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Patrick Waterson. *World War II and other historical influences on the formation of the Ergonomics Research Society.* Pages 1111-1129.

Little has been written about wartime ergonomics and the role this played in prompting the need for a society dedicated to ergonomics within the UK, namely the formation of the Ergonomics Research Society (ERS) in early 1950. This article aims to fill this gap in our understanding of the history of ergonomics in the UK and provide further details of the types of research undertaken by wartime research groups and committees such as the Institute of Aviation Medicine, Medical Research Council Applied Psychology Unit and the Flying Personnel Research Committee. In addition, the role of societal developments such as wartime links with the USA, the post-war drive to increase productivity and collaboration with industry and the recommendations of government committees in stimulating the work of the ERS are described in detail. This article also offers some reflection on present-day ergonomics in the UK and how this contrasts with the past.

Statement of Relevance: This article will provide practitioners with a historical perspective on the development of ergonomics from its roots in the Second World War. These developments shed light on current trends and challenges within the discipline as a whole.

- **Keywords:** history of human factors and ergonomics, Ergonomics Research Society, Second World War human factors and ergonomics

Yung-Hsiang Cheng & Yu-Chun Tsai. *Railway-controller-perceived competence in incidents and accidents.* Pages 1130-1146.

Railway controllers play a pivotal role in service recovery of normal rail system operations when incidents and accidents occur. Those in this position must have sufficient competence to overcome task difficulties caused by accident uncertainties. This study adopts Taiwan's railway system as a case study to diagnose railway-controller-perceived competence when facing diverse tasks during incidents and accidents that are derived from a proposed conceptual model. Railway-controller-perceived competence is measured using the Rasch model. Analytical results indicate that working with an external rescue agency handling a rescue operation, explanations to the public, and communication with an external rescue agency are considered the most troublesome tasks. Additionally, railway-controller-perceived competence differs based on the work experience. This information will prove useful for rail system operators and government

regulators when designing and regulating railway controller competence management systems. **Statement of Relevance:** This study presents a systematic approach for examining the gap between railway-controller-perceived competence and task difficulties associated with incidents and accidents. The relevance of findings encompasses the effects of transportation ergonomics and railway issues on the problem-solving competence and decision-making skills of railway controllers, and the competence management system.

- **Keywords:** railway controller, perceived competence, Rasch model, incidents and accidents

Charlie D. Frowd, Faye C. Skelton, Neelam Butt, Amal Hassan, Stephen Fields & Peter J.B. Hancock. *Familiarity effects in the construction of facial-composite images using modern software systems. Pages 1147-1158.*

We investigate the effect of target familiarity on the construction of facial composites, as used by law enforcement to locate criminal suspects. Two popular software construction methods were investigated. Participants were shown a target face that was either familiar or unfamiliar to them and constructed a composite of it from memory using a typical 'feature' system, involving selection of individual facial features, or one of the newer 'holistic' types, involving repeated selection and breeding from arrays of whole faces. This study found that composites constructed of a familiar face were named more successfully than composites of an unfamiliar face; also, naming of composites of internal and external features was equivalent for construction of unfamiliar targets, but internal features were better named than the external features for familiar targets. These findings applied to both systems, although benefit emerged for the holistic type due to more accurate construction of internal features and evidence for a whole-face advantage. **Statement of Relevance:** This work is of relevance to practitioners who construct facial composites with witnesses to and victims of crime, as well as for software designers to help them improve the effectiveness of their composite systems.

- **Keywords:** facial composite, eyewitness, evolutionary algorithms, facial feature, memory

Cheng-Jhe Lin & Changxu Wu. *Factors affecting numerical typing performance of young adults in a hear-and-type task. Pages 1159-1174.*

Numerical hear-and-type tasks, i.e. making immediate keypresses according to verbally presented numbers, possess both practical and theoretical importance but received relatively little attention. Effects of speech rates (500-ms vs. 1000-ms interval), urgency (urgent condition: performance-based monetary incentive plus time limit vs. non-urgent condition: flat-rate compensation) and finger strategies (single vs. multi-finger typing) on typing speed and accuracy were investigated. Fast speech rate and multi-finger typing produced more errors and slower typing speed. Urgency improved typing speed but decreased accuracy. Errors were almost doubled under urgent condition, while urgency effect on speed was similar to that of speech rate. Examination of error patterns did not fully support Salthouse's speculations about error-making mechanisms. The results implied that urgency could play a more important role in error-making than task demands. Numerical keyboard design and error detection could benefit from spatial incidence of errors found in this study. **Statement of Relevance:** This study revealed that classic speculations about error-making mechanisms in alphabetical typing do not necessarily translate to numerical typing. Factors other than external task demands such as urgency can affect typing performance to a similar or greater extent. Investigations of intrinsic error-making factors in non-traditional typing tasks are encouraged.

- **Keywords:** numerical typing, errors, multi-tasking, serial reaction time, speed-accuracy trade-off

Errol R. Hoffmann, Colin G. Drury & Carol J. Romanowski. *Performance in one-, two- and three-dimensional terminal aiming tasks.* Pages 1175-1185.

Arm movement times were measured to targets with independent constraints (target sizes) in one, two or three directions (width, height and depth). In each case, modified forms of Fitts' law give a good fit to the data, with the best form being dependent on all constraints in the 'Weighted Euclidean' model of Accot, J. and Zhai, S., 2003. (Refining Fitts' law models for bivariate pointing. *Proceedings of the SIGCHI conference on Human factors in computing systems CHI '03*, 5-10 April 2003, Ft. Lauderdale, FL. New York: ACM Press, 193-200). The best predictor includes all the individual ratios of amplitude of movement to target dimension related to the various constraints, with the maximum portion of variance accounted for by the index of difficulty (ID) in the direction of motion. The suggestion by various authors that the maximum of the ID associated with the different constraints will determine the movement times is only partially successful. An explanation for the results is given in terms of control strategy and the form of target. **Statement of Relevance:** In many tasks, workers move objects into limited spaces that allow only a single entry area. Termination of the movement may have constraints in one, two or three dimensions. Movement times for such tasks are important to predict industrial performance, and guide task designers in reducing physical constraints on performance.

- **Keywords:** Fitts' law, three-dimensional targets, movement times

Barbara E. Shykoff & Dan E. Warkander. *Physiologically acceptable resistance of an air purifying respirator.* Pages 1186-1196.

Physiologically acceptable limits of inspiratory impediment for air purifying respirators (APRs) were sought. Measurements on 30 subjects included pressure in, and flow through, an APR, and respiratory and cardiovascular variables. Exercise with and without APR included ladder climbing, load lift and transfer, incremental running and endurance running, with endurance at 85% peak oxygen uptake. Resistance that did not alter minute ventilation (\dot{V}_E) was judged acceptable long-term. Acceptable short-term impediments were deduced from end exercise conditions. Proposed long-term limits are inspiratory work of breathing per tidal volume (WOB_i/V_T) \leq 0.9 kPa and peak inspiratory pressure ($P_{i\ peak}$) \leq 1.2 kPa. Proposed short-term limits are: for $\dot{V}_E \leq 110$ L min⁻¹, $WOB_i/V_T \leq 1.3$ kPa and $P_{i\ peak} \leq 1.8$ kPa; and for $\dot{V}_E > 130$ L min⁻¹, $WOB_i/V_T \leq 1.6$ kPa. A design relation among \dot{V}_E , pressure-flow coefficients of an APR, and WOB_i/V_T is proposed. **Statement of Relevance:** This work generalises results from one APR by considering the altered physiological parameters related to factors inhibiting exercise. Simple expressions are proposed to connect bench-test parameters to the relation between ventilation and work of breathing. Population-based recommendations recognise that those who need more air flow can also generate higher pressures.

- **Keywords:** work of breathing, resistance, respirator, respiratory protective device, testing standards

Aitor Coca, Jung-Hyun Kim, Richard Duffy & W. Jon Williams. *Field evaluation of a new prototype self-contained breathing apparatus.* Pages 1197-1206.

Firefighters are required to use a self-contained breathing apparatus (SCBA) for respiratory protection when engaged in a variety of firefighting duties. While the SCBA provides crucial respiratory support and protection, it is also cumbersome and heavy, thus adding to the physical work performed by the firefighter. The purpose of the present study was to evaluate and compare the low profile SCBA prototype to a standard SCBA, as assessed by the objective and subjective measures of mobility and comfort, time of donning/doffing, as well as by acquiring user feedback on SCBA design features during field activities. The results of the present study indicated that the prototype SCBA was rated as a significant improvement over the standard SCBA in the areas of range of motion (ROM), mobility, comfort, induction of fatigue, interaction with protective clothing, and operability when worn over a standard firefighter ensemble, while performing a series of International Association of Fire Fighters Fire Ground Survival Program training exercises. **Statement of Relevance:** A prototype SCBA was evaluated and compared with a standard SCBA, focusing on the objective and subjective measures of mobility and comfort during field activities. Feedback from end users was collected during the evaluation. The findings of the present study can be used for improving the system design and overall performance of new prototype SCBAs.

- **Keywords:** self-contained breathing apparatus, range of motion, subjective perceptions, firefighters

Youlian Hong, Daniel Tik-Pui Fong & Jing Xian Li. *The effect of school bag design and load on spinal posture during stair use by children. Pages 1207-1213.*

Thirteen male children ascending and descending stairs with loads that equalled 0%, 10%, 15% and 20% of their body weight were the subject of our research: the boys were wearing an asymmetrical single-strap athletic bag or a symmetrical double-strap backpack during our experiments with them. The maximum spinal tilt to the loading side and to the support side, and the range of spinal motions, were obtained by using a motion analysis system. Our results showed that symmetry of spinal posture was observed both when they ascended staircase with all loads and descended in a backpack. When carrying an athletic bag with 15% and 20% of their body weight while ascending the staircase, the lateral spinal tilt to the supporting side was significantly increased. We concluded that a symmetrical backpack with a load not exceeding 20% or an asymmetrical single-strap athletic bag with a load not exceeding 10% should be recommended for school children in order to promote safer staircase use. **Statement of Relevance:** Children carrying heavy school bags may develop spinal problems. This study suggested that when they are using stairs, a symmetrical backpack with a load within 20% body weight is acceptable for them. When they are carrying an asymmetrical single-strap athletic bag, the bag's weight should not exceed 10% of the body weight in order to avoid excessive spinal tilt.

- **Keywords:** biomechanics, load-bearing, carrying, child, orthopaedics, gait

Bazil Basri & Michael J. Griffin. *The vibration of inclined backrests : perception and discomfort of vibration applied parallel to the back in the z-axis of the body. Pages 1214-1227.*

This study determined how backrest inclination and the frequency of vibration influence the perception and discomfort of vibration applied parallel to the back (vertical vibration when sitting upright, horizontal vibration when recumbent). Subjects experienced backrest vibration at frequencies in the range 2.5 to 25 Hz at vibration magnitudes up to 24 dB above threshold. Absolute thresholds, equivalent comfort contours, and the principal locations for feeling vibration were determined with four backrest inclinations: 0° (upright), 30°, 60° and 90° (recumbent). With all backrest inclinations, acceleration thresholds and equivalent comfort contours were similar and increased with increasing

frequency at 6 dB per octave (i.e. velocity constant). It is concluded that backrest inclination has little effect on the frequency dependence of thresholds and equivalent comfort contours for vibration applied along the back, and that the W_d frequency weighting in current standards is appropriate for evaluating z-axis vibration of the back at all backrest inclinations. **Statement of Relevance:** To minimise the vibration discomfort of seated people, it is necessary to understand how discomfort varies with backrest inclination. It is concluded that the vibration on backrests can be measured using a pad between the backrest and the back, so that it reclines with the backrest, and the measured vibration evaluated without correcting for the backrest inclination.

- **Keywords:** backrest angle, seat comfort, frequency weighting

Olivier Thuong & Michael J. Griffin. *The vibration discomfort of standing persons: evaluation of random and transient motions.* Pages 1228-1239.

The discomfort of standing people experiencing steady-state vibration can be predicted from the root-mean-square (rms) of the frequency-weighted acceleration, but alternative methods are advocated for evaluating motions containing transients. Using the method of magnitude estimation, 20 standing subjects estimated the discomfort caused by octave-bandwidth random vibrations at two centre frequencies (1 and 8 Hz) in each of three directions (fore-and-aft, lateral and vertical). For motions having seven different crest factors (i.e. the ratio of the peak to the rms value), the vibration magnitude required for similar discomfort, and a method predicting this equivalence, were determined. The rms method (with an exponent of 2) and the root-mean-quad method (exponent of 4) tended to, respectively, underestimate and overestimate the discomfort of high-crest factor motions. The optimum evaluation method had an exponent of about 3.0 for 1-Hz motions and 3.5 for 8-Hz motions. Current standards do not provide reliable indications of when vibration discomfort can be predicted by an rms measure. **Statement of Relevance:** Current standards recommend alternatives to the root-mean-square method (exponent of 2.0) for predicting the discomfort caused by transient vibration. The alternatives include the root-mean-quad or vibration dose value (exponent of 4.0) and peak values. An exponent of 2.0 underestimates, but an exponent of 4.0 slightly overestimates, the discomfort of transients experienced by standing people. Peak values are not appropriate.

- **Keywords:** vibration, discomfort, standing, transient