

# Human Factors – rok 2014, roč. 56

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### ATTENTIONAL PROCESSES

**Stephen M. Casner, Jonathan W. Schooler. Thoughts in Flight : Automation Use and Pilots' Task-Related and Task-Unrelated Thought. S. 433-442.**

**Objective:** The objective was to examine the relationship between cockpit automation use and task-related and task-unrelated thought among airline pilots. **Background:** Studies find that cockpit automation can sometimes relieve pilots of tedious control tasks and afford them more time to think ahead. Paradoxically, automation has also been shown to lead to lesser awareness. These results prompt the question of what pilots think about while using automation. **Method:** A total of 18 airline pilots flew a Boeing 747-400 simulator while we recorded which of two levels of automation they used. As they worked, pilots were verbally probed about what they were thinking. Pilots were asked to categorize their thoughts as pertaining to (a) a specific task at hand, (b) higher-level flight-related thoughts (e.g., planning ahead), or (c) thoughts unrelated to the flight. Pilots' performance was also measured. **Results:** Pilots reported a smaller percentage of task-at-hand thoughts (27% vs. 50%) and a greater percentage of higher-level flight-related thoughts (56% vs. 29%) when using the higher level of automation. However, when all was going according to plan, using either level of automation, pilots also reported a higher percentage of task-unrelated thoughts (21%) than they did when in the midst of an unsuccessful performance (7%). Task-unrelated thoughts peaked at 25% when pilots were not interacting with the automation. **Conclusion:** Although cockpit automation may provide pilots with more time to think, it may encourage pilots to reinvest only some of this mental free time in thinking flight-related thoughts. **Application:** This research informs the design of human–automation systems that more meaningfully engage the human operator.

- **Keywords:** cockpit automation, awareness, mind wandering, attention

**John G. Gaspar, Mark B. Neider, James A. Crowell, Aubrey Lutz, Henry Kaczmarek, Arthur F. Kramer. Are Gamers Better Crossers? : an Examination of Action Video Game Experience and Dual Task Effects in a Simulated Street Crossing Task. S. 443-452.**

**Objective:** A high-fidelity street crossing simulator was used to test the hypothesis that experienced action video game players are less vulnerable than nongamers to dual task costs in complex tasks. **Background:** Previous research has shown that action video game players outperform nonplayers on many single task measures of perception and attention. It is unclear, however, whether action video game players outperform

nonplayers in complex, divided attention tasks. **Method:** Experienced action video game players and nongamers completed a street crossing task in a high-fidelity simulator. Participants walked on a manual treadmill to cross the street. During some crossings, a cognitively demanding working memory task was added. **Results:** Dividing attention resulted in more collisions and increased decision making time. Of importance, these dual task costs were equivalent for the action video game players and the nongamers. **Conclusion** These results suggest that action video game players are equally susceptible to the costs of dividing attention in a complex task. **Application:** Perceptual and attentional benefits associated with action video game experience may not translate to performance benefits in complex, real-world tasks.

- **Keywords:** video games, dual task performance, pedestrian safety, distraction

**Paul Atchley, Mark Chan, Sabrina Gregersen. *A Strategically Timed Verbal Task Improves Performance and Neurophysiological Alertness During Fatiguing Drives.* S. 453-462.**

**Objective:** The objective of this study was to investigate if a verbal task can improve alertness and if performance changes are associated with changes in alertness as measured by EEG. **Background:** Previous research has shown that a secondary task can improve performance on a short, monotonous drive. The current work extends this by examining longer, fatiguing drives. The study also uses EEG to confirm that improved driving performance is concurrent with improved driver alertness. **Method:** A 90-min, monotonous simulator drive was used to place drivers in a fatigued state. Four secondary tasks were used: no verbal task, continuous verbal task, late verbal task, and a passive radio task. **Results:** When engaged in a secondary verbal task at the end of the drive, drivers showed improved lane-keeping performance and had improvements in neurophysiological measures of alertness. **Conclusion:** A strategically timed concurrent task can improve performance even for fatiguing drives. **Application:** Secondary-task countermeasures may prove useful for enhancing driving performance across a range of driving conditions.

- **Keywords:** countermeasures, monotony, fatigued driving, alertness, concurrent task, attention

## **AUTOMATION, EXPERT SYSTEMS**

**Ryan McKendrick, Tyler Shaw, Ewart de Visser, Haneen Saqer, Brian Kidwell, Raja Parasuraman. *Team Performance in Networked Supervisory Control of Unmanned Air Vehicles : Effects of Automation, Working Memory, and Communication Content.* S. 463-475.**

**Objective:** Assess team performance within a networked supervisory control setting while manipulating automated decision aids and monitoring team communication and working memory ability. **Background:** Networked systems such as multi-unmanned air vehicle (UAV) supervision have complex properties that make prediction of human-system performance difficult. Automated decision aid can provide valuable information to operators, individual abilities can limit or facilitate team performance, and team communication patterns can alter how effectively individuals work together. We hypothesized that reliable automation, higher working memory capacity, and increased communication rates of task-relevant information would offset performance decrements attributed to high task load. **Method:** Two-person teams performed a simulated air defense task with two levels of task load and three levels of automated aid reliability. Teams communicated and received decision aid messages via chat window text messages. **Results:** Task Load × Automation effects were significant across all performance measures. Reliable automation limited the decline in team performance with

increasing task load. Average team spatial working memory was a stronger predictor than other measures of team working memory. Frequency of team rapport and enemy location communications positively related to team performance, and word count was negatively related to team performance. **Conclusion:** Reliable decision aiding mitigated team performance decline during increased task load during multi-UAV supervisory control. Team spatial working memory, communication of spatial information, and team rapport predicted team success. **Application:** An automated decision aid can improve team performance under high task load. Assessment of spatial working memory and the communication of task-relevant information can help in operator and team selection in supervisory control systems.

- **Keywords:** UAVs, automation, decision aids, working memory, communications, teams, supervisory control

**Linda Onnasch, Christopher D. Wickens, Huiyang Li, and Dietrich Manzey.** *Human Performance Consequences of Stages and Levels of Automation : an Integrated Meta-Analysis.* S. 476-488.

**Objective:** We investigated how automation-induced human performance consequences depended on the degree of automation (DOA). **Background:** Function allocation between human and automation can be represented in terms of the stages and levels taxonomy proposed by Parasuraman, Sheridan, and Wickens. Higher DOAs are achieved both by later stages and higher levels within stages. **Method:** A meta-analysis based on data of 18 experiments examines the mediating effects of DOA on routine system performance, performance when the automation fails, workload, and situation awareness (SA). The effects of DOA on these measures are summarized by level of statistical significance. **Results:** We found (a) a clear automation benefit for routine system performance with increasing DOA, (b) a similar but weaker pattern for workload when automation functioned properly, and (c) a negative impact of higher DOA on failure system performance and SA. Most interesting was the finding that negative consequences of automation seem to be most likely when DOA moved across a critical boundary, which was identified between automation supporting information analysis and automation supporting action selection. **Conclusion:** Results support the proposed cost–benefit trade-off with regard to DOA. It seems that routine performance and workload on one hand, and the potential loss of SA and manual skills on the other hand, directly trade off and that appropriate function allocation can serve only one of the two aspects. **Application:** Findings contribute to the body of research on adequate function allocation by providing an overall picture through quantitatively combining data from a variety of studies across varying domains.

- **Keywords:** degree of automation, operator performance, workload, situation awareness, human-automation interaction, function allocation

## COGNITIVE PROCESSES

**Philip Bobko, Alex J. Barelka, and Leanne M. Hirshfield.** *The Construct of State-Level Suspicion : A Model and Research Agenda for Automated and Information Technology (IT) Contexts.* S. 489-508.

**Objective:** The objective was to review and integrate available research about the construct of state-level suspicion as it appears in social science literatures and apply the resulting findings to information technology (IT) contexts. **Background:** Although the human factors literature is replete with articles about trust (and distrust) in automation, there is little on the related, but distinct, construct of “suspicion” (in either automated or IT contexts). The construct of suspicion—its precise definition, theoretical correlates, and role in such applications—deserves further study. **Method:** Literatures that consider suspicion are reviewed and integrated. Literatures include communication, psychology,

human factors, management, marketing, information technology, and brain/neurology. We first develop a generic model of state-level suspicion. Research propositions are then derived within IT contexts. **Results:** Fundamental components of suspicion include (a) uncertainty, (b) increased cognitive processing (e.g., generation of alternative explanations for perceived discrepancies), and (c) perceptions of (mal)intent. State suspicion is defined as the simultaneous occurrence of these three components. Our analysis also suggests that trust inhibits suspicion, whereas distrust can be a catalyst of state-level suspicion. Based on a three-stage model of state-level suspicion, associated research propositions and questions are developed. These propositions and questions are intended to help guide future work on the measurement of suspicion (self-report and neurological), as well as the role of the construct of suspicion in models of decision making and detection of deception. **Conclusion:** The study of suspicion, including its correlates, antecedents, and consequences, is important. We hope that the social sciences will benefit from our integrated definition and model of state suspicion. The research propositions regarding suspicion in IT contexts should motivate substantial research in human factors and related fields.

- **Keywords:** state suspicion, information technology, distrust

**Susan S. Kirschenbaum, J. Gregory Trafton, Christian D. Schunn, Susan B. Trickett.** *Visualizing Uncertainty : The Impact on Performance.* S. 509-520.

**Objective:** This work investigated the impact of uncertainty representation on performance in a complex authentic visualization task, submarine localization. **Background:** Because passive sonar does not provide unique course, speed, and range information on a contact, the submarine operates under significant uncertainty. There are many algorithms designed to address this problem, but all are subject to uncertainty. The extent of this solution uncertainty can be expressed in several ways, including a table of locations (course, speed, range) or a graphical area of uncertainty. **Method:** To test the hypothesis that the representation of uncertainty that more closely matches the experts' preferred representation of the problem would better support performance, even for the nonexpert., performance data were collected using displays that were either stripped of the spatial or the tabular representation. **Results:** Performance was more accurate when uncertainty was displayed spatially. This effect was only significant for the nonexperts for whom the spatial displays supported almost expert-like performance. This effect appears to be due to reduced mental effort. **Conclusion:** These results suggest that when the representation of uncertainty for this spatial task better matches the expert's preferred representation of the problem even a nonexpert can show expert-like performance. **Application:** These results could apply to any domain where performance requires working with highly uncertain information.

- **Keywords:** decision making, naturalistic decision making, cognitive processes, knowledge representation, problem solving, reasoning

## COMPUTER SYSTEMS

**Alan H. S. Chan, Steve N. H. Tsang, Annie W. Y. Ng.** *Effects of Line Length, Line Spacing, and Line Number on Proofreading Performance and Scrolling of Chinese Text.* S. 521-534.

**Objective:** The main purpose of this study was to investigate the effects and interactions of line length, line number, and line spacing on Chinese screen-based proofreading performance and amount of scrolling. **Background:** Proofreading is an important process, and much of it is now done on screen. The Chinese language is increasingly important, but very little work has been done on the factors that affect proofreading performance for Chinese passages. **Method:** Three display factors related to screen size,

namely line length, line number, and line spacing, were selected to be investigated in an experiment to determine their effects on proofreading performance and amount of scrolling. Correlations between proofreading performance in time and accuracy and scrolling amount were also analyzed. **Results:** The results showed that line number and line spacing had significant main and interaction effects on both proofreading time and detection rate. Line length and line number influenced scrolling amount significantly, but there was no interaction effect for scrolling. Scrolling amount was negatively correlated with proofreading time and typo detection rate such that more scrolling movement was associated with faster proofreading, but lower detection rate. There was a trade-off between time and accuracy. **Conclusion:** For balancing time and detection rate and improving performance for on-screen Chinese proofreading, the display setting of medium line length (36 characters per line) with four lines and 1.5 line spacing should be used. **Application:** The findings provide information and recommendations for display factors and the screen design that should prove useful for improving proofreading time and accuracy.

- **Keywords:** proofreading, Chinese, screen design, scrolling

## DISPLAYS AND CONTROLS

**Michael C. Dorneich, Christopher J. Hamblin, Jeff A. Lancaster, Olu Olofinboba.** *Perceptual Grouping Effects on Cursor Movement Expectations.* S. 535-552.

**Objective:** Two studies were conducted to develop an understanding of factors that drive user expectations when navigating between discrete elements on a display via a limited degree-of-freedom cursor control device. **Background:** For the Orion Crew Exploration Vehicle spacecraft, a free-floating cursor with a graphical user interface (GUI) would require an unachievable level of accuracy due to expected acceleration and vibration conditions during dynamic phases of flight. Therefore, Orion program proposed using a “caged” cursor to “jump” from one controllable element (node) on the GUI to another. However, nodes are not likely to be arranged on a rectilinear grid, and so movements between nodes are not obvious. **Method:** Proximity between nodes, direction of nodes relative to each other, and context features may all contribute to user cursor movement expectations. In an initial study, we examined user expectations based on the nodes themselves. In a second study, we examined the effect of context features on user expectations. **Results:** The studies established that perceptual grouping effects influence expectations to varying degrees. Based on these results, a simple rule set was developed to support users in building a straightforward mental model that closely matches their natural expectations for cursor movement. **Conclusion:** The results will help designers of display formats take advantage of the natural context-driven cursor movement expectations of users to reduce navigation errors, increase usability, and decrease access time. **Application:** The rules set and guidelines tie theory to practice and can be applied in environments where vibration or acceleration are significant, including spacecraft, aircraft, and automobiles.

- **Keywords:** human–computer interaction, display–control compatibility, perceptual grouping, cursor control device, Orion Crew Exploration Vehicle

**Zhe Chen, Pei-Luen Patrick Rau, Cuiling Chen.** *The Effects of Human Finger and Chinese Character on Chinese Handwriting Performance on Mobile Touch Devices.* S. 553-568.

**Objective:** The aim of the present study is to investigate Chinese handwriting on mobile touch devices, considering the effects of three characteristics of the human finger (type, length, and width) and three characteristics of Chinese characters (direction of the first stroke, number of strokes, and structure). **Background:** Due to the popularity of touch

devices in recent years, finger input for Chinese characters has attracted more attention from both industry and academia. However, previous studies have no systematical consideration on the effects of human finger and Chinese characters on Chinese handwriting performance. **Method:** An experiment was reported in this article to illustrate the effects of the human finger and Chinese characters on the Chinese handwriting performance (i.e., input time, accuracy, number of protruding strokes, mental workload, satisfaction, and physical fatigue). **Results:** The experiment results indicated that all six factors have significant effects on Chinese handwriting performance, especially on the input time, accuracy, and number of protruding strokes. **Conclusion:** Finger type, finger length, finger width, direction of the first stroke, number of strokes, and character structures are significantly influencing Chinese handwriting performance. These factors should be taken into more consideration in future research and the practical design for Chinese handwriting systems.

- **Keywords:** finger input, Chinese characters, Chinese handwriting, mobile touch devices

## HEALTH AND MEDICAL SYSTEMS

**Frank A. Drews, Alexa Doig. *Evaluation of a Configural Vital Signs Display for Intensive Care Unit Nurses.* S. 569-580.**

**Objective:** The objective was to evaluate a configural vital signs (CVS) display designed to support rapid detection and identification of physiological deterioration by graphically presenting patient vital signs data. **Background:** Current display technology in the intensive care unit (ICU) is not optimized for fast recognition and identification of physiological changes in patients. To support nurses more effectively, graphical or configural vital signs displays need to be developed and evaluated. **Method:** A CVS display was developed based on findings from studies of the cognitive work of ICU nurses during patient monitoring. A total of 42 ICU nurses interpreted data presented either in a traditional, numerical format ( $n = 21$ ) or on the CVS display ( $n = 21$ ). Response time and accuracy in clinical data interpretation (i.e., identification of patient status) were assessed across four scenarios. **Results:** Data interpretation speed and accuracy improved significantly in the CVS display condition; for example, in one scenario nurses required only half of the time for data interpretation and showed up to 1.9 times higher accuracy in identifying the patient state compared to the numerical display condition. **Conclusion:** Providing patient information in a configural display with readily visible trends and data variability can improve the speed and accuracy of data interpretation by ICU nurses. **Application:** Although many studies, including this one, support the use of configural displays, the vast majority of ICU monitoring displays still present clinical data in numerical format. The introduction of configural displays in clinical monitoring has potential to improve patient safety.

- **Keywords:** patient monitoring, nursing, information displays, cognition, patient safety

## SENSORY AND PERCEPTUAL PROCESSES

**Eric L. Amazeen. *Box Shape Influences the Size-Weight Illusion During Individual and Team Lifting.* S. 581-591.**

**Objective:** The effects of box shape—specifically width and height—on the perception of heaviness were evaluated during individual and team lifting. **Background:** Large objects are perceived to be as much as 50% lighter than smaller objects with the same mass. This *size-weight illusion* presents an obvious risk when lifting large and heavy boxes. Recent research has shown that shape influences this illusion. Specifically, increases in length and width do not produce identical decreases in perceived heaviness. However,

this effect has been documented only in individual lifting, mostly with small objects. **Method:** Individuals and teams lifted large boxes and reported their perceptions of heaviness. The mass, height, and width of the boxes were varied independently to determine their unique effects on perceived heaviness. **Results:** For both types of lift, increasing width produced a greater mean illusory drop (expressed as a percentage decrease with 95% confidence intervals) in perceived heaviness ( $24 \pm 7\%$  during individual lifting and  $41 \pm 8\%$  during team lifting) than increasing height ( $15 \pm 7\%$  during individual lifting and  $18 \pm 8\%$  during team lifting). **Conclusion:** Size and shape are important factors in perceiving the heaviness of boxes during both individual and team lifting. **Application:** To avoid misperceiving weight and risking injury, lifters should be careful when approaching larger (especially wider) boxes.

- **Keywords:** weight perception, perceived heaviness, lifting injury, safe lifting, container size, height, width

## **SURFACE TRANSPORTATION SYSTEMS**

**Yu Zhang, David B. Kaber, Meghan Rogers, Yulan Liang, Shruti Gangakhedkar.** *The Effects of Visual and Cognitive Distractions on Operational and Tactical Driving Behaviors.* S. 592-604.

**Objective:** This study tested the effects of two fundamental forms of distraction, including visual-manual and cognitive-audio distraction, with comparison under both operational and tactical driving. Strategic control remains for future study. **Background:** Driving is a complex control task involving operational, tactical, and strategic control. Although operational control, such as lead-car following, has been studied, the influence of in-vehicle distractions on higher levels of control, including tactical and strategic, remains unclear. **Method:** Two secondary tasks were designed to independently represent visual-manual and cognitive-audio distractions, based on multiple resource theory. Drivers performed operational vehicle control maneuvers (lead-car following) or tactical control maneuvers (passing) along with the distraction tasks in a driving simulator. Response measures included driving performance and visual behavior. **Results:** Results revealed drivers' ability to accommodate either visual or cognitive distractions in following tasks but not in passing. The simultaneous distraction condition led to the greatest decrement in performance. **Conclusion:** Findings support the need to assess the impacts of in-vehicle distraction on different levels of driving control. Future study should investigate driver distraction under strategic control.

- **Keywords:** driver distraction, operational vehicle control, tactical vehicle control, eye tracking, attention resource theory

## **TRAINING, EDUCATION, AND INSTRUCTIONAL SYSTEMS**

**Allyson R. Colombo, Keith S. Jones.** *The Effects of Prism Adaptation on Egocentric Metric Distance Estimation.* S. 605-615.

**Objective:** The present experiment evaluated whether training involving throwing transferred to metric distance estimation (i.e., describing in feet and inches the distance between oneself and targets). **Background:** In prior work, we found that metric estimation training negatively transferred to throwing. We explained our results in terms of cognitive intrusion. The present study tested that possibility by swapping our training and transfer tasks. **Method:** During pretesting, participants verbally estimated the metric distances between themselves and targets, or they threw a beanbag to targets. During training, participants donned goggles that distorted their vision. While wearing the goggles, they threw a beanbag to targets. Half received feedback. During posttesting, participants removed the distorting goggles and completed the same task that they performed during pretesting. **Results:** The results indicated that the distorting goggles

degraded throwing at the beginning of training, visual feedback improved throwing during training, the effects of training with feedback persisted into the throwing posttest, and the effects of training with feedback did not transfer to the verbal metric estimation posttest. **Conclusion:** Training involving throwing was effective, but did not transfer to verbal metric distance estimation. This supports our argument that the negative transfer observed in our previous study stemmed from cognitive intrusion. **Application:** The present experiment suggests that the creation of distance estimation training should begin with a careful analysis of the transfer task, and that distance estimation training programs should explicitly teach trainees that their training will not generalize to all distance estimation tasks.

- **Keywords:** transfer, transfer of training, visual distortion, distorting goggles, throwing, verbal estimation, feedback, prism adaptation