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ACCIDENTS, HUMAN ERROR

Guangquan Lu, Miaomiao Liu, Yunpeng Wang, Huasen Wan, and Daxin Tian. *Logit-Based Analysis of Drivers' Crossing Behavior at Unsignalized Intersections in China*. S. 1101-1114.

Objective: This study aims to investigate the crossing behavior of straight-moving drivers when they encounter other straight-moving drivers at unsignalized intersections in China. **Background:** In China, when two vehicle drivers encounter at an unsignalized intersection, neither driver completely stops his or her vehicle in most cases. Instead, one driver gradually approaches the intersection and dynamically decides to either yield or preempt by gaming with the other vehicle. This process increases the probability of accidents. **Method:** A total of 305 crossing cases were collected at an unsignalized intersection in Kunming City. Motion parameters were extracted from the video detection program designed by our research group. Based on a logistic regression method, we analyzed decision making moment of straight-moving drivers under crossing conditions, established crossing behavior models, and identified the main factors that affected drivers' decisions. In all, 68 cases observed at a separate intersection were used to validate the established models. **Results:** For crossing processes at unsignalized intersections in China, straight-moving drivers from the right side completed preemptive/yielding decisions at 1.3 s before reaching the crossing point. However, the majority of straight-moving drivers from the left side completed decisions at 1.1 s before reaching the crossing point. The most important parameter that influenced the drivers' decisions was the difference between the speeds of the two vehicles. **Conclusion:** An effective method for preventing traffic conflict between two straight-moving drivers is to control the speeds of the vehicles before they enter the intersection. **Application:** This study explores crossing behavior of straight-moving drivers and provides significant insights for controlling driver behavior.

- **Keywords:** Traffic, safety, driving, straight-moving, decision

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Máire Curran, Leonard O'Sullivan, Peter O'Sullivan, Wim Dankaerts, and Kieran O'Sullivan. *Does Using a Chair Backrest or Reducing Seated Hip*

Flexion Influence Trunk Muscle Activity and Discomfort? : a Systematic Review. S. 1115-1148.

Objective: This paper systematically reviews the effect of chair backrests and reducing seated hip flexion on low back discomfort (LBD) and trunk muscle activation. **Background:** Prolonged sitting commonly exacerbates low back pain (LBP). Several modifications to seated posture and chair design have been recommended, including using chairs with backrests and chairs that reduce hip flexion. **Method:** Electronic databases were searched by two independent assessors. Part 1 of this review includes 26 studies comparing the effect of sitting with at least two different hip angles. In Part 2, seven studies that compared the effect of sitting with and without a backrest were eligible. Study quality was assessed using the PEDro scale. **Results:** Significant confounding variables and a relatively small number of randomized controlled trials (RCTs) involving people with LBP complicates analysis of the results. There was moderate evidence that chair backrests reduce paraspinal muscle activation, and limited evidence that chair backrests reduce LBD. There was no evidence that chairs involving less hip flexion reduce LBP or LBD, or consistently alter trunk muscle activation. However, participants in several studies subjectively preferred the modified chairs involving less hip flexion. **Conclusion:** The limited evidence to support the use of chairs involving less seated hip flexion, or the effect of a backrest, is consistent with the limited evidence that other isolated chair design features can reduce LBP. **Application:** LBP management is likely to require consideration of several factors in addition to sitting position. Larger RCTs involving people with LBP are required.

- **Keywords:** Sitting, back pain, discomfort, systematic review

Michael W. R. Holmes, Diana E. De Carvalho, Thomas Karakolis, and Jack P. Callaghan. Evaluating Abdominal and Lower-Back Muscle Activity While Performing Core Exercises on a Stability Ball and a Dynamic Office Chair. S. 1149-1161.

Objective: The purpose of this study was to evaluate the ability of a dynamic office chair to activate the core muscles while participants performed exercises sitting on the chair compared to a stability ball. **Background:** Prolonged sitting has become an accepted part of the modern office. However, epidemiological evidence suggests that sedentary postures are linked to many adverse effects on health. The concept of dynamic or active sitting is intended to promote movement while sitting to reduce the time spent in prolonged, static postures. **Methods:** Sixteen participants performed four pelvic rotation exercises (front-back, side-side, circular, and leg lift) on both a dynamic office chair and a stability ball. Muscle activity from 12 torso muscles were evaluated with surface electromyography. **Results:** For all exercises, trunk muscle activity on the chair was comparable to that on a stability ball. The right external oblique was the only muscle to produce greater peak activity ($p = .019$) when using the ball compared to the chair (21.4 ± 14.0 percent maximal voluntary excitations (%MVE) and 14.7 ± 10.8 %MVE for the ball and chair, respectively). The left thoracic erector spinae produced greater average activity ($p = .044$) on the chair than on the ball. **Conclusion:** These findings suggest that this dynamic sitting approach could be an effective tool for core muscle activation while promoting movement and exercise while sitting at work. **Application:** Muscle activations on the dynamic chair are comparable to those on a stability ball, and dynamic office chairs can promote movement and exercise while sitting at work.

- **Keywords:** stability ball, office chair, dynamic sitting, core exercises, trunk electromyography

Maria-Gabriela Garcia, Thomas Läubli, and Bernard J. Martin. Long-Term Muscle Fatigue After Standing Work. S. 1162-1173.

Objective: The aims of this study were to determine long-term fatigue effects in the lower limbs associated with standing work and to estimate possible age and gender influences. **Background:** The progressive accumulation of muscle fatigue effects is assumed to lead to musculoskeletal disorders, as fatigue generated by sustained low-level exertions exhibits long-lasting effects. However, these effects have received little attention in the lower limbs. **Method:** Fourteen men and 12 women from two different age groups simulated standing work for 5 hr including 5-min seated rest breaks and a 30-min lunch. The younger group was also tested in a control day. Muscle fatigue was quantified by electrically induced muscle twitches (muscle twitch force [MTF]), postural stability, and subjective evaluation of discomfort. **Results:** MTF showed a significant fatigue effect after standing work that persisted beyond 30 min after the end of the workday. MTF was not affected on the control day. The center of pressure displacement speed increased significantly over time after standing work but was also affected on the control day. Subjective evaluations of discomfort indicated a significant increase in perception of fatigue immediately after the end of standing work; however, this perception did not persist 30 min after. Age and gender did not influence fatigue. **Conclusion:** Objective measures show the long-term effects of muscle fatigue after 5 hr of standing work; however, this fatigue is no longer perceived after 30 min of rest postwork. **Application:** The present results suggest that occupational activities requiring prolonged standing are likely to contribute to lower-extremity and/or back disorders.

- **Keywords:** muscle twitch force, postural stability, discomfort, age, gender

COGNITION

Steven Estes. *The Workload Curve: Subjective Mental Workload*. S. 1174-1187.

Objective: In this paper I begin looking for evidence of a subjective workload curve. **Background:** Results from subjective mental workload assessments are often interpreted linearly. However, I hypothesized that ratings of subjective mental workload increase nonlinearly with unitary increases in working memory load. **Method:** Two studies were conducted. In the first, the participant provided ratings of the mental difficulty of a series of digit span recall tasks. In the second study, participants provided ratings of mental difficulty associated with recall of visual patterns. The results of the second study were then examined using a mathematical model of working memory. **Results:** An S curve, predicted a priori, was found in the results of both the digit span and visual pattern studies. A mathematical model showed a tight fit between workload ratings and levels of working memory activation. **Conclusion:** This effort provides good initial evidence for the existence of a workload curve. The results support further study in applied settings and other facets of workload (e.g., temporal workload). **Application:** Measures of subjective workload are used across a wide variety of domains and applications. These results bear on their interpretation, particularly as they relate to workload thresholds.

- **Keywords:** mental workload, working memory, mathematical models

DISPLAYS AND CONTROLS

Heather Madison, Anna Pereira, Mette Korshøj, Laura Taylor, Alan Barr, and David Rempel. *Mind the Gap : The Effect of Keyboard Key Gap and Pitch on Typing Speed, Accuracy, and Usability : Part 3*. S. 1188-1194.

Objective: The aim of this study was to evaluate the effects of key gap (distance between edges of keys) on computer keyboards on typing speed, percentage error, preference, and usability. **Background:** In Parts 1 and 2 of this series, a small key pitch (center-to-center distance between keys) was found to reduce productivity and usability,

but the findings were confounded by gap. In this study, key gap was varied while holding key pitch constant. **Method:** Participants ($N = 25$) typed on six keyboards, which differed in gap between keys (1, 3, or 5 mm) and pitch (16 or 17 mm; distance between centers of keys), while typing speed, accuracy, usability, and preference were measured. **Results:** There was no statistical interaction between gap and pitch. Accuracy was better for keyboards with a gap of 5 mm compared to a 1-mm gap ($p = .04$). Net typing speed ($p = .02$), accuracy ($p = .002$), and most usability measures were better for keyboards with a pitch of 17 mm compared to a 16-mm pitch. **Conclusions:** The study findings support keyboard designs with a gap between keys of 5 mm over 1 mm and a key pitch of 17 mm over 16 mm. **Applications:** These findings may influence keyboard standards and design, especially the design of small keyboards used with portable devices, such as tablets and laptops.

- **Keywords:** keyboard design, key cap, human–computer interaction, computer input devices

HEALTH CARE/HEALTH SYSTEMS

Sue Hignett, Laurie Wolf, Ellen Taylor, and Paula Griffiths. *Firefighting to Innovation: Using Human Factors and Ergonomics to Tackle Slip, Trip, and Fall Risks in Hospitals*. S. 1195-1207.

Objective: The aim of this study was to use a theoretical model (bench) for human factors and ergonomics (HFE) and a comparison with occupational slips, trips, and falls (STFs) risk management to discuss patient STF interventions (bedside). **Background:** Risk factors for patient STFs have been identified and reported since the 1950s and are mostly unchanged in the 2010s. The prevailing clinical view has been that STF events indicate underlying frailty or illness, and so many of the interventions over the past 60 years have focused on assessing and treating physiological factors (dizziness, illness, vision/hearing, medicines) rather than designing interventions to reduce risk factors at the time of the STF. **Method:** Three case studies are used to discuss how HFE has been, or could be, applied to STF risk management as (a) a design-based (building) approach to embed safety into the built environment, (b) a staff- (and organization-) based approach, and (c) a patient behavior-based approach to explore and understand patient perspectives of STF events. **Results and Conclusion:** The results from the case studies suggest taking a similar HFE integration approach to other industries, that is, a sustainable design intervention for the person who experiences the STF event—the patient. **Application:** This paper offers a proactive problem-solving approach to reduce STFs by patients in acute hospitals. Authors of the three case studies use HFE principles (bench/book) to understand the complex systems for facility and equipment design and include the perspective of all stakeholders (bedside).

- **Keywords:** hospital slips/trips/falls, facility design, Lean, Six Sigma, dynamic systems approach, participation

HUMAN-SYSTEMS INTEGRATION

Andrew S. Clare, Mary L. Cummings, and Nelson P. Repenning. *Influencing Trust for Human–Automation Collaborative Scheduling of Multiple Unmanned Vehicles*. S. 1208-1218.

Objective: We examined the impact of priming on operator trust and system performance when supervising a decentralized network of heterogeneous unmanned vehicles (UVs). **Background:** Advances in autonomy have enabled a future vision of single-operator control of multiple heterogeneous UVs. Real-time scheduling for multiple UVs in uncertain environments requires the computational ability of optimization

algorithms combined with the judgment and adaptability of human supervisors. Because of system and environmental uncertainty, appropriate operator trust will be instrumental to maintain high system performance and prevent cognitive overload. **Method:** Three groups of operators experienced different levels of trust priming prior to conducting simulated missions in an existing, multiple-UV simulation environment. **Results:** Participants who play computer and video games frequently were found to have a higher propensity to overtrust automation. By priming gamers to lower their initial trust to a more appropriate level, system performance was improved by 10% as compared to gamers who were primed to have higher trust in the automation. **Conclusion:** Priming was successful at adjusting the operator's initial and dynamic trust in the automated scheduling algorithm, which had a substantial impact on system performance. **Application:** These results have important implications for personnel selection and training for futuristic multi-UV systems under human supervision. Although gamers may bring valuable skills, they may also be potentially prone to automation bias. Priming during training and regular priming throughout missions may be one potential method for overcoming this propensity to overtrust automation.

- **Keywords:** human supervisory control, unmanned vehicles, mixed-initiative planning, priming, gaming

SENSORY AND PERCEPTUAL PROCESSES

Kyle M. Wilson, James Head, Neil R. de Joux, Kristin M. Finkbeiner, and William S. Helton. *Friendly Fire and the Sustained Attention to Response Task*. S. 1219-1234.

Objective: We investigated whether losses of inhibitory control could be responsible for some friendly-fire incidents. **Background:** Several factors are commonly cited to explain friendly-fire incidents, but failure of inhibitory control has not yet been explored. The Sustained Attention to Response Task (SART) could be a valid model for inhibition failures in some combat scenarios. **Method:** Participants completed small-arms simulations using near infrared emitter guns, confronting research assistants acting as friends or foes. In Experiment 1, seven participants completed three conditions with three different proportions of foes (high, medium, low). In Experiment 2, 13 participants completed high-foe (high-go) and low-foe (low-go) versions of a small-arms simulation as well as comparative computer tasks. **Results:** Participants made more friendly-fire errors (errors of commission) when foe proportion was high. A speed-accuracy trade-off was apparent, with participants who were faster to fire on foes also more likely to accidentally shoot friends. When foe proportion was higher, response times to foe stimuli were faster, and subjective workload ratings were higher. **Conclusion:** Failures of inhibitory control may be responsible for some friendly-fire incidents and the SART could be a suitable empirical model for some battlefield environments. The effect appears to be disproportionately greater at higher foe proportions. The exact nature of performance reductions associated with high-foe proportions requires further investigation. **Application:** The SART may be a useful model of friendly-fire scenarios. It could be used to indicate a soldier's likelihood to commit a friendly-fire mistake and to identify high-risk environments.

- **Keywords:** Fratricide, military, blue on blue, response inhibition, motor decoupling, attention, speed-accuracy trade-off

SIMULATION AND VIRTUAL REALITY

Michael N. Geuss, Jeanine K. Stefanucci, Sarah H. Creem-Regehr, William B. Thompson, and Betty J. Mohler. *Effect of Display Technology on Perceived Scale of Space*. S. 1235-1247.

Objective: Our goal was to evaluate the degree to which display technologies influence the perception of size in an image. **Background:** Research suggests that factors such as whether an image is displayed stereoscopically, whether a user's viewpoint is tracked, and the field of view of a given display can affect users' perception of scale in the displayed image. **Method:** Participants directly estimated the size of a gap by matching the distance between their hands to the gap width and judged their ability to pass unimpeded through the gap in one of five common implementations of three display technologies (two head-mounted displays [HMD] and a back-projection screen). **Results:** Both measures of gap width were similar for the two HMD conditions and the back projection with stereo and tracking. For the displays without tracking, stereo and monocular conditions differed from each other, with monocular viewing showing underestimation of size. **Conclusions:** Display technologies that are capable of stereoscopic display and tracking of the user's viewpoint are beneficial as perceived size does not differ from real-world estimates. Evaluations of different display technologies are necessary as display conditions vary and the availability of different display technologies continues to grow. **Applications:** The findings are important to those using display technologies for research, commercial, and training purposes when it is important for the displayed image to be perceived at an intended scale.

- **Keywords:** display evaluation, space perception, virtual environments

SURFACE TRANSPORTATION

Fridulv Sagberg, Selpi, Giulio Francesco Bianchi Piccinini, and Johan Engström. *A Review of Research on Driving Styles and Road Safety*. S. 1248-1275.

Objective: The aim of this study was to outline a conceptual framework for understanding driving style and, on this basis, review the state-of-the-art research on driving styles in relation to road safety. **Background:** Previous research has indicated a relationship between the driving styles adopted by drivers and their crash involvement. However, a comprehensive literature review of driving style research is lacking. **Method:** A systematic literature search was conducted, including empirical, theoretical, and methodological research, on driving styles related to road safety. **Results:** A conceptual framework was proposed whereby driving styles are viewed in terms of driving habits established as a result of individual dispositions as well as social norms and cultural values. Moreover, a general scheme for categorizing and operationalizing driving styles was suggested. On this basis, existing literature on driving styles and indicators was reviewed. Links between driving styles and road safety were identified and individual and sociocultural factors influencing driving style were reviewed. **Conclusion:** Existing studies have addressed a wide variety of driving styles, and there is an acute need for a unifying conceptual framework in order to synthesize these results and make useful generalizations. There is a considerable potential for increasing road safety by means of behavior modification. Naturalistic driving observations represent particularly promising approaches to future research on driving styles. **Application:** Knowledge about driving styles can be applied in programs for modifying driver behavior and in the context of usage-based insurance. It may also be used as a means for driver identification and for the development of driver assistance systems.

- **Keywords:** driver profiling, driving pattern, driving habit, driver behavior

Yuqing Wu, Linda Ng Boyle, Daniel McGehee, Cheryl A. Roe, Kazutoshi Ebe, and James Foley. *Modeling Types of Pedal Applications Using a Driving Simulator*. S. 1276-1288.

Objective: The aim of this study was to examine variations in drivers' foot behavior and identify factors associated with pedal misapplications. **Background:** Few studies have

focused on the foot behavior while in the vehicle and the mishaps that a driver can encounter during a potentially hazardous situation. **Method:** A driving simulation study was used to understand how drivers move their right foot toward the pedals. The study included data from 43 drivers as they responded to a series of rapid traffic signal phase changes. Pedal application types were classified as (a) direct hit, (b) hesitated, (c) corrected trajectory, and (d) pedal errors (incorrect trajectories, misses, slips, or pressed both pedals). A mixed-effects multinomial logit model was used to predict the likelihood of one of these pedal applications, and linear mixed models with repeated measures were used to examine the response time and pedal duration given the various experimental conditions (stimuli color and location). **Results:** Younger drivers had higher probabilities of direct hits when compared to other age groups. Participants tended to have more pedal errors when responding to a red signal or when the signal appeared to be closer. Traffic signal phases and locations were associated with pedal response time and duration. The response time and pedal duration affected the likelihood of being in one of the four pedal application types. **Conclusion and Application:** Findings from this study suggest that age-related and situational factors may play a role in pedal errors, and the stimuli locations could affect the type of pedal application.

- **Keywords:** pedal misapplications, foot trajectory, driver behavior, pedal application types