

# Human Factors – rok 2009, roč. 51

## Číslo 1



### **G. Robert Arrabito. *Effects of Talker Sex and Voice Style of Verbal Cockpit Warnings on Performance.* S. 3–20.**

**Objective:** The effects of talker sex and voice style of verbal cockpit warnings on performance were investigated to help make warning messages distinct from speech on the flight deck. **Background:** Auditory warnings are used in aircraft to alert the crew to hazards and their associated levels of danger. Failing to comply with a warning has led to aviation incidents and accidents. **Methods:** Participants were required to monitor the auditory channel and identify the verbal warning while simultaneously performing a visual pursuit tracking task. A male and a female actor announced the warning words in three styles: monotone, urgent, and whisper. In Experiment 1, warning words were presented in quiet, and in Experiment 2, they were presented in a background of speech babble that simulated cockpit radio communication. **Results:** Experiment 1 showed that the monotone and urgent styles resulted in the fastest identification response time (RT) regardless of the talker and listener's sex. Experiment 2 showed that the male talker announcing in either the monotone or the urgent style resulted in the largest proportion correct and fastest identification RT regardless of the listener's sex. Both experiments showed effects of word semantics on performance. **Conclusion:** Effective use of speech parameters and word semantics can increase the saliency of verbal cockpit warnings. **Application:** Potential applications of this research include improving the attention-getting capability of an alerting system, which could lead to increased warning compliance, potentially resulting in fewer incidents and accidents.

- **Keywords:** verbal warnings • talker sex • performance • voice style • signal words

### **Arathi Sethumadhavan and Francis T. Durso. *Selection in Air Traffic Kontrol : Is Nonradar Training a Predictor of Radar Performance?* S. 21–34.**

**Objective:** The purpose of the current research was to investigate whether performance in nonradar training would predict performance in radar training. **Background:** There is a discussion in the Federal Aviation Administration about the necessity of keeping nonradar training as part of the required selection criteria for radar controllers. In nonradar training, controllers separate traffic by relying on the estimated time over navigational fixes printed on flight progress strips, rather than monitoring the perceptually available positional information on a radar screen. The two ways of controlling traffic—nonradar and radar—are different along a number of dimensions. **Method:** Sixteen participants were taught to control simulated air traffic using nonradar and radar procedures. Performance on final radar scenarios was predicted from cognitive variables; performance on earlier,

simpler radar scenarios; and performance on nonradar scenarios. **Results:** Performance during nonradar trials predicted final radar performance (i.e., collisions and landed aircraft count) independent of the predictive power of cognitive variables and above and beyond earlier radar training. **Conclusion:** Performance in nonradar training enhanced users' ability to predict radar performance, even in addition to the predictive power of simpler, earlier radar performance variables. Good nonradar performers had higher situation awareness in the radar environment. **Application:** Performance in a nonradar environment may serve as an important selection tool in assessing the performance of student controllers in radar environments. The results indicate the need for future research with field controllers.

- **Keywords:** selection in air traffic control • radar performance • nonradar training • situation awareness • predictor

**Allison M. Anderson, Gary A. Mirka, Sharon M. B. Joines, and David B. Kaber. *Analysis of Alternative Keyboards Using Learning Curves*. S. 35–45.**

**Objective :** To quantify learning percentages for alternative keyboards (chord, contoured split, Dvorak, and split fixed angle) and understand how physical, cognitive, and perceptual demand affect learning. **Background:** Alternative keyboards have been shown to offer ergonomic benefits over the conventional, single-plane QWERTY keyboard design, but productivity-related challenges may hinder their widespread acceptance. **Method:** Sixteen participants repeatedly typed a standard text passage using each alternative keyboard. Completion times were collected and subsequent learning percentages were calculated. Participants were asked to subjectively rate the physical, cognitive, and perceptual demands of each keyboard, and these values were then related to the calculated learning percentages. **Results:** Learning percentage calculations revealed the percentage for the split fixed-angle keyboard (90.4%) to be significantly different ( $p < .05$ ) from the learning percentages for the other three keyboards (chord, 77.3%; contour split, 76.9%; Dvorak, 79.1%). The average task completion time for the conventional QWERTY keyboard was 40 s, and the average times for the fifth trial on the chord, contoured split, Dvorak, and split fixed-angle keyboards were 346, 69, 181, and 42 s, respectively. **Conclusions:** Productivity decrements can be quickly regained for the split fixed-angle and contour split keyboard but will take considerably longer for Dvorak and chord keyboards. The split fixed-angle keyboard involved physical learning, whereas the others involved some combination of physical and cognitive learning, a result supported by the subjective responses. **Application:** Understanding the changes in task performance time that come with learning can provide additional information for a cost-benefit analysis when considering the implementation of ergonomic interventions.

- **Keywords:** alternative keyboards • learning curve theory • ergonomic interventions • DVORAK • chord keyboards • split keyboards • musculoskeletal disorders

**Annemieke Houwink, Karen M. Oude Hengel, Dan Odell, and Jack T. Dennerlein. *Providing Training Enhances the Biomechanical Improvements of an Alternative Computer Mouse Design*. S. 46–55.**

**Objective:** The purpose of this study is to determine if an alternative mouse promotes more neutral postures and decreases forearm muscle activity and if training enhances these biomechanical benefits. **Background:** Computer mouse use is a risk factor for developing musculoskeletal disorders; alternative mouse designs can help lower these risks. Ergonomic training combined with alternative input devices could be even more effective than alternative designs alone. **Methods:** Thirty healthy adults (15 males, 15 females) performed a set of computer mouse tasks with a standard mouse and an alternative mouse while an electromagnetic motion analysis system measured their wrist

and forearm postures and surface electromyography measured the muscle activity of three wrist extensor muscles. Fifteen participants received no training on how to hold the alternative mouse, whereas the remaining 15 participants received verbal instructions before and during use of the alternative mouse. **Results:** The alternative mouse was found to promote a more neutral forearm posture compared with the standard mouse (up to 11.5° lower forearm pronation); however, pronation was further reduced when instructions on how to hold the mouse were provided. Wrist extensor muscle activity was reduced for the alternative mouse (up to 1.8% of maximum voluntary contraction lower) compared with the standard mouse, but only after participants received instructions. **Conclusion:** The alternative mouse design decreased biomechanical exposures; however, instructions enhanced this potential ergonomic benefit of the design. **Application:** User knowledge and training are important factors when effectively implementing an alternative ergonomic device.

- **Keywords:** computer mice • training • muscle activity • posture • biomechanics • anthropometry

**Joakim Dahlman, Anna Sjörs, Johan Lindström, Torbjörn Ledin, and Torbjörn Falkmer. *Performance and Autonomic Responses During Motion Sickness*. S. 56–66.**

**Objective:** The aim of the study was to investigate how motion sickness, triggered by an optokinetic drum, affects short-term memory performance and to explore autonomic responses to perceived motion sickness. **Background:** Previous research has found that motion sickness decreases performance, but it is not known how short-term memory in particular is affected. **Method:** Thirty-eight healthy participants performed a listening span test while seated in a rotating optokinetic drum. Measurements of motion sickness, performance, heart rate, skin conductance, blood volume pulse, and pupil size were performed simultaneously throughout the experiment. **Results:** A total of 16 participants terminated the trial because of severe nausea, and the other 22 endured the full 25 min. Perceived motion sickness increased over time in both groups but less among those who endured the trial. Short-term memory performance decreased toward the end for those who terminated but increased in the other group. Results from the measured autonomic responses were ambiguous. **Conclusion:** We conclude that performance, measured as short-term memory, declines as perceived motion sickness progresses. **Application:** This research has potential implications for command and control personnel at risk of developing motion sickness.

- **Keywords:** optokinetic drum • psychophysiology • memory • eye tracking • motion sickness • performance • autonomic responses • heart rate • skin conductance • blood volume pulse

**Thierry Morineau, Nadège Le Moëllic, Sylma Diabira, Laurent Riffaud, Claire Haegelen, Pierre-Louis Hénaux, and Pierre Jannin. *Decision Making During Preoperative Surgical Planning*. S. 67–77.**

**Objective:** This study analyzes decision making during preoperative surgical planning through two cognitive indicators: conflict and cognitive control. **Background:** Planning is a critical stage in naturalistic decision making, and there is some evidence suggesting that this activity depends on the level of expertise and the demands of the task. The specificity of surgery resides in the necessity to cope with (potential) conflicts between the purpose of the surgical intervention and the biological laws governing the patient's body. **Method:** Six neurosurgeons (two board-certified neurosurgeons, two chief residents, and two residents) described the operative procedure envisaged on nine surgical cases of increasing surgical complexity. A detailed analysis of one surgical case described by one expert was performed. Moreover, we measured the number of conflicts and controls reported by each surgeon. **Results:** Two experts were the only ones for

which the report of conflicts increased with surgical complexity (respectively, 75% and 73% of the conflict variance predicted by complexity). The two experts significantly activated a higher proportion of knowledge-based control (respectively, 43% and 38%) than did intermediates and residents. The residents significantly activated more motor skill—based controls (respectively, 40% and 44%) than did intermediates and experts. **Conclusion:** It seems that expert surgical decision making to cope with task demands is significantly associated with conflict monitoring. Knowledge-based control to regulate conflict is mainly produced by experts. **Application:** Conflicts and controls analyzed through verbal reports can be used as relevant indicators to highlight critical moments in decision making that potentially require assistance from information systems.

- **Keywords:** situation awareness • decision making • naturalistic decision making • expert-novice differences • automation • attentional processes • cognitive processes • expert systems • health and medical systems • cognitive engineering • surgery • verbal protocol analysis • cognitive control • planning • medical expertise • problem solving

**King Chung, Jennifer Tufts, and Lance Nelson. *Modulation-Based Digital Noise Reduction for Application to Hearing Protectors to Reduce Noise and Maintain Intelligibility*. S. 78–89.**

**Objective:** The objective of this study was to test the effects of modulation-based digital noise reduction (MB-DNR) on noise levels, speech intelligibility, and listening preference in four real-world noises. **Background:** A significant challenge in hearing protection device (HPD) design is to reduce ambient noise levels while maintaining users' ability to understand speech. MB-DNR technology, currently employed in hearing aids, potentially could be used to achieve these objectives. **Methods:** Speech and noise calibrated to signal-to-noise ratios (SNRs) of 0, -5, and -10 dB in the sound field were recorded at the outputs of two digital hearing aids in the ears of a Knowles Electronic Manikin for Acoustic Research with and without MB-DNR activated (i.e., NR and noNR, respectively). Listeners' speech intelligibility scores and sound quality preferences were evaluated while they listened to the recordings presented via ER-3A insert earphones at 85 dB SPL. **Results:** MB-DNR reduced the overall noise level by approximately 4 to 7 dB. Listeners obtained significantly higher speech intelligibility scores in the NR condition at an SNR of -10 dB in two noises and similar scores in the noNR and NR conditions in all other cases. They preferred the NR condition in all cases. **Conclusion:** MB-DNR reduced overall noise level, enhanced sound quality, and maintained or improved speech intelligibility in the four military noises tested. **Applications:** MB-DNR algorithms potentially could be incorporated into HPDs to enhance performance and increase user acceptance.

- **Keywords:** modulation-based noise reduction • DNR • hearing protector • hearing aid • military noise • speech intelligibility • sound quality • speech production and recognition • audition • sensory and perceptual processes • health and medical systems

**Maura C. Lohrenz, J. Gregory Trafton, Melissa R. Beck, and Marlin L. Gendron. *A Model of Clutter for Complex, Multivariate Geospatial Display*. S. 90–101.**

**Objective:** A novel model of measuring clutter in complex geospatial displays was compared with human ratings of subjective clutter as a measure of convergent validity. The new model is called the *color-clustering clutter* (C3) model. **Background:** Clutter is a known problem in displays of complex data and has been shown to affect target search performance. Previous clutter models are discussed and compared with the C3 model. **Method:** Two experiments were performed. In Experiment 1, participants performed subjective clutter ratings on six classes of information visualizations. Empirical results were used to set two free parameters in the model. In Experiment 2, participants

performed subjective clutter ratings on aeronautical charts. Both experiments compared and correlated empirical data to model predictions. **Results:** The first experiment resulted in a .76 correlation between ratings and C3. The second experiment resulted in a .86 correlation, significantly better than results from a model developed by Rosenholtz et al. Outliers to our correlation suggest further improvements to C3. **Conclusions:** We suggest that (a) the C3 model is a good predictor of subjective impressions of clutter in geospatial displays, (b) geospatial clutter is a function of color density and saliency (primary C3 components), and (c) pattern analysis techniques could further improve C3. **Application:** The C3 model could be used to improve the design of electronic geospatial displays by suggesting when a display will be too cluttered for its intended audience.

- **Keywords:** sensory and perceptual processes • display complexity • clutter • color perception • visualization • target saliency • human-computer interaction (HCI) • geospatial displays • data fusion • graphics • vision • computer systems

**Rayka Mohebbi, Rob Gray, and Hong Z. Tan. *Driver Reaction Time to Tactile and Auditory Rear-End Collision Warnings While Talking on a Cell Phone*. S. 102–110.**

**Objective:** This study examined the effectiveness of rear-end collision warnings presented in different sensory modalities while drivers were engaged in cell phone conversations in a driving simulator. **Background:** Tactile and auditory collision warnings have been shown to improve braking response time (RT) in rear-end collision situations. However, it is not clear how effective these warnings are when the driver is engaged in attentionally demanding secondary tasks, such as talking on a cell phone. **Method:** Sixteen participants in a driving simulator experienced three collision warning conditions (none, tactile, and auditory) in three conversation conditions (none, simple hands free, complex hands free). Driver RT was captured from warning onset to brake initiation (WON2B). **Results:** WON2B times for auditory warnings were significantly larger for simple conversations compared with no conversation (+148 ms), whereas there was no significant difference between these conditions for tactile warnings (+53 ms). For complex conversations, WON2B times for both tactile (+146 ms) and auditory warnings (+221 ms) were significantly larger than during no conversation. During complex conversations, tactile warnings produced significantly shorter WON2B times than no warning (−141 ms). **Conclusion:** Tactile warnings are more effective than auditory warnings during both simple and complex conversations. **Application:** These results indicate that tactile rear-end collision warnings have the potential to offset some of the driving impairments caused by cell phone conversations.

- **Keywords:** multimodal displays • cell phones • hearing • touch • haptic • driver safety • displays and controls • reaction time • psychomotor processes • dual-task performance • attentional processes • auditory displays • highway safety