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AUTOMATION, EXPERT SYSTEMS

Jessie Y. C. Chen, Michael J. Barnes. *Supervisory Control of Multiple Robots : Effects of Imperfect Automation and Individual Differences. S. 157-174.*

Objective: A military multitasking environment was simulated to examine the effects of an intelligent agent, RoboLeader, on the performance of robotics operators. **Background:** The participants' task was to manage a team of ground robots with the assistance of RoboLeader, an intelligent agent capable of coordinating the robots and changing their routes on the basis of battlefield developments. **Method:** In the first experiment, RoboLeader was perfectly reliable; in the second experiment, RoboLeader's recommendations were manipulated to be either false-alarm prone or miss prone, with a reliability level of either 60% or 90%. The visual density of the targeting environment was manipulated by the presence or absence of friendly soldiers. **Results:** RoboLeader, when perfectly reliable, was helpful in reducing the overall mission times. The type of RoboLeader imperfection (false-alarm vs. miss prone) affected operators' performance of tasks involving visual scanning (target detection, route editing, and situation awareness). There was a consistent effect of visual density (clutter of the visual scene) for multiple performance measures. Participants' attentional control and video gaming experience affected their overall multitasking performance. In both experiments, participants with greater spatial ability consistently outperformed their low-spatial-ability counterparts in tasks that required effective visual scanning. **Conclusion:** Intelligent agents, such as RoboLeader, can benefit the overall human-robot teaming performance. However, the effects of type of agent unreliability, tasking requirements, and individual differences have complex effects on human-agent interaction. **Application:** The current results will facilitate the implementation of robots in military settings and will provide useful data to designs of systems for multirobot control.

- **Keywords:** human-robot interaction, supervisory control, intelligent agent, military, imperfect automation, individual differences, spatial ability, attentional control, gaming experience

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Jim R. Potvin. *Predicting Maximum Acceptable Efforts for Repetitive Tasks : An Equation Based on Duty Cycle. S. 175-188.*

Objective: The objective was to develop an equation, for repetitive tasks, that uses frequency and/or duty cycle (DC) to predict maximum acceptable efforts (MAE) relative

to maximum voluntary efforts (MVE). **Background:** Ergonomists must determine acceptable physical demands for a wide variety of tasks. Although a large database exists in the literature for maximum single-effort strength, far fewer repetitive tasks have psychophysical and/or physiological data available to guide the prediction of acceptable submaximal, repeated efforts. **Method:** DC represents the total effort duration divided by the cycle time. MAEs were calculated by dividing average psychophysics-based acceptable loads by corresponding single-effort maximum strength using 69 values from studies of the upper extremities. The author developed an equation to characterize the relationship between MAE and DC. **Results:** The resulting equation had DC taken to the exponent 0.24, and it predicted MAE very well ($r^2 = 0.87$, root mean square [RMS] difference = 7.2% of the maximum strength). At higher DC values, the equation also demonstrated good agreement with the published physiological data. **Conclusion:** The limited psychophysical database in the literature makes it difficult for ergonomists and engineers to recommend acceptable efforts for the large variety of repetitive tasks they evaluate. However, the proposed equation now allows for a correction of the large strength database to estimate acceptable force and torque limits for repetitive occupational tasks. **Application:** The proposed equation will have wide applications for ergonomic practitioners performing evaluations of repetitive tasks.

- **Keywords:** physical workloading, models and measures, fatigue

COGNITIVE PROCESSES

William S. Helton, James Head. *Earthquakes on the Mind : Implications of Disasters for Human Performance. S. 189-194.*

Objective: The present study explored the impact a natural disaster has on human performance. **Background:** Previous research indicates that traffic accidents increase after disasters. A plausible explanation for this finding is that disasters induce cognitive disruption and this disruption negatively affects performance (e.g., driving quality). **Method:** A total of 16 participants (7 men and 9 women) performed a sustained-attention-to-response task before and after a 7.1-magnitude earthquake. Performance (errors of omission, errors of commission, and reaction time) was compared before and after the earthquake. **Results:** Errors of omission increased after the earthquake. Changes in errors of commission and reaction times were, however, dependent on individual differences in stress response to the earthquake. **Conclusion:** The results indicate that natural disasters may have a negative impact on performance. **Application:** Communities need to be aware of the increased risk of accidents following disasters and develop countermeasures, including individualized assessment tools.

- **Keywords:** Sttention, disaster, earthquake, response inhibition, stress, sustained attention, vigilance

HEALTH AND MEDICAL SYSTEMS

Ido Morag, Daniel Gopher, Avishag Spillinger, Yael Auerbach-Shpak, Neri Laufer, Yuval Lavy, Ariel Milwidsky, Rivka-Rita Feigin, Shimon Pollack, Itay Maza, Zaher S. Azzam, Hanna Admi, Michael Soudry. *Human Factors–Focused Reporting System for Improving Care Quality and Safety in Hospital Wards. S. 195-213.*

Objective: The aim was to develop a reporting system for collecting human factors problem reports to establish a database to guide activities for improving health care quality and patient safety. **Background:** The current error and incident report systems do not provide sufficient and adequate coverage of the factors contributing to impaired safety and care quality. They fail to examine the range of difficulties that clinical staff

encounters in the conduct of daily work. **Method:** A voluntary problem-reporting system was developed to be used by hospital wards' clinicians and was tested in four wards of two hospitals in Israel. The system is based on human factors-formatted problem reports submitted by physicians and nurses on difficulties and hazards they confront in their daily work. Reports are grouped and evaluated by a team of human factor professionals. **Results:** A total of 359 reports were collected in the wards during 12 weeks, as compared with a total of 200 incidents reports that were collected during a period of 5 years with the existing obligatory incident reporting system. In-depth observational studies conducted on the wards confirmed the ability of the new system to highlight major human factors problems, differentially identifying specific problems in each of the wards studied. Problems reported were directly related to general factors affecting care quality and patient safety. **Conclusion:** Validation studies confirmed the reliability of the reporting system in pinpointing major problems per investigated unit according to its specific characteristics. **Application:** This type of reporting system could fill an important information gap with the potential to be a cost-effective initial database source to guide human factors efforts to improve care quality, reduce errors, and increase patient safety.

- **Keywords:** health care quality, incident-reporting system, patient safety, problem-reporting systems

PSYCHOLOGICAL STATES AND NEUROERGONOMICS

Davin Pavlas, Florian Jentsch, Eduardo Salas, Stephen M. Fiore, Valerie Sims. *The Play Experience Scale : Development and Validation of a Measure of Play.* S. 214-225.

Objective: A measure of play experience in video games was developed through literature review and two empirical validation studies. **Background:** Despite the considerable attention given to games in the behavioral sciences, play experience remains empirically underexamined. One reason for this gap is the absence of a scale that measures play experience. **Method:** In Study 1, the initial Play Experience Scale (PES) was tested through an online validation that featured three different games ($N = 203$). In Study 2, a revised PES was assessed with a serious game in the laboratory ($N = 77$). **Results:** Through principal component analysis of the Study 1 data, the initial 20-item PES was revised, resulting in the 16-item PES-16. Study 2 showed the PES-16 to be a robust instrument with the same patterns of correlations as in Study 1 via (a) internal consistency estimates, (b) correlations with established scales of motivation, (c) distributions of PES-16 scores in different game conditions, and (d) examination of the average variance extracted of the PES and the Intrinsic Motivation Scale. **Conclusion:** We suggest that the PES is appropriate for use in further validation studies. Additional examinations of the scale are required to determine its applicability to other contexts and its relationship with other constructs. **Application:** The PES is potentially relevant to human factors undertakings involving video games, including basic research into play, games, and learning; prototype testing; and exploratory learning studies.

- **Keywords:** serious games, play, measure, motivation, game, PES

SENSORY AND PERCEPTUAL PROCESSES

Takahiro Wada, Hiroyuki Konno, Satoru Fujisawa, Shun'ichi Doi. *Can Passengers' Active Head Tilt Decrease the Severity of Carsickness? : Effect of Head Tilt on Severity of Motion Sickness in a Lateral Acceleration Environment.* S. 226-234.

Objective: We investigated the effect of the passenger head-tilt strategy on the severity of carsickness in lateral acceleration situations in automobiles. **Background:** It is well

known that the driver is generally less susceptible to carsickness than are the passengers. However, it is also known that the driver tilts his or her head toward the curve center when negotiating a curve, whereas the passenger's head moves in the opposite direction. Therefore, we hypothesized that the head-tilt strategy has the effect of reducing the severity of carsickness. **Method:** A passenger car was driven on a quasi-oval track with a pylon slalom while the participant sat in the navigator seat. The experiment was terminated when either the participant felt the initial symptoms of motion sickness or the car finished 20 laps. In the natural head-tilt condition, the participants were instructed to sit naturally, to relax, and not to oppose the lateral acceleration intentionally. In the active head-tilt condition, the participants were asked to tilt their heads against the centrifugal acceleration, thus imitating the driver's head tilt. **Results:** The number of laps achieved in the active condition was significantly greater than that in the natural condition. In addition, the subjective ratings of motion sickness and symptoms in the active condition were significantly lower than those in the natural condition. **Conclusion:** We suggest that an active head tilt against centrifugal acceleration reduces the severity of motion sickness. **Application:** Potential applications of this study include development of a methodology to reduce carsickness.

- **Keywords:** motion sickness, car, sickness, automobile, head-tilt strategy, ride comfort, vehicle motion

SIMULATION AND VIRTUAL REALITY

Timothy J. Buker, Dennis A. Vincenzi, John E. Deaton. *The Effect of Apparent Latency on Simulator Sickness While Using a See-Through Helmet-Mounted Display : Reducing Apparent Latency With Predictive Compensation.* S. 235-249.

Objective: The aim of this study was to determine the effect of head movement frequency and predictive compensation on (a) latency produced in a monocular see-through helmet-mounted display (HMD) test bed and (b) simulator sickness experienced by users wearing the HMD. **Background:** There is conflicting research regarding latency as a significant factor in the onset of simulator sickness. Predictive compensation has been shown to mitigate the magnitude of latency, but little is known about the extent of its effect on simulator sickness. **Method:** A video camera recorded HMD and simulator imagery to accurately measure apparent latency produced at three head movement frequencies. Predictive compensation strategies were manipulated to measure the difference in apparent latency produced by the test bed in various conditions. Similar methodology was employed with human participants to measure simulator sickness experienced by users of this test bed. **Results:** In Experiment 1, apparent latency increased significantly as head movement frequency increased. Predictive compensation strategies significantly reduced apparent latency present in the test bed. In Experiment 2, predictive compensation significantly reduced the magnitude of simulator sickness. **Conclusion:** Predictive compensation can be effectively implemented to reduce apparent latency, resulting in a lower magnitude of simulator sickness. **Application:** Potential applications include HMD use in which head position is tracked and visual imagery is linked to head or body movement, such as in virtual and augmented reality systems, and is thus critical to functionality and performance.

- **Keywords:** apparent latency, extrapolated frame correction, helmet-mounted display (HMD), neural network, predictive compensation, simulator sickness

SURFACE TRANSPORTATION SYSTEMS

John D. Lee, Shannon C. Roberts, Joshua D. Hoffman, Linda S. Angell. *Scrolling and Driving: How an MP3 Player and Its Aftermarket Controller Affect Driving Performance and Visual Behavior.* S. 250-263.

Objective: The aim of this study was to assess how scrolling through playlists on an MP3 player or its aftermarket controller affects driving performance and to examine how drivers adapt device use to driving demands. **Background:** Drivers use increasingly complex infotainment devices that can undermine driving performance. The goal activation hypothesis suggests that drivers might fail to compensate for these demands, particularly with long tasks and large search set sizes. **Method:** A total of 50 participants searched for songs in playlists of varying lengths using either an MP3 player or an aftermarket controller while negotiating road segments with traffic and construction in a medium-fidelity driving simulator. **Results:** Searching through long playlists (580 songs) resulted in poor driving performance and required more long glances (longer than 2 s) to the device compared with other playlist lengths. The aftermarket controller also led to more long glances compared with the MP3 player. Drivers did not adequately adapt their behavior to roadway demand, as evident in their degraded driving performance. No significant performance differences were found between short playlists, the radio-tuning task, and the no-task condition. **Conclusion:** Selecting songs from long playlists undermined driving performance, and drivers did not sufficiently adapt their use of the device to the roadway demands, consistent with the goal activation hypothesis. The aftermarket controller degraded rather than enhanced performance. **Application:** Infotainment systems should support drivers in managing distraction. Aftermarket controllers can have the unintended effect of making devices carried into the car less compatible with driving. These results can motivate development of new interfaces as alternatives to scrolling lists.

- **Keywords:** driver adaptation, driver behavior, driver distraction, interface evaluation, usability, MP3 player

Stephen D. Myers, Trevor D. Dobbins, Stuart King, Benjamin Hall, Sharon R. Holmes, Tom Gunston, Rosemary Dyson. *Effectiveness of Suspension Seats in Maintaining Performance Following Military High-Speed Boat Transits.* S. 264-276.

Objective: The aim of this study was to investigate whether suspension seats (SS) fitted to rigid inflatable boats (RIB) could help maritime boarding teams maintain running performance during the high-risk posttransit phase. **Background:** High-speed RIB transits have been reported to cause reductions in the running performance of boarding teams posttransit. **Method:** In this experiment, two pairs of teams completed a 3-hr transit in either calm or rough seas (calm, 5 vs. 5; rough, 6 vs. 6) in an RIB fitted with either fixed (FS) or Suspension seats (SS). Exhaustive shuttle run distance was measured pre- and immediately posttransit. Transit heart rate and perceived exertion (RPE) were measured and deck and seat pan acceleration recorded; the latter were reported as impacts count and peak magnitude. **Results:** Distance run was reduced for the FS teams following both transits (calm, -250 m, -20%, $p < .07$; rough, -398 m, -26%, $p < .05$), whereas it was unchanged for the SS teams. All transit heart rates and RPE indicated light exertion levels. Seat pan impacts were similarly reduced during the calm transit (FS, -42%; SS, -30%); however, during the rough transit, the SS was more than twice as effective (FS, -32%; SS, -71%). Peak impact magnitudes were reduced by the SS (calm, -38%; rough, -57%) and amplified by the FS (calm, +3%; rough, +28%). **Conclusion:** Suspension seats effectively maintained posttransit running performance by reducing magnitude of the vertical shocks imposed on the passengers. **Application:** High-speed RIB transits followed immediately by high-intensity activity are intrinsic to contemporary maritime operations; suspension seats can maintain post-transit physical performance, thereby enhancing safety and operational effectiveness.

- **Keywords:** RIB, RHIB, vibration, impact, sea, maritime interdiction, maritime operations

TRAINING, EDUCATION, INSTRUCTIONAL SYSTEMS

Winfred Arthur, Jr., Ryan M. Glaze, Alok Bhupatkar, Anton J. Villado, Winston Bennett, Jr., Leah J. Rowe. *Team Task Analysis: Differentiating Between Tasks Using Team Relatedness and Team Workflow as Metrics of Team Task Interdependence*. S. 277-295.

Objective: As a constructive replication and extension of Arthur, Edwards, Bell, Villado, and Bennett (2005), the objective of the current study was to further investigate the efficacy of team relatedness and team workflow ratings (along with their composite) as metrics of interdependence. **Background:** Although an analysis of task and job interdependence has important implications and uses in domains such as job design, selection, and training, the job analysis literature has been slow to develop an effective method to identify team-based tasks and jobs. **Method:** To achieve the study's objectives, 140 F-16 fighter pilots (35 four-person teams) rated 34 task and activity statements in terms of their team relatedness and team workflow. **Results:** The results indicated that team relatedness and team workflow effectively differentiated between tasks with varying levels of interdependency (as identified by instructor pilots who served as subject matter experts) within the same job. In addition, teams that accurately perceived the level of interdependency performed better on a four-ship F-16 flight-training program than those that did not. **Conclusion:** Team relatedness and team workflow ratings can effectively differentiate between tasks with varying levels of interdependency. **Application:** Like traditional individual task or job analysis, this information can serve as the basis for specified human resource functions and interventions, and as diagnostic indicators as well.

- **Keywords:** team task analysis, team relatedness, team workflow, team interdependence, task interdependence, team-based jobteams