

Human Factors – rok 2008, roč. 50

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AEROSPACE SYSTEMS

Pauley, Keryn A.; O'Hare, David; Mullen, Nadia W.; Wiggins, Mark. *Implicit Perceptions of Risk and Anxiety and Pilot Involvement in Hazardous Events. S. 723-733(11).*

Abstract: Objective: The aim of the studies was to examine the role of implicit processes in aeronautical risk perception and risk taking. **Background:** Aeronautical decision making consists of both explicit processes (e.g., comparing options, seeking information) and implicit, or intuitive, processes (e.g., immediate affective reactions). The present studies utilized a novel methodology, adapted from studies in social cognition, to examine the relationship between general aviation pilots' implicit reactions toward risk and their involvement in hazardous events. **Method:** The Implicit Association Test was used to measure pilots' (Study 1: $N = 23$; Study 2: $N = 32$) implicit associations between good and bad weather conditions and perceptions of risk and anxiety. **Results:** There was a relationship between the pilots' implicit perceptions and previous involvement in hazardous aeronautical events as measured by D. R. Hunter's (1995, 2002) Hazardous Events Scale. The more weather-related hazardous events the pilots had been involved in, the less they associated implicit risk with adverse weather (Study 1) and the less implicitly anxious they were toward adverse weather (Study 2). **Conclusion:** The results show a relationship between implicit associations and risk-taking behavior. **Application:** Pilots may be involved in risk-taking behavior because they perceive less risk in, and are implicitly less afraid of, hazardous conditions.

- **Keywords:** NATURALISTIC DECISION MAKING; GENERAL AVIATION PILOT; CREW BEHAVIOR; LEARNING; MEMORY; COGNITIVE PROCESSES; INDIVIDUAL DIFFERENCES; AEROSPACE SYSTEMS; IMPLICIT ASSOCIATIONS; RISK PERCEPTION; ANXIETY; RISK TAKING; WEATHER-RELATED DECISION-MAKING

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Seo, Na Jin; Armstrong, Thomas J. *Investigation of Grip Force, Normal Force, Contact Area, Hand Size, and Handle Size for Cylindrical Handles. S. 734-744(11).*

Abstract: Objective: To investigate relationships among grip forces, normal forces, contact area for cylindrical handles, handle diameter, hand size, and volar hand area. **Background:** Data describing those relationships are needed to predict thrust forces and torque capability. **Method:** Additional analyses were performed retrospectively on data collected in two previous studies in which participants performed maximum grip exertions on cylinders (diameter 38-83 mm) while grip force, normal force, and contact area were recorded. The length, width, and volar area of the hand were measured. **Results:** Average total normal force on cylinders was 2.3 times greater than grip force measured using a split cylinder ($R^2 = 65\%$), regardless of the handle diameter examined. The ratio of handle diameter to hand length explained 62%, 57%, and 71% of the variances in grip force, normal force, and contact area, respectively. Estimated hand area (hand length \times width) had a linear relationship with measured hand area (using photographs; $R^2 = 91\%$), although it was 8% less than the measured area. **Conclusion:** This work describes the relationship between normal force and grip force independent of handle size (for handle diameters from 38 to 83 mm). Normal force and contact area can be explained by the interaction between handle size and hand size. Hand area can be estimated by hand length times width. **Application:** The quantitative relationships described in this paper can be used in the design of objects and hand tools to determine optimal handle sizes for maximizing grip force, total normal force, or contact area.

- **Keywords:** CONTACT AREA; HAND SIZE; GRIP FORCE; HANDLE SIZE; NORMAL FORCE; GRIP BIOMECHANICS; CONTACT FORCE; HAND AREA; MODELS AND MEASURES

COGNITIVE PROCESSES

Cook, Maia B.; Smallman, Harvey S. *Human Factors of the Confirmation Bias in Intelligence Analysis : Decision Support From Graphical Evidence Landscapes. S. 745-754(10).*

Abstract: Objective: This study addresses the human factors challenge of designing and validating decision support to promote less biased intelligence analysis. **Background:** The confirmation bias can compromise objectivity in ambiguous medical and military decision making through neglect of conflicting evidence and judgments not reflective of the entire evidence spectrum. Previous debiasing approaches have had mixed success and have tended to place additional demands on users' decision making. **Method:** Two new debiasing interventions that help analysts picture the full spectrum of evidence, the relation of evidence to a hypothesis, and other analysts' evidence assessments were manipulated in a repeated-measures design: (a) an integrated graphical evidence layout, compared with a text baseline; and (b) evidence tagged with other analysts' assessments, compared with participants' own assessments. Twenty-seven naval trainee analysts and reservists assessed, selected, and prioritized evidence in analysis vignettes carefully constructed to have balanced supporting and conflicting evidence sets. Bias was measured for all three evidence analysis steps. **Results:** A bias to select a skewed distribution of confirming evidence occurred across conditions. However, graphical evidence layout, but not other analysts' assessments, significantly

reduced this selection bias, resulting in more balanced evidence selection. Participants systematically prioritized the most supportive evidence as most important. **Conclusion:** Domain experts exhibited confirmation bias in a realistic intelligence analysis task and apparently conflated evidence supportiveness with importance. Graphical evidence layout promoted more balanced and less biased evidence selection. **Application:** Results have application to real-world decision making, implications for basic decision theory, and lessons for how shrewd visualization can help reduce bias.

- **Keywords:** DEBIASING; HYPOTHESIS TESTING; INTELLIGENCE ANALYSIS; VISUALIZATION; DECISION SUPPORT SYSTEMS; NATURALISTIC DECISION MAKING; OBJECT DISPLAYS; DISPLAYS AND CONTROLS; COGNITIVE PROCESSES

COMPUTER SYSTEMS

Durso, Francis T.; Sethumadhavan, Arathi; Crutchfield, Jerry. *Linking Task Analysis to Information Relevance. S. 755-762(8).*

Abstract: Objective: The main objective of this study is to present a methodology for computing information relevance. **Background:** *Relevance* is a pervasive term used in several domains, such as pragmatics, information science, and psychology. Quantifying the relevance of information can be helpful in effective display design. Displays should be designed so that the more relevant information is more easily accessed. **Method:** This procedure focuses on computing the relevance of a piece of information by taking into account three aspects of tasks that use the information: the number of different tasks that make use of the information, the frequency of occurrence of those tasks, and the criticality of those tasks. The methodology can be used to compute the aggregate relevance of a piece of information for a particular component of a system or for the entire system. This methodology was illustrated using the domain of air traffic control (ATC). **Results:** In support of the validity of the methodology, we were able to confirm the value of weather information and traffic information in ATC towers. **Conclusion:** The method can be used to derive information relevance, a characteristic of information that has implications for display design for any domain. **Application:** Designers can use information about aggregate relevance to design information displays that feature the most relevant information.

- **Keywords:** INFORMATION RELEVANCE; TASK ANALYSIS; DISPLAY DESIGN; AIR TRAFFIC CONTROL; EUCLIDEAN DISTANCE; CRITICALITY FREQUENCY; COMPUTER SYSTEMS

Jones, Keith S.; Ballew, Timothy V.; Probst, Adam C. *Does Content Affect Whether Users Remember That Web Pages Were Hyperlinked? S. 763-771(9).*

Abstract: Objective: We determined whether memory for hyperlinks improved when they represented relations between the contents of the Web pages. **Background:** J. S. Farris (2003) found that memory for hyperlinks improved when they represented relations between the contents of the Web pages. However, Farris's (2003) participants could have used their knowledge of site content to answer questions about relations that were instantiated via the site's content and its hyperlinks. **Method:** In Experiment 1, users navigated a Web site and then answered questions about relations that were instantiated only via content, only via hyperlinks, and via content and hyperlinks. Unlike Farris (2003), we split the latter into two sets. One asked whether certain content elements were related, and the other asked whether certain Web pages were hyperlinked. Experiment 2 replicated Experiment 1 with one modification: The questions that were asked about relations instantiated via content and hyperlinks were changed so that each question's wrong answer was also related to the question's target. **Results:** Memory for hyperlinks improved when they represented relations instantiated within the content of the Web pages. This was true when (a) questions about content and

hyperlinks were separated (Experiment 1) and (b) each question's wrong answer was also related to the question's target (Experiment 2). **Conclusion:** The accuracy of users' mental representations of local architecture depended on whether hyperlinks were related to the site's content. **Application:** Designers who want users to remember hyperlinks should associate those hyperlinks with content that reflects the relation between the contents on the Web pages.

- **Keywords:** HYPERLINKS; MEMORY; MENTAL REPRESENTATION; LOCAL ARCHITECTURE; HUMAN-COMPUTER INTERACTION; HCI; COMPUTER SYSTEMS; INTERNET; USABILITY; COMPUTER SYSTEMS

Takayama, Leila; Nass, Clifford. *Assessing the Effectiveness of Interactive Media in Improving Drowsy Driver Safety*. S. 772-781(10).

Abstract: Objective: This study investigated the possibility of using interactive media to help drowsy drivers wake up, thereby enabling them to drive more safely. **Background:** Many studies have investigated the negative impacts of driver drowsiness and distraction in cars, separately. However, none has studied the potentially positive effects of slightly interactive media for rousing drowsy drivers to help them drive more safely. **Method:** In a 2 (drowsy vs. nondrowsy drivers) × 2 (passive vs. slightly interactive voice-based media) × 2 (monotonous vs. varied driving courses) study, participants ($N = 79$) used a driving simulator while interacting with a language-learning system that was either passive (i.e., drivers merely listen to phrases in another language) or slightly interactive (i.e., drivers verbally repeat those phrases). **Results:** (a) Drowsy drivers preferred and drove more safely with slightly interactive media, as compared with passive media. (b) Interactive media did not harm nondrowsy driver safety. (c) Drivers drove more safely on varied driving courses than on monotonous ones. **Conclusion:** Slightly interactive media hold the potential to improve the performance of drowsy drivers on the primary task of driving safely. **Application:** Applications include the design of interactive systems that increase user alertness, safety, and engagement on primary tasks, as opposed to systems that take attentional resources away from the primary task of driving.

- **Keywords:** DROWSY DRIVING; DRIVING SIMULATOR; INTERACTIVE MEDIA; INTERACTIVITY; HUMAN-COMPUTER INTERACTION; HCI; DRIVER BEHAVIOR; DUAL-TASK PERFORMANCE; INTERFACE EVALUATION; USABILITY; BOREDOM; MONOTONY; PSYCHOLOGICAL STATES; SURFACE TRANSPORTATION SYSTEMS; ATTENTIONAL PROCESSES; COMMUNICATION SYSTEMS; COMPUTER SYSTEMS

DISPLAYS AND CONTROLS

Dowell, John; Shmueli, Yael. *Blending Speech Output and Visual Text in the Multimodal Interface*. S. 782- 788(7).

Abstract: Objective: Simultaneous reading and listening with a redundant display of visual text with speech output was investigated to determine how variations in verbal working memory capacity and content complexity affected comprehension. **Background:** Previous work has found some evidence of a benefit for displays that blend speech and visual text; content complexity and verbal working memory capacity are likely to significantly determine this benefit. **Method:** In the experiment reported here, a multimodal display of e-mail messages was compared with speech output alone and with a purely visual display. Comprehension of the messages was examined in relation to verbal working memory capacity and the complexity of the messages. Thirty-two users participated in the study, which used a repeated measures design. **Results:** The data show that the multimodal interface did not affect comprehension relative to a purely visual interface, even when the content was more complex, although it did improve the comprehension of complex information relative to a purely auditory interface. Lower-capacity participants were neither especially advantaged nor disadvantaged by the

multimodal interface. Participants expressed a marked preference for the multimodal display of the more complex sentences. **Conclusion:** The experiment suggests that a redundant multimodal display will neither assist nor disrupt understanding when compared with a purely visual display, but it will assist understanding of complex content when compared with speech output alone. **Application:** Redundant displays of visual text and speech have potential application in multitask situations, in multimedia presentations, and for devices with small screens.

- **Keywords:** MULTIMEDIA; SPEECH OUTPUT; LISTENING; READING; REDUNDANCY; HUMAN-COMPUTER INTERACTION; HCI; DUAL-TASK PERFORMANCE; SIDE TASKS; ATTENTIONAL PROCESSES; MEMORY; MULTIMODAL INTERFACE; SMALL SCREENS; MOBILE DISPLAYS

Thompson, Matthew B.; Sanderson, Penelope M. *Multisensory Integration With a Head-Mounted Display : Sound Delivery and Self-Motion*. S. 789-800(12).

Abstract: Objective: We tested whether the method of sound delivery affects people's ability to integrate information from multiple modalities when they are walking and using a head-mounted display (HMD). **Background:** HMDs increasingly support mobile work. Human operators may benefit from auditory support when using an HMD. However, it is unclear whether sound is better delivered publicly in free field or privately via earpiece and what the effect of walking is. **Method:** Participants identified mismatches between sounds and visual information on an HMD. Participants heard the sounds via either earpiece or free field while they either sat or walked about the test room. **Results:** When using an earpiece, participants performed the mismatch task equally well whether sitting or walking, but when using free-field sound, participants performed the task significantly worse when walking than when sitting ($p=.006$). **Conclusion:** The worse performance for participants using free-field sound while walking may relate to spatial and motion inconsistencies between visual events on the head-referenced HMD and auditory events from world-referenced speakers. Researchers should more frequently examine the effect of self-motion on people's ability to perform various multisensory tasks. **Application:** When multisensory integration tasks are performed with an HMD and free-field delivery of sound, as may happen in medicine, transportation, or industry, performance may suffer when the relative location of sound changes as the user moves.

- **Keywords:** HEAD-MOUNTED DISPLAYS; AUDITORY DISPLAYS; MULTISENSORY INTEGRATION; SELF-MOTION; EARPIECE; FREE FIELD; MULTIMODAL DISPLAYS; PERCEPTUAL PROCESSES; VISUAL DISPLAYS; HUMAN PERFORMANCE; CROSSMODAL ATTENTION; VENTRILOQUISM

HEALTH AND MEDICAL SYSTEMS

Story, Molly Follette; Luce, Adam C.; Leung, Alexander; Omiatek, Elizabeth M.; Lemke, Melissa R.; Rempel, David M. *Accessibility of Radiology Equipment for Patients with Mobility Disabilities*. S. 801-810(10).

Abstract: Objective: The purpose was to evaluate accessibility of typical radiology platforms by participants with mobility disabilities. **Background:** These patients have difficulty using radiology equipment and have an increased risk of falling. **Methods:** This field study evaluated three common types of radiology platforms - X ray, computed tomography (CT) scan, and fluoroscopy - by 20 patients/participants with mobility impairments who used walking aids. The participants were required to get onto the equipment, simulate a typical radiological procedure, and get off. Each participant then watched a video of his or her own session and answered questions. Four researchers independently reviewed the videotapes and identified accessibility and safety barriers. **Results:** Overall, the CT scan platform was the easiest to use and the fluoroscopy platform the most difficult, primarily because of platform height differences. Sitting up on

the X-ray table was rated as difficult by most participants, primarily because of a lack of handholds and the surface pad not being fixed in place. Maintaining a position on the fluoroscopy platform while it rotated from horizontal to vertical was difficult and frightening for most participants. **Conclusion:** Some radiology platforms are difficult to use and are perceived to be less safe for patients with mobility disabilities. The interaction of patient disability and equipment design can impose substantial physical demands on medical personnel. Recommendations for improved design are provided to enhance radiology platform accessibility and safety. **Application:** The findings may be applicable to the design of a wide range of medical patient platforms.

- **Keywords:** ACCESSIBILITY; DISABILITY; USABILITY; USABILITY TESTING; PATIENT SAFETY; MEDICAL DEVICES; MEDICAL EQUIPMENT; HEALTH AND MEDICAL SYSTEMS; AGING; WORKSPACE; BUILT ENVIRONMENT DESIGN; MACROERGONOMICS AND THE ENVIRONMENT; ACCIDENTS; SAFETY; HUMAN ERROR

SENSORY AND PERCEPTUAL PROCESSES

Delucia, Patricia R. *Critical Roles for Distance, Task, and Motion in Space Perception: Initial Conceptual Framework and Practical Implications.* S. 811-820(10).

Abstract: Objective: A conceptual framework of visual space perception is proposed. **Background:** Prior studies suggest that the processes underlying space perception depend on viewing distance, the nature of a task, and the presence and nature of motion. **Method:** Evidence from neuropsychological, neuroimaging, and behavioral studies is reviewed. **Results:** A preliminary conceptual framework of space perception is proposed in which three critical factors of distance, task, and motion represent different dimensions. Different locations within the framework represent the involvement of different underlying processes. At one extreme, indirect perception underlies a stationary observer's perceptual judgments of stationary objects in far space. At the other extreme, direct perception underlies a moving observer's actions involving moving objects in near space. Between these extremes, both processes are utilized and allow for flexibility in human performance. **Conclusions:** Prior studies of space perception should be reevaluated based on viewing distances employed, the nature of the tasks, and the presence and nature of motion. Future studies of space perception should manipulate these variables. **Application:** If, as proposed by the framework, observers use different underlying mechanisms to perceive near and far spaces and to perform different types of tasks, it becomes important to identify the limits of such mechanisms and to design technologies to accommodate those limits. For example, collision-avoidance warning systems may have to utilize different criteria for providing warnings at near versus far headways. Further study of the proposed framework will help improve the design of such technologies.

- **Keywords:** VISUAL PERCEPTION; SPACE PERCEPTION; PERCEPTUAL-MOTOR PROCESSES; COLLISION-AVOIDANCE WARNING SYSTEMS; DEPTH PERCEPTION; MOTION PERCEPTION; TRANSPORTATION; DRIVING; VISION; SENSORY AND PERCEPTUAL PROCESSES; DRIVER BEHAVIOR; HIGHWAY SAFETY; NEUROPSYCHOLOGY; NEUROIMAGING; COGNITIVE SCIENCE; NEUROSCIENCE; COGNITIVE PROCESSES

Greco, Massimo; Stucchi, Natale; Zavagno, Daniele; Marino, Barbara. *On the Portability of Computer-Generated Presentations : The Effect of Text-Background Color Combinations on Text Legibility.* S. 821-833(13).

Abstract: Objective: The aim of our study was to investigate which text-background (TB) color combinations improve legibility and pleasantness of texts either presented on

a computer screen or projected on a wider surface. **Background:** Our work stems from the observation that multimedia presentations, even those by professionals in visual disciplines, are often spoiled by illegibility, which affects readability and the pleasantness of attending to such presentations. **Methods:** We investigated this problem through three experiments. Experiment 1 assessed the best TB color combinations in slides presented on a laptop. Experiment 2 verified the correlation between legibility and pleasantness for TB presentations. Experiment 3 investigated the legibility of a slide projected on a wide screen in different room lighting conditions. In all experiments participants expressed a rating score for stimulus legibility or pleasantness. **Results:** Experiments 1 and 3 showed that it is best to have a dark text on a light background for both displayed and projected texts. Experiment 2 showed that pleasantness is tightly correlated with legibility, though legibility depends on contrast between text and background. **Conclusions:** Our findings are not in complete agreement with the literature concerning legibility of text displayed on a computer screen, and they are in contrast with the common belief that for projection purposes it is best to have a light text on a dark background. **Applications:** Some practical rules on combining TB colors are given to enhance the legibility of presentations, especially important for the legibility of projected texts.

- **Keywords:** LEGIBILITY; COLOR; CONTRAST; VISION; VISUAL; PICTORIAL; OBJECT DISPLAYS; SENSORY AND PERCEPTUAL PROCESSES; DISPLAYS AND CONTROLS

SURFACE TRANSPORTATION SYSTEMS

Salvucci, Dario D.; Beltowska, Joanna. *Effects of Memory Rehearsal on Driver Performance: Experiment and Theoretical Account*. S. 834-844(11).

Abstract: Objective: We report an experiment and a theoretical analysis concerning the effects of an exclusively cognitive task, specifically a memory rehearsal task, on driver performance. **Background:** Although recent work on driver distraction has elucidated the sometimes significant effects of cognitive processing on driver performance, these studies have typically mixed cognitive with perceptual and motor processing, making it difficult to isolate the effects of cognitive processing alone. **Method:** We asked participants to drive in a driving simulator during only the rehearsal stage of a serial-recall memory task while we measured their ability to maintain a central lane position and respond to the illumination of a lead vehicle's brake lights. **Results:** Memory rehearsal significantly affected drivers' steering performance as measured by lateral deviation from lane center, and it also significantly affected drivers' response time to the braking stimulus for the higher load memory task. **Conclusion:** These results lend support to a theoretical account of cognitive distraction provided by threaded cognition theory in terms of a cognitive bottleneck in procedural processing, and they also suggest that consideration of task urgency may be important in accounting for performance trade-offs among concurrent tasks. **Application:** The experiment augments the current understanding of cognitive driver distraction and suggests that even exclusively cognitive secondary tasks may sometimes affect driver performance.

- **Keywords:** DRIVER BEHAVIOR; DRIVER PERFORMANCE; DUAL-TASK PERFORMANCE; ATTENTIONAL PROCESSES; COGNITIVE PROCESSES; MEMORY REHEARSAL; SERIAL RECALL; SURFACE TRANSPORTATION SYSTEMS

Sullivan, John M.; Tsimhoni, Omer; Bogard, Scott. *Warning Reliability and Driver Performance in Naturalistic Driving*. S. 845-852(8).

Abstract: Objective: This study examines how naturalistic driving performance is influenced by the perceived reliability of an in-vehicle warning system using a unique measure of perceived reliability. **Background:** Prior studies of warning reliability

conducted in simulator and test-track experiments demonstrate that the objective reliability of a warning can influence a driver's responsiveness to that warning. **Methods:** Driver responses to lateral drift warnings (LDWs) were examined to determine if the latency to initiate a corrective steering response was related to the subjective reliability of prior system performance. An operational definition of subjective reliability was developed based on measures of the proportion of LDWs responded to by a steering correction in the preceding 24-hr period - the day proportion. Age, gender, weather condition, light level, road class, weekday status, and day proportion were used to model correction latency in a linear model. **Results:** A main effect of day proportion was found, suggesting that reaction time to respond decreases by about 375 ms as the day proportion increases from 0 to 1. **Conclusion:** The study illustrates a method of quantifying subjective reliability and performance using naturalistic data. The results suggest that latency to make a steering correction is inversely related to the perceived reliability of the warning system in the 24 hr preceding the warning. **Application:** The results have direct application to the method of assessing the efficacy of in-vehicle collision warning systems, suggesting that use of a perceived reliability measure may better predict a driver's disposition to respond to a warning.

- **Keywords:** SUBJECTIVE RELIABILITY; LATERAL DRIFT WARNING; DRIVER BEHAVIOR; SAFETY; SURFACE TRANSPORTATION SYSTEMS