Human Factors – rok 2017, roč. 59

Číslo 5 (August)

AT THE FOREFRONT OF HF/E

Cleotilde Gonzalez, Pegah Fakhari, Jerome Busemeyer. *Dynamic Decision Making: Learning Processes and New Research Directions*. pp. 713–721

Objective: The aim of this manuscript is to provide a review of contemporary research and applications on dynamic decision making (DDM). **Background:** Since early DDM studies, there has been little systematic progress in understanding decision making in complex, dynamic systems. Our review contributes to better understanding of decision making *processes* in dynamic tasks. **Method:** We discuss new research directions in DDM to highlight the value of simplification in the study of complex decision processes, divided into experimental and theoretical/computational approaches, and focus on problems involving control tasks and search-and-choice tasks. In computational modeling, we discuss recent developments in instance-based learning and reinforcement learning that advance modeling the processes of dynamic decisions. **Results:** Results from DDM research reflect a trend to scale down the complexity of DDM tasks to facilitate the study of the process of decision making. Recent research focuses on the dynamic complexity emerging from the interactions of actions and outcomes over time even in simple dynamic tasks. **Conclusion:** The study of DDM in theory and practice continues to be a priority area of research. New research directions can help the human factors community to understand the effects of experience, knowledge, and adaption processes in DDM tasks, but research challenges remain to be addressed, and the recent perspectives discussed can help advance a systematic DDM research program.**Application:** Classical domains, such as automated pilot systems, fighting fires, and medical emergencies, continue to be central applications of basic DDM research, but new domains, such as cybersecurity, climate change, and forensic science, are emerging as other important applications.

- **Keywords:** dynamic decision making, cognitive models, reinforcement learning, instance-based learning, decisions from experience

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Ranjana K. Mehta, Lora Anne Cavuoto. *Relationship Between BMI and Fatigability Is Task Dependent*. pp. 722–733.

Objective: The objective of the current study was to determine the effect of body mass index (BMI) on fatigability of three different muscle groups at four different work intensities. **Methods:** Forty-nine normal-weight, 50 overweight, and 43 obese adults (32.1 ± 9.2 years; 50% males) performed fatiguing handgrip, shoulder flexion, and trunk extension exertions at 20%, 40%, 60%, and 80% of the associated maximum voluntary contractions. **Results:** Obese adults demonstrated 22% to 30% shorter endurance times than normal-weight adults, but this was only observed at lower intensities and with larger and more postural muscles of the shoulder and low back. Strength and fatigue-related strength loss remained comparable across BMI groups in both males and females in these task-specific conditions. Obesity was associated with faster progression in perception of effort at low-intensity shoulder and trunk exertions. While males were stronger than females across all muscle groups, females exhibited greater shoulder fatigue resistance than males at lower intensity levels. **Conclusion:** Findings indicate that the relationship between obesity and fatigability is task dependent. **Application:** These findings provide initial evidence on the impact of obesity on worker capacity. Future work that extends the current investigation to include more occupationally relevant scenarios are needed to facilitate occupational task (re)design and assessment practices, such that altered work capacities of two-thirds of the working population are accommodated.

COGNITION

Johan Engström, Gustav Markkula, Trent Victor, Natasha Merat. *Effects of Cognitive Load on Driving Performance: The Cognitive Control Hypothesis*. pp. 734–764.

Objective: The objective of this paper was to outline an explanatory framework for understanding effects of cognitive load on driving performance and to review the existing experimental literature in the light of this framework. **Background:** Although there is general consensus that taking the eyes off the forward roadway significantly impairs most aspects of driving, the effects of primarily cognitively loading tasks on driving performance are not well understood. **Method:** Based on existing models of driver attention, an explanatory framework was outlined. This framework can be summarized in terms of the cognitive control hypothesis: Cognitive load selectively impairs driving subtasks that rely on cognitive control but leaves automatic performance unaffected. An extensive literature review was conducted wherein existing results were reinterpreted based on the proposed framework. **Results:** It was demonstrated that the general pattern of experimental results reported in the literature aligns well with the cognitive control hypothesis and that several apparent discrepancies between studies can be reconciled based on the proposed framework. More specifically, performance on nonpracticed or inherently variable tasks, relying on cognitive control, is consistently impaired by cognitive load, whereas the performance on automatized (well-practiced and consistently mapped) tasks is unaffected and sometimes even improved. **Conclusion:** Effects of cognitive load on driving are strongly selective and task dependent. **Application:** The present results have important implications for the generalization of results obtained from experimental studies to real-world driving. The proposed framework can also serve to guide future research on the potential causal role of cognitive load in real-world crashes.

DISPLAYS AND CONTROLS

Simon Y. W. Li, Tsz-Lok Tang, Anna Hickling, Szeyuen Yau, Birgit Brecknell, Penelope M. Sanderson. *Spearcons for Patient Monitoring: Laboratory Investigation Comparing Earcons and Spearcons*. pp. 765–781.

Objective: We compared the effectiveness of single-tone earcons versus spearcons in conveying information about two commonly monitored vital signs: oxygen saturation and heart rate. **Background:** The uninformative nature of many medical alarms—and clinicians' lack of response to alarms—is a widespread problem that can compromise patient safety. Auditory displays, such as earcons and spearcons (speech-based earcons), may help clinicians maintain awareness of patients' well-being and reduce their reliance on alarms. Earcons are short abstract sounds whose properties represent different types and levels of information, whereas spearcons are time-compressed spoken phrases that directly state their meaning. Listeners might identify patient vital signs more accurately with spearcons than with earcons. **Method:** In Experiment 1 we compared how accurately 40 nonclinician participants using either (a) single-tone earcons differentiated by timbre and tremolo or (b) Cantonese spearcons recorded using a female Cantonese voice could identify both oxygen saturation and heart rate levels. In Experiment 2 we tested the identification performance of six further nonclinician participants with spearcons recorded using a male Cantonese voice. **Results:** In Experiment 1, participants using spearcons identified both vital signs together more accurately than did participants using earcons. Participants using Cantonese spearcons also learned faster, completed trials faster, identified individual vital signs more accurately, and felt greater ease and more confident when identifying oxygen saturation levels. Experiment 2 verified the previous findings with male-voice Cantonese spearcons. **Conclusion:** Participants identified vital signs more accurately using spearcons than with the single-tone earcons. **Application:** Spearcons may be useful for patient monitoring in situations in which intermittently presented information is desirable.

HUMAN-SYSTEMS INTEGRATION

Dechristian França Barbieri, Divya Srinivasan, Svend Erik Mathiassen, Ana Beatriz Oliveira. *Comparison of Sedentary Behaviors in Office Workers Using Sit-Stand Tables With and Without Semiautomated Position Changes*. pp. 782–795.

Objective: We compared usage patterns of two different electronically controlled sit-stand tables during a 2-month intervention period among office workers. **Background:** Office workers spend most of their working time sitting, which is likely detrimental to health. Although the introduction of sit-stand tables has been suggested as an effective intervention to decrease sitting time, limited evidence is available on usage patterns of sit-stand tables and whether patterns are influenced by table configuration. **Method:** Twelve workers were provided with standard sit-stand tables (nonautomated table group) and 12 with semiautomated sit-stand tables programmed to change table position according to a preset pattern, if the user agreed to the system-generated prompt (semiautomated table group). Table position was monitored continuously for 2 months after introducing the tables, as a proxy for sit-stand behavior. **Results:** On average, the table was in a "sit" position for 85% of the workday in both groups; this percentage did not change significantly during the 2-month period. Switches in table position from sit to stand were, however, more frequent in the semiautomated table group than in the nonautomated table group (0.65 vs. 0.29 hr^{-1}; $p = .001$). **Conclusion:** Introducing a semiautomated sit-stand table appeared to be an attractive alternative to a standard sit-stand table, because it led to more posture variation. **Application:** A semiautomated sit-stand table may effectively contribute to making postures more variable among office workers and thus aid in alleviating negative health effects of extensive sitting.

METHODS AND SKILLS

Richard J. Jagacinski, Gordon M. Hammond, Emanuele Rizzi. *Measuring Memory and Attention to Preview in Motion*. pp. 796–810.

Objective: Use perceptual-motor responses to perturbations to reveal the spatio-temporal detail of memory for the recent past and attention to preview when participants track a winding roadway. **Background:** Memory of the recently passed roadway can be inferred from feedback control models of the participants' manual movement patterns. Similarly, attention to preview of the upcoming roadway can be inferred from feedforward control models of manual movement patterns. **Method:** Perturbation techniques were used to measure these memory and attention functions. **Results:** In a laboratory tracking task, the bandwidth of lateral roadway deviations was found to primarily influence memory for the past roadway rather than attention to preview. A secondary auditory/verbal/vocal memory task resulted in higher velocity error and acceleration error in the tracking task but did not affect attention to preview. Attention to preview was affected by the frequency pattern of sinusoidal perturbations of the roadway. **Conclusion:** Perturbation techniques permit measurement of the spatio-temporal span of memory and attention to preview that affect tracking a winding roadway. They also provide new ways to explore goal-directed forgetting and spatially distributed attention in the context of movement. More generally, these techniques provide sensitive measures of individual differences in cognitive aspects of action. **Application:** Models of driving behavior and assessment of driving skill may benefit from more detailed spatio-temporal measurement of attention to preview.

MOTOR BEHAVIOR

Matthew Ray, Elizabeth Sanli, Robert Brown, Kerri Ann Ennis, Heather Carnahan. *The Influence of Hand Immersion Duration on Manual Performance*. pp. 811–820.

Objective: To investigate the effect of hand immersion duration on manipulative ability and tactile sensitivity. **Background:** Individuals in maritime settings often work with hands that have been immersed in water. Although research has shown that hand immersion duration differentially impacts skin adhesion and tactile sensitivity, the effect of hand immersion on manipulative ability has not been directly tested. Given how critical manipulative ability is for the safety and performance of those working at sea, the effect of hand immersion duration on manual performance was investigated. **Method:** Tests of manipulative ability (Purdue Pegboard, Grooved Pegboard, reef knot untying) and tactile sensitivity (Touch-Test) were completed following no-exposure, short-exposure, and long-exposure hand immersions in thermoneutral water. **Results:** Compared to the no immersion condition, the Purdue Pegboard performance was reduced in both immersion conditions (short exposure, −11%; long exposure, −8%). A performance decrement was only observed in the short exposure condition (+15% in time to complete task) for the reef knot untying task. There were no statistical differences in the Grooved Pegboard or Touch-Test scores between exposure conditions. **Conclusion:** Immersing the hands in water decreases manipulative ability except for when object properties reduce the slipperiness between the hand and object. **Application:** Manual performance in a wet environment may be conserved by designing tools and objects with edges and textures that can offset the slipperiness of wet hands. To maintain safety, the time requirements for working with wet hands needs to be considered.

PHYSIOLOGICAL AND PSYCHOLOGICAL CONDITIONS ("INTERNAL ENVIRONMENT")

Monique F. Crane, Sue Brouwers, Kirsty Forrest, Suyin Tan, Thomas Loveday, Mark W. Wiggins, Chris Munday, Leila David. *Positive Affect Is Associated With Reduced Fixation in a Realistic Medical Simulation*. pp. 821–832.

Objective: This study extends previous research by exploring the association between mood states (i.e., positive and negative affect) and fixation in practicing anesthetists using a realistic medical simulation. **Background:** The impact of practitioner emotional states on fixation is a neglected area of research. Emerging evidence is demonstrating the role of positive affect in facilitating problem solving and innovation, with demonstrated implications for practitioner fixation.**Method:** Twelve practicing anesthetists (4 females; M_{age}= 39 years; *SD* = 6.71) were involved in a medical simulation. Prior to the simulation, practitioners rated the frequency they had experienced various positive and negative emotions in the previous three days. During the simulation, the patient deteriorated rapidly, and anesthetists were observed for their degree of fixation. After the simulation, practitioners indicated the frequency of these same emotions during the simulation. **Results:** Nonparametric correlations were used to explore the independent relationships between positive and negative affect and the behavioral measures. Only positive affect impacted the likelihood of fixation. Anesthetists who reported more frequent recent positive affect in the three days prior to the simulation and during the simulation tended to be less fixated as judged by independent raters, identified a decline in patient oxygen saturation more quickly, and more rapidly implemented the necessary intervention (surgical cricothyroidotomy). **Conclusion:** These findings have some real-world implications for positive affect in patient safety. **Application:** This research has broad implications for professions where fixation may impair practice. This research suggests that professional training should teach practitioners to identify their emotions and understand the role of these emotions in fixation.

SIMULATION AND VIRTUAL REALITY

Steven M. Jarrett, Ryan M. Glaze, Ira Schurig, Winfred Arthur. *The Importance of Team Sex Composition in Team-Training Research Employing Complex Psychomotor Tasks*. pp. 833–843.

Objective: The relationship between team sex composition and team performance on a complex psychomotor task was examined because these types of tasks are commonly used in the lab-based teams literature. **Background:** Despite well-documented sex-based differences on complex psychomotor tasks, the preponderance of studies—mainly lab based—that use these tasks makes no mention of the sex composition of teams across or within experimental conditions. **Method:** A sample of 123 four-person teams with varying team sex composition learned and performed a complex psychomotor task, Steal Beasts Pro PE. Each team completed a 5-hr protocol whereby they conducted several performance missions. **Results:** The results indicated significant large mean differences such that teams with larger proportions of males had higher performance scores. **Conclusion:** These findings demonstrate the potential effect of team sex composition on the validity of studies that use complex psychomotor tasks to explore and investigate team performance–related phenomena when (a) team sex composition is not a focal variable of interest and (b) it is not accounted for or controlled. **Application:** Given the proclivity of complex psychomotor action-based tasks used in lab-based team studies, it is important to understand and control for the impact of team sex composition on team performance. When team sex composition is not controlled for, either methodologically or statistically, it may affect the validity of the results in teams studies using these types of tasks.

SURFACE TRANSPORTATION

Robert G. Radwin, John D. Lee, Oguz Akkas. *Driver Movement Patterns Indicate Distraction and Engagement*. pp. 844–860.

Objective: This research considers how driver movements in video clips of naturalistic driving are related to observer subjective ratings of distraction and engagement behaviors. **Background:** Naturalistic driving video provides a unique window into driver behavior unmatched by crash data, roadside observations, or driving simulator experiments. However, manually coding many thousands of hours of video is impractical. An objective method is needed to identify driver behaviors suggestive of distracted or disengaged driving for automated computer vision analysis to access this rich source of data. **Method:** Visual analog scales ranging from 0 to 10 were created, and observers rated their perception of driver distraction and engagement behaviors from selected naturalistic driving videos. Driver kinematics time series were extracted from frame-by-frame coding of driver motions, including head rotation, head flexion/extension, and hands on/off the steering wheel. **Results:** The ratings were consistent among participants. A statistical model predicting average ratings from the kinematic features accounted for 54% of distraction rating variance and 50% of engagement rating variance. **Conclusion:** Rated distraction behavior was positively related to the magnitude of head rotation and fraction of time the hands were off the wheel. Rated engagement behavior was positively related to the variation of head rotation and negatively related to the fraction of time the hands were off the wheel. **Application:** If automated computer vision can code simple kinematic features, such as driver head and hand movements, then large-volume naturalistic driving videos could be automatically analyzed to identify instances when drivers were distracted or disengaged.

SYSTEM DESIGN AND ANALYSIS (GENERAL)

David Kaber, Maryam Zahabi. *Enhanced Hazard Analysis and Risk Assessment for Human-in-the-Loop Systems*. pp. 861–873.

Objective: The objective of this study was to enhance the existing system hazard analysis (SHA) technique by introducing the concepts of human and automation reliability quantification as well as fuzzy classification of system risks. These enhancements led to formulation of a new overall system risk-reliability score. **Background:** Many system safety analysis methods focus on individual physical component failure. Some human reliability analyses (HRA) consider human-automation interaction in determining system failure rates. There is no system safety analysis technique that quantifies the impact of human and automation reliability on the risk of hazard exposure. **Method:** Classification of the probability and severity of hazard exposure is typically made in terms of linguistic rather than numerical variables. Fuzzy sets are applicable for transforming linguistic classifications to numerical quantities. We focused on using fuzzy sets to define overlapping bands of system risk exposure with reference to the hazard risk categories defined in MIL-STD 882B. Fuzzy sets were also used for human-automated system reliability classification. **Results:** Introduction of human and automation reliability assessment in the SHA allows for definition of a system risk-reliability modeling space. The enhanced SHA (E-SHA) technique yields a mishap risk index, which is projected based on a composite assessment of human-automated system reliability at the time of operation. The E-SHA was compared with one of the most advanced HRA techniques. **Conclusion:** The E-SHA technique supports broader safety control recommendations and provides comparable, if not more detailed, results than prior systems safety and HRA techniques.