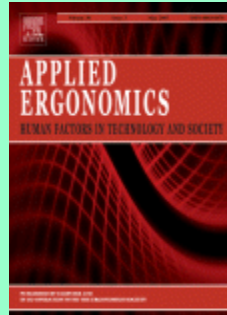


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Special Section: Ergonomics, health and working time organization

J.L. Paterson, J. Dorrian, S.A. Ferguson, S.M. Jay, N. Lamond, P.J. Murphy, S.S. Campbell, D. Dawson. *Changes in structural aspects of mood during 39–66 h of sleep loss using matched controls. Pages 196-201.*

A number of studies have described mood change during sleep loss in the laboratory, however, an understanding of fluctuations in structural aspects of mood under such conditions is lacking. Sixty-two healthy young adults completed one of three possible conditions: one ($n = 20$) or two ($n = 23$) nights of sleep loss or the control condition which consisted of one ($n = 9$) or two ($n = 10$) nights of 9 h time in bed. The Mood Scale II was completed every two waking hours and data were analysed in terms of the frequency and intensity of mood reports. Overall, sleep loss conditions were associated with significantly less frequent happiness and activation and more frequent fatigue reports ($p < 0.001$). Intensity was also significantly reduced for activation and happiness, and increased for depression, anger and fatigue ($p < 0.05$). Interestingly, there were no significant differences in anger following two nights in the laboratory with or without sleep. Further, two nights in the lab with normal sleep was associated with significant increases in depression intensity ($p < 0.05$). Findings support the hypothesis of a mood regulatory function of sleep and highlight the relative independence of frequency and intensity and of positive and negative mood dimensions. Findings also suggest that the laboratory environment, in the absence of sleep loss, may have a significant negative impact on mood.

Jillian Dorrian, Stuart D. Baulk, Drew Dawson. *Work hours, workload, sleep and fatigue in Australian Rail Industry employees. Pages 202-209.*

Research suggests that less than 5 h sleep in the 24 h prior to work and/or more than 16 h of wakefulness can significantly increase the likelihood of fatigue-related impairment and error at work. Studies have also shown exponential safety declines with time on shift, with roughly double the likelihood of accident or injury after 10 h relative to the first 8 h. While it is acknowledged that reduced sleep, increased wakefulness and longer work hours produce work-related fatigue, few studies have examined the impact of workload on this relationship. Studies in the rail industry have focused on drivers. This study investigated fatigue in a large sample of Australian Rail Industry Employees. Participants were from four companies ($n = 90$: 85m, 5f; mean age 40.2 ± 8.6 y). Data was analysed for a total of 713 shifts. Subjects wore wrist actigraphs and completed

sleep and work diaries for 14-days. They also completed the Samn-Perelli Fatigue Scale at the beginning and end of shifts, and the NASA-TLX workload scale at least twice during each shift. Average (\pm SD) sleep length (7.2 ± 2.6 h), prior wake at shift end (12.0 ± 4.7 h), shift duration (8.0 ± 1.3) and fatigue (4.1 ± 1.3 , "a little tired, less than fresh") were within limits generally considered acceptable from a fatigue perspective. However, participants received 5 h or less sleep in the prior 24 h on 13%, were awake for at least 16 h at the end of 16% and worked at least 10 h on 7% of shifts. Subjects reported that they felt "extremely tired, very difficult to concentrate," or "completely exhausted, unable to function effectively" on 13% of shifts. Sleep length (OR = 0.88, $p < 0.01$), shift duration (OR = 1.18, $p < 0.05$), night shift (REF = morning shift, OR = 2.12, $p < 0.05$) and workload ratings (OR = 1.2, $p < 0.05$) were significant predictors of ratings of extreme tiredness/exhaustion (yes/no). While on average, sleep loss, extended wakefulness, longer work hours and work-related fatigue do not appear problematic in this sample, there is still a notable percentage of shifts that are likely to be associated with high levels of work-related fatigue. Given the size of the Australian Rail Industry, with thousands of shifts occurring each day, this is potentially of operational concern. Further, results indicate that, in addition to sleep length, wakefulness and work hours, workload significantly influences fatigue. This has possible implications for bio-mathematical predictions of fatigue and for fatigue management more generally.

- **Keywords:** Rail industry; Work hours; Workload; Fatigue; Sleep

Sally A. Ferguson, Gemma M. Paech, Jillian Dorrian, Gregory D. Roach, Sarah M. Jay. *Performance on a simple response time task: Is sleep or work more important for miners?* Pages 210-213.

The purpose of the current study was to investigate the impact of work- and sleep-related factors on an objective measure of response time in a field setting. Thirty-five mining operators working 12-h shift patterns completed daily sleep and work diaries, wore activity monitors continuously and completed palm-based psychomotor vigilance tests (palmPVT) at the start and end of each shift. Linear mixed models were used to test the main effects on response time of roster, timing of test, sleep history and prior wake. The time at which the test occurred was a significant predictor of response time ($F_{3,403.4} = 6.72$, $p < .01$) with the end of night shifts being associated with significantly slower response times than the start of night shifts, and the start or end of day shifts. Further, the amount of sleep obtained in the 24 h prior to the test was also a significant predictor of response time ($F_{3,407.0} = 3.05$, $p < .01$). The results suggest that, as expected, the end of night shift is associated with changes in response time indicative of performance impairments. Of more interest however is that immediate sleep history was also predictive of changes in response time with lower amounts of prior sleep related to slower response times. The current data provides further evidence that sleep is a primary mediator of performance, independent of roster pattern.

- **Keywords:** Work hours; Sleep; Shiftwork; Psychomotor vigilance task; Mining

Gregory D. Roach, David Darwent, Tracey L. Sletten, Drew Dawson. *Long-haul pilots use in-flight napping as a countermeasure to fatigue.* Pages 214-218.

The aim of this study was to examine the effects of fatigue on the amount of in-flight sleep obtained by airline pilots during long-haul duty periods. A total of 301 pilots collected sleep/wake and work/rest data for a period of at least 2 weeks each. Fatigue likelihood, i.e. low, moderate, high, or extreme, was estimated for each duty period based on a pilot's sleep/wake behaviour prior to duty and the time of day that the duty period occurred. Participants obtained 1.8 h of sleep (i.e. 27% of their rest time) during duty periods with low fatigue likelihood and 3.7 h of sleep (i.e. 54% of their rest time)

during duty periods with extreme fatigue likelihood. These results indicate that (i) long-haul pilots obtain substantially more sleep during duty periods when fatigue is likely to be extreme than when fatigue is likely to be low and (ii) long-haul pilots use in-flight napping as a fatigue countermeasure, but more could be done to increase its efficacy.

- **Keywords:** Pilots; Duty; Sleep

Philip Bohle, Harold Willaby, Michael Quinlan, Maria McNamara. *Flexible work in call centres : working hours, work-life conflict & health. Pages 219-224.*

Call-centre workers encounter major psychosocial pressures, including high work intensity and undesirable working hours. Little is known, however, about whether these pressures vary with employment status and how they affect work-life conflict and health. Questionnaire data were collected from 179 telephone operators in Sydney, Australia, of whom 124 (69.3%) were female and 54 (30.2%) were male. Ninety-three (52%) were permanent full-time workers, 37 (20.7%) were permanent part-time, and 49 (27.4%) were casual employees. Hypothesised structural relationships between employment status, working hours and work organisation, work-life conflict and health were tested using partial least squares modelling in PLS (Chin, 1998). The final model demonstrated satisfactory fit. It supported important elements of the hypothesised structure, although four of the proposed paths failed to reach significance and the fit was enhanced by adding a path. The final model indicated that casual workers reported more variable working hours which were relatively weakly associated with greater dissatisfaction with hours. The interaction of schedule control and variability of hours also predicted dissatisfaction with hours. Conversely, permanent workers reported greater work intensity, which was associated with both lower work schedule control and greater work-life conflict. Greater work-life conflict was associated with more fatigue and psychological symptoms. Labour market factors and the undesirability of longer hours in a stressful, high-intensity work environment appear to have contributed to the results.

- **Keywords:** Working hours; Flexible employment; Work intensity; Work-life conflict; Health; Call centres

Maria McNamara, Philip Bohle, Michael Quinlan. *Precarious employment, working hours, work-life conflict and health in hotel work. Pages 225-232.*

Precarious or temporary work is associated with adverse outcomes including low control over working hours, work-life conflict and stress. The rise in precarious employment is most marked in the service sector but little research has been done on its health effects in this sector. This study compares permanent and temporary workers in the hotel industry, where working hours are highly variable. Survey data from 150 workers from eight 3-Star hotels in urban and regional areas around Sydney were analyzed. Forty-five per cent were male and 52 per cent were female. Fifty four per cent were permanent full-time and 46 per cent were temporary workers. The effects of employment status on perceived job security, control over working hours, and work-life conflict are investigated using PLS-Graph 3.0. The effects of control over working hours, on work-life conflict and subsequent health outcomes are also explored. Temporary workers perceived themselves as less in control of their working hours, than permanent workers ($\beta = .27$). However, they also reported lower levels of work intensity ($\beta = .25$) and working hours ($\beta = .38$). The effects of low hours control ($\beta = .20$), work intensity ($\beta = .29$), and excessive hours ($\beta = .39$) on work-life conflict ($r^2 = .50$), and subsequent health effects ($r^2 = .30$), are illustrated in the final structural equation model.

- **Keywords:** Precarious employment; Working hours; Work-life conflict; Health

Karin Boonstra-Hörwein, Dieter Punzengruber, Johannes Gärtner. *Reducing understaffing and shift work with Temporal Profile Optimization (TPO)*. Pages 233-237.

The ergonomic quality of shift schedules can be improved by reducing time periods with understaffing (resulting in work-pressure, poor quality, etc.) and evening, night and/or weekend work. Improving the quality of forecasts regarding future workforce requirements as well as the optimization of work processes by moving as much work as possible to more suitable time zones are two approaches to this. We introduce and propose Temporal Profile Optimization (TPO) as a systematic approach to question the demand as well as its translation to workforce planning. Temporal profiles describe the number of employees needed over time (e.g. for different days of the week, times of day, for different calendar days) as well as the shift-times and staffing levels planned to meet this workforce demand. With Temporal Profile Forecasts we introduce a forecasting method that is based on time-stamped historical data and methodologically supplements traditional time series models like SARIMA in many ways. With Temporal Profile Reengineering we use systematic and often participatory methods from business process reengineering to identify moveable work and streamline the load lines by (re-)distributing movable work such that shifts and schedules are improved. The approach is illustrated along two business cases. Using TP-Forecasts for air traffic controllers increased forecasting accuracy whereby a different shift design was possible resulting in 3–4% less shift work. In a warehouse of an Austrian freight carrier a TP-Forecast together with TP-Reengineering helped to rearrange work processes such that the resulting workforce requirements curve had a more even form. This allowed for shorter shifts than before (thereby decreasing overtime). Experiences made so far stress the potential of Temporal Profile Optimization.

- **Keywords:** Workforce requirements; Shift design; Staffing; Forecast; Temporal profile optimization; Shift schedules

Anne Helene Garde, Kirsten Nabe-Nielsen, Birgit Aust. *Influence on working hours among shift workers and effects on sleep quality : an intervention study*. Pages 238-243.

The aim of the present intervention study was to examine if increased influence on working hours among shift workers led to better sleep quality. 391 employees were categorized into groups based on the performed activities: High (self-rostering), moderate (education and/or policy for working hours), and low intensity intervention (meetings and discussions) and reference. Sleep quality was assessed by Karolinska Sleep Questionnaire (KSQ) at baseline and follow-up (12 months). To elucidate the process of the intervention interviews were conducted. Influence on one's own working hours increased only in the high intensity group ($p < 0.001$). No effects of interventions on sleep quality were observed. Thus, sleep quality was not improved by increasing work time influence in the present group of Danish elder care workers. This was partly due to program failure (failed intervention), but may also be due to other factors such as few participants working night and few working full time.

- **Keywords:** Intervention; Sleep; Work hours

Masaya Takahashi, Kenji Iwasaki, Takeshi Sasaki, Tomohide Kubo, Ipppei Mori, Yasumasa Otsuka. *Worktime control-dependent reductions in fatigue, sleep problems, and depression*. Pages 244-250.

We investigated the association between worktime control and fatigue, sleep problems, and depressive symptoms in a sample of daytime and shift workers. A total of 3681 permanent daytime workers and 599 shift workers completed a questionnaire designed

to assess the above variables. Worktime control was evaluated in terms of both “control over daily working hours” and “control over days off”. Worktime control × work schedule × gender analysis of covariance, adjusted for age and employment status, showed overall reductions in incomplete recovery, insomnia symptoms, daytime sleepiness, and depressive symptoms with increasing levels of worktime control. However, no associations between control over daily working hours and insomnia symptoms were observed in women. The reductions appeared to be more evident for control over days off. These results remained consistent after adjustments for other potential covariates. The present findings indicate that increased worktime control and enhanced control over days off in particular, may be associated with favorable health outcomes.

- **Keywords:** Worktime control; Fatigue; Sleep; Depression

Valérie Pueyo, Cathy Toupin, Serge Volkoff. *The role of experience in night work: Lessons from two ergonomic studies.* Pages 251-255.

The purpose of this article is to analyze some connections between experience, health and work, especially in the field of night work. As a result of the baby boom, the proportion of elderly workers is steadily increasing, while at the same time many workers are reaching retirement age and being replaced by younger people. And, in the same time, there is an overall gradual increase in shift work and night work. To our knowledge, worker experience has not been extensively studied in this context. This was our focus in studying work activity in two very different situations, in a hospital and in a steel industry. In these two studies we observed that the experienced workers endeavor to plan ahead, especially at night. They do this to limit fatigue and to avoid emergencies and ensure that work is stress-free and as far as possible under control. But experience not only brings workers to plan ahead, it also enables them to do so, thanks to the resources it confers: gaining familiarity with tasks and acquiring the ability to identify critical situations, gaining knowledge about themselves and awareness of situations that cause difficulty; and gaining a better overview of the collective aspects of their work and of ways to share tasks or obtain assistance. They are able to undertake these strategies thanks to specific skills and capacities they have built along their professional career, which notably leads them to find the best trade-off between several goals, possibly contradictory. Such experience is especially valuable at night, when the worker is tired, and when there are fewer supervisors present. This experience can only be gained, however, if the work environment fosters its acquisition and provides an opportunity to make use of it, especially during the night shift and especially with respect to planning tasks ahead of *time*.

- **Keywords:** Night work; Experience; Aging; Health; Compromise; Strategies

Irena Iskra-Golec, Lawrence Smith. *Bright light effects on ultradian rhythms in performance on hemisphere-specific tasks.* Pages 256-260.

Ultradian rhythms in indices of brain hemisphere activity and in cognitive performance have been found in numerous studies. Asymmetry of these rhythms with regard to phase and frequency have also been documented in some studies. There is some evidence that bright light can affect ultradian rhythms of arousal state and vigilance. A study on unilateral exposure to bright light has demonstrated more pronounced effects of bright light on the right hemisphere. The aim of this study was to examine whether daytime intermittent bright light could affect parameters of ultradian rhythms in performance speed on hemisphere-specific tasks, and whether the effect of bright light was symmetric for the rhythms in performance on hemisphere-specific tasks presented laterally. A counter-balanced, within-subject research design was applied. The performance of 15 participants on hemisphere-specific tasks exposed laterally was measured every 30 min starting at 08:00 h and ending at 20:30 h in intermittent bright light (IBL, pulses of

15 min of 4000 lux light regularly interspersed between 45 min of background light levels of 300 lux) and in ordinary room light (ORL) conditions (300 lux). Individual time series data were subjected to cosinor analysis. General linear model analyses (the factors were: level of processing, visual field, and the task) were performed on the rhythms' parameters. There was a substantial lengthening of the rhythms' periods in IBL conditions for performance speed on spatial tasks and an increase in amplitude of the rhythms of performance speed for spatial tasks in both visual fields and for verbal tasks in the left visual field in the IBL conditions when compared to the ORL conditions. The results showed that the schedule of light exposure affected ultradian rhythms of hemisphere-specific tasks differently and that the right hemisphere seems to be more "sensitive" to light than the left hemisphere.

- **Keywords:** Bright light; Ultradian rhythm; Cognitive performance

Regular Papers

R.H. Westgaard, J. Winkel. *Occupational musculoskeletal and mental health: Significance of rationalization and opportunities to create sustainable production systems : a systematic review. Pages 261-296.*

This literature review aims to identify occupational musculoskeletal and mental health effects of production system rationalization as well as organizational-level measures that may improve health outcome ("modifiers" in this review). A short review of the effect of ergonomic interventions is included as background and rationalization is discussed as a theoretical concept. Indicator variables for occupational musculoskeletal and mental health and related risk factors are presented. Variables with a generalized format were allowed in the literature searches (e.g., job satisfaction and absenteeism were accepted as risk factor and health indicator, respectively), suitable for the research fields of work sociology, organization science, human resource management (HRM) and economics research. One hundred and sixty-two studies of rationalization effects on health and risk factors and 72 organization-level modifier results were accepted into the final database. Entries were sorted by rationalization strategy and work life sector, and trends in outcome (positive, mixed, no effect, or negative effect on health and risk factors) were determined. Rationalizations have a dominant negative effect on health and risk factors (57% negative, 19% positive); the most negative effects were found for downsizing and restructuring rationalizations in general (71 studies negative, 13 positive) and for the health care sector in particular (36 studies negative, 2 positive). The rationalization strategy High Performance Work System (HPWS) was associated with the highest fraction positive outcome studies (6 of 10 studies). Other rationalization strategies (lean practices, parallel vs. serial production and mechanization level) reported intermediate results, in part dependent on work life sector, but also on the year when studies were carried out. Worker participation, resonant management style, information, support, group autonomy and procedural justice were modifiers with favourable influence on outcome. It is concluded that production system rationalization represents a pervasive work life intervention without a primary occupational health focus. It has considerable and mostly negative influence on worker health, but this can be reduced by attention to modifiers. The results create a basis for new priorities in ergonomic intervention research.

- **Keywords:** Intervention; Change management; Occupational health; Risk factor

Yanzhao Ma, Kunwoo Lee, Linlin Li, Junghoon Kwon. *Nonlinear regression equations for segmental mass-inertial characteristics of Korean adults estimated using three-dimensional range scan data. Pages 297-308.*

Human modeling and the biomechanical analysis of human movement require the accurate estimation of body segment parameters for various populations and individuals. In this study, the body characteristics of adult Koreans were investigated using three-dimensional range scan data for 40 males and 40 females aged between 18 and 59 years obtained from the SizeKorea anthropometric database. Each subject was divided into 16 segments, and the mass-inertial parameters of each segment were calculated under the assumption of a uniform density distribution for the segment. The length and at least one circumference of each segment were determined from the scan data for that segment. Nonlinear regression equations were then derived based on the segment lengths and circumferences. The body segment parameters of Korean adults can be estimated using these equations if the required dimensions are measured directly or derived from an anthropometric database.

- **Keywords:** Body segment parameters; Korean adults; Nonlinear regression equations

Eva Bernmark, Mikael Forsman, Christina Wiktorin. *Head movements during two computer work tasks assessed by akcelerometry. Pages 309-313.*

We investigated whether potential differences in head inclinations and accelerations for two highly similar computer work tasks could be detected using (1) a triaxial accelerometer and (2) a simulated uniaxial accelerometer. Ten subjects' head movements were registered with a triaxial accelerometer system for two similar document-management tasks at their work place: a fully electronic document-management task and one also involving paper documents. In situations where head movements were small, a triaxial accelerometer was able to discriminate between the different degrees of static work of the neck in terms of range of head inclinations and accelerations. A difference in head acceleration was also found by using a simulated uniaxial accelerometer. Thus, in terms of head movement and for work similar to this office work, potential dynamic differences in observationally similar work tasks can be investigated by using a triaxial accelerometer. For acceleration alone, a uniaxial accelerometer can also be used.

- **Keywords:** Accelerometer; Inclinator; Acceleration; Inclination; Technical measurement; Computer work; Neck

C.V. MacDonald, C.J. Brooks, J.W. Kozey, A. Habib. *An ergonomic evaluation of infant life jackets : donning time & donning accuracy. Pages 314-320.*

Canada is considering the development of a new standard for infant/child life jackets. Eight currently available (approved and non-approved) infant/child life jackets were procured for evaluation. Fifty-six participants were chosen as a sample of convenience from the general public for testing. The life jackets were divided into two groups of four, which were donned on a soft infant manikin procured from the Red Cross. In 224 attempts at donning, only 43 (19%) attempts resulted in the life jacket being donned correctly in less than 1 min. Only one life jacket came close to a good design and passed the life jacket standard for donning time and accuracy. Failure rates were observed across all the participants irrespective of age, gender, experience with children and experience with recreational marine equipment. Accuracy and speed of donning the life jacket were hampered as the number of donning sub-tasks increased. It was concluded that it is possible to design a life jacket that can be donned correctly in under 1 min. The life jacket must be of simple, intuitive design and fall naturally into the anatomical shape of the child. A minimum number of ties, zips and clips should be used in the design, and if such connectors are used they should be color coded or of different shapes and sizes to avoid confusion.

- **Keywords:** Marine safety; Drowning; Marine standards; Ergonomics; Donning time; Personal flotation devices

Alain Garrigou, Isabelle Baldi, Patricia Le Frious, Rémy Anselm, Martine Vallier. *Ergonomics contribution to chemical risks prevention : an ergotoxicological investigation of the effectiveness of coverall against plant pest risk in viticulture. Pages 321-330.*

The purpose of this article is to present the contribution of a trans-disciplinary approach focused on ergonomics and chemical risk control. We shall more precisely discuss how such an approach carried out in the field of agricultural work has made it possible to highlight serious shortcomings in the effectiveness of the coveralls that are supposed to protect vineyard workers from pesticides. The study results, as well as the whistle-blow that followed have questioned the control and prevention measures used until then. The aforementioned trans-disciplinary approach gathers knowledge and methods from epidemiology, industrial hygiene, occupational health and safety and ergonomics. Ergonomics were central in the development of the approach as it connected task and activity analysis with contamination measurements. Lastly, the first results that were obtained have been confirmed and reused by the AFSSET (Agence Française de Sécurité Sanitaire Environnement et Travail, the French governmental agency in charge of environmental health and occupational health and safety issues) regarding the agricultural sector but also for all other situations in which workers use coveralls as protection against chemical risks.

- **Keywords:** Agriculture; Pesticides; Ergonomics; Chemical risk; Ergotoxicology; Activity analysis; Trans-disciplinary research

Dale A. Gerke, Jean-Michel Brismée, Phillip S. Sizer, Gregory S. Dedrick, C. Roger James. *Change in spine height measurements following sustained mid-range and end-range flexion of the lumbar spine. Pages 331-336.*

Workers lose height during the day. Flexion-based exercises and body positions are commonly prescribed to unload the spine and prevent back pain. Lumbar extension positions have been researched and result in an increase in spine height. End-range lumbar extension postures increase spine height to a greater extent than mid-range lumbar extension postures, but these positions are not always tolerated by patients with lumbar conditions. No study to date has investigated the effect of end-range versus mid-range lumbar flexion postures on spine height changes. The purpose of this study was to investigate the effects of two techniques commonly used in clinical settings to unload the lumbar intervertebral disc (IVD) segments through increasing spine height in: (1) a sidelying mid-range lumbar flexion position; and (2) a sidelying end-range lumbar flexion position. A total of 20 asymptomatic women and 21 asymptomatic men with a mean age of 23.8 years (± 2.5) participated in the study. Subjects were randomized systematically into 2 groups to determine the order of testing position. Measurements were taken with a stadiometer in the sitting position to detect change in spine height after each position. Results of the paired *t*-tests indicated that compared to the spine height in sitting, the sidelying end-range lumbar flexion position resulted in a statistically significant ($p < .001$) mean spine height gain of 4.78 mm (± 4.01) while the sidelying mid-range lumbar flexion position resulted in a statistically significant ($p < .001$) mean spine height gain of 5.84 mm (± 4.4). No significant difference between the height changes observed following the two sidelying positions was found ($p = .22$). Sidelying lumbar flexion positions offer valuable alternatives to lumbar extension positions to increase spine height, possibly through increasing hydration levels of the lumbar IVD and could be proposed as techniques to offset spinal shrinkage and the biomechanical consequences of sustained loads.

- **Keywords:** Hydration; Intervertebral disc; Sidelying; Spine; Stadiometer

H. Kanis. *Estimating the number of usability problems.* Pages 337-347.

The number of usability problems discovered in a user trial or identified in a heuristic evaluation can never be claimed to be exhaustive. This raises the question of how many usability problems remained undetected. In ergonomics/human factors research this subject matter is often addressed by asking how many participants are sufficient to discover a specific proportion of the usability problems. Current approaches to answer this question suffer from various biasing mechanisms, which undermine the credibility of the popular 'rule of thumb' that five participants are sufficient for the discovery of 80% of 'all' usability problems. This 5-user rule appears to be speculative in its application as a stop rule. In this paper, I compare actual estimates of the number of usability problems. Underestimation surfaces as a permanent threat. The so-called Turing estimate (C_T) appears to be the most satisfactory. However, also C_T estimates may suffer from underestimation. Therefore $\max(C_T, C_F)$ with the C_F estimate based on partitioned frequencies is proposed as the most adequate estimate of the number of usability problems in the studies presented.

- **Keywords:** User trials; Heuristic evaluation; Number of usability problems; Biased estimates

Kerttu Huttunen, Heikki Keränen, Eero Väyrynen, Rauno Pääkkönen, Tuomo Leino. *Effect of cognitive load on speech prosody in aviation : evidence from military simulator flights.* Pages 348-357.

Mental overload directly affects safety in aviation and needs to be alleviated. Speech recordings are obtained non-invasively and as such are feasible for monitoring cognitive load. We recorded speech of 13 military pilots while they were performing a simulator task. Three types of cognitive load (load on situation awareness, information processing and decision making) were rated by a flight instructor separately for each flight phase and participant. As a function of increased cognitive load, the mean utterance-level fundamental frequency (F0) increased, on average, by 7 Hz and the mean vocal intensity increased by 1 dB. In the most intensive simulator flight phases, mean F0 increased by 12 Hz and mean intensity, by 1.5 dB. At the same time, the mean F0 range decreased by 5 Hz, on average. Our results showed that prosodic features of speech can be used to monitor speaker state and support pilot training in a simulator environment.

- **Keywords:** Pilot; Voice; Workload

Rich C. McIlroy, Neville A. Stanton. *Getting past first base : going all the way with Cognitive Work Analysis.* Pages 358-370.

This paper reports the application of Cognitive Work Analysis (CWA) to the problem of communications planning in military aviation. Applications of CWA rarely get beyond the first one or two phases; this paper presents an analysis in which all five phases have been completed. The method offers a formative description of the system, defining the set of boundaries and constraints that shape system activity in terms of work domain, recurring activities, decision making, social organisation and worker competency requirements. It is an analysis that is well suited to environments in which the occurrence of unanticipated events can have serious implications for both safety and productivity. Communications planning in military aviation is such an environment. The outputs of the analysis provided an extensive and exhaustive description of the system, highlighting the uneven spread of activity, across actors involved in communications planning and across the situations in which planning can occur. In addition, a new method for informing worker competency requirements based on abstract functions

rather than specific decision steps is proposed and discussed in terms of job design, interface design, and person specification.

- **Keywords:** Cognitive Work Analysis; Communications planning; Worker Competencies Analysis

Sophia Berolo, Richard P. Wells, Benjamin C. Amick III. *Musculoskeletal symptoms among mobile hand-held device users and their relationship to device use : a preliminary study in a Canadian university population.* Pages 371-378.

The study aims were, in a population of university students, staff, and faculty ($n = 140$), to: 1) determine the distribution of seven measures of mobile device use; 2) determine the distribution of musculoskeletal symptoms of the upper extremity, upper back and neck; and 3) assess the relationship between device use and symptoms. 137 of 140 participants (98%) reported using a mobile device. Most participants (84%) reported pain in at least one body part. Right hand pain was most common at the base of the thumb. Significant associations found included time spent internet browsing and pain in the base of the right thumb (odds ratio 2.21, 95% confidence interval 1.02–4.78), and total time spent using a mobile device and pain in the right shoulder (2.55, 1.25–5.21) and neck (2.72, 1.24–5.96). Although this research is preliminary, the observed associations, together with the rising use of these devices, raise concern for heavy users.

- **Keywords:** Upper extremity; Musculoskeletal symptoms; Mobile hand-held device

Errol R. Hoffmann, Richard C. Whitfield and Students of Design Studio III 2008. *The role of testing realism on experimentally obtained stereotype strength.* Pages 379-383.

It has been shown (Hoffmann 2009) that pencil-and-paper tests, when used to determine stereotype strength, may yield data quite different to that obtained from hardware tests. The purpose of this research was to determine the level of realism required in order to have stereotypes that are consistent with real-world values. It is surprising that there does not appear to be any published research addressing this problem; all previous researches have considered either paper/pencil or hardware tests or sometimes both, but no level of simulation in between these techniques. In order to determine the effect of level of testing realism, a specific example was chosen to test, that of water tap operation stereotypes. Tests used verbal questioning, photographs of tap arrangements, a partial hardware arrangement and finally a full hardware setup. The results of these four levels of realism were very different and illustrated that, only with a full realistic simulation, did participants respond as might be expected in a real-world environment, illustrating the importance of testing realism when determining population stereotypes. This result has strong implications for product designers when selecting appropriate layouts of displays and controls and the linkages relating these.

- **Keywords:** Stereotypes; Water taps; Simulation level

Monica Lundh, Margareta Lützhöft, Leif Rydstedt, Joakim Dahlman. *Working conditions in the engine department : a qualitative study among engine room personnel on board Swedish merchant ships.* Pages 384-390.

The specific problems associated with the work on board within the merchant fleet are well known and have over the years been a topic of discussion. The work conditions in the engine room (ER) are demanding due to, e.g. the thermal climate, noise and awkward working postures. The work in the engine control room (ECR) has over recent

years undergone major changes, mainly due to the introduction of computers on board. In order to capture the impact these changes had implied, and also to investigate how the work situation has developed, a total of 20 engine officers and engine ratings were interviewed. The interviews were semi-structured and Grounded Theory was used for the data analysis. The aim of the present study was to describe how the engine crew perceive their work situation and working environment on board. Further, the aim was to identify areas for improvements which the engine crew consider especially important for a safe and effective work environment. The result of the study shows that the design of the ECR and ER is crucial for how different tasks are performed. Design which does not support operational procedures and how tasks are performed risk inducing inappropriate behaviour as the crew members' are compelled to find alternative ways to perform their tasks in order to get the job done. These types of behaviour can induce an increased risk of exposure to hazardous substances and the engine crew members becoming injured.

- **Keywords:** Engine control room; Engine room; Grounded Theory; Engine officers; Ratings; Work place design

Angel Jesus Callejon-Ferre, Francisco Manzano-Agugliaro, Manuel Diaz-Perez, Juan Carreno-Sanchez. *Improving the climate safety of workers in Almería-type greenhouses in Spain by predicting the periods when they are most likely to suffer thermal stress. Pages 391-396.*

The humidex and wind-chill indices were used to determine the periods in which labourers working in Almería-type greenhouses in southeastern Spain are most likely to suffer conditions able to induce heat and cold stress. Over 500,000 pieces of data for wet and dry bulb temperatures and relative humidity, recorded over a period in excess of five years by a weather station located in an Almería-type greenhouse containing a grass crop, were used in the calculation of these indices. The wind-chill index results showed cold stress never to be a problem, but the humidex index results showed that conditions under which heat stress could develop were common in the warmer months. A clock diagram was produced showing the hours when heat stress is likely to occur in each month of the year. This information could be used to improve the conditions of labourers working in this type of greenhouse; some ways of reducing their exposure to heat stress-inducing conditions are discussed.

- **Keywords:** Ergonomics; Greenhouses; Humidex index; Wind-chill index