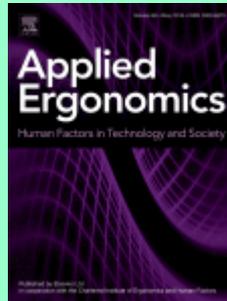


## **Applied Ergonomics - rok 2019, Volume 78**

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**A.M. West, D. Schönfisch, A. Picard, J. TARRIER, S. Hodder, G. Havenith. *Shoe microclimate: An objective characterisation and subjective evaluation.* Pages 1-12.**

Shoe microclimate (temperature and humidity) has been suggested to contribute to perceptions of foot thermal comfort. However, limited data is available for perceptual responses in relation to shoe microclimate development both over time and within different areas of the shoe. This study evaluates perceptions of foot thermal comfort for two running shoes different in terms of air permeability in relation to temporal and spatial characteristics of shoe microclimate. The temporal characteristics of shoe microclimate development were similar for both shoes assessed. However, higher temperatures and humidity were observed for the less permeable shoe. Changes to shoe microclimate over time and differences between shoes were perceivable by the users. This study provides the most detailed assessment of shoe microclimate in relation to foot thermal comfort to date, providing relevant information for footwear design and evaluation.

- **Keywords:** Footwear; Microclimate; Thermal comfort

**Jihyeon Yi, Sungryul Park, Gyouhyung Kyung. *Ambivalent effects of display curvature on smartphone usability.* Pages 13-25.**

The current study examined the effects of display curvature and hand length on various smartphone usability measures. In total, 20 young participants completed reading, image viewing, video watching, calling, and texting using four smartphone devices with distinct display curvatures. Diverse usability measures related to these tasks were obtained. The four curvatures (flat, horizontally convex, vertically concave, and horizontally concave) each demonstrated both beneficial and detrimental effects; however, hand size effects were non-significant across all usability measures. No single fixed display curvature was found to be beneficial across all considered smartphone usability measures, indicating multiple curvatures (e.g. combinations of flat and vertically concave curvatures) are required from a single smartphone model rather than a single fixed curvature to improve an overall smartphone usability. Such varying curvatures are feasible with bendable displays. Comprehensive usability evaluations, especially focusing on grip comfort and image distortion, are needed when applying display curvatures on small devices.

- **Keywords:** Smartphone usability; Typing; Eye discomfort; Presence; Image distortion; Grip comfort

**Sungryul Park, Gyouhyung Kyung, Donghee Choi, Jihhyeon Yi, Songil Lee, Byeonghwa Choi, Seungbae Lee. *Effects of display curvature and task duration on proofreading performance, visual discomfort, visual fatigue, mental workload, and user satisfaction.* Pages 26-36.**

This study examined the effects of display curvature and task duration on proofreading performance, visual discomfort, visual fatigue, mental workload, and user satisfaction. Five 27" rear-screen mock-ups with distinct curvature radii (600R, 1140R, 2000R, 4000R, and flat) were used. Ten individuals per display curvature completed a series of four 15 min comparison-proofreading trials at a 600 mm viewing distance. Only proofreading speed benefited from display curvature, with 600R providing the highest mean proofreading speed. Proofreading speed increased and accuracy decreased for all display curvatures over the 1 h proofreading period. Visual discomfort, visual fatigue, and mental workload increased during the first 15 min of proofreading. A decrease in critical fusion frequency during that period indicated increases in visual fatigue and mental workload. A short break between 15 min proofreading tasks could be considered to prevent further degradation of task performance and ocular health.

- **Keywords:** Display curvature; Task duration; Speed-accuracy trade-off

**April J. Chambers, Michelle M. Robertson, Nancy A. Baker. *The effect of sit-stand desks on office worker behavioral and health outcomes: A scoping review.* Pages 37-53.**

This scoping review examines the effects of sit-stand desks (SSDs) on six domains: behavior (e.g. time sitting and standing), physiological, work performance, psychological, discomfort, and posture. Fifty-three articles met criteria. We determined the percentage of significant results for each domain. Forty-seven studies were experimental trials. Sample sizes ranged from six to 231 participants. Follow-up time-frames ranged from one day to one year. Sixty-one percent of behavioral (24 studies), 37% of physiological (28 studies), 7% of work performance (23 studies), 31% of psychological (11 studies), 43% of discomfort (22 studies), and 18% of posture domain results (4 studies) were significant. We conclude that SSDs effectively change behaviors, but these changes only mildly effect health outcomes. SSDs seem most effective for discomfort and least for productivity. Further study is needed to examine long-term effects, and to determine clinically appropriate dosage and workstation setup.

- **Keywords:** Sit-stand desk; Standing desk; Workplace intervention

**Spencer Salter, Cyriel Diels, Paul Herriotts, Stratis Kanarachos, Doug Thake. *Motion sickness in automated vehicles with forward and rearward facing seating orientations.* Pages 54-61.**

Automated vehicles (AV's) offer greater flexibility in cabin design particularly in a future where no physical driving controls are required. One common concept for an automated vehicle is to have both forward and rearward facing seats. However, traveling backwards could lead to an increased likelihood of experiencing motion sickness due to the inability of occupants to anticipate the future motion trajectory. This study aimed to empirically evaluate the impact of seating orientation on the levels of motion sickness within an AV cabin. To this end, a vehicle was modified to replicate the common concept of automated vehicles with forward and rearward facing seats. Two routes were chosen to simulate motorway and urban driving. The participants were instructed to carry out typical office tasks whilst being driven in the vehicle which consisted of conducting a meeting, operating a personal device and taking notes. The participants conducted the test twice to experience both forward and rearward seating orientations in a randomised crossover design. Levels of sickness reported was relatively low with a significant increase in the

mean level of sickness recorded when traveling rearwards. As expected, this increase was particularly pronounced under urban driving conditions. It is concluded that rearward travel in automated vehicles will compromise the passenger experience.

- **Keywords:** Automated vehicle; Motion sickness; Seating orientation

**He Huang, Minggang Yang, Chaoxiang Yang, Taifeng Lv. *User performance effects with graphical icons and training for elderly novice users: A case study on automatic teller machines. Pages 62-69.***

This study investigated the effects with training and graphical icons on task performance for elderly novice users on automatic teller machines (ATMs). 124 elderly novice users who had no prior ATM experience participated in the training and test of ATM usage. Participants in the control group (n = 62) were training to use the traditional text-based ATM interface meanwhile those in the experimental group (n = 62) were training to use the alternative ATM interface with graphical icons. They were asked to learn how to perform three major tasks of ATMs. A test immediately following the training and a test one month after training was carried out. Task completion score was used for measuring user performance. The results showed although training could help elderly novice users succeed in learning to use ATMs, they still had a significant decline in user performance in the test one month later compared with the immediate test. Participants of the experimental group outperformed those of the control group in both the immediate test and one month test after training, especially in the latter. The finding suggested graphical icons could help to improve the learning and retention of ATM usage for elderly novice users, especially the latter, which would compensate for the drawback of training and reduce forgetting rate to some extent. Well-designed graphical icons could benefit elderly novice users much from learning phase to retention phase. The findings of this study can be applied to guide the design and development of ATMs or other public technology devices considering elderly novice users.

- **Keywords:** Training; Graphical icons; User performance; Elderly novice users; ATMs

**Florian G. Kaiser, Karolin Glatte, Mathis Lauckner. *How to make nonhumanoid mobile robots more likable: Employing kinesic courtesy cues to promote appreciation. Pages 70-75.***

Service robots that mimic human social behavior can appear polite. We tested the social and behavioral efficacy and legibility of two kinesic courtesy cues on people's approval of a service robot. In a repeated-measures design, 29 volunteers were randomly assigned to two test situations: A participant and the robot simultaneously approached a bottleneck either next to each other or from opposite ends. Nested within these two situations were three courtesy cue conditions: The robot moved without any explicit courtesy cues, stopped, or moved aside and then stopped. We found statistically significant effects of the courtesy cues on people's self-reported appreciation and the legibility of the robot's motion. Behavioral observations indicated that the robot exhibiting two courtesy cues was less disruptive to the human's own actions and was thus more behaviorally effective. This research demonstrates that kinesic politeness cues can be used effectively in the motion design of service robots.

- **Keywords:** Human-robot interaction; Motion planning; Autonomous agents; System design; Social processes

**Yulin Deng, James Shirley, Tyler Rose, Laura Geary, David Feltner, Karen Chen, Jeffery Hoyle, Mohini Dutt, David B. Kaber. *A usability assessment***

***of riding lawn-mowing equipment with varying levels of design standards compliance. Pages 76-85.***

The use of riding lawn equipment (RLE) is related to a significant number of accidents every year. To provide basis for product design and enhance user performance and safety, a usability and performance assessment of modern riding lawn-mowing tractor designs and features was conducted in a real-world test environment. Five current commercially available RLEs were tested with response measures including task performance time and accuracy, physiological workload, system usability scores (SUS), and subjective rankings of RLE models. This data was used to identify sensitivity of responses to variations in RLE design features and functionality. The data was also used to assess the validity of new tractor design standard conformance tool, the RLEval methodology. This tool made comprehensive evaluation of RLE models compliance with over 70 specific design standards and was applied by human factors experts. Experiment results revealed sensitivity of all response measures to design differences among the five RLE models, except the objective workload measures. Response measures including task performance, SUSs and subjective rankings showed partial agreement with the RLEval scores. In general, the study results demonstrated a comprehensive experimental methodology for usability and performance evaluations of RLEs as well as merit of using the RLEval as preliminary method to compare design features. Some aspects of the usability experimentation and the RLEval method appear to be complementary.

- **Keywords:** Riding lawn-mowing equipment; Standards compliance; Usability assessment; Human factors; Safety

***Sara Klueber, Erik Wolf, Tobias Grundgeiger, Birgit Brecknell, Ismail Mohamed, Penelope Sanderson. Supporting multiple patient monitoring with head-worn displays and spearcons. Pages 86-96.***

In hospitals, clinicians often need to monitor several patients while performing other tasks. However, visual displays that show patients' vital signs are in fixed locations and auditory alarms intended to alert clinicians may be missed. Information such as spearcons (time-compressed speech earcons) that 'travels' with the clinician and is delivered by earpiece and/or head-worn displays (HWDs), might overcome these problems. In this study, non-clinicians monitored five simulated patients in three 10-min scenarios while performing a demanding tracking task. Monitoring accuracy was better for participants using spearcons and a HWD (88.7%) or a HWD alone (86.2%) than for participants using spearcons alone (74.1%). Participants using the spearcons and HWD (37.7%) performed the tracking task no differently from participants using spearcons alone (37.1%) but participants using the HWD alone performed worse overall (33.1%). The combination of both displays may be a suitable solution for monitoring multiple patients.

- **Keywords:** Alarm fatigue; Auditory display; Head-worn display; Smartglasses

***Margaret Carey, Eoin J. White, Muireann McMahon, Leonard W. O'Sullivan. Using personas to exploit environmental attitudes and behaviour in sustainable product design. Pages 97-109.***

The aim of this research was to study the relationship between user sustainable design attitudes versus behaviour, and to develop and test environmental personas as design tools. Current approaches towards environmentally sustainable design are primarily focused on capturing the environmentally conscious and pro-environmental consumers, or changing the attitude and behaviour of the anti-environmental consumer. In a survey of 521 consumers, environmental attitude was a poor predictor of environmental behaviour. A series of interviews was performed with different profiles of environmentally

orientated users to assess their environmental attitudes and behaviour. The survey and interview data were used to develop four personas, one for each of the environmental attitude and behaviour types based on data from the consumer survey. A case study performed with university design students found that concepts generated by groups using environmentally orientated personas scored higher on environmental sustainability versus those generated by groups using an image board. This study illustrates how user-centred design approaches could be used to embed sustainable design in products by exploiting consumer environmental behaviour to overcome different attitudes and behaviour.

- **Keywords:** User centred design; Personas; Sustainability; Design; Environmental

**Hai-Ping Lim, Penelope Sanderson. *A comparison of two designs for earcons conveying pulse oximetry information.* Pages 110-119.**

We performed a randomised controlled trial comparing two kinds of earcons that could provide intermittent pulse oximetry information about a patient's oxygen saturation (SpO<sub>2</sub>) and heart rate (HR). Timbre-earcons represented SpO<sub>2</sub> levels with different levels of timbre, and pitch-earcons with different levels of pitch. Both kinds of earcons represented HR with tremolo. Participants using pitch-earcons identified SpO<sub>2</sub> levels alone, and both SpO<sub>2</sub> plus HR levels, significantly better than participants using timbre-earcons:  $p < .001$  in both cases. However, there was no difference between earcon conditions in how effectively HR was identified,  $p = .422$ . For both kinds of earcons, identification of SpO<sub>2</sub> levels was more compromised by simultaneous changes in HR than identification of HR levels was compromised by simultaneous changes in SpO<sub>2</sub>, suggesting asymmetric integrality. Overall, pitch-earcons may provide a better intermittent auditory pulse oximetry display than timbre-earcons, especially for clinical contexts when quiet is needed.

- **Keywords:** Auditory displays; Pulse oximetry; Earcons

**Mohammad Abdoli-Eramaki, Milena Agababova, Joseph Janabi, Elena Pasko, Caroline Damecour. *Evaluation and comparison of lift styles for an ideal lift among individuals with different levels of training.* Pages 120-126.**

Training for safe lifting techniques is used by employers to lower their workers' exposure to risk of workplace injuries. To determine effectiveness of training, 266 attendees at two professional conferences were asked to identify and demonstrate their preferred lift technique with the demonstration being an ideal floor-to-waist height lift of a 10-kg weighted crate. 'Bend your knees' was the most frequent preferred cue for each of the self-reported participant groups: untrained ( $n = 65$ ), trained ( $n = 86$ ), and trainers ( $n = 115$ ) according to safe lifting techniques. The demonstrations showed that this cue was incorporated into the skill of lifting by all groups. Trained participants showed a stronger conformity for depth of squat; but, the overall variability suggested a lack of consensus on the ideal depth of squat. The trained group experienced less loading at L5/S1 ( $p = .021$ ) compared to untrained that was countered by higher loading of the knee ( $p = .046$ ). Trainers showed lower knee ( $p = .006$ ) and shoulder ( $p = .03$ ) loading with similar L5/S1 loading as the trained participants suggesting a broader set of criteria for safe lifting. While the study population was likely biased towards a common understanding of safe lifting techniques given the conferences were for ergonomists and safety professionals, the results provided valuable insight into potential knowledge gaps, and key messaging that is being delivered and integrated into one's knowledge; a program review of lift training is recommended.

- **Keywords:** Lifting methods; Training; Kinetics; Kinematics

**Marco Costa, Leonardo Bonetti, Valeria Vignali, Arianna Bichicchi, Claudio Lantieri, Andrea Simone. *Driver's visual attention to different categories of roadside advertising signs. Pages 127-136.***

Roadside advertising signs are a salient potential source of driver's distraction. Previous research has mainly investigated driver's visual attention to billboards, which represents only one category of advertising signs. In this study, driver's visual attention was assessed in a naturalistic driving setting for six categories of roadside advertising signs: vendor signs, billboards, movable display boards, single and multiple commercial directional signs, and gas price LED displays. Fixation rate, fixation duration, fixation distance and driving speed were assessed in a sample of 15 drivers along a 30-km route including a total of 154 advertising signs belonging to the six categories described above. The role of clearance from the road, elevation, height, width, surface, number and size of characters, total number of characters, side of the road (driving side, opposite side), context (rural, urban), were also considered. Overall 24% of the roadside advertising signs were fixated. Fixation rate was significantly influenced by sign category, clearance from the road and number of characters. Median value for fixation duration was 297 ms. Fixation duration was significantly influenced by speed, elevation from road level, number of medium size characters, and was higher in the rural context. Median value for fixation distance was 58.10 m, and was significantly influenced by advertising sign category, character count and speed.

- **Keywords:** Roadside advertising signs; Eye movements; Distraction; Fixation duration; Fixation distance

**Tamar Ben-Bassat. *Are ergonomically designed road signs more easily learned? Pages 137-147.***

Traffic signs are used to control and regulate traffic and create a safe environment for road users. Therefore, it is of great importance to ensure that road signs are easily understood and easily learned, especially by drivers. The current study, conducted in Israel, focused on the ability to learn unfamiliar road signs and on the effect of the compliance of those signs with principles of physical and conceptual compatibility (ergonomic principles for symbol design). A preliminary experiment tested the extent to which each of 30 signs, not used in Israel, complied with the compatibility principle. Based on this evaluation, the signs were divided into two distinctive groups – “ergonomic” signs and “non-ergonomic” signs. In the second part of the study, we tested the differences between the two groups of signs in terms of comprehension and learnability, conducting recognition-recall tests among 33 teenagers without a driving license. Results showed a significant design main effect, with a higher comprehension level associated with the ergonomic signs compared to the non-ergonomic signs. A significant learnability main effect was also found, with comprehension levels in the recall test significantly higher than in the recognition test for both groups of signs. In addition, the probability for improvement in comprehension based on learning the meanings of the signs was higher among the ergonomic group of signs. These findings demonstrate the importance of ergonomic design in shaping the understandability and learnability of road signs. The implications of the current results can be most relevant to tourists, as well as novice drivers.

- **Keywords:** Traffic signs; Ergonomic principles; Compatibility; Recognition-recall; Learnability

**Jesse V. Jacobs, Lawrence J. Hettinger, Yueng-Hsiang Huang, Susan Jeffries, Mary F. Lesch, Lucinda A. Simmons, Santosh K. Verma, Joanna L. Willetts. *Employee acceptance of wearable technology in the workplace. Pages 148-156.***

Wearable technology has many industrial applications. Optimal use adherence and outcomes largely depend on employee acceptance of the technology. This study determined factors that predict employee acceptance of wearables. An online survey of 1273 employed adults asked about demographics, job and organizational characteristics, experience with and beliefs about wearables, and willingness to use wearables. Use cases focused on workplace safety elicited the highest acceptance. An employee's performance expectancy and their organizational safety climate were common predictors of acceptance across use cases. Positive past experiences coincided with involving employees in choosing the device and adequately informing them about data use. Organizations intending to implement wearable technology should (a) focus its use on improving workplace safety, (b) advance a positive safety climate, (c) ensure sufficient evidence to support employees' beliefs that the wearable will meet its objective, and (d) involve and inform employees in the process of selecting and implementing wearable technology.

- **Keywords:** Technology acceptance; Wearable technology; Safety climate; Industrial workplace ergonomics; Work measurement

**V. Riethmeister, R.W. Matthews, D. Dawson, M.R. de Boer, S. Brouwer, U. Bültmann. *Time-of-day and days-on-shift predict increased fatigue over two-week offshore day shifts. Pages 157-163.***

**Objectives:** The purpose of this study was to investigate the accumulation of fatigue over a two-week offshore period. In particular, the effects of (1) time-of-day and days-on-shift as well as (2) acute and chronic sleep loss on the rate at which fatigue accumulates were investigated. **Methods:** 42 day-shift offshore workers were examined. Fatigue was measured using pre- and post-shift scores on the Karolinska Sleepiness Scale (KSS). Total sleep time was measured using actigraphy (Motionwatch8, Camntech). Data was analyzed using a linear mixed model analyses. **Results:** Average sleep loss per night was 92 min (95%CI: 89.6–94.0;  $p < .001$ ). Mean cumulative sleep loss across the study was 21:20hrs (SD = 08:10hrs) over the 14 days. Chronic sleep loss was significantly related to a modest increase in sleepiness (KSS) across the shift (95%CI: 0.01–0.17;  $p = .020$ ) and in post-shift scores (95%CI: .07–0.19;  $p < .001$ ). Time-of-day (95%CI: 0.63 to  $-0.01$ ;  $p = .042$ ) and days-on-shift (95%CI: 0.03–0.08;  $p < .001$ ) as well as their interaction (95%CI: 0.08 to  $-0.00$ ;  $p = .027$ ) influenced the rate at which fatigue accumulated over a two-week offshore period. **Conclusions:** Pre- and post-shift fatigue accumulate in different ways over the two-week offshore period. The accumulation of post-shift fatigue scores was positively related to successive days-on-shift and chronic sleep loss. Our results suggest that prolonging offshore periods will likely result in elevated fatigue risk. Accumulating fatigue and sleep loss over two-week offshore periods should be considered in fatigue risk management plans and systems.

- **Keywords:** Fatigue risk management; Occupational health; Occupational safety; Sleep; Sleepiness

**Zhen Yang, Cheng Chen, Yuqing Lin, Duming Wang, Hongting Li, Weidan Xu. *Effect of spatial enhancement technology on input through the keyboard in virtual reality environment. Pages 164-175.***

Scientific developments have enabled the application of virtual reality (VR) technology in various fields. However, this technology is disadvantaged by low recognition, existence of bias, lack of precision, and fatigue of text input in VR environments. To address these problems, this study proposed a spatial enhancement technique. This study investigated the effectiveness of spatial enhancement keys of a virtual keyboard from various angles and explored the impact of enhanced response time and enhanced protrusion distance on the spatial enhancement technology. Finally, the following conclusions are obtained: (1) The average text input performance of the keyboard using the spatial enhancement

technique is significantly better than that of the ordinary virtual keyboard without using the spatial enhancement technique. (2) The recommended time interval for enhanced response time and the protrusion distance are 0–100 ms and 1.85 diopter, respectively. The keyboard angle insignificantly affects the input through the keyboard performance.

- **Keywords:** Virtual reality; Spatial enhancement technology; Text input

**Joseph Triglav, Erika Howe, Jaskirat Cheema, Blaire Dube, Mark J. Fenske, Nicholas Strzalkowski, Leah Bent. *Physiological and cognitive measures during prolonged sitting: Comparisons between a standard and multi-axial office chair. Pages 176-183.***

Prolonged sitting, common in many workplaces, reduces blood flow to the lower limb and has negative health outcomes. CoreChair is an active-sitting chair that encourages increased movement to help mitigate these outcomes. Physiological and cognitive measures were recorded in ten subjects over 4 h of sitting in both the CoreChair and a traditional office chair. Sitting in both chairs led to increases in calf circumference ( $p < 0.0001$ ), reduced tactile sensitivity ( $p = 0.02$ ), and a cognitive decline in attention ( $p = 0.035$ ) over time. However, the increase in calf circumference was smaller in the CoreChair at the second ( $p = 0.017$ ) and third hour ( $p = 0.012$ ) compared to the traditional chair. Additionally, for the attention task, the traditional chair generated more attention-task errors ( $p = 0.005$ ), while no changes were observed with the CoreChair ( $p = 0.13$ ). These findings suggest that during prolonged sitting CoreChair may have modest physiological and cognitive benefits compared to a traditional chair.

- **Keywords:** Prolonged sitting; Active sitting; Ergonomics; Monofilaments; Venous pooling; Attention

**David R. Large, Gary Burnett, Elizabeth Crundall, Glyn Lawson, Lee Skrypchuk, Alex Mouzakitis. *Evaluating secondary input devices to support an automotive touchscreen HMI: A cross-cultural simulator study conducted in the UK and China. Pages 184-196.***

Touchscreen Human-Machine Interfaces (HMIs) are a well-established and popular choice to provide the primary control interface between driver and vehicle, yet inherently demand some visual attention. Employing a secondary device with the touchscreen may reduce the demand but there is some debate about which device is most suitable, with current manufacturers favouring different solutions and applying these internationally. We present an empirical driving simulator study, conducted in the UK and China, in which 48 participants undertook typical in-vehicle tasks utilising either a touchscreen, rotary-controller, steering-wheel-controls or touchpad. In both the UK and China, the touchscreen was the most preferred/least demanding to use, and the touchpad least preferred/most demanding, whereas the rotary-controller was generally favoured by UK drivers and steering-wheel-controls were more popular in China. Chinese drivers were more excited by the novelty of the technology, and spent more time attending to the devices while driving, leading to an increase in off-road glance time and a corresponding detriment to vehicle control. Even so, Chinese drivers rated devices as easier-to-use while driving, and felt that they interfered less with their driving performance, compared to their UK counterparts. Results suggest that the most effective solution (to maximise performance/acceptance, while minimising visual demand) is to maintain the touchscreen as the primary control interface (e.g. for top-level tasks), and supplement this with a secondary device that is only enabled for certain actions; moreover, different devices may be employed in different cultural markets. Further work is required to explore these recommendations in greater depth (e.g. during extended or real-world testing), and to validate the findings and approach in other cultural contexts.

- **Keywords:** Touchscreen; Rotary controller; Steering wheel control; Touchpad; Visual demand; Preferences; Driving performance; Workload; Character recognition; Culture; HMI; UK; China; Driver acceptance

**Jose Antonio Diego-Mas, Diana Garzon-Leal, Rocio Poveda-Bautista, Jorge Alcaide-Marzal. *User-interfaces layout optimization using eye-tracking, mouse movements and genetic algorithms. Pages 197-209.***

Establishing the best layout configuration for software-generated interfaces and control panels is a complex problem when they include many controls and indicators. Several methods have been developed for arranging the interface elements; however, the results are usually conceptual designs that must be manually adjusted to obtain layouts valid for real situations. Based on these considerations, in this work we propose a new automatized procedure to obtain optimal layouts for software-based interfaces. Eye-tracking and mouse-tracking data collected during the use of the interface is used to obtain the best configuration for its elements. The solutions are generated using a slicing-trees based genetic algorithm. This algorithm is able to obtain really applicable configurations that respect the geometrical restrictions of elements in the interface. Results show that this procedure increases effectiveness, efficiency and satisfaction of the users when they interact with the obtained interfaces.

- **Keywords:** Interfaces; Layout; Eye-tracking; Genetic algorithms

**Silvana Piro, Iolanda Fiorillo, Shabila Anjani, Maxim Smulders, Alessandro Naddeo, Peter Vink. *Towards comfortable communication in future vehicles. Pages 210-216.***

This research aims to study the effect of seat and/or backrest rotation on comfort and quality of conversation. Different sitting arrangements were tested to study the effect of the seat layout on: 1) (dis)comfort experience; 2) conversation quality and 3) postures. Two seats were arranged in different angles (0°, 45°, 90°, and 180°) at the same distance (1 m) and participants were asked to talk to each other. The participants' postures were acquired by using cameras and markers on the participants' body. Questionnaires were used to rate the perceived (dis)comfort and quality of conversation. Results show that 90° configuration scored the best both in overall comfort and quality of conversation; while the 0° configuration scored the lowest in both ratings. A strong correlation was established between high comfort and good quality of conversation.

- **Keywords:** Comfort; Communication; Sitting arrangement; Quality of conversation

**Mohamed Badawy, Mark C. Schall, Michael E. Zabala, Jordan Coker, Gerard A. Davis, Richard F. Sesek, Sean Gallagher. *Trunk muscle activity among older and obese individuals during one-handed carrying. Pages 217-223.***

Manual material handling (MMH) is associated with the development of work-related musculoskeletal disorders (MSDs). One-handed carrying is a particularly challenging form of MMH. Age and obesity have been increasing among the general and working populations in the United States and worldwide. While older and obese workers are more susceptible to MSDs in comparison to younger, healthy workers, the effects of one-handed carrying on trunk muscle activity among these populations have not been comprehensively studied. In this paper, we evaluate the effects of age and obesity on trunk muscle activity of six trunk muscle pairs during one-handed carrying of different loads. The results suggest that older and obese individuals do not exhibit considerably larger muscle activity than young and non-obese individuals while carrying a load of

approximately 10 kg in one hand for relatively short distances. Accordingly, 10 kg appears to be an acceptable load to be occasionally carried in one hand by older and/or obese individuals from a muscle activity perspective.

- **Keywords:** One-handed carrying; Older; Obese; Muscle activity

**João Paulo Cabral, Gerard Bastiaan Remijn. *Auditory icons: Design and physical characteristics.* Pages 224-239.**

Auditory icons are short sound messages that convey information about an object, event or situation. Originally, auditory icons have been used in computer interfaces, but are nowadays found in many other fields. In this review article, an overview is given of the main theoretical ideas behind the use and design of auditory icons. We identified the most common fields in which auditory icons have been used, and analyzed their acoustic characteristics. The review shows that few studies have provided a precise description of the physical characteristics of the sounds in auditory icons, e.g., their intensity level, duration, and frequency range. To improve the validity and replicability of research on auditory icons, and their universal design, precise descriptions of acoustic characteristics should thus be provided.

- **Keywords:** Auditory warning; Auditory display; Product design

**Pascale Carayon, Ann Schoofs Hundt, Peter Hoonakker. *Technology barriers and strategies in coordinating care for chronically ill patients.* Pages 240-247.**

Care managers who coordinate care for chronically ill patients in hospitals and outpatient settings use multiple health information technologies for accessing, processing, documenting, and communicating patient-related information. Using a combination of 41 interviews and observations of 15 care managers, we identified a range of technology-related barriers experienced by care managers (total of 163 occurrences). The barriers are related to (lack of) access to information, inadequate information, limited usefulness and usability of the technologies, challenges associated with using multiple health IT, and technical problems. In 43% of the occurrences, care managers describe strategies to deal with the technology barriers; these fit in three categories: nothing/delay (9 occurrences), work-arounds (32 occurrences), and direct action at the individual, team, and organization levels (29 occurrences). Our data show the adaptive capacity of care managers who develop various strategies to deal with technology barriers and are, therefore, able to care for chronically ill patients. This information can be used as input to work system redesigns.

- **Keywords:** Work system; Barriers; Strategies; Adaptation; Care manager; Care coordination; Health information technology; Usability

**Judith Tiferes, Ahmed A. Hussein, Ann Bisantz, D. Jeffery Higginbotham, Mohamed Sharif, Justen Kozlowski, Basel Ahmad, Ryan O'Hara, Nicole Wawrzyniak, Khurshid Guru. *Are gestures worth a thousand words? Verbal and nonverbal communication during robot-assisted surgery.* Pages 251-262.**

Communication breakdowns in the operating room (OR) have been linked to errors during surgery. Robot-assisted surgery (RAS), a new surgical technology, can lead to new challenges in communication owing to the remote location of the surgeon away from the patient and bedside assistants. Nevertheless, few studies have studied communication strategies during RAS. In this study, 11 robot-assisted radical prostatectomies were recorded and the interaction events between the surgeon and two

bedside surgical team members were categorized by modality (verbal/nonverbal), topic, and pair (sender and receiver). Both verbal and nonverbal modalities were used by all pairs. The percentage of nonverbal interactions differed significantly by pair: 66% for the Surgeon-Physician Assistant, 50% for the Physician Assistant-Scrub Nurse, and 25% for the Surgeon-Scrub Nurse, indicating different communication strategies across pairs. In addition, there was a significant dependence between topic and the percentages of verbal and nonverbal events for all pairs. Strategies to improve team communication during RAS should take into account the use of verbal and nonverbal communication means and the variation in interaction strategies based on the topic of communication.

- **Keywords:** Robot-assisted; Surgery; Teams; Communication; Teamwork; Patient safety; Nonverbal

**Katherine L. Forsyth, Emily A. Hildebrand, M. Susan Hallbeck, Russell J. Branaghan, Renaldo C. Blocker. *Characteristics of team briefings in gynecological surgery. Pages 263-269.***

Preoperative briefings have been proven beneficial for improving team performance in the operating room. However, there has been minimal research regarding team briefings in specific surgical domains. As part of a larger project to develop a briefing structure for gynecological surgery, the study aimed to better understand the current state of pre-operative team briefings in one department of an academic hospital. Twenty-four team briefings were observed and video recorded. Communication was analyzed and social network metrics were created based on the team member verbal interactions. Introductions occurred in only 25% of the briefings. Network analysis revealed that average team briefings exhibited a hierarchical structure of communication, with the surgeon speaking the most frequently. The average network for resident-led briefings displayed a non-hierarchical structure with all team members communicating with the resident. Briefings conducted without a standardized protocol can produce variable communication between the role leading and the team members present.

- **Keywords:** Team briefings; Gynecological surgery; Communication

**Ken Catchpole, Ann Bisantz, M. Susan Hallbeck, Matthias Weigl, Rebecca Randell, Merrick Kossack, Jennifer T. Anger. *Human factors in robotic assisted surgery: Lessons from studies 'in the Wild'. Pages 270-276.***

This article reviews studies conducted "in the wild" that explore the "ironies of automation" in Robotic Assisted Surgery (RAS). Workload may be reduced for the surgeon, but increased for other team members, with postural stress relocated rather than reduced, and the introduction of a range of new challenges, for example, in the need to control multiple arms, with multiple instruments; and the increased demands of being physically separated from the team. Workflow disruptions were not compared with other surgeries; however, the prevalence of equipment and training disruptions differs from other types of surgeries. A consistent observation is that communication and coordination problems are relatively frequent, suggesting that the surgical team may need to be trained to use specific verbal and non-verbal cues during surgery. RAS also changes the necessary size of the operating room instrument cleaning processes. These studies demonstrate the value of clinically-based human factors engineers working alongside surgical teams to improve the delivery of RAS.

- **Keywords:** Surgery; Robotics; Human factors; Automation; Workload; Teamwork.

**Bethany R. Lowndes, Amro M. Abdelrahman, Cornelius A. Thiels, Amani O. Mohamed, Andrea L. McConico, Juliane Bingener, M. Susan Hallbeck.**

***Surgical team workload comparison for 4-port and single-port laparoscopic cholecystectomy procedures. Pages 277-285.***

Advanced minimally invasive procedures may cause postural constraints and increased workload and stress for providers. This study compared workload and stress across surgical team roles for 48 laparoscopic cholecystectomies (4-port vs single-port) using a task load index (NASA-TLX), a procedural difficulty question, and salivary stress hormones. Statistical analyses were performed based on the presence intra-cluster correlation within team roles, at  $\alpha=0.05$ . The single-port technique resulted in an 89% increase in physical workload for the surgeon and 63% increase for the assistant (both  $p<0.05$ ). The surgeon had significantly higher salivary stress hormones during single-port surgeries. The degree of procedural difficulty was positively correlated between the surgeon and most roles: resident ( $r=0.67$ ), assistant ( $r=0.81$ ), and technician ( $r=0.81$ ). There was a statistically significant positive correlation between the surgeon and assistant for all self-reported workload measures ( $p<0.05$ ). The single-port technique requires further improvement to balance surgical team workload for optimal patient safety and satisfaction.

- **Keywords:** Surgical Team; Workload; Laparoscopic Cholecystectomy

***T. Dalager, P.T. Jensen, T.S. Winther, T.R. Savarimuthu, A. Markauskas, O. Mogensen, K. Søgaard. Surgeons' muscle load during robotic-assisted laparoscopy performed with a regular office chair and the preferred of two ergonomic chairs: A pilot study. Pages 286-292.***

Surgeons work in awkward work postures and have high precision demands - well-known risk factors for musculoskeletal pain. Robotic-assisted laparoscopy is expected to be less demanding compared to conventional laparoscopy; however, studies indicate that robotic-assisted laparoscopy is also associated with poor ergonomics and musculoskeletal pain. The ergonomic condition in the robotic console is partially dependent upon the chair provided, which often is a regular office chair. Our study quantified and compared the muscular load during robotic-assisted laparoscopy using one of two custom built ergonomic chairs and a regular office chair. The results demonstrated no differences that could be considered clinically relevant. Overall, the study showed high levels of static and mean muscular activity, increased perceived physical exertion from pre-to-post surgery, and moderate to high risk for musculoskeletal injuries measured by the Rapid Upper Limb Assessment worksheet. Authors advocate for further investigation in surgeons' ergonomics and physical work demands in robotic surgery.

- **Keywords:** Robotic-assisted laparoscopy; Ergonomics; Electromyography

***David M. Neyens, Sara Bayramzadeh, Kenneth Catchpole, Anjali Joseph, Kevin Taaffe, Katherina Jurewicz, Amin Khoshkenar, Dee San. Using a systems approach to evaluate a circulating nurse's work patterns and workflow disruptions. Pages 293-300.***

The physical environment affects how work is done in operating rooms (OR). The circulating nurse (CN), in particular, requires access to and interacts with materials, equipment, and technology more than other OR team members. Naturalistic study of CN behavior is therefore valuable in assessing how OR space and physical configuration influences work patterns and disruptions. This study evaluated the CNs' work patterns and flow disruptions (FD) by analyzing 25 surgeries across three different ORs. The OR layouts were divided into transitional and functional zones, and the work of CNs was categorized into patient, equipment, material, and information tasks. The results reveal that information tasks involve less movement than other types of work, while across all ORs, CNs were more likely to be involved in layout and environmental hazard FDs when

involved in patient, material, or equipment-related tasks compared to information tasks. Different CN work patterns and flow disruptions between ORs suggest a link between OR layout and a CN's work. Future studies should examine how specific layout elements influence outcomes.

- **Keywords:** Operating room; Operating room layout; Spatial zones; Nurse tasks; Flow disruptions

**Eoin J. White, Muireann McMahon, Michael T. Walsh, J. Calvin Coffey, Leonard W. O'Sullivan. *A study of laparoscopic instrument use during colorectal surgery.* Pages 301-308.**

The aim of this study was to quantify laparoscopic instrument use and actions of both limbs during a sample of common colorectal surgical procedures. A method was devised using Observer XT software to code video recordings. Anonymised HD video recordings of nine laparoscopic colorectal procedures performed by a single surgeon were analysed. We determined the percentage and frequency of instrument use and limb actions throughout the total laparoscopic surgical duration, as well as the duration of instrument inactivity. Seven instruments and seven actions were studied across nine surgical procedures. Manoeuvring, blunt dissection, and tenting up tissues accounted for the longest amount of total surgical time (non-dominant hand (NDH) 29%, dominant hand (DH) 39%), followed by grasping (NDH 33%, DH 9%), and cauterising (NDH <0.2%, DH 8%). Least time was spent performing other actions such as suction/irrigation (NDH 0.01%, DH 3%) and stapling colorectal tissue (NDH 0.03%, DH 0.5%). The total duration of instrument use and hand actions by the dominant and non-dominant hands were similar overall. However, the frequency of actions performed was lower for the non-dominant hand. This indicates that the non-dominant hand spent more time holding actions than switching between actions, supporting the actions of the dominant hand. These findings highlight the lengthy durations of laparoscopic surgical procedures involved in navigating to anatomical planes and moving tissues. Further, the results detail the extent of secondary functions performed with the surgical instruments

- **Keywords:** Laparoscopic; Instrument hand actions; Video analysis