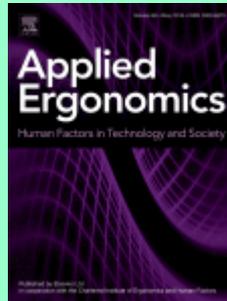


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Martina Truschzinski, Alberto Betella, Guido Brunnett, Paul F.M.J. Verschure. *Emotional and cognitive influences in air traffic controller tasks: An investigation using a virtual environment?* Pages 1-9.

Air traffic controllers are required to perform complex tasks which require attention and high precision. This study investigates how the difficulty of such tasks influences emotional states, cognitive workload and task performance. We use quantitative and qualitative measurements, including the recording of pupil dilation and changes in affect using questionnaires. Participants were required to perform a number of air traffic control tasks using the immersive human accessible Virtual Reality space in the "eXperience Induction Machine". Based on the data collected, we developed and validated a model which integrates personality, workload and affective theories. Our results indicate that the difficulty of an air traffic control task has a direct influence on cognitive workload as well as on the self-reported mood; whereas both mood and workload seem to change independently. In addition, we show that personality, in particular neuroticism, affects both mood and performance of the participants.

- **Keywords:** Air traffic control; Personality; Workload; Mood; Virtual reality

Chiuhsiang Joe Lin, Retno Widyaningrum. *The effect of parallax on eye fixation parameter in projection-based stereoscopic displays.* Pages 10-16.

The promising technology of stereoscopic displays is interesting to explore because 3D virtual applications are widely known. Thus, this study investigated the effect of parallax on eye fixation in stereoscopic displays. The experiment was conducted in three different levels of parallax, in which virtual balls were projected at the screen, at 20 cm and 50 cm in front the screen. The two important findings of this study are that parallax has significant effects on fixation duration, time to first fixation, number of fixations, and accuracy. The participant had more accurate fixations, fewer fixations, shorter fixation durations, and shorter times to first fixation when the virtual ball was projected at the screen than when it was projected at the other two levels of parallax.

- **Keywords:** Depth perception; Eye fixation; 3D tasks

Ali Shahvarpour, Richard Preuss, Michael J.L. Sullivan, Alessia Negrini, Christian Larivière. *The effect of wearing a lumbar belt on biomechanical*

and psychological outcomes related to maximal flexion-extension motion and manual material handling. Pages 17-24.

Workers with low back pain (LBP) may benefit from wearing a lumbar belt (LB), but the biomechanical and psychological mechanisms involved are not fully understood. Two types of flexible LB (extensible and non-extensible) were compared to a control condition (no LB) regarding pain-related (pain, fear of pain and catastrophizing) and biomechanical (range of motion – ROM) outcomes related to two tasks: maximal trunk flexion-extension and manual material handling. Healthy controls and participants with LBP were tested. During both tasks, the two LBs reduced the lumbar ROM in participants with LBP in the same way as healthy controls. This was observed even at the beginning of the trunk flexion movement, allowing generalization to many work tasks, that is to say tasks performed with small or deep trunk flexion. The two LBs reduced pain, fear of pain and catastrophizing in subjects with LBP. That may help a gradual re-exposure to physical work activities (disability prevention perspective), or maintaining these activities (secondary prevention perspective), following a LBP episode.

- **Keywords:** Low back pain; Range of motion; Fear of pain

Shi-Jian Luo, Ge Shu, Yan Gong. Real time relationship between individual finger force and grip exertion on distal phalanges in linear force following tasks. Pages 25-31.

Individual finger force (FF) in a grip task is a vital concern in rehabilitation engineering and precise control of manipulators because disorders in any of the fingers will affect the stability or accuracy of the grip force (GF). To understand the functions of each finger in a dynamic grip exertion task, a GF following experiment with four individual fingers without thumb was designed. This study obtained four individual FFs from the distal phalanges with a cylindrical handle in dynamic GF following tasks. Ten healthy male subjects with similar hand sizes participated in the four-finger linear GF following tasks at different submaximal voluntary contraction (SMVC) levels. The total GF, individual FF, finger force contribution, and following error were subsequently calculated and analyzed. The statistics indicated the following: 1) the accuracy and stability of GF at low %MVC were significantly higher than those at high SMVC; 2) at low SMVC, the ability of the fingers to increase the GF was better than the ability to reduce it, but it was contrary at high SMVC; 3) when the target wave (TW) was changing, all four fingers strongly participated in the force exertion, but the participation of the little finger decreased significantly when TW remained stable; 4) the index finger and ring finger had a complementary relationship and played a vital role in the adjustment and control of GF. The middle finger and little finger had a minor influence on the force control and adjustment. In conclusion, each of the fingers had different functions in a GF following task. These findings can be used in the assessment of finger injury rehabilitation and for algorithms of precise control.

- **Keywords:** Grip force following; Finger force; Finger force contribution; Real time; Distribution mechanism

Shota Yamanaka, Homei Miyashita. Paper-cutting operations using scissors in Drury's law tasks. Pages 32-39.

Human performance modeling is a core topic in ergonomics. In addition to deriving models, it is important to verify the kinds of tasks that can be modeled. Drury's law is promising for path tracking tasks such as navigating a path with pens or driving a car. We conducted an experiment based on the observation that paper-cutting tasks using scissors resemble such tasks. The results showed that cutting arc-like paths (1/4 of a circle) showed an excellent fit with Drury's law ($R^2 > 0.98$), whereas cutting linear paths showed a worse fit ($R^2 > 0.87$). Since linear paths yielded better fits when path

amplitudes were divided ($R^2 > 0.99$ for all amplitudes), we discuss the characteristics of paper-cutting operations using scissors.

- **Keywords:** Drury's law; Human motor performance; Paper-cutting tasks

Sarah M. Coppola, Michael Y.C. Lin, John Schilkowsky, Pedro M. Arezes, Jack T. Dennerlein. *Tablet form factors and swipe gesture designs affect thumb biomechanics and performance during two-handed use. Pages 40-46.*

Tablet computers' hardware and software designs may affect upper extremity muscle activity and postures. This study investigated the hypothesis that forearm muscle activity as well as wrist and thumb postures differ during simple gestures across different tablet form factors and touchscreen locations. Sixteen adult (8 female, 8 male) participants completed 320 tablet gestures across four swipe locations, with various tablet sizes (8" and 10"), tablet orientations (portrait and landscape), swipe orientations (vertical and horizontal), and swipe directions (medial and radial). Three-dimensional motion analysis and surface electromyography measured wrist and thumb postures and forearm muscle activity, respectively. Postures and muscle activity varied significantly across the four swipe locations ($p < .0001$). Overall, swipe location closest to the palm allowed users to swipe with a more neutral thumb and wrist posture and required less forearm muscle activity. Greater thumb extension and abduction along with greater wrist extension and ulnar deviation was required to reach the target as the target moved farther from the palm. Extensor Carpi Radialis, Extensor Carpi Ulnaris, Flexor Carpi Ulnaris, Extensor Pollicis Brevis, and Abductor Pollicis Longus muscle activity also increased significantly with greater thumb reach ($p < .001$). Larger tablet size induced greater Extensor Carpi Radialis, Extensor Carpi Ulnaris, Flexor Carpi Ulnaris, Flexor Carpi Radialis, and Abductor Pollicis Longus muscle activity ($p < .0001$). The study results demonstrate the importance of swipe locations and suggest that the tablet interface design can be improved to induce more neutral thumb and wrist posture along with lower forearm muscle load.

- **Keywords:** User interface design; Electromyography; Motion capture; Mobile computing

Marco Costa, Andrea Simone, Valeria Vignali, Claudio Lantieri, Nicola Palena. *Fixation distance and fixation duration to vertical road signs. Pages 48-57.*

The distance of first-fixation to vertical road signs was assessed in 22 participants while driving a route of 8.34 km. Fixations to road signs were recorded by a mobile eye-movement-tracking device synchronized to GPS and kinematic data. The route included 75 road signs. First-fixation distance and fixation duration distributions were positively skewed. Median distance of first-fixation was 51 m. Median fixation duration was 137 ms with a modal value of 66 ms. First-fixation distance was linearly related to speed and fixation duration. Road signs were gazed at a much closer distance than their visibility distance. In a second study a staircase procedure was used to test the presentation-time threshold that lead to a 75% accuracy in road sign identification. The threshold was 35 ms, showing that short fixations to a road signs could lead to a correct identification.

- **Keywords:** Road signs; Eye movements; Speed; Driver perception; First-fixation distance; Fixation duration

Jongryun Roh, Joonho Hyeong, Sayup Kim. *Influence of folding mechanism of bicycles on their usability. Pages 58-65.*

In this study, foldable bicycles were evaluated in terms of their usability. Four types of folding mechanisms were identified depending on the number of pivots and the pivot axis direction: single lateral pivot (SLP), single vertical pivot, dual lateral pivot, and combined vertical–lateral pivot. Next, four bicycles—one each of these four types—were selected as test specimens. Ten subjects performed folding and unfolding tasks on each of these bicycles, and three-dimensional body motions and ground reaction forces were measured. The maximum trunk flexion angles and maximum increments in the ground reaction force were used as governing parameters for evaluating the comfort level for each bicycle type. The SLP type provided the lowest upper body flexion and ground reaction force and was hence judged to be the most comfortable folding system. Hence, a promising type of easily foldable bicycle was proposed, thereby encouraging its incorporation into public transit systems.

- **Keywords:** Foldable bicycle; Pivot axis; Motion analysis

Hyun K. Kim, Jaehyun Park, Yeongcheol Choi, Mungyeong Choe. *Virtual reality sickness questionnaire (VRSQ): Motion sickness measurement index in a virtual reality environment. Pages 66-73.*

Abstract: This study aims to develop a motion sickness measurement index in a virtual reality (VR) environment. The VR market is in an early stage of market formation and technological development, and thus, research on the side effects of VR devices such as simulator motion sickness is lacking. In this study, we used the simulator sickness questionnaire (SSQ), which has been traditionally used for simulator motion sickness measurement. To measure the motion sickness in a VR environment, 24 users performed target selection tasks using a VR device. The SSQ was administered immediately after each task, and the order of work was determined using the Latin square design. The existing SSQ was revised to develop a VR sickness questionnaire, which is used as the measurement index in a VR environment. In addition, the target selection method and button size were found to be significant factors that affect motion sickness in a VR environment. The results of this study are expected to be used for measuring and designing simulator sickness using VR devices in future studies.

- **Keywords:** Virtual reality; Motion sickness; Simulator sickness questionnaire

Luca Orlandi, Benjamin Brooks. *Measuring mental workload and physiological reactions in marine pilots: Building bridges towards redlines of performance. Pages 74-92.*

This paper investigates the effects of shiphandling manoeuvres on mental workload and physiological reactions in ten marine pilots. Each pilot performed four berthings in a ship simulator. Those berthings were differentiated by two factors, level of difficulty and familiarity with the port. Each berthing could also be divided into five phases, three during the execution and two resting periods, one before and one after the execution (dedicated to baseline physiological data collection). Mental workload was measured through two self assessment scales: the NASA TLX and a Likert scale. Power spectral densities on Beta bands 1 and 2 were obtained from EEG. Heart rate and heart rate variability were obtained from ECG. Pupil dilation was obtained from eye tracking. Workload levels were higher as berthings increased in difficulty level and/or the pilots completed the berthings in unfamiliar ports. Responses differed across specific phases of the berthings. Physiological responses could indirectly monitor levels of mental workload, and could be adopted in future applications to evaluate training improvements and performance. This study provides an example of an applied methodology aiming to define an upper redline of task demands in the context of marine pilotage.

- **Keywords:** Mental workload; Marine pilotage; Physiological measures

Kristina Karstad, Reiner Rugulies, Jørgen Skotte, Pernille Kold Munch, Birgit A. Greiner, Alex Burdorf, Karen Søgaard, Andreas Holtermann. *Inter-rater reliability of direct observations of the physical and psychosocial working conditions in eldercare: An evaluation in the DOSES project.* Pages 93-103.

The aim of the study was to develop and evaluate the reliability of the “Danish observational study of eldercare work and musculoskeletal disorders” (DOSES) observation instrument to assess physical and psychosocial risk factors for musculoskeletal disorders (MSD) in eldercare work. During 1.5 years, sixteen raters conducted 117 inter-rater observations from 11 nursing homes. Reliability was evaluated using percent agreement and Gwet's AC1 coefficient. Of the 18 examined items, inter-rater reliability was excellent for 7 items ($AC1 > 0.75$) fair to good for 7 items ($AC1 0.40 - 0.75$) and poor for 2 items ($AC1 0 - 0.40$). For 2 items there was no agreement between the raters ($AC1 < 0$). The reliability did not differ between the first and second half of the data collection period and the inter-rater observations were representative regarding occurrence of events in eldercare work. The instrument is appropriate for assessing physical and psychosocial risk factors for MSD among eldercare workers.

- **Keywords:** Nursing home; Healthcare; Patient handling activities

Peter E. D. Love, Jim Smith, Pauline Teo. *Putting into practice error management theory: Unlearning and learning to manage action errors in construction.* Pages 104-111.

Error management theory is drawn upon to examine how a project-based organization, which took the form of a program alliance, was able to change its established error prevention mindset to one that enacted a learning mindfulness that provided an avenue to curtail its action errors. The program alliance was required to unlearn its existing routines and beliefs to accommodate the practices required to embrace error management. As a result of establishing an error management culture the program alliance was able to create a collective mindfulness that nurtured learning and supported innovation. The findings provide a much-needed context to demonstrate the relevance of error management theory to effectively address rework and safety problems in construction projects. The robust theoretical underpinning that is grounded in practice and presented in this paper provides a mechanism to engender learning from errors, which can be utilized by construction organizations to improve the productivity and performance of their projects.

- **Keywords:** Action errors; Construction; Error management; Learning; Rework; Safety incidents; Unlearning

Richard M. Kesler, Grace S. Deetjen, Faith F. Bradley, Michael J. Angelini, Matthew N. Petrucci, Karl S. Rosengren, Gavin P. Horn, Elizabeth T. Hsiao-Weckler. *Impact of SCBA size and firefighting work cycle on firefighter functional balance.* Pages 112-119.

Slips, trips and falls are leading causes of fireground injuries. A functional balance test (FBT) was used to investigate the effects of self-contained breathing apparatus (SCBA) size and design, plus firefighting work cycle. During the FBT, subjects walked along a narrow platform and turned in defined spaces, with and without an overhead obstacle. Thirty firefighters wore three varying-sized standard SCBAs and a low-profile prototype SCBA during three simulated firefighting work/rest cycles. Firefighters were tested pre- and post-firefighting activity (one bout, two bouts with a 5-min break, or back-to-back bouts with no break). Subjects committed more errors and required longer completion times with larger SCBAs. Use of the prototype SCBA lead to lower times and fewer

errors. Performing a second bout of firefighting increased completion time. Firefighters need to consider how SCBA and amount of physical activity on the fireground may influence balance in order to reduce the risk of injury.

- **Keywords:** Firefighting; Self-contained breathing apparatus; Work cycle; Functional balance

Mark W. Wiggins, Edward Whincup, Jaime C. Auton. *Cue utilisation reduces effort but increases arousal during a process control task. Pages 120-127.*

Abstract: Process control environments are characterised by rapid changes in work demands, the successful response to which is dependent upon the availability of cognitive resources. Since high cue utilisation is associated with a reduction in cognitive load and a consequent release of residual resources, it was hypothesised that participants with high cue utilisation would experience lower subjective arousal and lower physiological effort in response to increases in the work demands associated with a simulated rail control task. A total of 41 participants completed a 10 min, low work demand period, followed by a 10 min, high work demand condition. High cue utilisation was associated with a reduction in systolic blood pressure and the maintenance of sustained, superior performance in response to high work demands. However, an increase in subjective arousal was also evident. The outcomes have implications for the selection and assessment of operators of high reliability, dynamic, process control environments.

- **Keywords:** Cue utilisation; Effort; Arousal; Physiology; Process-control

Carole James, Daphne James, Valerie Nie, Tracy Schumacher, Maya Guest, John Tessier, Jeffrey Marley, Joanna Bohatko-Naismith, Suzanne Snodgrass. *Musculoskeletal discomfort and use of computers in the university environment. Pages 128-135.*

This cross-sectional study investigated musculoskeletal discomfort and computer use in university staff, through the use of online questionnaires. Results showed a high prevalence of staff reported musculoskeletal discomfort during the preceding year (80%), with neck (60%), shoulder (53%) and lower back discomfort (47%) being the most common. Most believed discomfort was caused by work, although neck discomfort was significantly less in those reporting excellent mental health (OR 0.44, $p < 0.01$). Computer navigation was performed primarily by mouse (77%); however, using a touch pad increased the odds (OR 1.17, $p < 0.01$) of wrist discomfort and the belief it was caused by work (OR 1.19, $p < 0.01$). Few staff attended ergonomic training (16%) or requested workstation assessments (26%). However, high rates of staff reporting musculoskeletal discomfort sought professional treatment (range: 35.2% wrist/hand to 65.0% shoulder). Strategies are needed to address uptake of preventive measures and reduce reliance on medical treatments following musculoskeletal discomfort in universities.

- **Keywords:** Musculoskeletal; Computer; University

Carl Pankok, David Kaber. *The effect of navigation display clutter on performance and attention allocation in presentation- and simulator-based driving experiments. Pages 136-145.*

Abstract: Display clutter can have differential effects based on environmental factors, such as workload, stress, and experiment paradigm. The objectives of the current study were to assess the effects of display clutter on driver performance and attention allocation and compare results across two experimental paradigms. Forty-two

participants searched high- and low-clutter in-car navigation displays for routine information either during a static, presentation-based experiment or in a dynamic, driving simulator experiment. Results revealed display clutter to significantly alter attention allocation and degrade performance in the presentation experiment, but had little to no effect on driver performance or attention allocation in the driving simulator experiment. Results suggest that display clutter may have its greatest effect on performance and attention allocation in domains requiring extended attention to the cluttered display compared to tasks in which the cluttered display acts as a support tool for secondary tasks.

- **Keywords:** Display clutter; Driving simulator; Driver performance; Attention allocation

Michal Glinka, Sabrina Metzger, Daniel Viggiani, Jack Callaghan. *The effect of task type and perceived demands on postural movements during standing work.* Pages 146-152.

Abstract: This study investigated how task demands affect postural behaviour during standing. Twenty-four participants completed three different 12-min tasks: (1) a cognitive task that involved answering questions based on a written passage; (2) a light manual assembly task; and (3) standing quietly with no secondary task. The manual task was associated with the lowest amount of postural movement and a more static pose than the other two conditions. Specifically, postural variability of the lumbar ($F = 5.8$; $p = 0.01$) and thoracic ($F = 4.2$; $p = 0.03$) spine, and fidgets and shifts of the spine ($F = 3.2$; $p = 0.048$), were lowest in the manual task. Additionally, individuals perceiving tasks to be more demanding—regardless of task type—tended to move less ($p = 0.049$) than those perceiving lower demands. These findings provide important initial evidence that the type and perceived demands of standing work tasks can affect postural movement.

- **Keywords:** Standing; Posture; Ergonomics; Back pain

Aaron P.J. Roberts, Neville A. Stanton, Daniel T. Fay. *Go Deeper, Go Deeper: Understanding submarine command and control during the completion of dived tracking operations.* Pages 162-175.

This is a world's first-of-a-kind study providing empirical evidence for understanding submarine control room performance when completing higher and lower demand Dived Tracking (DT) scenarios. A submarine control room simulator was built, using a non-commercial version of Dangerous Waters as the simulation engine. The creation of networked workstations allowed a team of nine operators to perform tasks completed by submarine command teams during DT. The Event Analysis of Systemic Teamwork (EAST) method was used to model the social, task and information networks and describe command team performance. Ten teams were recruited for the study, affording statistical comparisons of how command team roles and level of demand affected performance. Results indicate that command teams can covertly DT a contact differently depending on demand (e.g. volume of contacts). In low demand it was possible to use periscope more often than in high demand, in a 'duck-and-run' fashion. Therefore, the type of information and frequency of particular task completion, was significantly different between the higher and lower demand conditions. This resulted in different operators in the command team experiencing greater demand depending on how the DT mission objective was completed. Potential bottlenecks in the command team were identified and implications are discussed alongside suggestions for future work.

- **Keywords:** Submarine; Team work; Command and control; Networks

Tyler Rose, Chang S. Nam, Karen B. Chen. *Immersion of virtual reality for rehabilitation – Review. Pages 153-161.*

Abstract: Virtual reality (VR) shows promise in the application of healthcare and because it presents patients an immersive, often entertaining, approach to accomplish the goal of improvement in performance. Eighteen studies were reviewed to understand human performance and health outcomes after utilizing VR rehabilitation systems. We aimed to understand: (1) the influence of immersion in VR performance and health outcomes; (2) the relationship between enjoyment and potential patient adherence to VR rehabilitation routine; and (3) the influence of haptic feedback on performance in VR. Performance measures including postural stability, navigation task performance, and joint mobility showed varying relations to immersion. Limited data did not allow a solid conclusion between enjoyment and adherence, but patient enjoyment and willingness to participate were reported in care plans that incorporates VR. Finally, different haptic devices such as gloves and controllers provided both strengths and weakness in areas such movement velocity, movement accuracy, and path efficiency.

- **Keywords:** Haptic feedback; Rehabilitation; Virtual reality