Institute *Insider*

The Newsletter of the Institute for Ergonomics at The Ohio State University

At the forefront of Human Factors since 1950 Volume 7, No. 1, Winter, 2004

Cognitive Systems Engineering Consortium Formed

Several members of the Institute for Ergonomics have joined the Cognitive Systems Engineering Consortium. CSEC officially began in the autumn of 2003 as part of the Wright Brothers Institute.

The purpose of the Consortium is to organize cognitive systems engineering professionals and promote their work to government and industry.

Organizations currently a part of the Consortium include Ohio State's Institute for Ergonomics, the Psychology Department at Wright State University (Dayton, Ohio), the Industrial & Systems Engineering Department at Georgia Institute of Technology (Atlanta, Georgia), Klein Associates (Fairborn, Ohio), Riso National Lab (Denmark), and the University of Linkoping in Sweden.

A kickoff Computer Systems Engineering workshop was held October 29th - 31st, 2003, which attracted approximately 200 regional, national, and international participants.

Several Institute members gave lectures at this workshop. They included:

- **David Woods**, *Supporting Cognitive Work* and *Future of Collaborative Work*
- **Phil Smith**, **Nadine Sarter**, and **James Tittle**, *Building Expertise*

Abstracts of the presentations given at the CSE Workshop can be found at: www.cognitive-systems.org/workshop/.

"Technology continues to greatly enrich our lives, increasing our ability to manage complex data, and in many cases enhancing productivity. However, not all of the promises of technology have been realized (e.g., paperless offices, increased leisure time, and increased safety). Automation systems that were intended to empower humans often overwhelm us with data, surprise us with unexpected actions, and impede our understanding of situations. The result is that we are beginning to reassess the relations among humans, science, and technology. Cognitive Systems Engineering is an emerging discipline that integrates across the classical disciplines of cognitive and engineering sciences with the goal of a deeper understanding of socio-technical systems. It is hoped that this understanding will contribute to the design of systems where humans are empowered to adapt creatively to the demands of an increasingly complex world."

Americans Feel Immune to Workplace Injuries

More than half of all working Americans don't think a workplace injury will happen to them, according to a 2003 study released by Missouri Employers Mutual Insurance (MEM), Missouri's largest writer of workers compensation insurance.

StrategyOne of Chicago conducted MEM's workplace attitude study. The telephone survey was completed among a national sample of employed adults in March, 2003. The margin of error on a sample of 614 is ±4 percentage points.

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In *This* Issue . . .

Institute *for* Ergonomics

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On the Move

In October, 2003, **Stuart Zweben** spoke on *The Changing State of Computing* at the Northwest Ohio Computer Science Conference in Bowling Green, Ohio.

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In November 2003, **William Marras** was inducted into the Wayne State University's College of Engineering Hall of Fame. This award is given to distinguished engineering alumni who have made significant career achievements.

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David Woods received a $585,000 research award from NASA. This project will begin in June, 2004 and run through September, 2006.

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Stuart Zweben is the Principal Investigator of a grant totaling nearly $60,000, which was received from the Honda Research Institute USA, to study *Advanced Research Trends of Computer and Information Science*. This project, begun in July 2003, will run through June, 2004.

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Emily Patterson has become an Advisory Board Member for ECRI's *Health Technology Forecast*, which identifies developing healthcare technologies and those soon to emerge from the research pipeline into the marketplace. ECRI (formerly the Emergency Care Research Institute) is an independent nonprofit health services research agency, whose mission is to promote the highest standards of safety, quality, and cost-effectiveness in healthcare to benefit patient care through research, publishing, education, and consultation.

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ABET and Software Engineering Education was the focus of a presentation given by **Stuart Zweben** at the Frontiers in Education Conference in Westminster, Colorado (November 2003).

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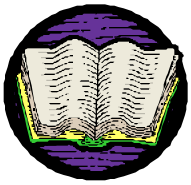

Newly released publications written by Institute members include:

Mistaking Error, David D. Woods and Richard I. Cook, in B. J. Youngberg and M. J. Hatlie (Eds.), *Patient Safety Handbook*, Jones and Bartlett, 2003.

❖

Securing the Future of U.S. Air Transportation: A System in Peril, David D. Woods (member of the Committee on Aeronautics Research and Technology for Vision 2050, Studies and Information Services, National Research Council), National Academies Press, Washington DC, 2003.

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Understanding the Complexity of Registered Nurse Work in Acute Care Settings, Patricia R. Ebright, Emily S. Patterson, Barbara A. Chalko, and Marta L. Render, *Journal of Nursing Administration*, 33(12), 630-638, 2003.

❖

Using Observational Study as a Tool for Discovery: Uncovering Cognitive and Collaborative Demands and Adaptive Strategies, E. M. Roth and Emily S. Patterson, in H. Montgomery, R. Lipshitz, and B. Brehmer, (Eds.), *How Professionals Make Decisions*, Mahwah, NJ: Lawrence Erlbaum Associates, 2004.

❖

Why Pilots Miss the Green Box: How Display Context Undermines Attention Capture, Mark I. Nikolic, James M. Orr, and Nadine B. Sarter, The International Journal of Aviation Psychology, 14(1), 39–52, 2004.

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Selected Research Abstracts

Message Overload from the Inbox to Intelligence Analysis: How Spam and Blogs Point to New Tools

David Tinapple and **David D. Woods**

Abstract: Patterns of responses to "message overload" can be seen in the ways in which people adapt messaging systems and capabilities. Blogging is an effective and increasingly popular decentralized form of group communication that is proving useful in helping people find and share what is informative. We look to blogging for clues to new solutions to the problem of "data overload" in the world of email. These design solutions to email overload go beyond efforts to block spam, and are based on shifting the basic unit of organization toward communication relationships that allow patterns in communications to emerge.

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Comparing Findings from Cognitive Engineering Evaluations

Emily Patterson and José Orlando Gomes

Abstract: Cognitive engineering evaluations are broader in scope than the more common usability test. In particular, organizational, team, and contextual factors that impact system "usefulness" are incorporated. In this paper, we propose a framework of factors commonly considered in cognitive engineering evaluations and illustrate the use of the framework in comparing findings from evaluations of two tools: HIV clinical reminders and a search and browse tool for intelligence analysts.

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Differences in the Use of Bar Code Mediciation Administration in Acute Care and Long-Term Care Settings

Emily Patterson and Roger Chapman

Abstract: In this paper, we explore how the use of a software package, Bar Code Medication Administration (BCMA), differs in acute care and long-term care settings. Direct observation of BCMA use during medication administration was conducted on acute care and long-term care wards in a small, medium, and large hospital. The following differences were found for all three hospitals: 1) Acute care ward nurses used more detailed printed reports to plan medication passes and detect errors in ordering and dispensing than on the long-term care wards; 2) Barcoded wristbands were scanned more frequently to identify patients on acute care than long-term care wards (53% vs. 8%); and 3) Nurses administered medications immediately after scanning and opening medication packets more frequently on acute care than long-term care wards (93% vs. 23%). The findings highlight the need to tailor the BCMA software for the long-term care setting in order to improve patient safety.

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HFES Activities

Student HFES Chapter Begun

Ergonomics graduate students at Ohio State have established a student chapter of the Human Factors & Ergonomics Society. The newly elected officers are:

- **Bill Hess**, President
- **Sahika Vatan**, Secretary/Program Chair
- **Jeff Hoyle**, Treasurer
- **Molly Waters**, Webmaster

Dr. Carolyn Sommerich and Dr. Gary Allread are currently serving as chapter advisors.

There are currently 27 members. More details, including upcoming events and membership information, can be found on the chapter's newly created web site, http://hfes.org.ohio-state.edu.

Institute Participation at the 47th Annual HFES Meeting

Members and students of the Institute were very active at the 47th Annual Meeting of the Human Factors and Ergonomics Society, held October 13th - 17th, 2003, in Denver, Colorado. Their involvement is summarized below, with Institute members' names in boldface.

Panels

Human Factors Challenges in Future Air Traffic Management

Raja Parasuraman, Earl Stein, **Philip J. Smith**, and Kevin Corker

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Human-Robot Coordination

Rene de Pontbriand, Jean Scholtz, **David D. Woods**, Sue Archer, Mica Endsley, and Alan Schultz

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Importance of Ergonomics for the Aging Worker

James Grosch, Don Chaffin, Mark Redfern, **William S. Marras**, and Sara Czaja

Lectures

The Cognitive Engineering of Everyday Activities

Lawrence Shattuck and **Jodi Obradovich**

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Compression and Shear Loads on Lumbar Spine Motion Segments in Neutral and Flexed Postures

Sean Gallagher, **William Marras**, Alan Litsky, and **Deb Burr**

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Converging on Error Management: A Review of Current Findings and Future Needs

Mark I. Nikolic and **Nadine B. Sarter**

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Design Concepts for Distributed Work Systems: An Empirical Investigation into Distributed Teams in Complex Domains

Jodi Obradovich and **Philip J. Smith**

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The Effects of Personality Type and Stress on Muscle Activity during Simulated Work Tasks

Naomi Glasscock, Gary Mirka, **Carolyn M. Sommerich**, and Katherine Klein

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Elicitation by Critiquing: An Exploratory Study

Janet Miller, **Emily S. Patterson**, and **David D. Woods**

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Estimation of EMG Activity of Trunk Muscles in Manual Lifting Tasks Based on Trunk Dynamics Using the Fuzzy Relational Rule Network

Waldemar Karwowski, Adam Gaweda, **William S. Marras**, Kermit Davis, and Jacek Zurada

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How Are We Doing? Presenting System Confidence Information to Support Trust Calibration and Adaptive Function Allocation

John M. McGuirl and **Nadine B. Sarter**

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Message Overload from the Inbox to Intelligence Analysis: How Spam and Blogs Point to New Tools

David Tinapple and **David D. Woods**

Symposia

The Messy Details: Insights from Technical Work Studies in Health Care

Richard Cook & **David D. Woods**

A Summit for People & Technology

IN THE NEWS

In November, 2003, **Roger Chapman** took a new job with CHI Systems, Inc. He will be working as a Senior Cognitive Engineer in Fort Washington, Pennsylvania, just outside of Philadelphia. Roger's initial assignment will be to work on a Close Air Support training application for the Navy. Over time, he expects to work in multiple domains (such as working on military, aviation, and medical applications), conducting cognitive task and cognitive work analysis, as well as developing systems for both training and decision support that are realistic, useable, and useful. Roger can now be reached at 215-542-1400 or rchapman@chisystems.com.

Graduate Student News

New Student

Riley Splittstoesser
(splittstoesser.1@osu.edu)
Advisor: William S. Marras
Hometown: Urbana, Illinois

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Sean Gallagher successfully defended his doctoral dissertation and graduated during Autumn quarter, 2003. The subject of his research was "Effects of Torso Flexion on Fatigue Failure of the Human Lumbosacral Spine." Dr. Gallagher's advisor was Dr. William Marras.

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Under advisor William Marras, **Kevin Butler** graduated with his Masters degree during Autumn quarter, 2003. His thesis was titled, *A Regression Model for Predicting Peak Compressive Spine Loads during Asymmetric Lifting Tasks for Inexperienced Lifters Over the Course of a Work Day*.

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Erich Theado successfully defended his Masters thesis and graduated during Autumn quarter, 2003. His thesis was, "Modification of an EMG-Assisted Biomechanical Model: For Pushing and Pulling Applications." Erich's advisor was Dr. William Marras.

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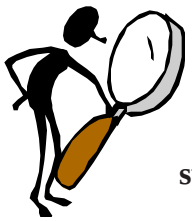

Research Corner

This issue of the Bulletin summarizes research conducted by recent graduates

Effects of Torso Flexion on Fatigue Failure of the Human Lumbosacral Spine

Sean Gallagher, PhD
Advisor: William S. Marras

Dissertation Abstract

Twelve fresh, frozen lumbosacral spines were dissected into three motion segments (L_1-L_2, L_3-L_4, and L_5-S_1). Care was taken to reproduce the postures, spinal loads, and loading rates associated with lifting a 9 kg box in three torso flexion angles.

An EMG-assisted model was used to develop loads and load rates at three torso flexion angles (0, 22.5, and 45 degrees). Motion segments were randomly assigned to torso flexion postures using a partially-balanced incomplete block design.

Specimens were potted in trays containing polymethylmethacrylate, with proper flexion angles being confirmed using multiple radiographs during fixation. Motion segments were placed in a humidified environmental chamber at 37 deg C, creep-loaded for 15 minutes, and then repetitively loaded at 0.33 Hz (up to 10,000 cycles) using an MTS servohydraulic test frame [Bionix 858, MTS Systems, Eden Prairie, MN]. Failure was defined as displacement of the specimen by 10 mm (after creep loading).

Torso flexion angle had an immense impact on fatigue life ($p < 0.0001$). Motion segments loaded in the 0 degree condition averaged 8,253 cycles to failure ($\pm$ 2,895), specimens at 22.5 degrees lasted 3,257 ($\pm$ 4,443), while those at 45 degrees lasted an average of 263 ($\pm$ 646) cycles. No differences in fatigue life was observed by lumbar level or flexion x level interaction ($p > 0.05$).

Logistic regression uncovered associations between specific damage patterns and loading and/or motion segment characteristics. As examples, stellate endplate fractures were associated with less degenerated discs ($p < 0.01$) and increased shear forces ($p < 0.05$), while lateral endplate fractures were seen in larger segments ($p < 0.01$). Damage to facets was more common at 0 degrees torso flexion ($p < 0.01$). Results of this study imply greatly increased risk of fatigue failure of spinal tissues while lifting in flexed torso postures.

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Modification of an EMG-Assisted Biomechanical Model: For Pushing and Pulling Applications

Erich Theado, MS
Advisor: William S. Marras

Thesis Summary

The goal of this study is to modify an EMG-assisted biomechanical model to be more sensitive to tasks involving pushing and pulling. The modified model has been used in numerous studies to evaluate a variety of lifting tasks. This increased sensitivity will result from changes in muscle geometry and modeled muscle physiology.

As the spine deviates from the neutral upright posture muscle length undergoes lengthening or shortening depending on its orientation relative to the spine. These changes affect the muscle's ability to produce force and counteract external loads, which is known as the muscle's length-strength relationship. A muscle's length-strength has been proven to vary depending on the architecture and geometry of the muscle. This has strong implications when modeling muscles for spine loading predictions.

Muscle area and geometry modification were made to an existing EMG-assisted free dynamic model. These modifications render the current empirically derived length-strength relationships invalid because they were based on preexisting muscle geometry. The preexisting length-strength relationship was based on the erector spinae muscle group, which has considerably different muscular architecture than the rectus abdominis musculature.

Thus, empirically derived length-strengths were developed to independently represent the flexor and extensor musculature. Four subjects were used to derive these new relationships, which were then incorporated into the model for validation. It was then exercised over several lifting, pushing, and pulling conditions to assess the effect of these adjustments on its ability to predict externally measured spinal moments. Results found that the modification made to the preexisting EMG-driven model did not strongly affect the model performance during lifting or pulling but did greatly improve the model performance during pushing.

Using this newly derived model, a sequence of pushing and pulling tasks was analyzed to assess spinal loads. Exertions were categorized by task (pushing or pulling), handle height (50%, 65%, and 80% of subject's stature), and cart weight (158 kg, 192 kg, and 226 kg). Results indicated significantly different spine loads when pushing compared to pulling at different height levels. Under the current experimental conditions, spine loads were not found to be biomechanically problematic for any of the independent variables. This conclusion was most likely a result of the low level of exertion force required to perform these tasks.

A Regression Model for Predicting Peak Compressive Spine Loads during Asymmetric Lifting Tasks for Inexperienced Lifters Over the Course of a Work Day

Kevin Butler, MS
Advisor: William S. Marras

Thesis Summary

The objective of this study was to develop a simple regression equation to estimate maximum compressive spine loads during dynamic, asymmetric lifting over the course of a workday, using an EMG-assisted dynamic biomechanical model. Lab-based models have been developed to provide accurate compressive spine load values, but they are expensive, time-consuming, and impractical for use in industry.

This research presents a regression model to predict L_5-S_1 compressive spine loads using working condition variables that have been neglected in the past, such as lift frequency, to predict values over the course of an entire work day.

Seven males and one female participated in six (eight-hour) lifting sessions, each at a different lifting frequency. Data from four subjects were used to build a regression model and four were used to validate the results. The most prognostic variables collected from two different lab apparatus were used, to predict maximum spinal compression values during an asymmetric lift. This model was based on values computed using a dynamic EMG-assisted biomechanical model developed in the Biodynamics Lab at The Ohio State University.

This work produced a model using, as input variables: lifting frequency; load weight; maximum clockwise (CW) torso moment; maximum CW twisting moment; maximum CW lateral moment; maximum flexion angle position; maximum right lateral bend position; maximum CW twisting deceleration; and an interaction of time elapsed throughout a lifting session and maximum force in the positive forward direction. The final model was able to explain 78% of the variability in the lift. Model testing was able to show a fairly accurate prediction of maximum compressive spinal load for inexperienced subjects but performed poorly for experienced lifters.

This research shows the importance and complexity of one's internal musculature when performing a manual handling task involving lifting or twisting. This internal vs. external balance is achieved primarily through two types of muscle recruitment methods. For portions of a task that are purely sagittal, a single set of muscles is primarily used, but for more dynamic activities, additional muscles are recruited to control motion. Muscle coactivity from these dynamic activities can lead to increased spinal loading.

Institute Co-Sponsors Conference

The Institute for Ergonomics is a proud academic co-sponsor for the 7th Annual Applied Ergonomics conference. As the core assembly of the ergonomics community, this conference is the leading forum for presenting ergonomics applications.

The AEC will be held March 8th - 11th, 2004, at the Rosen Centre Hotel in Orlando, Florida. More information is available at the conference's web site, www.appliedergo.org.

Workplace Injuries

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A total of 64.1% of working Americans disagreed with the statement that a workplace injury will happen to them, and 53.4% said the odds are slim that a work injury will make them permanently disabled. Nearly half said they think about themselves or a loved one getting injured on the job a few times a year or less.

The reality is very different, says MEM Loss Prevention Manager Steve Holmes. In 2001, 3.9 million people—more than the populations of North Dakota, Montana, Wyoming and Nebraska combined—experienced a disabling injury, according to the National Safety Council. This excludes injuries resulting from the Sept. 11 terrorist attacks. Major contributors include overexertion, coming into contact with an object or piece of equipment, and falls.

"Many employees adopt the 'It won't happen to me' attitude when it comes to workplace safety," Holmes says. "The reality is workplace injuries can and do happen. Employees need to understand they are not immune to their devastating effects and work with their employers to prevent them."

Workplace deaths are also plaguing America's workforce. Excluding Sept. 11, 5,300 people died on the job in 2001, the last year numbers are available from the National Safety Council. That's up 6% from 2000. Leading causes include transportation incidents, assaults and violent acts, and contact with objects and equipment.

Employees admit they could be more safety conscious at work.

According to the MEM study, nearly three out of four employees admit they could be more safety conscious at work, and more than 95% say they should take a more proactive role in ensuring that injuries don't happen.

Employees also think workplace safety is their employer's responsibility. 95.7% of respondents say employers are responsible for creating a safe environment for employees.

These numbers are particularly troublesome, Holmes says, because they show that employees understand the need for workplace safety but are not willing to take the responsibility to ensure a workplace injury doesn't happen to them or a co-worker.

"Employers are caught in a real catch-22," Holmes says. "Workplace injuries are disabling America's workforce, and yet employees are unwilling to take on the personal responsibility involved in preventing them."

Holmes says five main attitudes contribute to all on-the-job injuries and deaths. Employees must change these opinions if they want to be safe on the job.

- "It won't happen to me"—Employees feel they are immune to workplace injuries.
- "I've done this job before"—Long-time employees think experience is a substitute for safety.
- "Safety training is not important"—Employees aren't interested in safety training.
- "I don't have time"—Company demands often take precedence over safety.
- "It's not my job"—Employees think their employers are responsible for safety.

Workplace injuries are also costing employers money. On average, each disabling workplace injury costs $29,000, and each workplace death totals $1.02 million. Collectively, all workplace injuries in the U.S. in 2001 cost employers $132.1 billion, according to the National Safety Council—more than the combined revenues of the top 10 Fortune 500 companies.

"The cost of workplace injuries can be staggering for employers," Holmes says. "But, they still don't compare to the physical and emotional consequences injured employees and their families suffer."

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