AEROSPACE SYSTEMS

Langan-Fox, Janice; Sankey, Michael J.; Canty, James M. Human Factors Measurement for Future Air Traffic Control Systems. S. 595-637(43).

Objective: This article provides a critical review of research pertaining to the measurement of human factors (HF) issues in current and future air traffic control (ATC).

Background: Growing worldwide air traffic demands call for a radical departure from current ATC systems. Future systems will have a fundamental impact on the roles and responsibilities of ATC officers (ATCOs). Valid and reliable methods of assessing HF issues associated with these changes, such as a potential increase (or decrease) in workload, are of utmost importance for advancing theory and for designing systems, procedures, and training. Method: We outline major aviation changes and how these relate to five key HF issues in ATC. Measures are outlined, compared, and evaluated and are followed by guidelines for assessing these issues in the ATC domain. Recommendations for future research are presented. Results: A review of the literature suggests that situational awareness and workload have been widely researched and assessed using a variety of measures, but researchers have neglected the areas of trust, stress, and boredom. We make recommendations for use of particular measures and the construction of new measures. Conclusion: It is predicted that, given the changing role of ATCOs and profound future airspace requirements and configurations, issues of stress, trust, and boredom will become more significant. Researchers should develop and/or refine existing measures of all five key HF issues to assess their impact on ATCO performance. Furthermore, these issues should be considered in a holistic manner. Application: The current article provides an evaluation of research and measures used in HF research on ATC that will aid research and ATC measurement.

Keywords: SITUATION AWARENESS; VIGILANCE; MONITORING; EFFORT/MOTIVATION; STRESS; MENTAL WORKLOAD; ATTENTIONAL PROCESSES; BOREDOM; MONOTONY; PSYCHOLOGICAL STATES; TRUST; COMPLACENCY; OVER-RELIANCE; HUMAN FACTORS MEASUREMENT; AIR TRAFFIC CONTROL SYSTEMS; FUTURE AIRSPACE REQUIREMENTS; LITERATURE REVIEW; MEASUREMENT OF AIR TRAFFIC CONTROL SYSTEMS

Wickens, Christopher D.; Hooey, Becky L.; Gore, Brian F.; Sebok, Angelia; Koenicke, Corey S. Identifying Black Swans in NextGen : Predicting Human Performance in Off-Nominal Conditions. S. 638-651(14).

Objective: The objective is to validate a computational model of visual attention against empirical data—derived from a meta-analysis—of pilots’ failure to notice safety-critical
unexpected events. **Background:** Many aircraft accidents have resulted, in part, because of failure to notice nonsalient unexpected events outside of foveal vision, illustrating the phenomenon of change blindness. A model of visual noticing, N-SEEV (noticing-salience, expectancy, effort, and value), was developed to predict these failures. **Method:** First, 25 studies that reported objective data on miss rate for unexpected events in high-fidelity cockpit simulations were identified, and their miss rate data pooled across five variables (phase of flight, event expectancy, event location, presence of a head-up display, and presence of a highway-in-the-sky display). Second, the parameters of the N-SEEV model were tailored to mimic these dichotomies. **Results:** The N-SEEV model output predicted variance in the obtained miss rate ($r = .73$). The individual miss rates of all six dichotomous conditions were predicted within 14%, and four of these were predicted within 7%. **Conclusion:** The N-SEEV model, developed on the basis of an independent data set, was able to successfully predict variance in this safety-critical measure of pilot response to abnormal circumstances, as collected from the literature. **Applications:** As new technology and procedures are envisioned for the future airspace, it is important to predict if these may compromise safety in terms of pilots’ failing to notice unexpected events. Computational models such as N-SEEV support cost-effective means of making such predictions.

**Keywords:** AEROSPACE SYSTEMS (PILOT); ATTENTIONAL PERFORMANCE (MONITORING); COMPUTATIONAL MODELING; AVIATION SAFETY; META-ANALYSIS; NEXTGEN; OFF-NOMINAL CONDITIONS; VISUAL ATTENTION; VISUAL NOTICING; AIRCRAFT ACCIDENTS; UNEXPECTED AVIATION EVENTS; CHANGE BLINDNESS; HEAD UP DISPLAY; HIGHWAY IN THE SKY DISPLAY; EXPECTANCY

**AGING**


**Objective:** This study aimed (a) to determine whether older drivers looked less often for potential threats while turning than younger drivers and (b) to compare the effectiveness of active and passive training on older drivers' performance and evaluation of their driving skills in intersections. **Background:** Age-related declines in vision, physical abilities, psychomotor coordination, and cognition combine to make it less likely that older drivers will look for potential threats during a turn. Research suggests that active training should be an effective means of improving older drivers' performance and self-awareness. **Method:** In Experiment 1, younger and older participants drove a series of virtual intersection scenarios, were shown video replays, and were provided feedback. In Experiment 2, older drivers were assigned to one of three cohorts: active simulator training, passive classroom training, or no training. Pre- and posttraining simulator and field drives assessed training effectiveness. **Results:** In Experiment 1, older drivers looked less often during turns than younger drivers. Customized feedback was successful in altering drivers' perception of their abilities. In Experiment 2, active training increased a driver's probability of looking for a threat during a turn by nearly 100% in both posttraining simulator and field drives. Those receiving passive training or no training showed no improvement. **Conclusion:** Compared with passive training, active training is a more effective strategy for increasing older drivers' likelihood of looking for threats during a turn. **Application:** The results of this research can guide the development of programs that could reduce intersection crashes among older drivers.

**Keywords:** AGING; DRIVER BEHAVIOR; SURFACE TRANSPORTATION SYSTEMS; TRAINING TECHNOLOGIES; TRAINING; EDUCATION; INSTRUCTIONAL SYSTEMS; OLDER DRIVERS; SITUATION AWARENESS; ATTENTIONAL PROCESSES; OLDER DRIVER PERFORMANCE; ROAD SCANNING; INTERSECTION CRASHES; TRAINING STRATEGIES; SIMULATOR TRAINING
Seidel, David; Crilly, Nathan; Matthews, Fiona E.; Jagger, Carol; Brayne, Carol; Clarkson, P. John. Patterns of Functional Loss Among Older People: A Prospective Analysis. S. 669-680(12).

Objective: Patterns of capability loss and disability onset among older people were investigated prospectively. Background: With aging, the gap between personal capability and environmental demand becomes wider, resulting in higher levels of disability in daily activities. Methods: Data from a longitudinal, population-based study were obtained for analysis, which recruited a representative sample of 13,004 people aged 65 years and older from five sites in Great Britain. Participants completed a baseline interview during 1990 to 1994 and follow-up interviews after 1, 2, 3, 6, 8, and 10 years. Those who reported full vision, hearing, thinking, locomotion, reaching, and dexterity ability as well as no disability in cooking, housework, shopping, and transportation at baseline were included in a survival analysis. Results: Locomotion was the first ability to be lost, followed by reaching, thinking, hearing, vision, and dexterity. Age at onset of disability was earliest for shopping, then housework, transportation, and cooking. Women were consistently younger at capability loss and disability onset than men except in terms of hearing and cooking. Conclusion: These findings suggest that capabilities required for product and service interaction follow a hierarchical pattern of loss, which has practical implications for design. Although interventions to reduce disability in the older population are likely to require changes that address more than one demand, capabilities lost early in old age should take precedence over those lost later. Application: A potential application of this research is in the development of an overall design strategy to enhance older people’s ability to live independently.

Keywords: AGING; INCLUSIVE DESIGN; PRODUCT INTERACTION; HUMAN CAPABILITY; DISABILITY IN DAILY ACTIVITIES; ENVIRONMENTAL DEMAND; INDEPENDENT LIVING

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Maikala, Rammohan V.; Ciriello, Vincent M.; Dempsey, Patrick G.; O’Brien, Niall V. Psychophysiological Responses in Women During Cart Pushing on Different Frictional Walkways. S. 681-693(13).

Objective: The aim of this study was to evaluate psychophysically determined acceptable forces, cardiopulmonary, and calf muscle metabolic responses in 15 workers while they pushed an instrumented cart on two walkways. Background: In addition to the potential for increased musculoskeletal disorders in workers, pushing on various terrains is associated with occurrence of slips and falls at the workplace. Method: Using a psychophysical approach, participants chose the maximum acceptable cart weight they could push without strain on walkways with coefficient of friction equaling 0.68 (plywood) and 0.26 (Teflon-coated.). Then, while participants pushed their psychophysically chosen cart weight for 2 hr on each walkway, horizontal and vertical forces applied on the cart handle and physiological responses were collected. Cardiopulmonary responses were measured using a telemetric metabolic cart. A tissue hemoglobin index (THI) and a tissue oxygenation index (TOI) from the right and left calf muscles were obtained using near-infrared spectroscopy. Results: Participants generated higher horizontal forces (by 26%) on plywood than that on Teflon. Cardiopulmonary and TOI and THI responses were similar between walkways. However, greater ratios of absolute oxygen uptake per force (by 19%) and TOI per force (by 24%) on Teflon were demonstrated in the horizontal direction than on plywood. Conclusions: This increased muscle oxygenation-force ratio, coupled with increased oxygen uptake per force generated on Teflon, might suggest that pushing on the slippery surface results in higher metabolic demand. Application: Findings from the present study will assist in revising previously established acceptable
forces and in relating these forces to physiological responses with respect to pushing on different frictional walkways.

- **Keywords:** TISSUE HEMOGLOBIN INDEX; TISSUE OXYGENATION INDEX; NEAR-INFRARED SPECTROSCOPY; PSYCHOPHYSICS; SLIPS AND FALLS; DYNAMIC PUSHING; BIOMECHANICS; WORK PHYSIOLOGY; PHYSICAL WORK; LOADING; MODELS AND MEASURES; PSYCHOPHYSIOLOGICAL RESPONSES; CART PUSHING; FRICIONAL WALKWAYS

**Telfer, Scott; Spence, William D.; Solomonidis, Stephan E. The Potential for Actigraphy to be Used as an Indicator of Sitting Discomfort. S. 694-704(11).**

**Objective:** A novel technique that uses actigraphy, the study of activity involving the use of body-mounted accelerometers, to detect the discomfort-related movements of a sitting individual has been proposed as a potential indicator of sitting discomfort, and the purpose of this study was to test its validity. **Background:** Objective measurement of sitting discomfort has always been challenging for researchers. Electromyographic measurements, pressure mapping, and a wide range of other techniques have all been investigated with limited success. **Method:** The activity monitor's ability to detect and measure seated movement was assessed, and 12 participants were tested on four different chairs (100-min sessions for each). **Results:** The activity monitor was able to detect participants' sitting movements (Pearson coefficients > 0.9). The chairs were shown to have significantly different subjective discomfort ratings, all of which increased over time. The movements detected by the activity monitor also increased significantly with time, and the amount measured was greater in the chairs rated as most uncomfortable. Regression analysis indicated that the actigraphy data were able to account for 29.6% of the variation in perceived discomfort ratings. **Conclusion:** Actigraphy can reliably detect sitting movements and may be of use in measuring sitting discomfort. **Application:** Potential applications of this technique exist for seating research in the automotive industry, health care, and office and leisure chairs.

- **Keywords:** BIOMECHANICS; SITTING DISCOMFORT; BODY MOUNTED ACCELEROMETERS; ACTIGRAPHY; WORK PHYSIOLOGY; MODELS AND METHODS; SEATED MOVEMENT; ANTHROPOMETRY

**Young, Justin G.; Woolley, Charles; Armstrong, Thomas J.; Ashton-Miller, James A. Hand-Handhold Coupling: Effect of Handle Shape, Orientation, and Friction on Breakaway Strength. S. 705-717(13).**

**Objective:** The aim was to determine the maximum force that can be exerted on an object before it is pulled or slips from the grasp of the hand ("breakaway strength") for fixed overhead handholds of varying orientation, shape, and friction. **Background:** Many studies have quantified hand strength by having participants squeeze, pull on, or create torque on an object or handle, but few studies have measured breakaway strength directly. **Method:** In two experiments, hand strength was measured as both overhead breakaway strength for handholds typical of fixed industrial ladders and as maximum isometric grip strength measured using a common Jamar grip dynamometer. **Results:** Breakaway strength was greatest for a fixed horizontal cylinder ("high friction"; 668 ± 40 N and 691 ± 132 N for Experiments 1 and 2, respectively), then for a horizontal cylinder that simulated low surface friction ("low friction"; 552 ± 104 N), then for a vertical cylinder (435 ± 27 N), and finally, for a vertical rectangular-shaped rail (337 ± 24 N). Participants are capable of supporting only their own body weight with one hand when grasping the fixed horizontal cylinder. Breakaway strength for both the high- and low-friction horizontal cylinders was significantly greater than isometric grip strength (1.58 ± 0.25 and 1.26 ± 0.19 times, respectively). **Conclusion:** Results support the hypothesis that hand-handhold coupling is composed of active (isometric or eccentric finger flexion)
and passive (frictional) components. Traditional isometric grip strength alone does not predict the strength of a couple between a hand and a handhold well. **Application:** This research shows that handhold shape, orientation, and friction are important in the safe design of grab rails or ladders.

- **Keywords:** BREAKAWAY STRENGTH; GRIP STRENGTH; LADDERS; FALLS; FRICITION; ECCENTRIC GRIP; HAND BIOMECHANICS; HANDLES; HANDHOLDS; GRABRAILS; HAND STRENGTH; SHAPE; ORIENTATION; LADDER SAFETY; PULL STRENGTH; RUNGS AND RAILS

**DISPLAYS AND CONTROLS**

**Donmez, Birsen; Cummings, M.L.; Graham, Hudson D. Auditory Decision Aiding in Supervisory Control of Multiple Unmanned Aerial Vehicles. S. 718-729(12).**

**Objective:** This article is an investigation of the effectiveness of sonifications, which are continuous auditory alerts mapped to the state of a monitored task, in supporting unmanned aerial vehicle (UAV) supervisory control. **Background:** UAV supervisory control requires monitoring a UAV across multiple tasks (e.g., course maintenance) via a predominantly visual display, which currently is supported with discrete auditory alerts. Sonification has been shown to enhance monitoring performance in domains such as anesthesiology by allowing an operator to immediately determine an entity's (e.g., patient) current and projected states, and is a promising alternative to discrete alerts in UAV control. However, minimal research compares sonification to discrete alerts, and no research assesses the effectiveness of sonification for monitoring multiple entities (e.g., multiple UAVs). **Method:** The authors conducted an experiment with 39 military personnel, using a simulated setup. Participants controlled single and multiple UAVs and received sonifications or discrete alerts based on UAV course deviations and late target arrivals. **Results:** Regardless of the number of UAVs supervised, the course deviation sonification resulted in reactions to course deviations that were 1.9 s faster, a 19% enhancement, compared with discrete alerts. However, course deviation sonifications interfered with the effectiveness of discrete late arrival alerts in general and with operator responses to late arrivals when supervising multiple vehicles. **Conclusions:** Sonifications can outperform discrete alerts when designed to aid operators to predict future states of monitored tasks. However, sonifications may mask other auditory alerts and interfere with other monitoring tasks that require divided attention. **Applications:** This research has implications for supervisory control display design.

- **Keywords:** SONIFICATION; UNMANNED VEHICLES; AUDITORY ALERTS; SUPERVISION CONTROL; MULTIPLE UNMANNED VEHICLES; AUDITORY AIDS; CONTINUOUS AUDITORY ALERTS; DISCRETE AUDITORY ALERTS; AUDITORY DECISION AIDING; UNMANNED AERIAL VEHICLES; UNMANNED AERIAL SYSTEMS; SONIFICATION EFFECTIVENESS; MONITORING PERFORMANCE; MONITORING TASKS; MULTIPLE UNMANNED VEHICLE SUPERVISION; SUPERVISION CONTROL DISPLAYS; UAV; UAS; UGV

**INDIVIDUAL DIFFERENCES**

**Sanchez, Christopher A.; Wiley, Jennifer. To Scroll or Not to Scroll : Scrolling, Working Memory Capacity, and Comprehending Complex Texts. S. 730-738(9).**

**Objective:** The purpose of these experiments was to examine the effects of user characteristics on learning from scrolling interfaces. **Background:** Although scrolling Web pages are now common, few studies have explored the effects of scrolling on
understanding the content that is being conveyed. **Method:** This set of studies investigated whether presenting text in two particular formats has an effect on comprehension for readers who differ in working memory capacity. **Results:** Results from both studies indicated that a scrolling format reduced understanding of complex topics from Web pages, especially for readers who were lower in working memory capacity. **Conclusion:** These findings show that the way text is presented can interact with learner abilities to affect learning outcomes. **Application:** These results have implications for both educational technology and human interfaces that present information using displays that can vary in size and construction.

- **Keywords:** SCROLLING; WEB PAGES; WORKING MEMORY; SCIENCE LEARNING; EDUCATIONAL TECHNOLOGY; READING COMPREHENSION; EDUCATIONAL TECHNOLOGY

**SIMULATION AND VIRTUAL REALITY**

**Ji, Jennifer T.T.; So, Richard H.Y.; Cheung, Raymond T.F. Isolating the Effects of Vection and Optokinetic Nystagmus on Optokinetic Rotation-Induced Motion Sickness. S. 739-751(13).**

**Objective:** This study investigates isolated effects of vection and optokinetic nystagmus (OKN) on visually induced motion sickness (VIMS) provoked by rotating optokinetic drum patterns. **Background:** VIMS was the subject of recent standardization activities, but the effects of OKN have not been studied in the absence of vection. **Method:** Experiment 1 suppressed OKN by eye fixation and examined VIMS severity (both ordinal and ratio scale) and time spent in saturated vection at four pattern rotating velocities of 0, 2, 14, and 34 degrees per second (dps). Experiment 2 suppressed vection by adding a peripheral visual field rotating in the opposite direction to the rotating patterns. VIMS severity and OKN slow-phase velocity were studied at four rotating velocities of 0, 30, 60, and 90 dps. **Results:** Results from Experiment 1 indicated that VIMS severity increased as the pattern velocity increased from 0 dps to 34 dps. Results from Experiment 2 indicated that as the velocity of the rotating pattern increased, the slow-phase velocity of OKN and the severity of VIMS increased and peaked in the 60-dps condition. In both experiments, ratio-scaled nausea data significantly correlated with ordinal-scaled nausea ratings. **Conclusion:** VIMS can still occur in the absence of either vection or OKN. Interestingly, the profile of the summed results of the two experiments matches nicely with the profile reported by Hu et al. in which neither OKN nor vection were controlled. **Application:** Potential applications include modeling and reduction of VIMS in computer gaming environments.

- **Keywords:** VISUALLY INDUCED MOTION SICKNESS (VIMS); VECTION; OPTOKINETIC NYSTAGMUS (OKN); NAUSEA; EYE FIXATION; VECTION SUPPRESSION; RETINAL SLIP VELOCITY; OKN SLOW-PHASE VELOCITY (SPV); PATTERN ROTATING VELOCITY; RATIO-SCALED NAUSEA SEVERITY; ORDINAL-SCALED NAUSEA SEVERITY; SIMULATOR SICKNESS QUESTIONNAIRE (SSQ) SCORES; SENSORY REARRANGEMENT THEORY; EXTRAOCULAR AFFERENT HYPOTHESIS; ELECTROOCULOGRAM (EOG)

**Muth, Eric R. The Challenge of Uncoupled Motion: Duration of Cognitive and Physiological Aftereffects. S. 752-761(10).**

**Objective:** This study aimed to document the cognitive aftereffects of exposure to uncoupled motion and the time course of recovery from these aftereffects. **Background:** Uncoupled motion refers to a situation in which an individual is simultaneously exposed to two asynchronous motions, either real or virtual. These environments are a challenge for designers because technology that is supposed to increase the user's task performance may actually lead to decreased task performance. **Method:** In the study, 11
male participants, (median age = 32 years) with prior flight experience (median = 600 hr) were exposed to an uncoupled motion environment consisting of a flight simulator on a vertically oscillating platform. Participants completed a cognitive test battery, a balance test, and a dynamic visual acuity test preexposure, immediately postexposure, and 2, 4, 6, 8, and 24 hr postexposure. **Results:** The uncoupled motion scenario led to significant cognitive aftereffects that cannot be solely attributed to motion sickness. These aftereffects lasted between 2 and 4 hr postexposure. The scenario generated some physiological aftereffects that lasted between 1 and 2 hr postexposure. However, it is likely that these aftereffects can be attributed to motion sickness. **Conclusion:** Uncoupled motion can cause unappreciated effects, such as degraded cognitive performance. **Application:** System designs that create uncoupled motion need to be evaluated for the potential to generate operator impairment, and designs should be modified to minimize this potential wherever possible. When redesign is not possible, system-use guidelines should be developed to minimize impairment. The current results suggest operators avoid performing cognitively demanding tasks for at least 2 hr postexposure.

- **Keywords:** SIMULATORS; MOTION SICKNESS; PERFORMANCE; COGNITIVE AND PHYSIOLOGICAL AFTEREFFECTS; HUMAN-COMPUTER INTERACTION (HCI)

**SURFACE TRANSPORTATION SYSTEMS**

Drews, Frank A.; Yazdani, Hina; Godfrey, Celeste N.; Cooper, Joel M.; Strayer, David L. *Text Messaging During Simulated Driving*. S. 762-770(9).

**Objective:** This research aims to identify the impact of text messaging on simulated driving performance. **Background:** In the past decade, a number of on-road, epidemiological, and simulator-based studies reported the negative impact of talking on a cell phone on driving behavior. However, the impact of text messaging on simulated driving performance is still not fully understood. **Method:** Forty participants engaged in both a single task (driving) and a dual task (driving and text messaging) in a high-fidelity driving simulator. **Results:** Analysis of driving performance revealed that participants in the dual-task condition responded more slowly to the onset of braking lights and showed impairments in forward and lateral control compared with a driving-only condition. Moreover, text-messaging drivers were involved in more crashes than drivers not engaged in text messaging. **Conclusion:** Text messaging while driving has a negative impact on simulated driving performance. This negative impact appears to exceed the impact of conversing on a cell phone while driving. **Application:** The results increase our understanding of driver distraction and have potential implications for public safety and device development.

- **Keywords:** DRIVER DISTRACTION; TEXT MESSAGING; SURFACE TRANSPORTATION SYSTEMS; ACCIDENTS; SAFETY