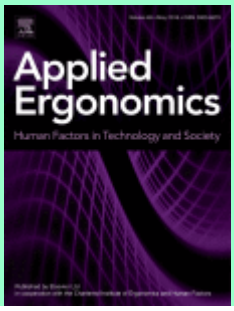
Applied Ergonomics - rok 2023, Volume 111

September



Dominique Engome Tchupo, Gretchen A. Macht. *Entropy for team communication pattern recognition*. 104038.

This work aims to demonstrate entropy as a method that can be used to analyze team coordination using naturalistic team communication content. Much of team coordination happens through communication; understanding team communication is vital to better formulate and train teams for successful performance outcomes. Several decades of team communication research have led to various methods for analyzing team communication patterns. Many existing methods for team communication analysis have not been tested with naturalistic communication or only consider the frequency or flow of communication. Sliding-window entropy is used to analyze team coordination dynamics with team communication as a proxy. The resulting time series are evaluated using nonlinear dynamical systems analysis and clustering. Various team coordination patterns are identified using communication entropy at the team level. Entropy can be used to identify team communication patterns and their relation to team performance. While team coordination happens at the team level, a posteriori analysis indicates members' individual characteristics affect the overall team coordination patterns. In teams where the contribution is unequal, some members disproportionately affect the overall team coordination, which may undermine the team impact and affect team performance.

- **Keywords:** Entropy; Team communication; Team performance; Communication patterns

Mamiko Noguchi, Jackie D. Zehr, Liana M. Tennant, Donna J. Fok, Jack P. Callaghan. *Increasing movement during office work at sit-stand workstations: A novel seating device to facilitate transitions*. 104044.

A novel active office chair (Movably Pro) was designed to facilitate frequent sit-stand movement 1) through auditory and tactile prompts and 2) with minimal-to-no work surface adjustment when transitioning. The purpose of this study was to compare lumbopelvic kinematics, discomfort, and task performance between the novel chair and traditional sitting/standing. Sixteen participants completed three separate 2-h sedentary exposures. Although participants transitioned every 3 min between sitting and standing with the novel chair, productivity was not affected. When standing in the novel chair, the lumbopelvic angles fell in between traditional sitting and standing ($p < 0.01$). Movement and/or postural changes that occurred with the novel chair reduced low back and leg discomfort for pain developers (PDs) ($p < 0.01$). All participants classified as PDs in traditional standing were non-PDs with the novel chair. This intervention was effective in reducing sedentary time without the time loss associated with desk movement.

- **Keywords:** Low back pain; Chair design; Sit-stand workstation

Ziqing Xu, Waldemar Karwowski, Erman Çakıt, Lauren Reineman-Jones, Atsuo Murata, Awad Aljuaid, Nabin Sapkota, Peter Hancock. *Nonlinear dynamics of EEG responses to unmanned vehicle visual detection with different levels of task difficulty*. 104045.

The main objective of this study was to examine the presence of chaos in the EEG recordings of brain activity under simulated unmanned ground vehicle visual detection scenarios with different levels of task difficulty. One hundred and fifty people participated in the experiment and completed four visual detection task scenarios: (1) change detection, (2) a threat detection task, (3) a dual-task with different change detection task rates, and (4) a dual-task with different threat detection task rates. We used the largest Lyapunov exponent and correlation dimension of the EEG data and performed 0–1 tests on the EEG data. The results revealed a change in the level of nonlinearity in the EEG data corresponding to different levels of cognitive task difficulty. The differences in EEG nonlinearity measures among the studied levels of task difficulty, as well as between a single task scenario and a dual-task scenario, have also been assessed. The results increase our understanding of the nature of unmanned systems' operational requirements.

- **Keywords:** Cognitive task difficulty; Workload; EEG; Nonlinear dynamics; Unmanned systems

Mads Daabeck Boysen, Mathias Munk-Hansen, Mike Steffensen, Anders Holsgaard-Larsen, Pascal Madeleine. *The biomechanical differences of wearing safety shoes compared with everyday shoes on dynamic balance when tripping over an obstacle*. 104040.

Safety shoes are known to challenge dynamic balance, but the interaction between footwear and trips has not been thoroughly explored. This study investigated the biomechanical differences on dynamic balance during unexpected trip perturbations between safety shoes and everyday shoes. The vertical position of the whole-body center of mass (CoM) and the linear momentum of the swing leg from seven females and sixteen males were analyzed in five subsequent gait cycles. Additionally, the recovery strategies (i.e., the displacement of the foot after tripping) were classified. Wearing safety shoes, the linear momentum of the foot and whole leg increased, and the vertical position of the whole-body CoM was lower after the perturbation. Additionally, the recovery strategy when wearing safety shoes demonstrated a lower displacement of the foot. In conclusion, wearing safety shoes was found to have negative biomechanical effects when having to circumvent a trip, and this potentially increased the risk of falling.

- **Keywords:** Trip; Fall; Perturbation; Locomotion; Statistical parametric mapping

D. Buser, A. Schwaninger, J. Sauer, Y. Sterchi. *Time on task and task load in visual inspection: A four-month field study with X-ray baggage screeners*. 103995.

Previous studies suggest that performance in visual inspection and typical vigilance tasks depend on time on task and task load. European regulation mandates that security officers (screeners) take a break or change tasks after 20 min of X-ray baggage screening. However, longer screening durations could reduce staffing challenges. We investigated the effects of time on task and task load on visual inspection performance in a four-month field study with screeners. At an international airport, 22 screeners inspected X-ray images of cabin baggage for up to 60 min, while a control group (N = 19) screened for 20 min. Hit rate remained stable for low and average task loads.

However, when the task load was high, the screeners compensated by speeding up X-ray image inspection at the expense of the hit rate over time on task. Our results support the dynamic-allocation resource theory. Moreover, extending the permitted screening duration to 30 or 40 min should be considered.

- **Keywords:** Time on task; Visual search; X-ray image inspection

Kyung Hun Jung, Jack T. Labriola, Hyunjin Baek. *Projecting the planned trajectory of a Level–2 automated vehicle in the windshield: Effects on human drivers' take–over response to silent failures*. 104047.

To enhance the take–over performance by human drivers of Level–2 automated vehicles (AV), we developed a design concept that presents the AV's planned trajectory as augmented reality in the windshield. We hypothesized that, even when the AV does not release a take–over request before a potential crash (i.e., silent failure), the planned trajectory would allow the driver to foresee the crash and enhance the take–over performance. To test this hypothesis, we conducted a driving–simulator experiment where participants monitored the driving status of an AV with or without the planned trajectory in the context of silent failures. The results showed that, when the planned trajectory was projected in the windshield as if it were an augmented–reality display, the crash rate decreased by 10% and the take–over response time decreased by 825 ms compared to when the planned trajectory was not provided.

- **Keywords:** Automated vehicles; Planned trajectory; Take–over performance; Silent failure; Augmented reality

Hamid Norasi, Tianke Wang, Emmanuel Tetteh, Tianqi Smith, Victor J. Davila, Young Erben, Randall R. DeMartino, M. Susan Hallbeck, Bernardo C. Mendes. *Intraoperative workload in elective open vascular and endovascular surgery: A study of procedural drivers*. 104049.

This study investigated vascular surgeon workload and its association with specific procedural drivers over different procedure types. Thirteen attending vascular surgeons (two females) were emailed a survey over a 3-month period. Data from 253 surgical procedures (118 open, 85 endovascular, 18 hybrid, and 32 venous) revealed high physical and cognitive workload among vascular surgeons. Based on the statistically significant findings and similar non-significant trends in the data (significance level of 0.01), open and hybrid vascular procedures showed higher levels of physical and cognitive workload compared to venous cases, while endovascular procedures were relatively more moderate. Additionally, the workload subscales for five subcategories of open procedures (e.g., arteriovenous access) as well as three subcategories of endovascular procedures (e.g., aortic) were compared. The granularity of the intraoperative workload drivers across various vascular procedure types and adjunct equipment could be the key to create targeted ergonomic interventions to reduce workload during vascular surgeries.

- **Keywords:** Vascular surgeons; Musculoskeletal disorders; Adjunct equipment

Christofer Rydenfält, Johanna Persson, Gudbjörg Erlingsdóttir, Roger Larsson, Gerd Johansson. *Home care nurses' and managers' work environment during the Covid-19 pandemic: Increased workload, competing demands, and unsustainable trade-offs*. 104056.

Little research exists on how home care nursing personnel have experienced the Covid-19 pandemic. This qualitative study explores the work environment related challenges nurses and managers in home care faced during the pandemic. We discuss these

challenges in relation to the Demand-Control-Support Model and reflect on how the organizational dynamics associated with them can be understood using the competing pressures model. During the pandemic, home care nurses and managers experienced both an increased workload and psychosocial strain. For managers, the increased complexity of work was a major problem. We identify three key takeaways related to sustainable crisis management: 1) to support managers' ability to provide social support to their personnel, 2) to increase crisis communication preparedness, and 3) to apply a holistic perspective on protective gear use. We also conclude that the competing pressures model is useful when exploring the dynamics of the work environment in complex organizational contexts.

- **Keywords:** Covid-19; Work environment; Home care nursing; Competing pressures and crisis management

Lewis Cockram, Megan L. Bartlett, Jason S. McCarley. *Simple manipulations of anthropomorphism fail to induce perceptions of humanness or improve trust in an automated agent*. 104027.

Although automation is employed as an aid to human performance, operators often interact with automated decision aids inefficiently. The current study investigated whether anthropomorphic automation would engender higher trust and use, subsequently improving human-automation team performance. Participants performed a multi-element probabilistic signal detection task in which they diagnosed a hypothetical nuclear reactor as in a state of safety or danger. The task was completed unassisted and assisted by a 93%-reliable agent varying in anthropomorphism. Results gave no evidence that participants' perceptions of anthropomorphism differed between conditions. Further, anthropomorphic automation failed to bolster trust and automation-aided performance. Findings suggest that the benefits of anthropomorphism may be limited in some contexts.

- **Keywords:** Automation; Anthropomorphism; Signal detection

Brandon J. King, Gemma J.M. Read, Paul M. Salmon. *Identifying risk controls for future advanced brain-computer interfaces: A prospective risk assessment approach using work domain analysis*. 104028.

Brain-computer interface (BCI) technologies are progressing rapidly and may eventually be implemented widely within society, yet their risks have arguably not yet been comprehensively identified, nor understood. This study analysed an anticipated invasive BCI system lifecycle to identify the individual, organisational, and societal risks associated with BCIs, and controls that could be used to mitigate or eliminate these risks. A BCI system lifecycle work domain analysis model was developed and validated with 10 subject matter experts. The model was subsequently used to undertake a systems thinking-based risk assessment approach to identify risks that could emerge when functions are either undertaken sub-optimally or not undertaken at all. Eighteen broad risk themes were identified that could negatively impact the BCI system lifecycle in a variety of unique ways, while a larger number of controls for these risks were also identified. The most concerning risks included inadequate regulation of BCI technologies and inadequate training of BCI stakeholders, such as users and clinicians. In addition to specifying a practical set of risk controls to inform BCI device design, manufacture, adoption, and utilisation, the results demonstrate the complexity involved in managing BCI risks and suggests that a system-wide coordinated response is required. Future research is required to evaluate the comprehensiveness of the identified risks and the practicality of implementing the risk controls.

- **Keywords:** Brain-computer interfaces; Risk assessment; System modelling

Luce Drouet, Carine Lallemand, Vincent Koenig, Francesco Viti, Kerstin Bongard-Blanchy. Uncovering factors influencing railway passenger experiences through love and breakup declarations. 104030.

While existing approaches for assessing passenger experience are often limited to surveys of customer satisfaction, societal and technological challenges push the railway industry to adopt a user-centric approach to the design of their service. We used the love and breakup method in a study involving N = 53 passengers making a declaration to their railway company to collect qualitative feedback on the passenger experience. The method allowed to gather personal, emotional, and contextual insights into passengers' experiences that can inform the transportation service design process. We describe 21 factors and 8 needs influencing the passenger experience, thereby consolidating and deepening prior work in the railway context. Using the lens of user experience theories, we argue that the service should be assessed against fulfilling these needs, which can act as guiding principles regarding service improvement. The study also presents valuable insights into the love and breakup method to explore service experiences.

- **Keywords:** Customer experience; Service design; Railway transportation

Siobhan E. Merriman, Katherine L. Plant, Kirsten M.A. Revell, Neville A. Stanton. *A new approach for Training Needs Analysis: A case study using an Automated Vehicle*. 104014.

Considerable resources are invested each year into training to ensure trainees have the required competencies to safely and effectively perform their tasks/jobs. As such, it is important to develop effective training programmes which target those required competencies. One method that can be used at the start of the training lifecycle to establish the tasks and competencies that are required for a task/job and is considered an important activity to perform when developing a training programme is a Training Needs Analysis (TNA). This article presents a new TNA approach and uses an Automated Vehicle (AV) case study to demonstrate this new approach for a specific AV scenario within the current UK road system. A Hierarchical Task Analysis (HTA) was performed in order to identify the overall goal and tasks that drivers need to perform to operate the AV system safely on the road. This HTA identified 7 main tasks which were decomposed into 26 sub-tasks and 2428 operations. Then, six AV driver training themes from the literature were combined with the Knowledge, Skills and Attitudes (KSA) taxonomy to identify the KSAs that drivers need to perform the tasks, sub-tasks and operations that were identified in the HTA (training needs). This resulted in the identification of over 100 different training needs. This new approach helped to identify more tasks, operations and training needs than previous TNAs which applied the KSA taxonomy alone. As such, a more comprehensive TNA for drivers of the AV system was produced. This can be more easily translated into the development and evaluation of future training programmes for drivers of AV systems.

- **Keywords:** Automated Vehicles; Training Needs Analysis; Driver training; Hierarchical Task Analysis

S.E. Kranenborg, C. Greve, M.F. Reneman, C.C. Roossien. *Side-effects and adverse events of a shoulder- and back-support exoskeleton in workers: A systematic review*. 104042.

Introduction: While the biomechanical effects of exoskeletons are well studied, research about potential side-effects and adverse events are limited. The aim of this systematic review was to provide an overview of the side-effects and adverse events on shoulder- and back-support exoskeletons during work tasks. **Methods:** Four in-field studies and 32 laboratory studies were included in this review, reporting on n = 18 shoulder

exoskeletons, n = 9 back exoskeletons, n = 1 full body with a supernumerary arm, and n = 1 combination of shoulder and back exoskeleton. **Results:** The most frequent side-effect reported is discomfort (n = 30), followed by a limited usability of the exoskeleton (n = 16). Other identified side-effects and adverse events were changes in muscle activity, mobility, task performance, balance and posture, neurovascular supply, gait parameters and precision. An incorrect fit of the exoskeleton and the decreased degrees of freedom are most often reported as causes of these side-effects. Two studies did not find any side-effects. This review also showed that there are differences in the occurrence of side-effects in gender, age, and physical fitness. Most studies (89%) were conducted in a laboratory setting. Most studies (97%) measured short-term effects only. Psychological and social side-effects or adverse events were not reported. Side-effects and adverse events for active exoskeletons were understudied (n = 4). **Conclusion:** It was concluded that the evidence for side-effects and adverse events is limited. If available, it mainly consists of reports of mild discomfort and limited usability. Generalisation is limited because studies were conducted in lab settings and measured short term only, and most participants were young male workers.

- **Keywords:** Musculoskeletal disorders; Human-machine interaction; Prevention

Siri Hegna Berge, Joost de Winter, Marjan Hagenzieker. *Support systems for cyclists in automated traffic: A review and future outlook*. 104043.

Interaction with vulnerable road users in complex urban traffic environments poses a significant challenge for automated vehicles. Solutions to facilitate safe and acceptable interactions in future automated traffic include equipping automated vehicles and vulnerable road users, such as cyclists, with awareness or notification systems, as well as connecting road users to a network of motorised vehicles and infrastructure. This paper provides a synthesis of the current literature on communication technologies, systems, and devices available to cyclists, including technologies present in the environment and on motorised interaction partners such as vehicles, and discusses the outlook for technology-driven solutions in future automated traffic. The objective is to identify, classify, and count the technologies, systems, and devices that have the potential to aid cyclists in traffic with automated vehicles. Additionally, this study aims to extrapolate the potential benefits of these systems and stimulate discourse on the implications of connected vulnerable road users. We analysed and coded 92 support systems using a taxonomy of 13 variables based on the physical, communicational, and functional attributes of the systems. The discussion frames these systems into four categories: cyclist wearables, on-bike devices, vehicle systems, and infrastructural systems, and highlights the implications of the visual, auditory, motion-based, and wireless modes of communication of the devices. The most common system was cyclist wearables (39%), closely followed by on-bike devices (38%) and vehicle systems (33%). Most systems communicated visually (77%). We suggest that interfaces on motorised vehicles accommodate cyclists with visibility all around the car and incorporate two-way communication. The type of system and the effect of communication modality on performance and safety needs further research, preferably in complex and representative test scenarios with automated vehicles. Finally, our study highlights the ethical implications of connected road users and suggests that the future outlook of transport systems may benefit from a more inclusive and less car-centred approach, shifting the burden of safety away from vulnerable road users and promoting more cyclist-friendly solutions.

- **Keywords:** Support systems; Cyclist; Automated vehicles

Megan J. Blakely, Samantha L. Smith, Paul N. Russell, William S. Helton. *Dual-task effects between tone counting and mathematical calculations*. 104052.

We examined the impact of performing a tone counting task of varying cognitive loads and mathematical calculations simultaneously, compared to performance on the same tasks done individually. Participants performed continuous mathematical calculations, performed a high and a low cognitive load tone counting task, and also performed the math and counting tasks simultaneously. Performing the two tasks together resulted in significant dual-task interference. We also compared these results to previous studies employing the tone counting tasks with physically demanding tasks (climbing, kayaking and running). The interference between tone counting and mathematical calculations was worse than the interference between tone counting and running and kayaking. For climbing, the difference in interference was more nuanced with evidence indicating climbing uniquely asserts task prioritization. These findings have implications for operations requiring dual or multi-tasking.

- **Keywords:** Calculations; Climbing; Dual-task; Tone counting