design affects users' sitting posture and comfort. As sitting applies pressure to the user, it is necessary to investigate how chair design affects sitting pressure and tissue perfusion during sitting. **Method:** We tested five chair designs (Suspension A, Suspension B, Foam A, Foam B, and bicompliant) on 15 young, healthy females. Sitting interface pressure and buttock-thigh tissue perfusion (in terms of transcutaneous partial pressure of oxygen and carbon dioxide, $tcPO_2$ and $tcPCO_2$, respectively) were measured during 10-min sitting on each chair. **Results:** We found that chair design significantly affected the distribution of the sitting pressure ($p < .001$) and buttock-thigh tissue perfusion ($p < .023$). Average pressure and total contact area were found highest in both foam designs, and the average pressure was the lowest in one of the suspension designs. Across all tested chair designs, the anterior portion of the seat sustained the lowest contact pressure. It was

also found that $tcPO_2$ was the lowest ($p < .003$) and $tcPCO_2$ was the highest ($p < .001$) in tissue around ischial tuberosity for all chair designs. **Conclusion:** Chair design and materials of the seat significantly affect the sitting interface pressure distribution and tissue perfusion in sitting area. Further evaluation of these outcomes may provide useful information to correlate chair design with sitting comfort.

- **Keywords:** office chair design, sitting posture, interface pressure, low back pain

Health and Medical Systems

Meike Jipp. *Individual Differences and Their Impact on the Safety and the Efficiency of Human-Wheelchair Systems.* S. 1075-1086.

Objective: The extent to which individual differences in fine motor abilities affect indoor safety and efficiency of human-wheelchair systems was examined. **Background:** To reduce the currently large number of indoor wheelchair accidents, assistance systems with a high level of automation were developed. It was proposed to adapt the wheelchair's level of automation to the user's ability to steer the device to avoid drawbacks of highly automated wheelchairs. The state of the art, however, lacks an empirical identification of those abilities. **Method:** A study with 23 participants is described. The participants drove through various sections of a course with a powered wheelchair. Repeatedly measured criteria were safety (numbers of collisions) and efficiency (times required for reaching goals). As covariates, the participants' fine motor abilities were assessed. **Results:** A random coefficient modeling approach was conducted to analyze the data, which were available on two levels as course sections were nested within participants. The participants' aiming, precision, and arm-hand speed contributed significantly to both criteria: Participants with lower fine motor abilities had more collisions and required more time for reaching goals. **Conclusion:** Adapting the wheelchair's level of automation to these fine motor abilities can improve indoor safety and efficiency. In addition, the results highlight the need to further examine the impact of individual differences on the design of automation features for powered wheelchairs as well as other applications of automation. **Application:** The results facilitate the improvement of current wheelchair technology.

- **Keywords:** level of automation, human-machine interaction, fine motor abilities, assistance systems, multilevel regression model, random coefficient modeling

Kristen Miller, Mark Benden, Adam Pickens, Eva Shipp, and Qi Zheng. *Ergonomics Principles Associated With Laparoscopic Surgeon Injury/Illness.* S. 1087-1092.

Objective: This study sought to investigate the prevalence of laparoscopic surgeon injury/illness symptoms and evaluate associations between symptoms and operating room ergonomics. **Background:** Although laparoscopic procedures significantly benefit patients in terms of decreased recovery times and improved outcomes, they contribute to mental fatigue and musculoskeletal problems among surgeons. A variety of ergonomic interventions and applications are implemented by surgeons to reduce health problems. Currently, there is a gap in knowledge regarding a surgeon's individual assessment of the operating room, an assessment that, in turn, would prompt the implementation of these interventions. **Method:** A new survey instrument solicited information from surgeons ($N = 61$) regarding surgeon demographics, perception, frequency of operating room equipment adjustment, and self-reported symptoms. Surgeons responded to questions addressing safety, ergonomics, and fatigue in the operating room, using a 5-point Likert-type scale that included the option *undecided*. **Results:** Surgeons who responded *undecided* were more likely to experience symptoms of injury/illness than respondents

who were able to assess the features of their operating rooms. Symptoms were experienced by 100% of participants. The most prevalent symptoms were neck stiffness, back stiffness, and back pain. **Conclusion:** This study supports hypotheses that surgeons are experiencing body part discomfort and indicators of fatigue that may be associated with performing laparoscopy. Results suggest that awareness, knowledge, and utilization of ergonomic principles could protect surgeons against symptoms that lead to occupational injury. **Application:** The purpose of this brief report is to convey the importance of ergonomic principles in the operating room, specific to laparoscopic surgery and surgeon injury/illness symptoms.

- **Keywords:** surgeon, injury, assessment, operating room, fatigue

Psychomotor Processes

Mary K. Ngo, Russell S. Pierce, and Charles Spence. *Using Multisensory Cues to Facilitate Air Traffic Management*. S. 1093-1103.

Objective: In the present study, we sought to investigate whether auditory and tactile cuing could be used to facilitate a complex, real-world air traffic management scenario. **Background:** Auditory and tactile cuing provides an effective means of improving both the speed and accuracy of participants' performance in a variety of laboratory-based visual target detection and identification tasks. **Method:** A low-fidelity air traffic simulation task was used in which participants monitored and controlled aircraft. The participants had to ensure that the aircraft landed or exited at the correct altitude, speed, and direction and that they maintained a safe separation from all other aircraft and boundaries. The performance measures recorded included en route time, handoff delay, and conflict resolution delay (the performance measure of interest). In a baseline condition, the aircraft in conflict was highlighted in red (visual cue), and in the experimental conditions, this standard visual cue was accompanied by a simultaneously presented auditory, vibrotactile, or audiotactile cue. **Results:** Participants responded significantly more rapidly, but no less accurately, to conflicts when presented with an additional auditory or audiotactile cue than with either a vibrotactile or visual cue alone. **Conclusion:** Auditory and audiotactile cues have the potential for improving operator performance by reducing the time it takes to detect and respond to potential visual target events. **Application:** These results have important implications for the design and use of multisensory cues in air traffic management.

- **Keywords:** multisensory cuing, auditory cuing, vibrotactile cuing, temporal cuing, air traffic control, visual target detection, attention, multisensory facilitation

Surface Transportation Systems

Yulan Liang, John D. Lee, and Lora Yekhshatyan. *How Dangerous Is Looking Away From the Road? Algorithms Predict Crash Risk From Glance Patterns in Naturalistic Driving*. S. 1104-1116.

Objective: In this study, the authors used algorithms to estimate driver distraction and predict crash and near-crash risk on the basis of driver glance behavior using the data set of the 100-Car Naturalistic Driving Study. **Background:** Driver distraction has been a leading cause of motor vehicle crashes, but the relationship between distractions and crash risk lacks detailed quantification. **Method:** The authors compared 24 algorithms that varied according to how they incorporated three potential contributors to distraction—glance duration, glance history, and glance location—on how well the algorithms predicted crash risk. **Results:** Distraction estimated from driver eye-glance patterns was positively associated with crash risk. The algorithms incorporating ongoing off-road glance duration predicted crash risk better than did the algorithms incorporating

glance history. Augmenting glance duration with other elements of glance behavior—1.5th power of duration and duration weighted by glance location—produced similar prediction performance as glance duration alone. **Conclusions:** The distraction level estimated by the algorithms that include current glance duration provides the most sensitive indicator of crash risk. **Application:** The results inform the design of algorithms to monitor driver state that support real-time distraction mitigation systems.

- **Keywords:** distraction estimation, algorithm development, driver distraction, eye-glance patterns

Gustav Markkula, Ola Benderius, Krister Wolff, and Mattias Wahde. A Review of Near-Collision Driver Behavior Models. S.1117-1143.

Objective: This article provides a review of recent models of driver behavior in on-road collision situations. **Background:** In efforts to improve traffic safety, computer simulation of accident situations holds promise as a valuable tool, for both academia and industry. However, to ensure the validity of simulations, models are needed that accurately capture near-crash driver behavior, as observed in real traffic or driving experiments. **Method:** Scientific articles were identified by a systematic approach, including extensive database searches. Criteria for inclusion were defined and applied, including the requirement that models should have been previously applied to simulate on-road collision avoidance behavior. Several selected models were implemented and tested in selected scenarios. **Results:** The reviewed articles were grouped according to a rough taxonomy based on main emphasis, namely avoidance by braking, avoidance by steering, avoidance by a combination of braking and steering, effects of driver states and characteristics on avoidance, and simulation platforms. **Conclusion:** A large number of near-collision driver behavior models have been proposed. Validation using human driving data has often been limited, but exceptions exist. The research field appears fragmented, but simulation-based comparison indicates that there may be more similarity between models than what is apparent from the model equations. Further comparison of models is recommended. **Application:** This review provides traffic safety researchers with an overview of the field of driver models for collision situations. Specifically, researchers aiming to develop simulations of on-road collision accident situations can use this review to find suitable starting points for their work.

- **Keywords:** driver behavior, models, simulation, collisions, accidents, crashes, avoidance