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Aerospace Systems

Stephen M. Casner, Richard W. Geven, and Kent T. Williams. *The Effectiveness of Airline Pilot Training for Abnormal Events*. S. 477-485.

Objective: To evaluate the effectiveness of airline pilot training for abnormal in-flight events. **Background:** Numerous accident reports describe situations in which pilots responded to abnormal events in ways that were different from what they had practiced many times before. One explanation for these missteps is that training and testing for these skills have become a highly predictable routine for pilots who arrive to the training environment well aware of what to expect. Under these circumstances, pilots get plentiful practice in responding to abnormal events but may get little practice in recognizing them and deciding which responses to offer. **Method:** We presented 18 airline pilots with three abnormal events that are required during periodic training and testing. Pilots were presented with each event under the familiar circumstances used during training and also under less predictable circumstances as they might occur during flight. **Results:** When presented in the routine ways seen during training, pilots gave appropriate responses and showed little variability. However, when the abnormal events were presented unexpectedly, pilots' responses were less appropriate and showed great variability from pilot to pilot. **Conclusion:** The results suggest that the training and testing practices used in airline training may result in rote-memorized skills that are specific to the training situation and that offer modest generalizability to other situations. We recommend a more complete treatment of abnormal events that allows pilots to practice recognizing the event and choosing and recalling the appropriate response. **Application:** The results will aid the improvement of existing airline training practices.

- **Keywords:** abnormal events; generalizability; effectiveness; rote learning; training; pilots

Kristen L. Casto and John G. Casali. *Effects of Headset, Flight Workload, Hearing Ability, and Communications Message Quality on Pilot Performance*. S. 486-498.

Objective: This study was designed to determine the effects of hearing loss, aviation headset type, flight workload complexity, and communication signal quality on pilots' performance in an army rotary-wing flight simulator. **Background:** To maintain flight status, army aviators who do not meet current audiometric standards require a hearing loss waiver, which is based on speech intelligibility in quiet conditions. Because hearing loss characteristics of hearing-impaired aviators can vary greatly, and because performance is likely also influenced by degree of flight workload and communication demand, it was expected that performance among hearing-impaired aviators would also

vary. **Method:** Participants were 20 army helicopter pilots. Pilots flew three flights in a full motion-based helicopter simulator, with a different headset configuration and varying flight workload levels and communication signal quality characterizing each flight. Objective flight performance parameters of heading, altitude, and airspeed deviation and air traffic control command read-backs were measured. **Results:** Statistically significant results suggest that high levels of flight workload, especially in combination with poor communications signal quality, lead to deficits in flight performance and speech intelligibility. **Conclusion:** These results support a conclusion that factors other than hearing thresholds and speech intelligibility in quiet should be considered when evaluating helicopter pilots' flight safety. The results also support a recommendation that hearing-impaired pilots use assistive communication technology and not fly with strictly passive headsets. **Application:** The combined effects of flight environment with individual hearing levels should be considered when making recommendations concerning continued aviation flight status and those concerning communications headsets used in high-noise cockpits.

- **Keywords:** aviation; communication headset; flight workload; speech intelligibility; hearing loss; hearing protection

Jane Ford, David O'Hare, and Robert Henderson. *Putting the "We" Into Teamwork: Effects of Priming Personal or Social Identity on Flight Attendants' Perceptions of Teamwork and Communication*. S. 499-508.

Objective: The study was designed to investigate the effectiveness of a manipulation derived from social categorization and social identity theory to promote greater cabin crew willingness to engage in intergroup communication and teamwork in airline operations. **Background:** Failures of communication and teamwork between airline crew have been implicated in a number of airline crashes. **Method:** Flight attendants based domestically ($n = 254$) or overseas ($n = 230$) received a manipulation designed to prime either their social identity or personal identity and then read a brief outline of an in-flight event before completing a teamwork questionnaire. **Results:** Flight attendants who received a social identity prime indicated increased willingness to engage in coordinated team action compared with those who received a personal identity prime. **Conclusion:** Priming social identity can enhance attitudes toward teamwork and communication, potentially leading to increased willingness to engage in intergroup cooperation. **Application:** Social categorization and social identity theories can be used to inform joint training program development for flight attendants and pilots to create increased willingness for group members to participate in effective communication and teamwork behaviors.

- **Keywords:** cooperation; intergroup behavior

Attentional Processes

Martina I. Klein, Patricia R. DeLucia, and Ryan Olmstead. *The Impact of Visual Scanning in the Laparoscopic Environment After Engaging in Strain Doping*. S. 509-519.

Objective: We aimed to determine whether visual scanning has a detrimental impact on the monitoring of critical signals and the performance of a concurrent laparoscopic training task after participants engaged in Hockey's strain coping. *Strain coping* refers to straining cognitive (attentional) resources joined with latent decrements (i.e., stress). **Background:** DeLucia and Betts (2008) reported that monitoring critical signals degraded performance of a laparoscopic peg-reversal task compared with no monitoring. However, performance did not differ between displays in which critical signals were shown on split screens (less visual scanning) and separated displays (more visual scanning). We hypothesized that effects of scanning may occur after prolonged strain

coping. **Method:** Using a between-subjects design, we had undergraduates perform a laparoscopic training task that induced strain coping. Then they performed a laparoscopic peg-reversal task while monitoring critical signals with a split-screen or separated display. We administered the NASA–Task Load Index (TLX) and Dundee Stress State Questionnaire (DSSQ) to assess strain coping. **Results:** The TLX and DSSQ profiles indicated that participants engaged in strain coping. Monitoring critical signals resulted in slowed peg-reversal performance compared with no monitoring. Separated displays degraded critical-signal monitoring compared with split-screen displays. **Conclusion:** After novice observers experience strain coping, visual scanning can impair the detection of critical signals. **Application:** Results suggest that the design and arrangement of displays in the operating room must incorporate the attentional limitations of the surgeon. Designs that induce visual scanning may impair monitoring of critical information at least in novices. Presenting displays closely in space may be beneficial.

- **Keywords:** laparoscopic surgery; minimally invasive surgery; perceptual-motor distortion; critical signal detection; vigilance

Automation, Expert Systéme

Stephanie M. Merritt, Heather Heimbaugh, Jennifer LaChapell, and Deborah Lee. *I Trust It, but I Don't Know Why: Effects of Implicit Attitudes Toward Automation on Trust in an Automated System.* S. 520-534.

Objective: This study is the first to examine the influence of implicit attitudes toward automation on users' trust in automation. **Background:** Past empirical work has examined explicit (conscious) influences on user level of trust in automation but has not yet measured implicit influences. We examine concurrent effects of explicit propensity to trust machines and implicit attitudes toward automation on trust in an automated system. We examine differential impacts of each under varying automation performance conditions (clearly good, ambiguous, clearly poor). **Method:** Participants completed both a self-report measure of propensity to trust and an Implicit Association Test measuring implicit attitude toward automation, then performed an X-ray screening task. Automation performance was manipulated within-subjects by varying the number and obviousness of errors. **Results:** Explicit propensity to trust and implicit attitude toward automation did not significantly correlate. When the automation's performance was ambiguous, implicit attitude significantly affected automation trust, and its relationship with propensity to trust was additive: Increments in either were related to increases in trust. When errors were obvious, a significant interaction between the implicit and explicit measures was found, with those high in both having higher trust. **Conclusion:** Implicit attitudes have important implications for automation trust. **Application:** Users may not be able to accurately report why they experience a given level of trust. To understand why users trust or fail to trust automation, measurements of implicit and explicit predictors may be necessary. Furthermore, implicit attitude toward automation might be used as a lever to effectively calibrate trust.

- **Keywords:** automation; trust; reliance; propensity to trust; implicit; unconscious; ambiguous

Nathan C. Perry, Mark W. Wiggins, Merilyn Childs, and Gerard Fogarty. *The Application of Reduced-Processing Decision Support Systems to Facilitate the Acquisition of Decision-Making Skills.* S. 535-544.

Objective: The study was designed to examine whether the availability of reduced-processing decision support system interfaces could improve the decision making of inexperienced personnel in the context of firefighting. **Background:** Although research into reduced-processing decision support systems has demonstrated benefits in

minimizing cognitive load, these benefits have not typically translated into direct improvements in decision accuracy because of the tendency for inexperienced personnel to focus on less-critical information. The authors investigated whether reduced-processing interfaces that direct users' attention toward the most critical cues for decision making can produce improvements in decision-making performance. **Method:** Novice participants made incident command-related decisions in experimental conditions that differed according to the amount of information that was available within the interface, the level of control that they could exert over the presentation of information, and whether they had received decision training. **Results:** The results revealed that despite receiving training, participants improved in decision accuracy only when they were provided with an interface that restricted information access to the most critical cues. **Conclusion:** It was concluded that an interface that restricts information access to only the most critical cues in the scenario can facilitate improvements in decision performance. **Application:** Decision support system interfaces that encourage the processing of the most critical cues have the potential to improve the accuracy and timeliness of decisions made by inexperienced personnel.

- **Keywords:** decision making; expertise; cognitive load; interface; skill acquisition

Biomechanics, Anthropometry, Work Physiology

Peter F. Ehrlich, Justin G. Young, Sheryl Ulin, Charles Woolley, Thomas J. Armstrong, Andrzej Galecki, Shu Chen, and James A. Ashton-Miller. *Maximum Hand-Rung Coupling Forces in Children: The Effects of Handhold Diameter.* S. 545-556.

Objective: To quantify the effect of handhold size (diameter) on the maximum breakaway strength between a hand and handhold for children. **Background:** Falls from playground equipment are a major cause of childhood injury and death. It is unclear if recommendations for handholds on playground equipment are too broad. **Methods:** Breakaway strength was defined as the maximum quasistatic force that can be exerted on a grasped object before the object is forcibly pulled from the grasp. Hand anthropometry, grip, and breakaway strengths were measured for 397 children between the ages of 6 and 11 years. Three cylindrical handhold diameters were tested. **Results:** Breakaway strength was significantly affected by handhold size, gender, and hand dominance. Significant covariate predictors for breakaway strength included grip strength, age, and hand breadth. Breakaway strength was reduced for the largest diameter (3.81 cm) for children of all ages. **Conclusion:** Handhold design factors significantly affect the breakaway strength of children. **Application:** The results can be used as a basis for design recommendations for hand rungs used by children to reliably support their bodyweight.

- **Keywords:** breakaway strength; grip strength; playgrounds; falls; climbing; growth and development

Anna Pereira, David L. Lee, Harini Sadeeshkumar, Charles Laroche, Dan Odell, and David Rempel. *The Effect of Keyboard Key Spacing on Typing Speed, Error, Usability, and Biomechanics: Part 1.* S. 557-566.

Objective: In this study, we evaluated the effects of key spacing on a conventional computer keyboard on typing speed, percentage error, usability, and forearm muscle activity and wrist posture. **Background:** International standards that specify the spacing between keys on a keyboard have been guided primarily by design convention because few studies have evaluated the effects of key spacing on productivity, usability, and biomechanical factors. **Method:** Experienced male typists ($N = 37$) with large fingers

(middle finger length ≥ 8.7 cm or finger breadth of ≥ 2.3 cm) typed on five keyboards that differed only in horizontal and vertical key spacing (19 × 19 mm, 18 × 19 mm, 17 × 19 mm, 16 × 19 mm, and 17 × 17 mm) while typing speed, percentage error, fatigue, preference, extensor carpi ulnaris and flexor carpi ulnaris muscle activity, and wrist extension and ulnar deviation were recorded. **Results:** Productivity and usability ratings were significantly worse for the keyboard with spacing of 16 × 19 mm compared with the other keyboards. Differences on these measures between the other keyboards were not significant. Muscle activity tended to increase in the left forearm and decrease in the right with decreasing horizontal key spacing. There was also a trend for left wrist extension to increase and left ulnar deviation to decrease with decreasing horizontal key spacing. Reducing vertical key spacing from 19 to 17 mm had no significant effect on productivity or usability ratings. **Conclusions:** The study findings support key spacing on a computer keyboard between 17 and 19 mm in both vertical and horizontal directions. **Applications:** These findings may influence keyboard standards and the design of keyboards.

- **Keywords:** key pitch; keyboard design; tool design; switch; wrist posture; electromyography

Maria Luisa Toro, Alicia M. Koontz, and Rory A. Cooper. *The Impact of Transfer Setup on the Performance of Independent Wheelchair Transfers.* S. 567-580.

Objective: The aim of this study was to determine how selected environmental factors affect transfers and to compare our results to the Americans with Disabilities Act Accessibility Guidelines (ADAAG). **Background:** Few data are available to support standards development related to transfers in the built environment. **Method:** Participants were 120 wheeled mobility device (WMD) users who transferred to and from a modular transfer station that consisted of a height-adjustable platform with a lateral grab bar, optional obstacle to the transfer, and an optional height-adjustable front grab bar. Maximum and minimum vertical heights of the transfer surface, maximum gap distance between the WMD and transfer surface, grab bar use, and WMD space needs were recorded. **Results:** The 95th percentile lowest and highest heights attained were similar to the median WMD seat-to-floor height (56 cm). We found that 42% (47/113) could not perform a transfer with the obstacle present. Participants transferred higher when the front grab bar was added to the setup ($p = .005$) and higher and lower with the front grab bar than without it when the obstacle was present in the setup ($p = .003$ and $p = .005$, respectively). We found that 95% of participants performed a transfer across an 8.9-cm gap. ADAAG recommendations fall short for the height and clear-space needs of the 50th-percentile WMD users. **Conclusion:** Revisions concerning transfer heights, gaps, clear spaces, and grab bar heights are necessary to make transfers more accessible to WMD users. **Application:** The data will be used to revise the guidelines related to transfers and to enable designers and engineers to create an environment that is more accessible.

- **Keywords:** activities of daily living; accessibility standards; wheeled mobility; wheelchair; disability

Cognitive Processes

Mark S. Avnet and Annalisa L. Weigel. *The Structural Approach to Shared Knowledge: An Application to Engineering Design Teams.* S. 581-594.

Objective: We propose a methodology for analyzing shared knowledge in engineering design teams. **Background:** Whereas prior work has focused on shared knowledge in small teams at a specific point in time, the model presented here is both scalable and dynamic. **Method:** By quantifying team members' common views of design drivers, we

build a network of shared mental models to reveal the structure of shared knowledge at a snapshot in time. Based on a structural comparison of networks at different points in time, a metric of change in shared knowledge is computed. **Results:** Analysis of survey data from 12 conceptual space mission design sessions reveals a correlation between change in shared knowledge and each of several system attributes, including system development time, system mass, and technological maturity. **Conclusion:** From these results, we conclude that an early period of learning and consensus building could be beneficial to the design of engineered systems. **Application:** Although we do not examine team performance directly, we demonstrate that shared knowledge is related to the technical design and thus provide a foundation for improving design products by incorporating the knowledge and thoughts of the engineering design team into the process.

- **Keywords:** shared mental model; team cognition; social network analysis; space mission design

Computer Systéme

Cyriel Diels and Peter A. Howarth. *Frequency Characteristics of Visually Induced Motion Sickness*. S. 595-604.

Objective: The aim of this study was to explore the frequency response of visually induced motion sickness (VIMS) for oscillating linear motion in the fore-and-aft axis. **Background:** Simulators, virtual environments, and commercially available video games that create an illusion of self-motion are often reported to induce the symptoms seen in response to true motion. Often this human response can be the limiting factor in the acceptability and usability of such systems. Whereas motion sickness in physically moving environments is known to peak at an oscillation frequency around 0.2 Hz, it has recently been suggested that VIMS peaks at around 0.06 Hz following the proposal that the summed response of the visual and vestibular self-motion systems is maximized at this frequency. **Methods:** We exposed 24 participants to random dot optical flow patterns simulating oscillating fore-and-aft motion within the frequency range of 0.025 to 1.6 Hz. Before and after each 20-min exposure, VIMS was assessed with the Simulator Sickness Questionnaire. Also, a standard motion sickness scale was used to rate symptoms at 1-min intervals during each trial. **Results:** VIMS peaked between 0.2 and 0.4 Hz with a reducing effect at lower and higher frequencies.

Conclusion: The numerical prediction of the “crossover frequency” hypothesis, and the design guidance curve previously proposed, cannot be accepted when the symptoms are purely visually induced. **Application:** In conditions in which stationary observers are exposed to optical flow that simulates oscillating fore-and-aft motion, frequencies around 0.2 to 0.4 Hz should be avoided.

- **Keywords:** simulator sickness; frequency; fore-and-aft motion; stimulus parameters

Varun Dutt, Young-Suk Ahn, and Cleotilde Gonzalez. *Cyber Situation Awareness: Modeling Detection of Cyber Attacks With Instance-Based Learning Theory*. S. 605-618.

Objective: To determine the effects of an adversary’s behavior on the defender’s accurate and timely detection of network threats. **Background:** Cyber attacks cause major work disruption. It is important to understand how a defender’s behavior (experience and tolerance to threats), as well as adversarial behavior (attack strategy), might impact the detection of threats. In this article, we use cognitive modeling to make predictions regarding these factors. **Method:** Different model types representing a defender, based on Instance-Based Learning Theory (IBLT), faced different adversarial

behaviors. A defender's model was defined by experience of threats: threat-prone (90% threats and 10% nonthreats) and nonthreat-prone (10% threats and 90% nonthreats); and different tolerance levels to threats: risk-averse (model declares a cyber attack after perceiving one threat out of eight total) and risk-seeking (model declares a cyber attack after perceiving seven threats out of eight total). Adversarial behavior is simulated by considering different attack strategies: patient (threats occur late) and impatient (threats occur early). **Results:** For an impatient strategy, risk-averse models with threat-prone experiences show improved detection compared with risk-seeking models with nonthreat-prone experiences; however, the same is not true for a patient strategy. **Conclusions:** Based upon model predictions, a defender's prior threat experiences and his or her tolerance to threats are likely to predict detection accuracy; but considering the nature of adversarial behavior is also important. **Application:** Decision-support tools that consider the role of a defender's experience and tolerance to threats along with the nature of adversarial behavior are likely to improve a defender's overall threat detection.

- **Keywords:** cyber situation awareness; Instance-Based Learning Tudyory; defender; adversarial behavior; experiences; tolerance

Health and Medical Systems

Bernadette McCrory, Bethany R. Lowndes, Chad A. LaGrange, Emily E. Miller, and M. Susan Hallbeck. *Comparative Usability Testing of Conventional and Single Incision Laparoscopic Surgery Device. S. 619-631.*

Objective: The objective was to perform competitive usability testing to assess the user experience of conventional laparoscopic and laparoendoscopic single-site surgery (LESS) devices. **Background:** Recent advancements in single-incision instrumentation have created more interest in and usage of LESS. However, neither LESS nor its novel multichannel access devices have been thoroughly studied. **Method:** Using a simulation test bed and standardized laparoscopic surgery task, the user experience of three commercially available LESS devices was compared to conventional laparoscopic ports based on time on task, errors, task success, and perceived ease of use. **Results:** There were no significant differences between devices for time on task, errors, or task success ($p > .05$). For all devices, there were significantly more recoverable than unrecoverable errors, and errors occurred more frequently during the second phase of the task when the dominant hand was more active ($p < .0001$). Conventional laparoscopy was rated as easier to use than were the LESS devices ($p < .01$). **Conclusion:** Device performance of a basic laparoscopic task was similar in both conventional laparoscopy and LESS. Each of the LESS devices facilitated efficient and accurate aiming and grasping movements compared to conventional laparoscopy. Further investigation of human factors and ergonomics of LESS is needed to further develop, evaluate, and refine single-site surgery technologies to create a user experience equivalent to conventional laparoscopy. **Application:** Competitive usability testing of medical devices yields objective performance data that can be used to inform purchase decisions and future device design improvements.

- **Keywords:** LESS; ergonomics; competitive usability testing; performance; errors; simulation

Sensory and Perceptual Processes

David A. Guth, Richard G. Long, Robert S. Wall Emerson, Paul E. Ponchillia, and Daniel H. Ashmead. *Blind and Sighted Pedestrians' Road-Crossing Judgments at a Single-Lane Roundabout. S. 632-642.*

Objective: The aim of this study was to evaluate the relative risk and efficiency of road crossing experienced by blind and sighted pedestrians at a single-lane roundabout with two levels of traffic volume and at two distances from the roundabout. **Background:** With the rapid spread of modern roundabouts across the United States, their accessibility to blind pedestrians has become an important concern. To date, accessibility research relevant to blind pedestrians has focused on multilane roundabouts, and single-lane roundabouts have been virtually ignored. **Method:** Blind and sighted participants made judgments about when they would cross a single-lane roundabout with high and low traffic volumes, at exit and entry lanes, and at the actual crosswalks and at locations farther from the roundabout. **Results:** Relative to sighted participants, blind participants' judgments about when to cross were more frequently risky, especially when traffic volume was high. Blind participants also were slower to make crossing judgments and accepted fewer crossing opportunities. Both groups made somewhat safer and more efficient judgments at locations farther from the roundabout. **Conclusion:** Some single-lane roundabouts may pose greater risk to blind pedestrians than to sighted pedestrians, especially when traffic volume is high. Crosswalk location merits further investigation as a design issue. **Application:** These findings are relevant to transportation planners and engineers who are responsible for the accessibility of public rights-of-way.

- **Keywords:** safety; audition; vision; individual differences; blindness; highway design; disability; risk assessment

Surface Transportation Systems

Mark C. Schall, Jr., Michelle L. Rusch, John D. Lee, Jeffrey D. Dawson, Geb Thomas, Nazan Aksan, and Matthew Rizzo. *Augmented Reality Cues and Elderly Driver Hazard Perception*. S. 643-658.

Objective: The aim of this study was to evaluate the effectiveness of augmented reality (AR) cues in improving driving safety among elderly drivers who are at increased crash risk because of cognitive impairments. **Background:** Cognitively challenging driving environments pose a particular crash risk for elderly drivers. AR cuing is a promising technology to mitigate risk by directing driver attention to roadway hazards. We investigate whether AR cues improve or interfere with hazard perception in elderly drivers with age-related cognitive decline. **Method:** A total of 20 elderly ($M = 73$ years, $SD = 5$) licensed drivers with a range of cognitive abilities measured by a speed-of-processing (SOP) composite participated in a 1-hr drive in an interactive, fixed-base driving simulator. Each participant drove through six straight, 6-mile-long, rural roadway scenarios following a lead vehicle. AR cues directed attention to potential roadside hazards in three of the scenarios, and the other three were uncued (baseline) drives. Effects of AR cuing were evaluated with respect to (a) detection of hazardous target objects, (b) interference with detecting nonhazardous secondary objects, and (c) impairment in maintaining safe distance behind a lead vehicle. **Results:** AR cuing improved the detection of hazardous target objects of low visibility. AR cues did not interfere with detection of nonhazardous secondary objects and did not impair ability to maintain safe distance behind a lead vehicle. SOP capacity did not moderate those effects. **Conclusion:** AR cues show promise for improving elderly driver safety by increasing hazard detection likelihood without interfering with other driving tasks, such as maintaining safe headway.

- **Keywords:** driver behavior; simulation and virtual reality; sensory and perceptual processes; psychomotor processes; aging and individual differences; displays and controls

Training, Education, Instructional Systems

Stefan Röttger, Saskia Vetter, and Jens T. Kowalski. *Ship Management Attitudes and Their Relation to Behavior and Performance*. S. 659-671.

Objective: The aim of this study was to adapt the Crew Resource Management (CRM) Attitudes Questionnaire (CMAQ) to the maritime domain, to assess the ship management attitudes of junior naval officers, and to determine the extent to which these attitudes correlate with behavior and performance in a naval exercise. **Background:** CRM attitudes have been shown to be associated with performance in aviation, but it is unclear whether this construct is applicable and relevant to the maritime domain. **Method:** Participants were 121 active seafarers and 101 junior officers of the German Navy who completed the Ship Management Attitudes Questionnaire–German Navy (SMAQ-GN). Ratings of nontechnical skills and ratings of mission success of the junior officers were collected during a real-world naval exercise. **Results:** Internal consistencies of SMAQ-GN were similar to those of the original CMAQ and retest reliability was rather high. Attitudes of junior officers toward communication and coordination were positive. Regarding command responsibility and the recognition of stressor effects, positive as well as neutral and negative attitudes were found. Overall, attitudes did not correlate with behavior and performance. Separate analysis of those participants reporting negative to neutral ship management attitudes showed substantial positive correlations of attitudes with behavior and performance. **Conclusion:** Ship management attitudes play a significant role in commanding ships. The attitude–performance linkage is not linear. Behavior and performance are less effective in officers with negative attitudes and equally effective in officers with slightly positive and very positive attitudes. **Application:** Ship management attitudes can be used to assess training needs for nautical teams.

- **Keywords:** crew resource management attitudes; bridge resource management; ship management; bridge teams; naval teams; team training; teamwork; leadership

Grant S. Taylor and John S. Barnett. *Evaluation of Wearable Simulation Interface for Military Training*. S. 672-690.

Objective: This research evaluated the training effectiveness of a novel simulation interface, a wearable computer integrated into a soldier's load-bearing equipment. **Background:** Military teams often use game-based simulators on desktop computers to train squad-level procedures. A wearable computer interface that mimics the soldier's equipment was expected to provide better training through increased realism and immersion. **Method:** A heuristic usability evaluation and two experiments were conducted. Eight evaluators interacted with both wearable and desktop interfaces and completed a usability survey. The first experiment compared the training retention of the wearable interface with a desktop simulator and interactive training video. The second experiment compared the training transfer of the wearable and desktop simulators with a live training environment. **Results:** Results indicated the wearable interface was more difficult to use and elicited stronger symptoms of simulator sickness. There was no significant difference in training retention between the wearable, desktop, or interactive video training methods. The live training used in the second experiment provided superior training transfer than the simulator conditions, with no difference between the desktop and wearable. **Conclusion:** The wearable simulator interface did not provide better training than the desktop computer interface. It also had poorer usability and caused worse simulator sickness. Therefore, it was a less effective training tool. **Application:** This research illustrates the importance of conducting empirical evaluations of novel training technologies. New and innovative technologies are always coveted by users, but new does not always guarantee improvement.

- **Keywords:** simulator; training; computer interface; usability; training effectiveness; training transfer; wearable simulation interface