

## Human Factors – rok 2018, roč. 60

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#### AGING

**Brandon J. Pitts, Nadine Sarter. *What You Don't Notice Can Harm You: Age-Related Differences in Detecting Concurrent Visual, Auditory, and Tactile Cues.* pp. 445–464.**

**Objective:** This research sought to determine whether people can perceive and process three nonredundant (and unrelated) signals in vision, hearing, and touch at the same time and how aging and concurrent task demands affect this ability. **Background:** Multimodal displays have been shown to improve multitasking and attention management; however, their potential limitations are not well understood. The majority of studies on multimodal information presentation have focused on the processing of only two concurrent and, most often, redundant cues by younger participants. **Method:** Two experiments were conducted in which younger and older adults detected and responded to a series of singles, pairs, and triplets of visual, auditory, and tactile cues in the absence (Experiment 1) and presence (Experiment 2) of an ongoing simulated driving task. Detection rates, response times, and driving task performance were measured. **Results:** Compared to younger participants, older adults showed longer response times and higher error rates in response to cues/cue combinations. Older participants often missed the tactile cue when three cues were combined. They sometimes falsely reported the presence of a visual cue when presented with a pair of auditory and tactile signals. Driving performance suffered most in the presence of cue triplets. **Conclusion:** People are more likely to miss information if more than two concurrent nonredundant signals are presented to different sensory channels. **Application:** The findings from this work help inform the design of multimodal displays and ensure their usefulness across different age groups and in various application domains.

- **Keywords:** multimodal information processing, trimodal cueing, concurrent signals, aging, driving

#### AUTOMATION, EXPERT SYSTEMS

**Eric T. Greenlee, Patricia R. DeLucia, David C. Newton. *Driver Vigilance in Automated Vehicles: Hazard Detection Failures Are a Matter of Time.* pp. 465–476.**

**Objective:** The primary aim of the current study was to determine whether monitoring the roadway for hazards during automated driving results in a vigilance decrement. **Background:** Although automated vehicles are relatively novel, the nature of human-automation interaction within them has the classic hallmarks of a vigilance task. Drivers must maintain attention for prolonged periods of time to detect and respond to rare and unpredictable events, for example, roadway hazards that automation may be ill equipped to detect. Given the similarity with traditional vigilance tasks, we predicted that drivers of a simulated automated vehicle would demonstrate a vigilance decrement in hazard detection performance. **Method:** Participants “drove” a simulated automated vehicle for 40 minutes. During that time, their task was to monitor the roadway for roadway hazards. **Results:** As predicted, hazard detection rate declined precipitously, and reaction times slowed as the drive progressed. Further, subjective ratings of workload and task-related stress indicated that sustained monitoring is demanding and distressing and it is a challenge to maintain task engagement. **Conclusion:** Monitoring the roadway for potential hazards during automated driving results in workload, stress, and performance decrements similar to those observed in traditional vigilance tasks. **Application:** To the degree that vigilance is required of automated vehicle drivers, performance errors and associated safety risks are likely to occur as a function of time on task. Vigilance should be a focal safety concern in the development of vehicle automation.

- **Keywords:** vigilance, vehicle automation, human-automation interaction, driver behavior, fatigue

**Nora Balfe, Sarah Sharples, John R. Wilson. *Understanding Is Key: An Analysis of Factors Pertaining to Trust in a Real-World Automation System.* pp. 477–495.**

**Objective:** This paper aims to explore the role of factors pertaining to trust in real-world automation systems through the application of observational methods in a case study from the railway sector. **Background:** Trust in automation is widely acknowledged as an important mediator of automation use, but the majority of the research on automation trust is based on laboratory work. In contrast, this work explored trust in a real-world setting. **Method:** Experienced rail operators in four signaling centers were observed for 90 min, and their activities were coded into five mutually exclusive categories. Their observed activities were analyzed in relation to their reported trust levels, collected via a questionnaire. **Results:** The results showed clear differences in activity, even when circumstances on the workstations were very similar, and significant differences in some trust dimensions were found between groups exhibiting different levels of intervention and time not involved with signaling. **Conclusion:** Although the empirical, lab-based studies in the literature have consistently found that reliability and competence of the automation are the most important aspects of trust development, understanding of the automation emerged as the strongest dimension in this study. The implications are that development and maintenance of trust in real-world, safety-critical automation systems may be distinct from artificial laboratory automation. **Application:** The findings have important implications for emerging automation concepts in diverse industries including highly automated vehicles and Internet of things.

- **Keywords:** human-automation interaction, supervisory control, technology acceptance, trust in automation, ethnographic observations

## **CONSUMER PRODUCTS, TOOLS**

**Claudia Geitner, Stewart Birrell, Claudia Krehl, Paul Jennings. *Haptic Foot Pedal: Influence of Shoe Type, Age, and Gender on Subjective Pulse Perception.* pp. 496–509.**

**Objective:** This study investigates the influence of shoe type (sneakers and safety boots), age, and gender on the perception of haptic pulse feedback provided by a prototype accelerator pedal in a running stationary vehicle. **Background:** Haptic feedback can be a less distracting alternative to traditionally visual and auditory in-vehicle feedback. However, to be effective, the device delivering the haptic feedback needs to be in contact with the person. Factors such as shoe type vary naturally over the season and could render feedback that is perceived well in one situation, unnoticeable in another. In this study, we evaluate factors that can influence the subjective perception of haptic feedback in a stationary but running car: shoe type, age, and gender. **Method:** Thirty-six drivers within three age groups ( $\leq 39$ , 40–59, and  $\geq 60$ ) took part. For each haptic feedback, participants rated intensity, urgency, and comfort via a questionnaire. **Results:** The perception of the haptic feedback is significantly influenced by the interaction between the pulse's duration and force amplitude and the participant's age and gender but not shoe type. **Conclusion:** The results indicate that it is important to consider different age groups and gender in the evaluation of haptic feedback. Future research might also look into approaches to adapt haptic feedback to the individual driver's preferences. **Application:** Findings from this study can be applied to the design of an accelerator pedal in a car, for example, for a nonvisual in-vehicle warning, but also to plan user studies with a haptic pedal in general.

- **Keywords:** tactile interaction, haptic perception, driver assistance system

## HUMAN-COMPUTER INTERACTION, COMPUTER SYSTEMS

**Euijung Yang, Michael C. Dorneich. *Affect-Aware Adaptive Tutoring Based on Human–Automation Etiquette Strategies*. pp. 510–526.**

**Objective:** We investigated adapting the interaction style of intelligent tutoring system (ITS) feedback based on human–automation etiquette strategies. **Background:** Most ITSs adapt the content difficulty level, adapt the feedback timing, or provide extra content when they detect cognitive or affective decrements. Our previous work demonstrated that changing the interaction style via different feedback etiquette strategies has differential effects on students' motivation, confidence, satisfaction, and performance. The best etiquette strategy was also determined by user frustration. **Method:** Based on these findings, a rule set was developed that systemically selected the proper etiquette strategy to address one of four learning factors (motivation, confidence, satisfaction, and performance) under two different levels of user frustration. We explored whether etiquette strategy selection based on this rule set (systematic) or random changes in etiquette strategy for a given level of frustration affected the four learning factors. Participants solved mathematics problems under different frustration conditions with feedback that adapted dynamic changes in etiquette strategies either systematically or randomly. **Results:** The results demonstrated that feedback with etiquette strategies chosen systematically via the rule set could selectively target and improve motivation, confidence, satisfaction, and performance more than changing etiquette strategies randomly. The systematic adaptation was effective no matter the level of frustration for the participant. **Conclusion:** If computer tutors can vary the interaction style to effectively mitigate negative emotions, then ITS designers would have one more mechanism in which to design affect-aware adaptations that provide the proper responses in situations where human emotions affect the ability to learn.

- **Keywords:** adaptive automation, affective factors, intelligent tutors, human–computer interaction, etiquette

## HUMAN-SYSTEMS INTEGRATION

**Yusuke Yamani, Jason S. McCarley. *Effects of Task Difficulty and Display Format on Automation Usage Strategy: A Workload Capacity Analysis.* pp. 527–537.**

**Objective:** An experiment used workload capacity analysis to quantify automation usage strategy across different task difficulty and display format types in a speeded task. **Background:** *Workload capacity* measures the efficiency of concurrent information processing and can serve as a gauge of automation usage strategy in speeded decision tasks. The present study used workload capacity analysis to investigate automation usage strategy while information display format and task difficulty were manipulated. **Method:** Subjects performed a speeded judgment task assisted by an automated aid that issued decision cues at varying onset times. Response time distributions were converted to measures of workload capacity. **Results:** Two variants of a workload capacity measure,  $C_{ZOR}$  and  $C_{ZAND}$ , gave evidence that operators moderated their own decision times both in anticipation of and following the arrival of the aid's diagnosis under difficult task conditions regardless of display format. **Conclusion:** Assistance from an automated decision aid may cause operators to delay their own responses in a speeded decision task, producing joint response time distributions that are slower than optimal. **Application:** Even when it renders its own judgments quickly and with high accuracy, an automated decision aid may slow responses from a user. Automation designers should consider the relative costs and benefits of response accuracy and time when choosing whether and how to implement an automated decision aid.

- **Keywords:** human-automation system, workload capacity, visual interface, task difficulty

## **SPECIAL POPULATIONS**

**Errol R. Hoffmann, Alan H. S. Chan, Judy P. C. Tai. *Children's Control/Display Stereotypes.* pp. 538–555.**

**Objective:** The aim of this study was to determine control/display stereotypes for children of a range of ages and development of these stereotypes with age. **Background:** Little is known about control/display stereotypes for children of different ages and the way in which these stereotypes develop with age. This study is part of a program to determine the need to design differentially for these age groups. **Method:** We tested four groups of children with various tasks (age groups 5 to 7, 8 to 10, 11 to 13, 14 to 16), with about 30 in each group. Examples of common tasks were opening a bottle, turning on taps, and allocating numbers to keypads. More complex tasks involved rotating a control to move a display in a requested direction. **Results:** Tasks with which different age groups were familiar showed no effect of age group. Different control/display arrangements generally showed an increase in stereotype strength with age, with dependence on the form of the control/display arrangement. Two-dimensional arrangements, with the control on the same plane as the display, had higher stereotype strength than three-dimensional arrangements for all age groups, suggesting an effect of familiarity with controls and displays with increasing age. **Conclusion:** Children's control/display stereotypes do not differ greatly from those of adults, and hence, design for children older than 5 years of age, for control/display stereotypes, can be the same as that for adult populations. **Application:** When designing devices for children, the relationship between controls and displays can be as for adult populations, for which there are considerable experimental data.

- **Keywords:** control/display, children stereotypes, design for children, age effects

## **SURFACE TRANSPORTATION**

**Jordan Navarro, François Osiurak, Emanuelle Reynaud. *Does the Tempo of Music Impact Human Behavior Behind the Wheel?* pp. 556–574.**

**Objective:** Assess the influence of background music tempo on driving performance. **Background:** Music with a fast tempo is known to increase the level of arousal, whereas the reverse is observed for slow music. The relationship between driving performance and level of arousal was expected to take the form of an inverted U-curve. **Method:** Three experiments were undertaken to manipulate the musical background during driving. In Experiment 1, the driver's preferred music track played at its original and modified (plus or minus 30%) tempo were used together with the simple ticking of a metronome. In Experiment 2, music tracks of different tempos were played during driving. In Experiment 3, music tracks were categorized as arousing or relaxing based on the associated perceived level of arousal. **Results:** Listening to music tended to influence drivers' performances in a car-following task by improving coherence and gain adjustments relative to the followed vehicle but simultaneously shortened the intervehicular time. Although the tempo of the music per se did not directly affect driving behavior, arousing music tracks improved drivers' adjustments to the followed vehicle (Experiment 3). **Conclusion:** The tempo of the music listened to behind the wheel was not found to influence driving behaviors. However, arousing music improved drivers' responsiveness to changes in the speed of the followed vehicle. However, this benefit was canceled out by a reduction in the drivers' intervehicle safety margin. **Application:** Listening to arousing music while driving cannot be considered to improve road safety, at least in a car-following task without attentional impairments.

- **Keywords:** music, tempo, car driving, driving behavior, arousal

**Huei-Yen Winnie Chen, Liberty Hoekstra-Atwood, Birsen Donmez. *Voluntary- and Involuntary-Distraction Engagement: An Exploratory Study of Individual Differences.* pp. 575–588.**

**Objective:** The aim of this study was to explore individual differences in voluntary and involuntary driver-distraction engagement. **Background:** Distractions may stem from intentional engagement in secondary tasks (voluntary) or failing to suppress non-driving-related stimuli or information (involuntary). A wealth of literature has examined voluntary distraction; involuntary distraction is not particularly well understood. Individual factors, such as age, are known to play a role in how drivers engage in distractions. However, it is unclear which individual factors are associated with voluntary-versus involuntary-distraction engagement and whether there is a relation between how drivers engage in these two distraction types. **Method:** Thirty-six participants, ages 25 to 39, drove in a simulator under three conditions: voluntary distraction with a self-paced visual-manual task on a secondary display, involuntary distraction with abrupt onset of irrelevant visual-audio stimuli on the secondary display, and no distraction. **Results:** The number of glances toward the secondary display under voluntary distraction was not correlated to that under involuntary distraction. The former was associated with gender, age, annual mileage, and self-reported distraction engagement; such associations were not observed for the latter. Accelerator release time in response to lead-vehicle braking was delayed similarly under both conditions. **Conclusion:** Propensity to engage in voluntary distractions appears to be not related to the inability of suppressing involuntary distractions. Further, voluntary and involuntary distraction both affect braking response. These findings have implications for design of in-vehicle technologies, which may be sources of both distraction types.

- **Keywords:** driver distraction, driving simulator, voluntary distraction, involuntary distraction, individual differences