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HOW THE HF/E KNOWLEDGE BASE CAN CONTRIBUTE TO ADDRESSING THE CORONAVIRUS CRISIS

Anne Collins McLaughlin, Patricia R. DeLucia, Frank A. Drews, Monifa Vaughn-Cooke, Anil Kumar, Robert R. Nesbitt, Kevin Cluff. [Evaluating Medical Devices Remotely: Current Methods and Potential Innovations.](#) pp. 1041–1060.

Objective: We present examples of laboratory and remote studies, with a focus on studies appropriate for medical device design and evaluation. From this review and description of extant options for remote testing, we provide methods and tools to achieve research goals remotely. **Background:** The FDA mandates human factors evaluation of medical devices. Studies show similarities and differences in results collected in laboratories compared to data collected remotely in non-laboratory settings. Remote studies show promise, though many of these are behavioral studies related to cognitive or experimental psychology. Remote usability studies are rare but increasing, as technologies allow for synchronous and asynchronous data collection. **Method:** We reviewed methods of remote evaluation of medical devices, from testing labels and instruction to usability testing and simulated use. Each method was coded for the attributes (e.g., supported media) that need consideration in usability studies. **Results:** We present examples of how published usability studies of medical devices could be moved to remote data collection. We also present novel systems for creating such tests, such as the use of 3D printed or virtual prototypes. Finally, we advise on targeted participant recruitment. **Conclusion:** Remote testing will bring opportunities and challenges to the field of medical device testing. Current methods are adequate for most purposes, excepting the validation of Class III devices. **Application:** The tools we provide enable the remote evaluation of medical devices. Evaluations have specific research goals, and our framework of attributes helps to select or combine tools for valid testing of medical devices.

- **Keywords:** analysis and evaluation, design strategies, tools, qualitative methods, remote usability testing and evaluation, medical devices and technologies

Farzan Sasangohar, Jason Moats, Ranjana Mehta, S. Camille Peres. [*Disaster Ergonomics: Human Factors in COVID-19 Pandemic Emergency Management.*](#) pp. 1061–1068

Objective: We aimed to identify opportunities for application of human factors knowledge base to mitigate disaster management (DM) challenges associated with the unique characteristics of the COVID-19 pandemic. **Background:** The role of DM is to minimize and prevent further spread of the contagion over an extended period of time. This requires addressing large-scale logistics, coordination, and specialized training needs. However, DM-related challenges during the pandemic response and recovery are significantly different than with other kinds of disasters. **Method:** An expert review was conducted to document issues relevant to human factors and ergonomics (HFE) in DM. **Results:** The response to the COVID-19 crisis has presented complex and unique challenges to DM and public health practitioners. Compared to other disasters and previous pandemics, the COVID-19 outbreak has had an unprecedented scale, magnitude, and propagation rate. The high technical complexity of response and DM coupled with lack of mental model and expertise to respond to such a unique disaster has seriously challenged the response work systems. Recent research has investigated the role of HFE in modeling DM systems' characteristics to improve resilience, accelerating emergency management expertise, developing agile training methods to facilitate dynamically changing response, improving communication and coordination among system elements, mitigating occupational hazards including guidelines for the design of personal protective equipment, and improving procedures to enhance efficiency and effectiveness of response efforts. **Conclusion:** This short review highlights the potential for the field's contribution to proactive and resilient DM for the ongoing and future pandemics.

- **Keywords:** emergency response, pandemic, disasters, training, communication

Neal Wiggermann, Jie Zhou, Dee Kumpar. [*Proning Patients With COVID-19: A Review of Equipment and Methods.*](#) pp. 1069–1076.

Objective: To identify and critically evaluate methods for proning patients with COVID-19 in the intensive care unit (ICU). **Background:** Acute respiratory distress syndrome (ARDS) is common in hospitalized patients with COVID-19. Proning improves blood oxygenation and survival rates in these patients but is not commonly performed due to the difficulty of the procedure. **Methods:** An academic literature review, internet video search, and consultation with five subject-matter experts was performed to identify known methods for proning. Evaluation of each method considered the number of healthcare workers required, physical stresses on staff, risk of adverse events to patients, and equipment cost and availability. **Results:** Several variations of manual techniques and lift-assisted techniques were identified in addition to a specialized proning bed. Manual methods require more healthcare workers, higher physical stresses, and greater risk of adverse events than lift-assisted methods or the proning bed. **Conclusion:** Both the specialized proning bed and a lift-assisted method using straps largely eliminated manual forces required for proning while allowing for a controlled lowering and positioning of the patient. **Application:** This review will guide practitioners to the most suitable methods for proning patients in the ICU.

- **Keywords:** patient handling, prone positioning, proning, medical devices and technologies, nursing and nursing systems

Philip Kortum, Robert Stein, Claudia Ziegler Acemyan, Dan S. Wallach, Elizabeth Vann. [*How Human Factors Can Help Preserve Democracy in the Age of Pandemics.*](#) pp. 1077–1086.

Objective: To describe user-centered voting systems that would support the safe conduct of voting in a pandemic environment. **Background:** The COVID-19 pandemic has complicated our democratic processes. Voters and poll workers feel threatened by the potential dangers of voting in business-as-usual polling stations. Indeed, significant problems were encountered in the recent 2020 primary elections in Wisconsin, where the National Guard had to be mobilized because so few poll workers reported to work, and more than 90% of polling places had to remain closed. **Method:** We describe a number of possible user-centered solutions that would help protect voters and poll workers in times of pandemic, and also report the results of a survey that asked voters and poll workers about what kinds of systems might make them willing to vote. **Results:** Political as well as safety considerations will need to be considered as these safer voting solutions are designed since, surprisingly, the kinds of solutions preferred depend on the political affiliation of the voters. **Conclusion:** Human factors professionals have a large role to play in realizing the safe, successful implementation of these user-centered systems. Good human factors analysis can help minimize the risk to voters and poll workers. Moreover, human factors methods can help safeguard democracy by creating safe and well-engineered environments that are conducive to voting in the age of pandemics. **Application:** Creating safe and effective voting solutions that protect voters and poll workers during pandemic outbreaks is crucial to the preservation of democracy.

Keywords: voting, user-centered design, pandemic, COVID-19, system design

Yusuke Yamani, Shelby K. Long, Makoto Itoh. [*Human–Automation Trust to Technologies for Naïve Users Amidst and Following the COVID-19 Pandemic.*](#) pp. 1087–1094.

Objective and background Trust is a critical factor that influences the success or failure of human–automation interaction in a variety of professional domains such as transportation, military, and healthcare. The unprecedented COVID-19 crisis will likely accelerate the implementation of automation and create unique problems involving human–automation trust for naïve users of automated technologies in the future. **Method:** We briefly review factors that can influence the development of human–automation trust amidst and following the COVID-19 pandemic. We focus on two theories on human-automation trust and how naïve users develop and maintain their trust in unfamiliar technologies. **Results:** The current review identifies user workload and perceived risk as critical factors that will impact human–automation trust during the COVID-19 pandemic. Both theories predict that it is important for naïve users to accumulate and analyze behavioral evidence of automated technologies to maintain appropriate trust levels as the pandemic progresses. **Conclusion and application:** Theories of human–automation trust inform trajectories of trust development toward unfamiliar technologies for naïve users. In application, manufacturers and distributors should focus on communicating system information effectively to retain users who may be “forced” to use unfamiliar technologies during the COVID-19 pandemic.

- **Keywords:** human–automation trust, trust development, COVID-19, naïve automation users

Robin Welsch, Heiko Hecht, Lewis Chuang, Christoph von Castell. [*Interpersonal Distance in the SARS-CoV-2 Crisis.*](#) pp. 1095–1101.

Background: Mandatory rules for social distancing to curb the SARS-CoV-2 pandemic require individuals to maintain a critical interpersonal distance above 1.5 m. However, this contradicts our natural preference, which is closer to 1 m for non-intimate encounters, for example, when asking a stranger for directions. **Objective:** This review addresses how humans typically regulate interpersonal distances, in order to highlight the challenges of enforcing atypically large interpersonal distances. **Method:** To understand the challenges posed by social distancing requirements, we integrate relevant

contributions from visual perception, social perception, and human factors. **Results:** To date, research on preferred interpersonal distances suggests that social distancing could induce discomfort, heighten arousal, and decrease social signaling in the short term. While the protracted effects of social distancing are unclear, we propose hypotheses on the mid- to long-term consequences of violating preferred norms of interpersonal distances. **Conclusion:** We suggest that enforcing a physical distance of 1.5–2 m presents a serious challenge to behavioral norms. **Application:** We address how notifications, architectural design, and visualizations could be effectively applied to promote interpersonal distance requirements.

- **Keywords:** SARS-CoV-2, interpersonal distance, proxemics, discomfort

ACCIDENTS, HUMAN ERROR

Hailiang Wang, Calvin K. L. Or. [*Effects of Text Enhancement, Identical Prescription-Package Names, Visual Cues, and Verbal Provocation on Visual Searches of Look-Alike Drug Names: A Simulation and Eye-Tracking Study.*](#) pp. 1102–1116.

Objective: Simulation and eye tracking were used to examine the effects of text enhancement, identical prescription-package names, visual cues, and verbal provocation on visual searches of look-alike drug names. **Background:** Look-alike drug names can cause confusion and medication errors, which jeopardize patient safety. The effectiveness of many strategies that may prevent these problems requires evaluation. **Method:** We conducted two experiments that were based on a four-way, repeated-measures design. The within-subject factors were text enhancement, identical prescription-package names, visual cues, and verbal provocation. In Experiment 1, 40 nurses searched for and selected a target drug from an array of drug packages on a pharmacy shelf mock-up. In Experiment 2, the eye movements of another 40 nurses were tracked while they performed a computer-based drug search task. **Results:** Text enhancement had no significant effect on the drug search. Nurses selected the target drugs more quickly and easily when the prescriptions and drug packages shared identical drug name formats. The use of a visual cue to direct nurses' attention facilitated their visual searches and improved their eye gaze behaviors. The nurses reported greater mental effort if they were provoked verbally during the drug search. **Conclusion:** Efficient and practical strategies should be adopted for designs that facilitate accurate drug search. Among these strategies are using identical name appearances on drug prescriptions and packages, using a visual cue to direct nurses' attention, and avoiding rushing nurses while they are concentrating. **Application:** The findings aim to inspire recommendations for work system designs that will improve the visual search of look-alike drug names.

- **Keywords:** medication management and safety, visual search, decision making, simulation, eye movements

COGNITION

Katja Kircher, Tuomo Kujala, Christer Ahlström. [*On the Difference Between Necessary and Unnecessary Glances Away From the Forward Roadway: An Occlusion Study on the Motorway.*](#) pp. 1117–1131.

Objective: The present study strove to distinguish traffic-related glances away from the forward roadway from non-traffic-related glances while assessing the minimum amount

of visual information intake necessary for safe driving in particular scenarios. **Background:** Published gaze-based distraction detection algorithms and guidelines for distraction prevention essentially measure the time spent looking away from the forward roadway, without incorporating situation-based attentional requirements. Incorporating situation-based attentional requirements would entail an approach that not only considers the time spent looking elsewhere but also checks whether all necessary information has been sampled. **Method:** We assess the visual sampling requirements for the forward view based on 25 experienced drivers' self-paced visual occlusion in real motorway traffic, dependent on a combination of situational factors, and compare these with their corresponding glance behavior in baseline driving. **Results:** Occlusion durations were on average 3 times longer than glances away from the forward roadway, and they varied substantially depending on particular maneuvers and on the proximity of other traffic, showing that interactions with nearby traffic increase perceived uncertainty. The frequency of glances away from the forward roadway was relatively stable across proximity levels and maneuvers, being very similar to what has been found in naturalistic driving. **Conclusion:** Glances away from the forward roadway proved qualitatively different from occlusions in both their duration and when they occur. Our findings indicate that glancing away from the forward roadway for driving purposes is not the same as glancing away for other purposes, and that neither is necessarily equivalent to distraction.

- **Keywords:** driver behavior, attention, distraction, occlusion, glance behavior

Andrew Stets, Samantha L. Smith, William S. Helton. [Dual-Task Interference Between Swimming and Verbal Memory](#). pp. 1132–1140.

Objective: A dual-task study was performed to explore the performance effects for swimming, word recall, and the combination of the two tasks performed simultaneously. **Background:** Dual-task interference studies have been performed for a variety of tasks; however, there has not been much dual-task interference research where one of the tasks is a naturalistic physically strenuous task. Swimming is a unique physical task that requires spatial orientation on three dimensional axes, similar to that of flying, but has no risk of falling. Previous studies have been conducted in other activity combinations with word-free recall, such as running and climbing, but swimming has yet to be explored. **Method:** A verbal memory recall task and swimming task were performed in isolated (single-task) and simultaneous conditions. A comparison of effects across these different activities was also explored. **Results:** Swimming and the word-recall task resulted in significant dual-task interference: almost as much as when word recall was paired with another verbal task, but more than running and less than climbing. **Conclusion:** Consistent with other dual-task studies, this study observed dual-task interference between the physical swimming task and the cognitive verbal memory task. **Application:** Future technologies and training for personnel who engage in water rescue or commercial diving, such as underwater welding and fiber optic cable, may be improved by these findings.

- **Keywords:** skilled performance, auditory displays, posture control, dual task, mental workload

HEALTH CARE/HEALTH SYSTEMS

Carlo Cantarella, Giulia Stucchi, Olga Menoni, Dario Consonni, Silvia Cairoli, Rosa Manno, Marco Tasso, Luca Galinotti, Natale Battevi. *MAPO Method to Assess the Risk of Patient Manual Handling in Hospital Wards: A Validation Study*. pp. 1141–1149.

Objective: To validate the effectiveness of MAPO method (Movement and Assistance of Hospital Patient) after the introduction of some changes to improve assessment objectivity. **Background:** The number of operators exposed to patient manual handling is increasing considerably. MAPO, proposed in 1999 as a useful tool to estimate the risk of patient manual handling, is a method characterized by analytical quickness. It has recently been improved to better match the 2012 ISO (International Organization for Standardization) technical report. **Methods:** A multicenter study was conducted between 2014 and 2016 involving 26 Italian hospitals in the Apulia Region. MAPO method was used to assess the risk of patient manual handling in 116 wards. A total of 1,998 exposed subjects were evaluated for the presence or absence of acute low back pain in the previous 12 months. **Results:** Only 12% of the investigated wards fell in the green exposure level (MAPO index = 0.1–1.5), 37% resulted in the average exposure level (MAPO index = 1.51–5) and the remaining 51% in the higher exposure level (MAPO index >5). The results confirmed a positive association between increasing levels of MAPO index and the number of episodes of acute low back pain (adjusted p trend = .001). **Conclusion:** The improvements made over the past years led to a more objective assessment procedure. Despite the changes, the study confirmed the effectiveness of :MAPO method to predict low back pain. **Application:** MAPO method is an accurate risk assessment tool that identifies and evaluates workplace risks. The proper application of the method significantly improves working conditions.

- **Keywords:** patient manual handling, low back pain, risk assessment, caregivers

NEUROERGONOMICS

Ardaman Kaur, Rishu Chaujar, Vijayakumar Chinnadurai. [*Effects of Neural Mechanisms of Pretask Resting EEG Alpha Information on Situational Awareness: A Functional Connectivity Approach.*](#) pp. 1150–1170.

Objective: In this study, the influence of pretask resting neural mechanisms on situational awareness (SA)-task is studied. **Background:** Pretask electroencephalography (EEG) information and Stroop effect are known to influence task engagement independently. However, neural mechanisms of pretask resting absolute alpha (PRAA) and pretask resting alpha frontal asymmetry (PRAFA) in influencing SA-task which is undergoing Stroop effect is still not understood. **Method:** The study involved pretask resting EEG measurements from 18 healthy individuals followed by functional magnetic resonance imaging (fMRI) acquisition during SA-task. To understand the effect of pretask alpha information and Stroop effect on SA, a robust correlation between mean reaction time, SA Index, PRAA, and PRAFA were assessed. Furthermore, neural underpinnings of PRAA, PRAFA in SA-task, and functional connectivity were analyzed through the EEG-informed fMRI approach. **Results:** Significant robust correlation of reaction time was observed with SA Index (Pearson: $r = .50$, $pcorr = .05$) and PRAFA (Pearson: $r = .63$; $pcorr = .01$), respectively. Similarly, SA Index significantly correlated with PRAFA (Pearson: $r = .56$, $pcorr = .01$; Spearman: $r = .61$, $pcorr = .007$), and PRAA (Pearson: $r = .59$, $pcorr = .005$; Spearman: $r = .59$, $pcorr = .002$). Neural underpinnings of SA-task revealed regions involved in visual-processing and higher-order cognition. PRAA was primarily underpinned at frontal-temporal areas and functionally connected to SA-task regions pertaining to the emotional regulation. PRAFA has correlated with limbic and parietal regions, which are involved in integration of visual, emotion, and memory information of SA-task. **Conclusion:** The results suggest a strong association of reaction time with SA-task and PRAFA and strongly support the hypothesis that PRAFA, PRAA, and associated neural mechanisms significantly influence the outcome of SA-task. **Application:** It is beneficial to study the effect of pretask resting information on SA-task to improve SA.

- **Keywords:** situational awareness, cognition, physiological measurement, methods and skills, neuroimaging, neuroergonomics, analysis and evaluation

SENSORY AND PERCEPTUAL PROCESSES

Zhuofan Liu, Christer Ahlström, Åsa Forsman, Katja Kircher. [*Attentional Demand as a Function of Contextual Factors in Different Traffic Scenarios*](#). pp. 1171–1189.

Objective: To assess the attentional demand of different contextual factors in driving. **Background:** The attentional demand on the driver varies with the situation. One approach for estimating the attentional demand, via spare capacity, is to use visual occlusion. **Method:** Using a 3 × 5 within-subjects design, 33 participants drove in a fixed-base simulator in three scenarios (i.e., urban, rural, and motorway), combined with five fixed occlusion durations (1.0, 1.4, 1.8, 2.2, and 2.6 s). By pressing a microswitch on a finger, the driver initiated each occlusion, which lasted for the same predetermined duration within each trial. Drivers were instructed to occlude their vision as often as possible while still driving safely. **Results:** Stepwise logistic regression per scenario indicated that the occlusion predictors varied with scenario. In the urban environment, infrastructure-related variables had the biggest influence, whereas the distance to oncoming traffic played a major role on the rural road. On the motorway, occlusion duration and time since the last occlusion were the main determinants. **Conclusion:** Spare capacity is dependent on the scenario, selected speed, and individual factors. This is important for developing workload managers, infrastructural design, and aspects related to transfer of control in automated driving. **Application:** Better knowledge of the determinants of spare capacity in the road environment can help improve workload managers, thereby contributing to more efficient and safer interaction with additional tasks.

- **Keywords:** attentional demand, visual occlusion, traffic situation, spare capacity, driving simulator

SURFACE TRANSPORTATION

Tobias Vogelpohl, Franziska Gehlmann, Mark Vollrath. [*Task Interruption and Control Recovery Strategies After Take-Over Requests Emphasize Need for Measures of Situation Awareness*](#). pp. 1190–1211.

Objective: Our objective was to determine whether there is a need to go beyond measures of automation deactivation time to understand the transition to manual driving after take-over requests (TORs) using the example of office tasks as nondriving-related tasks (NDRTs). **Background:** Office tasks are likely NDRTs during automated commutes to/from work. Complex tasks can influence how manual control and visual attention is recovered after TORs. **Method:** N = 51 participants in a driving simulator performed either one of two office tasks or no task (between subjects). We recorded reaction times in a high-urgency and low-urgency scenario (within subjects) and analyzed task interruption strategies. **Results:** 90% of the participants who performed an NDRT deactivated the automation after 7 to 8 s. However, 90% of the same drivers looked at the side mirror for the first time only after 11 to 14 s. Drivers with office tasks either interrupted the tasks sequentially or in parallel. Strategies were not adapted to the take-over situation or the task but appeared to be due to individual preferences. **Conclusion:** Drivers engaged in NDRTs may neglect lower priority subtasks after a TOR, such as

mirror checking. Therefore, there is a need to go beyond measures of automation deactivation time to understand the transition to manual driving. Using analyses of attentional dynamics during take-over situations may enhance the safety of future car-driver handover assistance systems. **Application:** If low driver availability is detected, TORs should only be used as a fallback option if sufficient time and adaptive driver support can be provided.

- **Keywords:** take-over request, driving simulator, nondriving-related tasks, reaction time, situation awareness

Giulio Bianchi Piccinini, Esko Lehtonen, Fabio Forcolin, Johan Engström, Deike Albers, Gustav Markkula, Johan Lodin, Jesper Sandin. [How Do Drivers Respond to Silent Automation Failures? Driving Simulator Study and Comparison of Computational Driver Braking Models](#). pp. 1212–1229.

Objective: This paper aims to describe and test novel computational driver models, predicting drivers' brake reaction times (BRTs) to different levels of lead vehicle braking, during driving with cruise control (CC) and during silent failures of adaptive cruise control (ACC). **Background:** Validated computational models predicting BRTs to silent failures of automation are lacking but are important for assessing the safety benefits of automated driving. **Method:** Two alternative models of driver response to silent ACC failures are proposed: a looming prediction model, assuming that drivers embody a generative model of ACC, and a lower gain model, assuming that drivers' arousal decreases due to monitoring of the automated system. Predictions of BRTs issued by the models were tested using a driving simulator study. **Results:** The driving simulator study confirmed the predictions of the models: (a) BRTs were significantly shorter with an increase in kinematic criticality, both during driving with CC and during driving with ACC; (b) BRTs were significantly delayed when driving with ACC compared with driving with CC. However, the predicted BRTs were longer than the ones observed, entailing a fitting of the models to the data from the study. **Conclusion:** Both the looming prediction model and the lower gain model predict well the BRTs for the ACC driving condition. However, the looming prediction model has the advantage of being able to predict average BRTs using the exact same parameters as the model fitted to the CC driving data. **Application:** Knowledge resulting from this research can be helpful for assessing the safety benefits of automated driving.

- **Keywords:** adaptive cruise control, autonomous driving, cruise control, driver models, visual looming