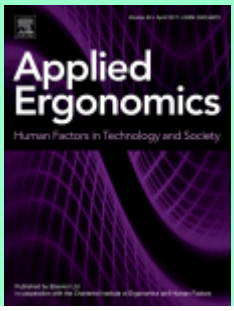
# Applied Ergonomics - rok 2017, Volume 62

# July 2017




**Kristina Eliasson, Peter Palm, Teresia Nyman, Mikael Forsman. *Inter- and intra- observer reliability of risk assessment of repetitive work without an explicit method*. Pages 1-8.**

A common way to conduct practical risk assessments is to observe a job and report the observed long term risks for musculoskeletal disorders. The aim of this study was to evaluate the inter- and intra-observer reliability of ergonomists' risk assessments without the support of an explicit risk assessment method. Twenty-one experienced ergonomists assessed the risk level (low, moderate, high risk) of eight upper body regions, as well as the global risk of 10 video recorded work tasks. Intra-observer reliability was assessed by having nine of the ergonomists repeat the procedure at least three weeks after the first assessment. The ergonomists made their risk assessment based on his/her experience and knowledge. The statistical parameters of reliability included agreement in %, kappa, linearly weighted kappa, intraclass correlation and Kendall's coefficient of concordance. The average inter-observer agreement of the global risk was 53% and the corresponding weighted kappa (Kw) was 0.32, indicating fair reliability. The intra-observer agreement was 61% and 0.41 (Kw). This study indicates that risk assessments of the upper body, without the use of an explicit observational method, have non-acceptable reliability. It is therefore recommended to use systematic risk assessment methods to a higher degree.

- **Keywords:** Inter-observer reliability; Intra-observer reliability; Risk assessment; Observational methods

**Elisabeth Schmidt, Ralf Decke, Ralph Rasshofer, Angelika C. Bullinger. *Psychophysiological responses to short-term cooling during a simulated monotonous driving task*. Pages 9-18.**

For drivers on monotonous routes, cognitive fatigue causes discomfort and poses an important risk for traffic safety. Countermeasures against this type of fatigue are required and thermal stimulation is one intervention method. Surprisingly, there are hardly studies available to measure the effect of cooling while driving. Hence, to better understand the effect of short-term cooling on the perceived sleepiness of car drivers, a driving simulator study (n = 34) was conducted in which physiological and vehicular data during cooling and control conditions were compared. The evaluation of the study showed that cooling applied during a monotonous drive increased the alertness of the car driver. The sleepiness rankings were significantly lower for the cooling condition. Furthermore, the significant pupillary and electrodermal responses were physiological indicators for increased sympathetic activation. In addition, during cooling a better driving performance

was observed. In conclusion, the study shows generally that cooling has a positive short-term effect on drivers' wakefulness; in detail, a cooling period of 3 min delivers best results.


- **Keywords:** Fatigue countermeasures; Cooling; Driver sleepiness; Thermal stimulation


**Thomas J. Albin. *Design with limited anthropometric data: A method of interpreting sums of percentiles in anthropometric design*. Pages 19-27.**


Occasionally practitioners must work with single dimensions defined as combinations (sums or differences) of percentile values, but lack information (e.g. variances) to estimate the accommodation achieved. This paper describes methods to predict accommodation proportions for such combinations of percentile values, e.g. two 90th percentile values. Kreifeldt and Nah z-score multipliers were used to estimate the proportions accommodated by combinations of percentile values of 2–15 variables; two simplified versions required less information about variance and/or correlation. The estimates were compared to actual observed proportions; for combinations of 2–15 percentile values the average absolute differences ranged between 0.5 and 1.5 percentage points. The multipliers were also used to estimate adjusted percentile values, that, when combined, estimate a desired proportion of the combined measurements. For combinations of two and three adjusted variables, the average absolute difference between predicted and observed proportions ranged between 0.5 and 3.0 percentage points.



- **Keywords:** Adding percentiles; Subtracting percentiles; Anthropometric accommodation; Indicator function variables


**Thomas M. Hlavenka, Vanessa F.K. Christner, Diane E. Gregory. *Neck posture during lifting and its effect on trunk muscle activation and lumbar spine posture*. Pages 28-33.**


Neck and head posture have been found to have a significant influence on the posture of the lower spine region during lifting and both an extended/upward gaze and a flexed/downward gaze have been hypothesized to lead to increased pain and/or overuse of the neck musculature. As a result, strength training recommendations have turned to the use of a retracted neck posture as being the safer posture to assume during lifting. This study examined trunk and neck muscle activity and lumbar spine posture in seven participants while performing moderate load lifts using a retracted neck posture (chin drawn in posteriorly; recently gaining popularity among coaches, trainers, and physical therapists to reduce neck pain during lifting, and freestyle neck posture (no instructions given). The retracted neck resulted in less lumbar spine flexion and increased lumbar erector spinae, external oblique, and sternocleidomastoid activity. The retracted posture also resulted in decreased activity in the thoracic erector spinae and dorsal neck musculature. The increased trunk and sternocleidomastoid activity and decreased spine flexion observed in the seven participants of this study when lifting with a retracted neck may have the potential to help lower the risk of spine pain/injury.



- **Keywords:** Lifting; Spine posture; Cervical spine; Lumbar spine; Neck posture; Pain; Muscle activation; Electromyography


**Daniel P. Armstrong, Richard Ferron, Cindi Taylor, Brent McLeod, Steve Fletcher, Renée S. MacPhee, Steven L. Fischer.. Pages 34-42. *Implementing powered stretcher and load systems was a cost effective intervention to reduce the incidence rates of stretcher related injuries in a paramedic service***

Paramedic services are considering moving towards the use of powered stretcher and load systems to reduce stretcher related injuries, but cost is perceived as a barrier. This study compared injury incidence rates, days lost, and compensation costs between Niagara Emergency Medical Service (NEMS) and Hamilton Paramedic Service (HPS) pre- (four years) and post- (one year) implementation of powered stretcher and load systems in NEMS. Prior to the intervention stretcher related musculoskeletal disorder (MSD) incidence rates averaged 20.0 (±6.8) and 17.9 (±6.4) per 100 full time equivalent (FTE), in NEMS and HPS respectively. One-year post intervention rates decreased to 4.3 per 100 FTE in NEMS, a 78% reduction. Rates modestly increased to 24.6 per 100 FTE in HPS in same period. Cost-benefit analysis estimated that the added cost to purchase powered stretcher and load systems would be recovered within their expected 7-year service life due to the reduction in compensation costs.


- **Keywords:** Cost-benefit; Economics; Ergonomics; MSD prevention


### K.B. Velt, H.A.M. Daanen. *Optimal bus temperature for thermal comfort during a cool day*. Pages 72-76.

A challenge for electric buses is to minimize heating and cooling power to maximally extend the driving range, but still provide sufficient thermal comfort for the driver and passengers. Therefore, we investigated the thermal sensation (TS) and thermal comfort (TC) of passengers in buses during a cool day (temperature 13.4 ± 0.5 °C, relative humidity (RH) 60 ± 5.8%) typical for the Dutch temperate maritime climate. 28 Males and 72 females rated TS and TC and gave information on age, stature, body weight and worn garments. The temperature in the bus of 22.5 ± 1.1 °C and RH of 59.9 ± 5.8% corresponded to a slightly warm feeling (TS = 0.85 ± 1.06) and TC of 0.39 ± 0.65. TS related significantly to bus temperature, clothing insulation and age. Linear regression based on these parameters showed that the temperature in the bus corresponding to TC = 0 and TS = 0 would have been 20.9 ± 0.6 °C. In conclusion, a 1.6 °C lower bus temperature during the investigated cool day probably would have led to less thermal discomfort and energy savings of electrical busses. The methodology to relate climatic measurements to subjective assessments is currently employed in a wider climatic range and may prove to be useful to find a better balance between thermal comfort and energy savings of the bus.


- **Keywords:** Thermal comfort; Thermal sensation; Bus; Climate; Humidity; Temperature


### Sara L. Arena, Christina R. Garman, Maury A. Nussbaum, Michael L. Madigan. *Required friction during overground walking is lower among obese compared to non-obese older men, but does not differ with obesity among women*. Pages 77-82.

Obesity and aging have been independently associated with altered required friction during walking, but it is unclear how these factors interact to influence the likelihood of slipping. Therefore, the purpose of this study was to determine whether there are differences related to obesity and aging on required friction during overground walking. Fourteen older non-obese, 11 older obese, 20 younger non-obese, and 20 younger obese adults completed walking trials at both a self-selected and hurried speed. When walking at a hurried speed, older obese men walked at a slower gait speed and exhibited lower frictional demands compared both to older non-obese men and to younger obese men. No differences in required friction were found between non-obese and obese younger adults. These results suggest that the increased rate of falls among obese or older adults is not likely due to a higher risk of slip initiation.


- **Keywords:** Required friction; Obesity; Aging

**Eric Weston, Peter Le, William S. Marras. *A biomechanical and physiological study of office seat and tablet device interaction*. Pages 83-93.**

Twenty subjects performed typing tasks on a desktop computer and touch-screen tablet in two chairs for an hour each, and the effects of chair, device, and their interactions on each dependent measure were recorded. Biomechanical measures of muscle force, spinal load, and posture were examined, while discomfort was measured via heart rate variability (HRV) and subjective reports. HRV was sensitive enough to differentiate between chair and device interactions. Biomechanically, a lack of seat back mobility forced individuals to maintain an upright seating posture with increased extensor muscle forces and increased spinal compression. Effects were exacerbated by forward flexion upon interaction with a tablet device or by slouching. Office chairs should be designed with both the human and workplace task in mind and allow for reclined postures to off-load the spine. The degree of recline should be limited, however, to prevent decreased lumbar lordosis resulting from posterior hip rotation in highly reclined postures.

- **Keywords:** Sitting; Mobile device; Seating discomfort

**Clive D'Souza, Victor Paquet, James A. Lenker, Edward Steinfeld. *Effects of transit bus interior configuration on performance of wheeled mobility users during simulated boarding and disembarking*. Pages 94-106.**

The emergence of low-floor bus designs and related regulatory standards in the U.S. have resulted in substantial improvements in public transit accessibility. However, passengers using wheeled mobility devices still experience safety concerns and inefficiencies in boarding, disembarking, and interior circulation on low-floor buses. This study investigates effects of low-floor bus interior configuration and passenger crowding on boarding and disembarking efficiency and safety. Users of manual wheelchairs (n = 18), powered wheelchairs (n = 21) and electric scooters (n = 9) simulated boarding and disembarking in three interior layout configurations at low and high passenger crowding conditions on a full-scale laboratory mock-up of a low-floor bus. Dependent measures comprised task times and critical incidents during access ramp use, fare payment, and movement to and from the doorway and wheeled mobility securement area. Individual times for unassisted boarding ranged from 15.2 to 245.3 s and for disembarking ranged from 9.1 to 164.6 s across layout and passenger crowding conditions. Nonparametric analysis of variance showed significant differences and interactions across vehicle design conditions, passenger load and mobility device type on user performance. The configuration having electronic on-board fare payment, rear-bus entrance doorways and adjacent device securement areas demonstrated greatest efficiency and safety. High passenger load adversely impacted efficiency and frequency of critical incidents during on-board circulation across all three layouts. Findings have broader implications for improving transit system efficiency and quality of service across the spectrum of transit users.

- **Keywords:** Wheelchairs; Accessibility; Usability; Low-floor bus; Public transportation

**Nipun D. Nath, Reza Akhavian, Amir H. Behzadan. *Ergonomic analysis of construction worker's body postures using wearable mobile sensors*. Pages 107-117.**

Construction jobs are more labor-intensive compared to other industries. As such, construction workers are often required to exceed their natural physical capability to cope with the increasing complexity and challenges in this industry. Over long periods of time, this sustained physical labor causes bodily injuries to the workers which in turn, conveys

huge losses to the industry in terms of money, time, and productivity. Various safety and health organizations have established rules and regulations that limit the amount and intensity of workers' physical movements to mitigate work-related bodily injuries. A precursor to enforcing and implementing such regulations and improving the ergonomics conditions on the jobsite is to identify physical risks associated with a particular task. Manually assessing a field activity to identify the ergonomic risks is not trivial and often requires extra effort which may render it to be challenging if not impossible. In this paper, a low-cost ubiquitous approach is presented and validated which deploys built-in smartphone sensors to unobtrusively monitor workers' bodily postures and autonomously identify potential work-related ergonomic risks. Results indicates that measurements of trunk and shoulder flexions of a worker by smartphone sensory data are very close to corresponding measurements by observation. The proposed method is applicable for workers in various occupations who are exposed to WMSDs due to awkward postures. Examples include, but are not limited to industry laborers, carpenters, welders, farmers, health assistants, teachers, and office workers.

- **Keywords:** Ergonomics; Construction safety; Risk assessment; Posture analysis; Smartphone sensor; Wearable technology

### M. Susan Hallbeck, Bethany R. Lowndes, Bernadette McCrory, Melissa M. Morrow, Kenton R. Kaufman, Chad A. LaGrange. *Kinematic and ergonomic assessment of laparoendoscopic single-site surgical instruments during simulator training tasks*. Pages 118-130.

While laparoendoscopic single-site surgery (LESS) appears to be feasible and safe, instrument triangulation, tissue handling, and other bimanual tasks are difficult even for experienced surgeons. Novel technologies emerged to overcome LESS' procedural and ergonomic difficulties of "tunnel vision" and "instrument clashing." Surgeon kinematics, self-reported workload and upper body discomfort were used to compare straight, bent and two articulating instruments while performing two basic surgical tasks in a LESS simulator. All instruments resulted in bilateral elevation and rotation of the shoulders, excessive forearm motion and flexion and ulnar deviation of wrists. Surgeons' adopted non-neutral upper extremity postures and performed excessive joint excursions to compensate for reduced freedom of movement at the single insertion site and to operate the instrument mechanisms. LESS' cosmetic benefits continue to impact laparoscopic surgery and by enabling performance through improved instruments, ergonomic improvement for LESS can reduce negative impact on surgeon well-being and patient safety.

- **Keywords:** workload; surgical instrument; LESS

### Liuxing Tsao, Jing Chang, Liang Ma. *Fatigue of Chinese railway employees and its influential factors: Structural equation modelling*. Pages 131-141.

Fatigue is an identifiable and preventable cause of accidents in transport operations. Regarding the railway sector, incident logs and simulation studies show that employee fatigue leads to lack of alertness, impaired performance, and occurrence of incidents. China has one of the largest rail systems in the world, and Chinese railway employees work under high fatigue risks; therefore, it is important to assess their fatigue level and find the major factors leading to fatigue. We designed a questionnaire that uses Multidimensional Fatigue Instrument (MFI-20), NASA-TLX and subjective rating of work overtime feelings to assess employee fatigue. The contribution of each influential factor of fatigue was analysed using structural equation modelling. In total, 297 employees from the rail maintenance department and 227 employees from the locomotive department returned valid responses. The average scores and standard deviations for the

five subscales of MFI-20, namely General Fatigue, Physical Fatigue, Reduced Activity, Reduced Motivation, and Mental Fatigue, were 2.9 (0.8), 2.8 (0.8), 2.5 (0.8), 2.5 (0.7), and 2.4 (0.8) among the rail maintenance employees and 3.5 (0.8), 3.5 (0.7), 3.3 (0.7), 3.0 (0.6), and 3.1 (0.7), respectively, among the locomotive employees. The fatigue of the locomotive employees was influenced by feelings related to working overtime (standardized r = 0.22) and workload (standardized r = 0.27). The work overtime control and physical working environment significantly influenced subjective feelings (standardized r = −0.25 and 0.47, respectively), while improper work/rest rhythms and an adverse physical working environment significantly increased the workload (standardized r = 0.48 and 0.33, respectively).


- **Keywords:** Railway safety; Fatigue; Structural equation modelling


### Rosemary Bom Conselho Sales, Romeu Rodrigues Pereira, Maria Teresa Paulino Aguilar, Antônio Valadão Cardoso. *Thermal comfort of seats as visualized by infrared thermography*. Pages 142-149.


Published studies that deal with the question of how the temperature of chair seats influences human activities are few, but the studies considering such a factor, a function of the type of material, could contribute to improvements in the design of chairs. This study evaluates seat temperatures of 8 types of chairs made of different materials. The parts of the furniture that people come into contact with, and the thermal response of the material to heating and cooling have been evaluated. Infrared thermography was used for this, as it is a non-contact technique that does not present any type of risk in the measurement of temperatures. Seats made of synthetic leather (leatherette), wood and polyester fabric were found to have the highest temperatures, and the plywood seat showed the lowest. The study has also revealed that thermography can contribute to studies of thermal comfort of chair seats in addition to determining the most suitable material.



- **Keywords:** Thermal comfort; Infrared thermography; Chair seats


### Chu-Hsiang Chang, Thomas E. Bernard, Jennifer Logan. *Effects of heat stress on risk perceptions and risk taking*. Pages 150-157.


Exposure to extreme heat at work is a serious occupational hazard, as exposure can result in heat-related illnesses, and it has been linked to increased risk of accidents and injuries. The current study aimed to examine whether heat exposure is related to changes in individuals' psychological process of risk evaluation, and whether acclimatization can mitigate the effect of heat exposure. A study with quasi-experiment research design was used to compare participants' risk perceptions and risk-taking behaviors at baseline, initial exposure to heat, and exposure after acclimatization across male participants who were exposed to heat (N = 6), and males (N = 5) and females (N = 6) who were in the control group who were exposed to ambient temperature. Results show that participants perceived the same risky behaviors to be less risky ($p = 0.003$) and demonstrated increased risk-taking behaviors ($p = 0.001$) after initial heat exposure. While their risk perceptions returned to baseline level after acclimatization, their risk-taking behaviors remained heightened ($p = 0.031$). Participants who were not exposed to heat showed no significant fluctuation in their risk perceptions and risk-taking. Our findings support that risk-related processes may explain the effects of heat exposure on increased accidents and injuries beyond its direct impact on heat-related illnesses.



- **Keywords:** Heat stress; Risk behavior; Risk evaluation

**Min-Koo Kang, Hohyun Cho, Han-Mu Park, Sung Chan Jun, Kuk-Jin Yoon. *A wellness platform for stereoscopic 3D video systems using EEG-based visual discomfort evaluation technology*. Pages 158-167.**

Recent advances in three-dimensional (3D) video technology have extended the range of our experience while providing various 3D applications to our everyday life. Nevertheless, the so-called visual discomfort (VD) problem inevitably degrades the quality of experience in stereoscopic 3D (S3D) displays. Meanwhile, electroencephalography (EEG) has been regarded as one of the most promising brain imaging modalities in the field of cognitive neuroscience. In an effort to facilitate comfort with S3D displays, we propose a new wellness platform using EEG. We first reveal features in EEG signals that are applicable to practical S3D video systems as an index for VD perception. We then develop a framework that can automatically determine severe perception of VD based on the EEG features during S3D video viewing by capitalizing on machine-learning-based braincomputer interface technology. The proposed platform can cooperate with advanced S3D video systems whose stereo baseline is adjustable. Thus, the optimal S3D content can be reconstructed according to a viewer's sensation of VD. Applications of the proposed platform to various S3D industries are suggested, and further technical challenges are discussed for follow-up research.

- **Keywords:** Visual discomfort; Stereoscopic 3D; Wellness platform

**Yanto, Chih-Wei Lu, Jun-Ming Lu. *Evaluation of the Indonesian National Standard for elementary school furniture based on children's anthropometry*. Pages 168-181.**

In Indonesia, National Standardization Agency of Indonesia issued the Indonesian National Standard SNI 12-1015-1989 and SNI 12-1016-1989 to define the type of furniture dimensions that should be used by children in the elementary school level. This study aims to examine whether the current national standards for elementary school furniture dimensions issued by National Standardization Agency of Indonesia match the up-to-date Indonesian children's anthropometry. Two types of school furniture, small type (Type I, for grade 1–3) and large type (Type II, for grade 4–6), were evaluated in terms of seat height, seat depth, seat width and backrest height of a chair as well as the height and underneath height of a desk. 1146 students aged between 6 and 12 years old participated in the study. Seven anthropometric measurements were taken including stature, sitting shoulder height, sitting elbow height, popliteal height, buttock-popliteal length, knee height and hip breadth. Based on the standard school furniture dimensions and students' body dimensions, numbers of matches and mismatches between them were computed. Results indicated a substantial degree of mismatch between children's anthropometry and the standard dimensions of school furniture. The standard seat height was not appropriate for students among different grades with the mismatch percentage ranging from 63.4% to 96.7% for Type I and 72.7% to 99.0% for Type II. For desk height, the standard dimensions were not appropriate for students among different grades with the mismatch percentage ranging from 32.3% to 88.9% for Type I and 67.7% to 99.0% for Type II. Apparently, the current standards are out of date and need to be updated. Four different sizes of school furniture were hence proposed to accommodate the variation in students' anthropometry from Grade 1 to Grade 6. The proposed standard dimensions (PrS) of school furniture cover a slightly broader range of age and present a higher cumulative fit than the current standard dimensions (CrS). In addition, a better strategy for sizing can be also developed to fit chairs and desks to a larger number of students.

- **Keywords:** The Indonesian national standard; Chair and desk dimensions; Children anthropometry; Mismatch

**Michelle M. Robertson, Yueng Hsiang Huang, Jin Lee. *Improvements in musculoskeletal health and computing behaviors: Effects of a macroergonomics office workplace and training intervention*. Pages 182-196.**

Computer use and its association with musculoskeletal and visual symptoms is an escalating concern. Organizations are shifting to a more proactive injury prevention perspective. Accordingly, a macroergonomics intervention consisting of flexible workplace design and office ergonomics training was designed to examine the effects on worker's computing behaviors, postures, and musculoskeletal discomfort, and their relationship to psychosocial factors. Participants were assigned to either group: 1) no-intervention control 2) flexible Workplace-only (WP-only), and 3) flexible Workplace + Training (WP+T). Observational findings indicate both intervention groups experienced positive, significant changes in improved workstation arrangements and computing postures, with the WP+T intervention group exhibiting a higher, significant change of behavioral translation. Also, significant, positive relationships between observed postures and musculoskeletal discomfort/pain were found. The intervention effect was stronger when management was responsive to workers' ergonomics needs. This study suggests that a macroergonomics intervention can produce beneficial effects for office and computer workers and organizations.

- **Keywords:** Office ergonomics intervention; Musculoskeletal risk; Ergonomics training; Macroergonomics

**Han Zhang, Alan Hedge, Daniel Cosley. *Thermal sensation, rate of temperature change, and the heat dissipation design for tablet computers*. Pages 197-203.**

Past research has shown that the rate of change of skin surface temperature can affect thermal sensation. This study investigated users' thermal responses to a tablet heating surface with different heat pads and different temperature change rates. The test conditions included: A. keeping the surface at a constant 42 °C, B. increasing the surface temperature from 38 °C to 42 °C at a rate of 0.02 °C/s in progressive intervals, C. increasing the temperature at 0.15 °C/s in progressive intervals, and D. Heating two left and right side pads alternately from 38 °C to 42 °C at 0.15 °C/s in progressive intervals. Overall results showed the lowest temperature change rate of 0.02 °C/s was most preferred in terms of thermal comfort. The findings suggest a potential to improve user thermal experience by dissipating tablet computer heat at a lower temperature change rate, or by alternating the dissipation areas.

- **Keywords:** Heat dissipation; Tablet computer; Thermal comfort; Hardware design; Thermal management

**Sebastiaan Petermeijer, Pavlo Bazilinskyy, Klaus Bengler, Joost de Winter. *Take-over again: Investigating multimodal and directional TORs to get the driver back into the loop*. Pages 204-215.**

When a highly automated car reaches its operational limits, it needs to provide a take-over request (TOR) in order for the driver to resume control. The aim of this simulator-based study was to investigate the effects of TOR modality and left/right directionality on drivers' steering behaviour when facing a head-on collision without having received specific instructions regarding the directional nature of the TORs. Twenty-four participants drove three sessions in a highly automated car, each session with a different TOR modality (auditory, vibrotactile, and auditory-vibrotactile). Six TORs were provided per session, warning the participants about a stationary vehicle that had to be avoided by changing lane left or right. Two TORs were issued from the left, two from the right, and

two from both the left and the right (i.e., nondirectional). The auditory stimuli were presented via speakers in the simulator (left, right, or both), and the vibrotactile stimuli via a tactile seat (with tactors activated at the left side, right side, or both). The results showed that the multimodal TORs yielded statistically significantly faster steer-touch times than the unimodal vibrotactile TOR, while no statistically significant differences were observed for brake times and lane change times. The unimodal auditory TOR yielded relatively low self-reported usefulness and satisfaction ratings. Almost all drivers overtook the stationary vehicle on the left regardless of the directionality of the TOR, and a post-experiment questionnaire revealed that most participants had not realized that some of the TORs were directional. We conclude that between the three TOR modalities tested, the multimodal approach is preferred. Moreover, our results show that directional auditory and vibrotactile stimuli do not evoke a directional response in uninstructed drivers. More salient and semantically congruent cues, as well as explicit instructions, may be needed to guide a driver into a specific direction during a take-over scenario.

- **Keywords:** Human-machine interfaces; Highly automated driving; Vibrotactile displays; Auditory displays; Take-over requests

**Lizandra da Silva Menegon, Silvana Ligia Vincenzi, Dalton Francisco de Andrade, Pedro Alberto Barbetta, Eugenio Andrés Díaz Merino, Peter Vink. *Design and validation of an aircraft seat comfort scale using item response theory*. Pages 216-226.**

This article aims to evaluate the psychometric properties of a scale that measures aircraft seat comfort. Factor analysis was used to study data variances. Psychometric quality was checked by using Item Response Theory. The sample consisted of 1500 passengers who completed a questionnaire at a Brazilian airport. Full information factor analysis showed the presence of one dominant factor explaining 34% of data variance. The scale generated covered all levels of comfort data, from 'no comfort' to 'maximum comfort'. The results show that the passengers consider there is comfort, but this is very minimal when these passengers have to perform their desired activities. It tends to increase when aspects of the aircraft seating are improved and positive emotions are elicited. Comfort peaks when pleasure is experienced and passenger expectations are exceeded (maximum comfort). This outcome seems consistent with the literature. Further research is advised to compare the outcome of this questionnaire with other research methods, and to check if the questionnaire is sensitive enough and whether its conclusions are useful in practice.

- **Keywords:** Comfort; Aircraft seat; Scale; Item response theory

**Benoît Valéry, Sébastien Scannella, Vsevolod Peysakhovich, Pascal Barone, Mickaël Causse. *Can an aircraft be piloted via sonification with an acceptable attentional cost? A comparison of blind and sighted pilots*. Pages 227-236.**

In the aeronautics field, some authors have suggested that an aircraft's attitude sonification could be used by pilots to cope with spatial disorientation situations. Such a system is currently used by blind pilots to control the attitude of their aircraft. However, given the suspected higher auditory attentional capacities of blind people, the possibility for sighted individuals to use this system remains an open question. For example, its introduction may overload the auditory channel, which may in turn alter the responsiveness of pilots to infrequent but critical auditory warnings. In this study, two groups of pilots (blind versus sighted) performed a simulated flight experiment consisting of successive aircraft maneuvers, on the sole basis of an aircraft sonification. Maneuver difficulty was varied while we assessed flight performance along with subjective and electroencephalographic (EEG) measures of workload. The results showed that both groups of participants reached target-attitudes with a good accuracy. However, more

complex maneuvers increased subjective workload and impaired brain responsiveness toward unexpected auditory stimuli as demonstrated by lower N1 and P3 amplitudes. Despite that the EEG signal showed a clear reorganization of the brain in the blind participants (higher alpha power), the brain responsiveness to unexpected auditory stimuli was not significantly different between the two groups. The results suggest that an auditory display might provide useful additional information to spatially disoriented pilots with normal vision. However, its use should be restricted to critical situations and simple recovery or guidance maneuvers.


- **Keywords:** Auditory display; Spatial disorientation; Irrelevant-probe technique


### George Adamides, Christos Katsanos, Yisrael Parmet, Georgios Christou, Michalis Xenos, Thanasis Hadzilacos, Yael Edan. *HRI usability evaluation of interaction modes for a teleoperated agricultural robotic sprayer*. Pages 237-246.


Teleoperation of an agricultural robotic system requires effective and efficient human-robot interaction. This paper investigates the usability of different interaction modes for agricultural robot teleoperation. Specifically, we examined the overall influence of two types of output devices (PC screen, head mounted display), two types of peripheral vision support mechanisms (single view, multiple views), and two types of control input devices (PC keyboard, PS3 gamepad) on observed and perceived usability of a teleoperated agricultural sprayer. A modular user interface for teleoperating an agricultural robot sprayer was constructed and field-tested. Evaluation included eight interaction modes: the different combinations of the 3 factors. Thirty representative participants used each interaction mode to navigate the robot along a vineyard and spray grape clusters based on a 2 × 2 × 2 repeated measures experimental design. Objective metrics of the effectiveness and efficiency of the human-robot collaboration were collected. Participants also completed questionnaires related to their user experience with the system in each interaction mode. Results show that the most important factor for human-robot interface usability is the number and placement of views. The type of robot control input device was also a significant factor in certain dependents, whereas the effect of the screen output type was only significant on the participants' perceived workload index. Specific recommendations for mobile field robot teleoperation to improve HRI awareness for the agricultural spraying task are presented.



- **Keywords:** Human-robot interaction; Usability; Agricultural robot; Teleoperation


### Guy Walker, Andrea Taylor, Craig Whittet, Craig Lynn, Catherine Docherty, Bruce Stephen, Edward Owens, Stuart Galloway. *A practical review of energy saving technology for ageing populations*. Pages 247-258.


Fuel poverty is a critical issue for a globally ageing population. Longer heating/cooling requirements combine with declining incomes to create a problem in need of urgent attention. One solution is to deploy technology to help elderly users feel informed about their energy use, and empowered to take steps to make it more cost effective and efficient. This study subjects a broad cross section of energy monitoring and home automation products to a formal ergonomic analysis. A high level task analysis was used to guide a product walk through, and a toolkit approach was used thereafter to drive out further insights. The findings reveal a number of serious usability issues which prevent these products from successfully accessing an important target demographic and associated energy saving and fuel poverty outcomes. Design principles and examples are distilled from the research to enable practitioners to translate the underlying research into high quality design-engineering solutions.

- **Keywords:** Design-led approaches; Energy saving technology; Older people

**Tad T. Brunyé, Marianna D. Eddy, Matthew S. Cain, Lisa B. Hepfinger, Kathryn Rock. *Masked priming for the comparative evaluation of camouflage conspicuity*. Pages 259-267.**

Human observer test and evaluation of camouflage patterns is critical for understanding relative pattern conspicuity against a range of background scenes. However, very few validated methodologies exist for this purpose, and those that do carry several limitations. Five experiments examined whether masked priming with a dot probe could be used to reliably differentiate camouflage patterns. In each experiment, participants were primed with a camouflaged target appearing on the left or right of the screen, and then made a speeded response to a dot probe appearing on the same (congruent) or different (incongruent) side. Across experiments we parametrically varied prime duration between 35, 42, 49, 56, and 63 ms. Results demonstrated that as prime duration increased, a response time disadvantage for incongruent trials emerged with certain camouflage patterns. Interestingly, the most conspicuous patterns showed behavioral differences at a relatively brief (49 ms) prime duration, whereas behavioral differences were only found at longer prime durations for less conspicuous patterns; this overall results pattern matched that predicted by a visual salience model. Together, we demonstrate the viability of masked priming for the test and evaluation of camouflage patterns, and correlated outcomes for saliency models and primed object processing.

- **Keywords:** Masked priming; Camouflage; Perception; Spatial orienting

**Rupa Sheth Valdez, Kerry Margaret McGuire, A. Joy Rivera. *Qualitative ergonomics/human factors research in health care: Current state and future directions*. Pages 43-71.**

The objective of this systematic review was to understand the current state of Ergonomics/Human Factors (E/HF) qualitative research in health care and to draw implications for future efforts. This systematic review identified 98 qualitative research papers published between January 2005 and August 2015 in the seven journals endorsed by the International Ergonomics Association with an impact factor over 1.0. The majority of the studies were conducted in hospitals and outpatient clinics, were focused on the work of formal health care professionals, and were classified as cognitive or organizational ergonomics. Interviews, focus groups, and observations were the most prevalent forms of data collection. Triangulation and data archiving were the dominant approaches to ensuring rigor. Few studies employed a formal approach to qualitative inquiry. Significant opportunities remain to enhance the use of qualitative research to advance systems thinking within health care.

- **Keywords:** Ergonomics and human factors; Health care; Systematic review; Qualitative research