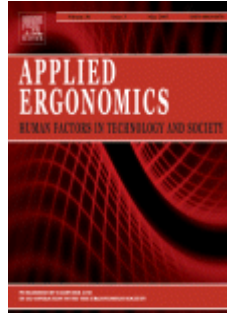


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J. Rowson, A. Yoxall. *Hold, grasp, clutch or grab : consumer grip choices during food container opening.* Pages 627-633.

Society is ageing and sadly that ageing leads to a host of issues, not least a society in which the majority are likely to have some loss of strength and dexterity. This can lead to complications in undertaking everyday tasks such as using transport, bathing or even handling and opening food. Packaging has to provide a multitude of services; to protect and preserve the product, to provide information to the consumer and not least to allow access to the contents. This access to packaging - or 'openability' - has become a significant issue for designers and manufacturers with the change in demographics as described above. Understanding the choices consumers make in how they manipulate packaging can help designers produce packaging that is more able to meet the requirements of modern society. Studies previously undertaken by the authors showed that consumers did use different grips when opening packaging and that certain grips were theoretically more comfortable and stronger than others. This paper outlines a further study whereby consumers were asked to apply the most common grips to a specially designed torque measuring device. Details were taken about the consumers: age, gender, occupation, hand size, plus their preferred grip choice for packaging of this type. The study showed that typically women chose a grip that maximised their opportunity of opening the closure and that this grip choice was more limited than that available for men. This has implications for inclusive design of many everyday products.

- **Keywords:** Openability; Inclusive design; Packaging

Michael H. Lau, Thomas J. Armstrong. *The effect of viewing angle on wrist posture estimation from photographic images using novice raters.* Pages 634-643.

Observational assessment of wrist posture using photographic methods is theoretically affected by camera view angle. A study was conducted to investigate whether wrist flexion/extension and radial/ulnar deviation postures were estimated differently by raters depending on the viewing angle and compared to predictions using a quantitative 2D model of parallax. Novice raters ($n = 26$) estimated joint angles from images of wrist postures photographed from ten different viewing angles. Results indicated that *ideal* views, orthogonal to the plane of motion, produced more accurate estimates of posture compared to non-ideal views. The neutral (0°) posture was estimated the most accurately even at different viewing angles. Raters were more accurate than model predictions. Findings demonstrate a need for more systematic methods for collecting and

analyzing photographic data for observational studies of posture. Renewed caution in interpreting existing studies of wrist posture where viewing angle was not controlled is advised.

- **Keywords:** Parallax; Wrist; Posture; Viewing angle

R.J. Parkinson, M. Bezaire, J.P. Callaghan. *A comparison of low back kinetic estimates obtained through posture matching, rigid link modeling and an EMG-assisted model. Pages 644-651.*

This study examined errors introduced by a posture matching approach (3DMatch) relative to dynamic three-dimensional rigid link and EMG-assisted models. Eighty-eight lifting trials of various combinations of heights (floor, 0.67, 1.2 m), asymmetry (left, right and center) and mass (7.6 and 9.7 kg) were videotaped while spine postures, ground reaction forces, segment orientations and muscle activations were documented and used to estimate joint moments and forces (L5/S1). Posture matching over predicted peak and cumulative extension moment ($p < 0.0001$ for all variables). There was no difference between peak compression estimates obtained with posture matching or EMG-assisted approaches ($p = 0.7987$). Posture matching over predicted cumulative ($p < 0.0001$) compressive loading due to a bias in standing, however, individualized bias correction eliminated the differences. Therefore, posture matching provides a method to analyze industrial lifting exposures that will predict kinetic values similar to those of more sophisticated models, provided necessary corrections are applied.

- **Keywords:** Spine loading; Posture matching; 3DMatch

Margarita Vergara, Salvador Mondragón, Joaquín Luis Sancho-Bru, Pedro Company, María-Jesús Agost. *Perception of products by progressive multisensory integration : a study on hammers. Pages 652-664.*

The aim of this work is to determine the influence of multisensory (visual-haptic) integration and the level of interaction (seeing photographs, seeing the actual product, touching it and using it) on the perception of products, including perceived ergonomics. The product selected for the experiment was the hammer, as this will help to establish whether emotional design studies can also apply to 'commercial' products. Subjective opinions of users were evaluated through semantic differential tests. A factor analysis identified six semantic factors or axes (Quality/Robustness, Ergonomics/Appearance, Innovation, Lightness, Dynamic Effects, and Efficacy). Results show that Lightness and Dynamic Effects are quite sensitive to the level of interaction, while Ergonomics/Appearance is partially affected. However, the perceptions of Innovation, Quality/Robustness and Efficacy are not so affected and they could be detected through a lower level of interaction (i.e. seeing photographs). This suggests that commercial products seem sensitive to emotional design studies and that multisensory integration enhances the perception of the factors that are clearly linked with physical interaction between users and tools, i.e. Ergonomics/Appearance, Lightness and Dynamic Effects. Additionally, it should be highlighted that some aspects related with the ergonomics and ease of use of products are also perceived at different stages of interaction.

- **Keywords:** Multisensory integration; Semantic differential; Emotional design

SangWoo Tak, Bryan Buchholz, Laura Punnett, Susan Moir, Victor Paquet, Scott Fulmer, Helen Marucci-Wellman, David Wegman. *Physical ergonomic hazards in highway tunnel construction : overview from the Construction Occupational Health Program. Pages 665-671.*

This report provides an overview of physical ergonomic exposures in highway construction work across trades and major operations. For each operation, the observational method "PATH" (Posture, Activity, Tools and Handling) was used to estimate the percentage of time that workers spent in specific tasks and with exposure to awkward postures and load handling. The observations were carried out on 73 different days, typically for about 4 h per day, covering 120 construction workers in 5 different trades: laborers, carpenters, ironworkers, plasterers, and tilers. Non-neutral trunk postures (forward or sideways flexion or twisting) were frequently observed, representing over 40% of observations for all trades except laborers (28%). Kneeling and squatting were common in all operations, especially tiling and underground utility relocation work. Handling loads was frequent, especially for plasterers and tilers, with a range of load weights but most often under 15 pounds. The results of this study provide quantitative evidence that workers in highway tunnel construction operations are exposed to ergonomic factors known to present significant health hazards. Numerous opportunities exist for the development and implementation of ergonomic interventions to protect the health and safety of construction workers.

- **Keywords:** PATH; Trade; Operation; Postural load; Highway tunnel construction

P. Simeonov, H. Hsiao, J. Powers, D. Ammons, T. Kau, A. Amendola. *Postural stability effects of random vibration at the feet of construction workers in simulated elevation. Pages 672-681.*

The risk of falls from height on a construction site increases under conditions which degrade workers' postural control. At elevation, workers depend heavily on sensory information from their feet to maintain balance. The study tested two hypotheses: "sensory enhancement" – sub-sensory (undetected) random mechanical vibrations at the plantar surface of the feet can improve worker's balance at elevation; and "sensory suppression" – supra-sensory (detectable) random mechanical vibrations can have a degrading effect on balance in the same experimental settings. Six young (age 20–35) and six aging (age 45–60) construction workers were tested while standing in standard and semi-tandem postures on instrumented gel insoles. The insoles applied sub- or supra-sensory levels of random mechanical vibrations to the feet. The tests were conducted in a surround-screen virtual reality system, which simulated a narrow plank at elevation on a construction site. Upper body kinematics was assessed with a motion-measurement system. Postural stability effects were evaluated by conventional and statistical mechanics sway measures, as well as trunk angular displacement parameters. Analysis of variance did not confirm the "sensory enhancement" hypothesis, but provided evidence for the "sensory suppression" hypothesis. The supra-sensory vibration had a destabilizing effect, which was considerably stronger in the semi-tandem posture and affected most of the sway variables. Sensory suppression associated with elevated vibration levels on a construction site may increase the danger of losing balance. Construction workers at elevation, e.g., on a beam or narrow plank might be at increased risk of fall if they can detect vibrations under their feet. To reduce the possibility of losing balance, mechanical vibration to supporting structures used as walking/working surfaces should be minimized when performing construction tasks at elevation.

- **Keywords:** Fall prevention; Balance control; Vibration; Sensory suppression

Daniel(Jian) Sun, Lily Elefteriadou. *Lane-changing behavior on urban stress : a focus group-based study. Pages 682-691.*

As lane-changing behavior has received increasing attention during the recent years, various algorithms have been developed. However, most of these models were derived and validated using data such as vehicle trajectories, with no consideration of driver characteristics. In this research, focus group studies were conducted to obtain driver-related information so that the driver characteristics can be incorporated into lane-

changing models. Different urban lane-changing scenarios were examined and discussed in the focus group meetings. The likelihood for initiating lane changes under each scenario was obtained. The participating drivers were categorized according to their background information and verbal responses, so that the lane-changing behavior can be related to driver characteristics for each group. Two types of information, quantitative and qualitative responses from participants, were used to establish this relationship. The paper concludes by providing recommendations related to the implementation of study findings into micro-simulators to better replicate driver behavior in urban street networks.

- **Keywords:** Driver aggressiveness; Focus group studies; Lane changing; Traffic flow models; Microscopic traffic simulation

T. Murphy, M.L. Oliver. *Evaluation of a dynamic armrest for hydraulic-actuation controller use. Pages 692-698.*

The efficacy of a newly designed dynamic armrest was evaluated during joystick operation of a typical North American hydraulic-actuation joystick. The dynamic design was evaluated against a stationary armrest condition as well as no armrest condition. Electromyography (EMG) and subjective measurements were used to make the evaluation. The dynamic armrest, which mimics the natural pendulation of a joystick operator's arm in the forward and backward directions, was shown to significantly decrease the muscular activation in the upper trapezius, posterior deltoid, and anterior deltoid ($p \leq 0.01$) over a stationary armrest. A questionnaire revealed that subjects significantly ($p = 0.01$) preferred the dynamic armrest design over either a standard armrest or no armrest with 17 of 21 operators preferring the dynamic armrest. Ratings from the questionnaire indicated that subjects felt that the dynamic armrest required less effort, was more comfortable, and was more effective than either of the other two armrest conditions.

- **Keywords:** Armrest; Joystick; Ergonomics

Sue A. Ferguson, Williams S. Marras, W. Gary Allread, Gregory G. Knapik, Kimberly A. Vandlen, Riley E. Splittstoesser, Gang Yang. *Musculoskeletal disorder risk as a function of vehicle rotation angle during assembly tasks. Pages 699-709.*

Musculoskeletal disorders (MSD) are costly and common problem in automotive manufacturing. The research goal was to quantify MSD exposure as a function of vehicle rotation angle and region during assembly tasks. The study was conducted at the Center for Occupational Health in Automotive Manufacturing (COHAM) Laboratory. Twelve subjects participated in the study. The vehicle was divided into seven regions, (3 interior, 2 underbody and 2 engine regions) representative of work areas during assembly. Three vehicle rotation angles were examined for each region. The standard horizontal assembly condition (0° rotation) was the reference frame. Exposure was assessed on the spine loads and posture, shoulder posture and muscle activity, neck posture and muscle activity as well as wrist posture. In all regions, rotating the vehicle reduced musculoskeletal exposure. In five of the seven regions 45° of vehicle rotation represented the position that reduced MSD exposure most. Two of the seven regions indicated 90° of vehicle rotation had the greatest impact for reducing MSD exposure. This study demonstrated that vehicle rotation shows promise for reducing exposure to risk factors for MDS during automobile assembly tasks.

- **Keywords:** Musculoskeletal disorder risk; Injury prevention; Automotive

R.S. Bridger, K. Brasher, A. Dew, S. Kilminster. *Job stressors in naval personnel serving on ships and in personnel serving ashore over a twelve month period. Pages 710-718.*

Sixty one percent of respondents to a questionnaire survey of occupational stress (Phase I) returned follow-up questionnaires twelve months later (Phase II). The Phase I questionnaire measured psychological strain resulting from exposure to occupational stressors, and measured the presence of stress buffers and demographic, psychological and lifestyle-related confounding factors, including age, rank and gender, mood state and the occurrence of stressful life events outside of work. The prevalence of strain was 31% at Phase I and 33% at Phase II. Fifty percent of personnel had no strain on either occasion, 15% had strain on both occasions and the remainder had strain on one occasion. The main stressor associated with strain at Phase I was an inability to disengage from work and this stressor accounted for a greater proportion of the variance in strain in personnel serving on ships than those serving ashore. The twelve-month follow-up questionnaire (Phase II) re-assessed psychological strain. A multiple linear regression analysis was conducted to identify factors measured at Phase I that predicted strain at Phase II in previously strain-free individuals. A lack of autonomy and control and dissatisfaction with living conditions predicted strain twelve months later in those serving on ships. Of the living conditions assessed, lack of privacy was the most strongly associated with strain twelve months later in those serving on ships. These stressors were not associated with strain twelve months later in those serving ashore. The findings suggest that improvements to the design of the environment on ships may have benefits for the psychological health of personnel.

- **Keywords:** Occupational stress; Psychological strain; Work environment; Maritime ergonomics

Sylvia Natvik, Bjørn Bjorvatn, Bente Elisabeth Moen, Nils Magerøy, Børge Sivertsen, Ståle Pallesen. *Personality factors related to shift work tolerance in two- and three-shift workers. Pages 719-724.*

This study aimed to investigate whether different personality variables were associated with shift work tolerance, and whether these potential associations were moderated by various types of shift work. The sample comprised 1505 nurses who worked either two or three rotating shifts. Personality traits were measured in terms of morningness, flexibility, languidity and hardiness. Morningness reflects the tendency to be alert relatively early in the morning and sleepy relatively early in the evening. Flexibility denotes the ability to both work and sleep at odd times of the day, while languidity concerns the tendency to become tired/sleepy when cutting down on sleep. Hardiness relates to resilience to stressful life events. The dependent variables in this study comprised of measures of insomnia, sleepiness, depression and anxiety. Hierarchical regression analyses, which controlled for demographic variables and work load, revealed that Morningness was significantly and negatively related to insomnia. The Morningness by Shift type interaction was overall significant for depressive symptoms. Morningness was near significantly associated with lower levels of depressive symptoms in three-shift workers, but unrelated to depressive symptoms in two-shift workers. Flexibility was associated with higher levels of depressive symptoms. Flexibility by Shift type interaction was significant for insomnia, indicating that flexibility was negatively associated with insomnia for three-shift workers and unrelated with insomnia for two-shift workers. Languidity was associated with higher levels of sleepiness, depressive and anxiety symptoms. Hardiness was associated with lower levels of all four dependent variables.

- **Keywords:** Shift work tolerance; Personality; Rotating shifts

Nathan B. Fethke, Lauren C. Gant, Fred Gerr. *Comparison of biomechanical loading during use of conventional stud welding equipment and an alternate system. Pages 725-734.*

We investigated the effect of an alternative welding system designed to reduce exposure to extreme trunk flexion on measures of trunk inclination and muscle activity. Among 10 participants, data were collected while using conventional stud welding equipment and while using the alternate system. Paired *t*-tests were used to compare results between the two welding systems. Mean trunk inclination angle was reduced with the alternate system (34.4° versus 9.7°, $p < 0.01$). Percent time with trunk inclination angles greater than 60° was also reduced (40.0% versus 4.7%, $p < 0.01$). In general, the alternate system resulted in less desirable upper trapezius muscle activity levels. The alternate system appears to be effective in reducing exposure to extreme trunk flexion among stud welders. Continued development of the system should explore features designed to reduce shoulder forces and improve productivity.

- **Keywords:** Construction; Ergonomics; Trunk posture

Afshin Samani, Josué Fernández-Carnero, Lars Arendt-Nielsen, Pascal Madeleine. *Interactive effects of acute experimental pain in trapezius and sore wrist extensor on the electromyography of the forearm muscles during computer work. Pages 735-740.*

We investigated the interactive effects of shoulder pain and wrist extensor muscle soreness on surface electromyography (EMG) during computer mouse work. On day one, subjects ($N = 12$) performed computer work with/without acute muscle pain induced in the trapezius muscle. Subsequently, eccentric exercise was performed to induce delayed onset muscle soreness (DOMS) in wrist extensor muscles. In presence of DOMS on day two, computer work recordings with/without pain were repeated. EMG signals were recorded from the descending part of trapezius bilaterally, flexor carpi ulnaris and extensor carpi radialis brevis. Experimental muscle pain in trapezius led to a decrease in the muscular activity of the wrist extensor ($P < 0.02$) and decreased the relative rest time in the wrist flexor even in presence of DOMS ($P < 0.01$). The present result suggests that shoulder pain plays a role in the coordination of wrist flexors and extensors during computer work.

- **Keywords:** Lateral epicondylalgia; Tennis elbow; Work-related disorders

Denham L. Phipps, George H. Meakin, Paul C.W. Beatty. *Extending hierarchical task analysis to identify cognitive demands and information design requirements. Pages 741-748.*

While hierarchical task analysis (HTA) is well established as a general task analysis method, there appears a need to make more explicit both the cognitive elements of a task and design requirements that arise from an analysis. One way of achieving this is to make use of extensions to the standard HTA. The aim of the current study is to evaluate the use of two such extensions – the sub-goal template (SGT) and the skills–rules–knowledge (SRK) framework – to analyse the cognitive activity that takes place during the planning and delivery of anaesthesia. In quantitative terms, the two methods were found to have relatively poor inter-rater reliability; however, qualitative evidence suggests that the two methods were nevertheless of value in generating insights about anaesthetists' information handling and cognitive performance. Implications for the use of an extended HTA to analyse work systems are discussed.

- **Keywords:** Task analysis; Cognition; Human error; Information design; Anaesthesia

Londa Vanderwal, Risto Rautiainen, Rex Kuye, Corinne Peek-Asa, Thomas Cook, Marizen Ramirez, Kenneth Culp, Kelley Donham. *Evaluation of long- and short-handled hand hoes for land preparation, developed in a participatory manner among women vegetable farmers in The Gambia. Pages 749-756.*

Objective: This study evaluated land preparation interventions (new short- and long-handled hoes), developed in a participatory manner with women vegetable farmers in West Africa, and identified indicators of long-term adoption of these interventions. **Methods:** Subjects ($n = 48$) engaged in timed trials, alternating between using an intervention tool and their traditional hand hoe to till specified plots of land. Heart rates were measured and subjects reported the relative ergonomic comfort and safeness of the tool after each trial. Follow-up interviews and focus groups were held one, two, and three months after the trials. **Results:** Compared to the traditional hoe, the new long-handled hoe required 22% less time ($p = 0.01$), while the new short hoe took 20% more time ($p = 0.05$) to till the standard plots in this study. Two months after the initial trials, 94% of subjects preferred the new hoes over the traditional hoe. Most subjects (75%) preferred the new short hoe over the new long hoe and thought it was faster (81%), despite measurements to the contrary. **Conclusions:** While the new long-handled hoe performed better in the timed trials in this study, most subjects preferred the new short-handled hoe. Subjects should be sensitized on the benefits of the long-handled hoe.

- **Keywords:** Agriculture; Vegetable farming; Women; Safety; Hand tools; Africa

Daniel P. Jenkins, Neville A. Stanton, Paul M. Salmon, Guy H. Walker. *A formative approach to developing synthetic environment fidelity requirements for decision-making training. Pages 757-769.*

This paper describes a new approach for developing design specifications for synthetic environments that support decisions making training. The approach starts by modelling the constraints governing decision-making activity in the real world. A focus is placed on what could happen in the decision-making process, rather than what does or what should. Importantly, the developed model is independent of specific actors and events, providing a robust description of the domain that remains applicable in almost all perceivable situations. By modelling the relationship between information elements, and the way decision-makers develop an understanding of their environment, the approach identifies the information that may be pertinent to the decision-maker. It is contended that the approach has utility in the design of first-of-a-kind synthetic environments, as well as the evaluation of existing simulators for the specific role of decision-making training.

- **Keywords:** Decision-making; Training; Synthetic environments