

## Human Factors – rok 2013, roč. 55

### Číslo 4 (August 2013)



#### Attentional Processes

**Sara A. Lu, Christopher D. Wickens, Julie C. Prinet, Shaun D. Hutchins, Nadine Sarter, and Angelia Sebok. *Supporting Interruption Management and Multimodal Interface Design: Three Meta-Analyses of Task Performance as a Function of Interrupting Task Modality*. S. 697-724.**

**Objective:** The aim of this study was to integrate empirical data showing the effects of interrupting task modality on the performance of an ongoing visual-manual task and the interrupting task itself. The goal is to support interruption management and the design of multimodal interfaces. **Background:** Multimodal interfaces have been proposed as a promising means to support interruption management. To ensure the effectiveness of this approach, their design needs to be based on an analysis of empirical data concerning the effectiveness of individual and redundant channels of information presentation. **Method:** Three meta-analyses were conducted to contrast performance on an ongoing visual task and interrupting tasks as a function of interrupting task modality (auditory vs. tactile, auditory vs. visual, and single modality vs. redundant auditory-visual). In total, 68 studies were included and six moderator variables were considered. **Results:** The main findings from the meta-analyses are that response times are faster for tactile interrupting tasks in case of low-urgency messages. Accuracy is higher with tactile interrupting tasks for low-complexity signals but higher with auditory interrupting tasks for high-complexity signals. Redundant auditory-visual combinations are preferable for communication tasks during high workload and with a small visual angle of separation. **Conclusion:** The three meta-analyses contribute to the knowledge base in multimodal information processing and design. They highlight the importance of moderator variables in predicting the effects of interruption task modality on ongoing and interrupting task performance. **Applications:** The findings from this research will help inform the design of multimodal interfaces in data-rich, event-driven domains.

- **Keywords:** meta-analysis; multimodal interfaces; interface design guidelines; time sparing; interruption management; multiple resources; auditory; tactile; redundancy

**Michael E. R. Nicholls, Nicole A. Thomas, and Tobias Loetscher. *An Online Means of Testing Asymmetries in Seating Preference Reveals a Bias for Airplanes and Theaters*. S. 725-731.**

**Objective:** The aim of this study was to investigate asymmetrical interactions between humans and their environment using online seat booking sites. **Background:** Functional differences between the cerebral hemispheres affect the choices people make. For

example, when asked to imagine going to a cinema, people preferentially select seats to the right. We investigated whether this experimental research generalizes to online booking sites for aircraft and theaters. **Method:** Occupancy rates for seats taken on the left and right sides were assessed for 100 airline flights with 12,762 available seats and 37 theater performances with 34,456 seats. On the basis of previous research, a rightward bias was predicted for aircraft and theaters. **Results:** For aircraft, contrary to expectation, occupancy rate was higher for left-compared with right-side seats. For theaters, a rightward bias was observed when the theater was less than half full. The bias was not affected by the orientation of the map. **Conclusion:** For aircraft, the leftward preference could be attributable to a rightward turning bias or a “feeling” that the port seats are closer to the exit, even though they are not. For theaters, the data demonstrate that the rightward preference observed in earlier studies exists only when the theater is relatively empty. **Application:** Asymmetrical seating may play an important role in the efficient assimilation of information from the environment, and this role should take this into account when designing effective human–environment interfaces. The online method of assessing seating used in the current study provides an informative and potentially powerful means of assessing asymmetries in human perception and action.

- **Keywords:** lateralization; cinema; left; right; attention

### **Michael Yu and Cleotilde Gonzalez. *Stopping Decisions: Information Order Effects on Nonfocal Evaluations*. S. 732-746.**

**Objective:** We investigated how the order in which information is presented affects when a person decides to stop performing a task. **Background:** A *stopping decision* is a decision to stop performing a task on the basis of a sequence of cues. Previous order-effects models do not account for how these contexts limit available working memory for making such decisions. **Method:** Participants decided how long to perform a task known as the Work Hazard Game that began by rewarding points but later cost points if work continued after an unannounced “emergency.” An additive sequence of cues indicated the probability of an emergency. Study 1 involved a three-group design with cue sequences that indicated the same risk at each decision point but whose final cue presented a high, medium, or low probability. Study 2 had a 2 × 2 design with high or low final cues and an easy or a challenging task. **Results:** In Study 1, participants stopped sooner when the most recent cue presented a high rather than low probability ( $p = .09$ ), despite the same emergency risk. In Study 2, participants stopped sooner when the most recent cue presented a high rather than low probability for the challenging task but not for the easy task ( $p = .08$ ). **Conclusion:** Stopping decisions appear sensitive to the most recent cue observed while experiencing task load. Participants responded to the same risks differently only on the basis of a change in presentation. **Application:** Findings may be relevant for research and training for hazardous jobs, such as subsurface coal mining, fishing, and trucking.

- **Keywords:** order effects; recency; attention; working memory; stopping decisions; coal mining

### **Automation, Expert Système**

### **Melissa R. Beck, Benjamin A. Martin, Emily Smitherman, and Lorrie Gaschen. *Eyes-On Training and Radiological Expertise: An Examination of Expertise Development and Its Effects on Visual Working Memory*. S. 747-763.**

**Objective:** Our aim was to examine the specificity of the effects of acquiring expertise on visual working memory (VWM) and the degree to which higher levels of experience within the domain of expertise are associated with more efficient use of VWM.

**Background:** Previous research is inconsistent on whether expertise effects are specific to the area of expertise or generalize to other tasks that also involve the same cognitive processes. It is also unclear whether more training and/or experience will lead to continued improvement on domain-relevant tasks or whether a plateau could be reached.

**Method:** In Experiment 1, veterinary medicine students completed a one-shot visual change detection task. In Experiment 2, veterinarians completed a flicker change detection task. Both experiments involved stimuli specific to the domain of radiology and general stimuli. **Results:** In Experiment 1, veterinary medicine students who had completed an "eyes-on" radiological training demonstrated a domain-specific effect in which performance was better on the domain-specific stimuli than on the domain-general stimuli. In Experiment 2, veterinarians again showed a domain-specific effect, but performance was unrelated to the amount of experience veterinarians had accumulated.

**Conclusion:** The effect of experience is domain specific and occurs during the first few years of training, after which a plateau is reached. **Application:** VWM training in one domain may not lead to improved performance on other VWM tasks. In acquiring expertise, eyes-on training is important initially, but continued experience may not be associated with further improvements in the efficiency of VWM.

- **Keywords:** change detection; radiology; medical training

## **Biomechanics, Anthropometry, Work Physiology**

**Neal Wiggermann and W. Monroe Keyserling. *Effects of Anti-Fatigue Mats on Perceived Discomfort and Weight-Shifting During Prolonged Standing*. S. 764-775.**

**Objective:** The aim of this experiment was to investigate the effects of anti-fatigue mats on perceived discomfort and behavioral responses (weight-shifting between the feet) during prolonged standing. **Background:** Prolonged standing is a common requirement in the workplace and is a well-known cause of discomfort. Anti-fatigue mats have been shown to reduce discomfort resulting from standing, but no study has identified a particular mat that performs better than others or examined the relationship between discomfort and weight-shifting. **Methods:** Participants stood for 4 hours on four commercially available "anti-fatigue" mats and a hard surface (control condition). Subjective ratings of discomfort were measured, and in-shoe pressure was recorded and used to evaluate weight-shifting during standing. **Results:** Compared to the control condition, after 4 hours of standing discomfort was reduced by three of the four mats, but discomfort ratings did not significantly differ among mats. However, significant differences among mats were found in the frequency of weight-shifting, and weight-shifting was positively correlated to discomfort. **Conclusion:** These results suggest that subjective reports of discomfort were not sufficiently sensitive to detect differences among mats for the experimental conditions tested. Behavioral responses, specifically weight-shifting between feet, may provide a more sensitive alternative to subjective reports.

- **Keywords:** weight-shifting; anti-fatigue mats

## **Cognitive Processes**

**Brent Morgan, Sidney D'Mello, Robert Abbott, Gabriel Radvansky, Michael Haass, and Andrea Tamplin. *Individual Differences in Multitasking Ability and Adaptability*. S. 776-788.**

**Objective:** The aim of this study was to identify the cognitive factors that predictability and adaptability during multitasking with a flight simulator. **Background:** Multitasking has become increasingly prevalent as most professions require individuals to perform

multiple tasks simultaneously. Considerable research has been undertaken to identify the characteristics of people (i.e., individual differences) that predict multitasking ability. Although working memory is a reliable predictor of general multitasking ability (i.e., performance in normal conditions), there is the question of whether different cognitive faculties are needed to rapidly respond to changing task demands (*adaptability*). **Method:** Participants first completed a battery of cognitive individual differences tests followed by multitasking sessions with a flight simulator. After a baseline condition, difficulty of the flight simulator was incrementally increased via four experimental manipulations, and performance metrics were collected to assess multitasking ability and adaptability. **Results:** Scholastic aptitude and working memory predicted general multitasking ability (i.e., performance at baseline difficulty), but spatial manipulation (in conjunction with working memory) was a major predictor of adaptability (performance in difficult conditions after accounting for baseline performance). **Conclusion:** Multitasking ability and adaptability may be overlapping but separate constructs that draw on overlapping (but not identical) sets of cognitive abilities. **Application:** The results of this study are applicable to practitioners and researchers in human factors to assess multitasking performance in real-world contexts and with realistic task constraints. We also present a framework for conceptualizing multitasking adaptability on the basis of five adaptability profiles derived from performance on tasks with consistent versus increased difficulty.

- **Keywords:** cognitive abilities; spatial manipulation; working memory; MATB; task switching

## Computer Systems

**Amrish O. Chourasia, Douglas A. Wiegmann, Karen B. Chen, Curtis B. Irwin, and Mary E. Sesto. *Effect of Sitting or Standing on Touch Screen Performance and Touch Characteristics*. S. 789-802.**

**Objective:** The aim of this study was to evaluate the effect of sitting and standing on performance and touch characteristics during a digit entry touch screen task in individuals with and without motor-control disabilities. **Background:** Previously, researchers of touch screen design have not considered the effect of posture (sitting vs. standing) on touch screen performance (accuracy and timing) and touch characteristics (force and impulse). **Method:** Participants with motor-control disabilities ( $n = 15$ ) and without ( $n = 15$ ) completed a four-digit touch screen number entry task in both sitting and standing postures. Button sizes varied from 10 mm to 30 mm (5-mm increments), and button gap was 3 mm or 5 mm. **Results:** Participants had more misses and took longer to complete the task during standing for smaller button sizes (<20 mm). At larger button sizes, performance was similar for both sitting and standing. In general, misses, time to complete task, and touch characteristics were increased for standing. Although disability affected performance (misses and timing), similar trends were observed for both groups across posture and button size. **Conclusion:** Standing affects performance at smaller button sizes (<20 mm). For participants with and without motor-control disabilities, standing led to greater exerted force and impulse. **Application:** Along with interface design considerations, environmental conditions should also be considered to improve touch screen accessibility and usability.

- **Keywords:** performance; workload; force; disability; touch screen

## Health and Medical Systems

**Anne Collins McLaughlin, Fran Walsh, and Michelle Bryant. *Effects of Knowledge and Internal Locus of Control in Groups of Health Care Workers Judging Likelihood of Pathogen Transfer*. S. 803-814.**

**Objective:** A study was conducted to measure the effects of attitudes and beliefs on the risk judgments of health care workers. **Background:** Lack of hand hygiene compliance is a worldwide issue in health care, contributing to infections, fatalities, and increased health care costs. Human factors methods are a promising solution to the problem of compliance, although thus far, the concentration has been on process and engineering methods, such as the design of no-touch sinks. Factors internal to the health care worker, such as their attitudes and beliefs about hand hygiene, have received less attention. **Method:** For this study, three groups of health care workers completed measures of attitudes, control beliefs, and hand hygiene knowledge. They then provided risk judgments of touching various surfaces via a factorial survey. **Results:** Attitudes, knowledge, control beliefs, and surface type all predicted the risk judgments of the sample of health care workers, with differences between professional groups. **Conclusion:** Health care workers perceive less risk when touching surfaces, which may explain historically low rates of hand hygiene compliance after surface contact. **Application:** Although more research is needed to directly connect risk judgments to failures of hand hygiene, the current results can inform interventions targeting the internal attitudes and beliefs of health care workers.

- **Keywords:** accidents; safety; human error; medical; health; individual differences; cognition; decision making; judgment; perceived risk

## Psychomotor Processes

**Jamie C. Gorman and Michael J. Crites. *Are Two Hands (From Different People) Better Than One? Mode Effects and Differential Transfer Between Manual Coordination Modes.* S. 815-829.**

**Objective:** We report an experiment in which we investigated differential transfer between unimanual (one-handed), bimanual (two-handed), and intermanual (different peoples' hands) coordination modes. **Background:** People perform some manual tasks faster than others ("mode effects"). However, little is known about transfer between coordination modes. To investigate differential transfer, we draw hypotheses from two perspectives—information based and constraint based—of bimanual and interpersonal coordination and skill acquisition. **Method:** Participants drove a teleoperated rover around a circular path in sets of two 2-min trials using two of the different coordination modes. Speed and variability of the rover's path were measured. Order of coordination modes was manipulated to examine differential transfer and mode effects. **Results:** Differential transfer analyses revealed patterns of positive transfer from simpler (localized spatiotemporal constraints) to more complex (distributed spatiotemporal constraints) coordination modes paired with negative transfer in the opposite direction. Mode effects indicated that intermanual performance was significantly faster than unimanual performance, and bimanual performance was intermediate. Importantly, all of these effects disappeared with practice. **Conclusion:** The observed patterns of differential transfer between coordination modes may be better accounted for by a constraint-based explanation of differential transfer than by an information-based one. Mode effects may be attributable to anticipatory movements based on dyads' access to mutual visual information. **Application:** Although people may be faster using more-complex coordination modes, when operators transition between modes, they may be more effective transitioning from simpler (e.g., bimanual) to more complex (e.g., intermanual) modes than vice versa. However, this difference may be critical only for novel or rarely practiced tasks.

- **Keywords:** bimanual; intermanual; interpersonal; unimanual; team; teleoperations

## Sensory and Perceptual Processes

**Kinneret Teodorescu, Sylvain Bouchigny, and Maria Korman. *Training Haptic Stiffness Discrimination: Time Course of Learning With or Without Visual Information and Knowledge of Results*. S. 830-840.**

**Objective:** In this study, we explored the time course of haptic stiffness discrimination learning and how it was affected by two experimental factors, the addition of visual information and/or knowledge of results (KR) during training. **Background:** Stiffness perception may integrate both haptic and visual modalities. However, in many tasks, the visual field is typically occluded, forcing stiffness perception to be dependent exclusively on haptic information. No studies to date addressed the time course of haptic stiffness perceptual learning. **Method:** Using a virtual environment (VE) haptic interface and a two-alternative forced-choice discrimination task, the haptic stiffness discrimination ability of 48 participants was tested across 2 days. Each day included two haptic test blocks separated by a training block. Additional visual information and/or KR were manipulated between participants during training blocks. **Results:** Practice repetitions alone induced significant improvement in haptic stiffness discrimination. Between days, accuracy was slightly improved, but decision time performance was deteriorated. The addition of visual information and/or KR had only temporary effects on decision time, without affecting the time course of haptic discrimination learning. **Conclusion:** Learning in haptic stiffness discrimination appears to evolve through at least two distinctive phases: A single training session resulted in both immediate and latent learning. This learning was not affected by the training manipulations inspected. **Application:** Training skills in VE in spaced sessions can be beneficial for tasks in which haptic perception is critical, such as surgery procedures, when the visual field is occluded. However, training protocols for such tasks should account for low impact of multisensory information and KR.

- **Keywords:** haptic interfaces; virtual environment; human performance; learning; stiffness perception; training

## **Surface Transportation Systems**

**Nazan Aksan, Jeffrey D. Dawson, Jamie L. Emerson, Lixi Yu, Ergun Y. Uc, Steven W. Anderson, and Matthew Rizzo. *Naturalistic Distraction and Driving Safety in Older Drivers*. S. 841-853.**

**Objective:** In this study, we aimed to quantify and compare performance of middle-aged and older drivers during a naturalistic distraction paradigm (visual search for roadside targets) and to predict older drivers' performance given functioning in visual, motor, and cognitive domains. **Background:** Distracted driving can imperil healthy adults and may disproportionately affect the safety of older drivers with visual, motor, and cognitive decline. **Method:** A total of 203 drivers, 120 healthy older (61 men and 59 women, ages 65 years and older) and 83 middle-aged drivers (38 men and 45 women, ages 40 to 64 years), participated in an on-road test in an instrumented vehicle. Outcome measures included performance in roadside target identification (traffic signs and restaurants) and concurrent driver safety. Differences in visual, motor, and cognitive functioning served as predictors. **Results:** Older drivers identified fewer landmarks and drove slower but committed more safety errors than did middle-aged drivers. Greater familiarity with local roads benefited performance of middle-aged but not older drivers. Visual cognition predicted both traffic sign identification and safety errors, and executive function predicted traffic sign identification over and above vision. **Conclusion:** Older adults are susceptible to driving safety errors while distracted by common secondary visual search tasks that are inherent to driving. The findings underscore that age-related cognitive decline affects older drivers' management of driving tasks at multiple levels and can help inform the design of on-road tests and interventions for older drivers.

- **Keywords:** instrumented vehicle; distraction; older drivers; neuropsychological tests

## **Training, Education, Instructional Système**

**Shaun D. Hutchins, Christopher D. Wickens, Thomas F. Carolan, and John M. Cumming. *The Influence of Cognitive Load on Transfer With Error Prevention Training Methods: A Meta-Analysis*. S. 854-874.**

**Objective:** The objective was to conduct research synthesis for the U.S. Army on the effectiveness of two error prevention training strategies (training wheels and scaffolding) on the transfer of training. **Background:** Motivated as part of an ongoing program of research on training effectiveness, the current work presents some of the program's research into the effects on transfer of error prevention strategies during training from a cognitive load perspective. Based on cognitive load theory, two training strategies were hypothesized to reduce intrinsic load by supporting learners early in acquisition during schema development. **Method:** A transfer ratio and Hedges'  $g$  were used in the two meta-analyses conducted on transfer studies employing the two training strategies. Moderators relevant to cognitive load theory and specific to the implemented strategies were examined. The transfer ratio was the ratio of treatment transfer performance to control transfer. Hedges'  $g$  was used in comparing treatment and control group standardized mean differences. Both effect sizes were analyzed with versions of sample weighted fixed effect models. **Results:** Analysis of the training wheels strategy suggests a transfer benefit. The observed benefit was strongest when the training wheels were a worked example coupled with a principle-based prompt. Analysis of the scaffolding data also suggests a transfer benefit for the strategy. **Conclusion:** Both training wheels and scaffolding demonstrated positive transfer as training strategies. As error prevention techniques, both support the intrinsic load-reducing implications of cognitive load theory. **Application:** The findings are applicable to the development of instructional design guidelines in professional skill-based organizations such as the military.

- **Keywords:** training strategies; transfer of training; cognitive load theory; training Wheel; worked examples; scaffolding; meta-analysis