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Dorotea Kovačević, Maja Brozović & Klementina Možina. *Improving visual search in instruction manuals using pictograms*. Pages 1405-1419.

Instruction manuals provide important messages about the proper use of a product. They should communicate in such a way that they facilitate users' searches for specific information. Despite the increasing research interest in visual search, there is a lack of empirical knowledge concerning the role of pictograms in search performance during the browsing of a manual's pages. This study investigates how the inclusion of pictograms improves the search for the target information. Furthermore, it examines whether this search process is influenced by the visual similarity between the pictograms and the searched for information. On the basis of eye-tracking measurements, as objective indicators of the participants' visual attention, it was found that pictograms can be a useful element of search strategy. Another interesting finding was that boldface highlighting is a more effective method for improving user experience in information seeking, rather than the similarity between the pictorial and adjacent textual information. Implications for designing effective user manuals are discussed. **Practitioner Summary:** Users often view instruction manuals with the aim of finding specific information. We used eye-tracking technology to examine different manual pages in order to improve the user's visual search for target information. The results indicate that the use of pictograms and bold highlighting of relevant information facilitate the search process.

- **Keywords:** Consumer ergonomics, perception, attention and vigilance, manuals and instructions, eye-tracking

Inae C. Gadotti, Leonard Elbaum, YoungJin Jung, Victor Garbalosa, Stephen Kornbluth, Bruno Da Costa, Kinsuk Maitra & Denis Brunt. *Evaluation of eye, head and trunk coordination during target tracking tasks*. Pages 1420-1427.

This study tested the feasibility of a method to synchronise and to evaluate eye, head and trunk movement patterns during target tracking tasks performed by 10 subjects. A projected central target was randomly repositioned at 40° and 70° of rotation to the left and right. Subjects were instructed to change gaze as quickly as possible. Head and trunk motion was measured using a motion analysis system, and eye movement was measured using an eye-tracker; all data were synchronised. For healthy subjects, the eye

moved faster than the head, there was no trunk movement and the head moved more than the eye to reach further displaced targets. The method tested was feasible, and it could be used to evaluate eye, head and trunk movement patterns of subjects with injuries such as whiplash and concussions. **Practitioner Summary:** Studies of eye, head and trunk movements using synchronised methods are needed. We tested the feasibility of a method to synchronise and evaluate eye, head and trunk movement patterns. The method tested was feasible, and it could be used to evaluate movement patterns of subjects with injuries such as whiplash.

- **Keywords:** Kinematics, eye movement, head movement, motion analysis, response time

Régis Lobjois, Virginie Dagonneau & Brice Isableu. *The contribution of visual and proprioceptive information to the perception of leaning in a dynamic motorcycle simulator.* Pages 1428-1441.

Compared with driving or flight simulation, little is known about self-motion perception in riding simulation. The goal of this study was to examine whether or not continuous roll motion supports the sensation of leaning into bends in dynamic motorcycle simulation. To this end, riders were able to freely tune the visual scene and/or motorcycle simulator roll angle to find a pattern that matched their prior knowledge. Our results revealed idiosyncrasy in the combination of visual and proprioceptive information. Some subjects relied more on the visual dimension, but reported increased sickness symptoms with the visual roll angle. Others relied more on proprioceptive information, tuning the direction of the visual scenery to match three possible patterns. Our findings also showed that these two subgroups tuned the motorcycle simulator roll angle in a similar way. This suggests that sustained inertially specified roll motion have contributed to the sensation of leaning in spite of the occurrence of unexpected gravito-inertial stimulation during the tilt. Several hypotheses are discussed. **Practitioner Summary:** Self-motion perception in motorcycle simulation is a relatively new research area. We examined how participants combined visual and proprioceptive information. Findings revealed individual differences in the visual dimension. However, participants tuned the simulator roll angle similarly, supporting the hypothesis that sustained inertially specified roll motion contributes to a leaning sensation.

- **Keywords:** Motorcycle simulator, motion perception, visuo-proprioceptive gain, simulator sickness

Victoria A. Banks & Neville A. Stanton. *Driver-centred vehicle automation: using network analysis for agent-based modelling of the driver in highly automated driving systems.* Pages 1442-1452.

To the average driver, the concept of automation in driving infers that they can become completely 'hands and feet free'. This is a common misconception, however, one that has been shown through the application of Network Analysis to new Cruise Assist technologies that may feature on our roads by 2020. Through the adoption of a Systems Theoretic approach, this paper introduces the concept of driver-initiated automation which reflects the role of the driver in highly automated driving systems. Using a combination of traditional task analysis and the application of quantitative network metrics, this agent-based modelling paper shows how the role of the driver remains an integral part of the driving system implicating the need for designers to ensure they are provided with the tools necessary to remain actively in-the-loop despite giving increasing opportunities to delegate their control to the automated subsystems. **Practitioner Summary:** This paper describes and analyses a driver-initiated command and control system of automation using representations afforded by task and social networks to understand how drivers remain actively involved in the task. A network analysis of

different driver commands suggests that such a strategy does maintain the driver in the control loop.

- **Keywords:** Automation, command and control, driver-initiated automation, network analysis

Xiaofei Guan, Guoxin Fan, Zhengqi Chen, Ying Zeng, Hailong Zhang, Annan Hu, Guangfei Gu, Xinbo Wu, Xin Gu & Shisheng He. *Gender difference in mobile phone use and the impact of digital device exposure on neck posture*. Pages 1453-1461.

This cross-sectional study aimed to identify gender differences in the cervical postures when young adults were using mobile phones, as well as the correlations between the postures and the digital devices use (computer and mobile phone). Questionnaires regarding the habits of computer and mobile phone use were administered to 429 subjects aged from 17 to 33 years old (19.75 ± 2.58 years old). Subjects were instructed to stand habitually and use a mobile phone as in daily life; the sagittal head and cervical postures were measured by head flexion, neck flexion angle and gaze angle. Male participants had a significantly larger head flexion angle ($96.41^\circ \pm 12.23^\circ$ vs. $93.57^\circ \pm 12.62^\circ$, $p = 0.018$) and neck flexion angle ($51.92^\circ \pm 9.55^\circ$ vs. $47.09^\circ \pm 9.45^\circ$, $p < 0.001$) than females. There were significant differences in head ($F = 3.62$, $p = 0.014$) and neck flexion ($F = 3.99$, $p = 0.009$) between different amounts of computer use.

Practitioner Summary: We investigated possible gender differences in head and neck postures of young adults using mobile phones, as well as the potential correlations between these postures and digital device use. We found that males displayed larger head and neck flexion angles than females, which were associated with the amount of computer use.

- **Keywords:** Forward head posture, mobile phone use, gender, neck pain

Songil Lee, Gyouhyung Kyung, Jungyong Lee, Seung Ki Moon & Kyoung Jong Park. *Grasp and index finger reach zone during one-handed smartphone rear interaction: effects of task type, phone width and hand length*. Pages 1462-1472.

Recently, some smartphones have introduced index finger interaction functions on the rear surface. The current study investigated the effects of task type, phone width, and hand length on grasp, index finger reach zone, discomfort, and muscle activation during such interaction. We considered five interaction tasks (neutral, comfortable, maximum, vertical, and horizontal strokes), two device widths (60 and 90 mm) and three hand lengths. Horizontal (vertical) strokes deviated from the horizontal axis in the range from -10.8° to -13.5° ($81.6-88.4^\circ$). Maximum strokes appeared to be excessive as these caused 43.8% greater discomfort than did neutral strokes. The 90-mm width also appeared to be excessive as it resulted in 12.3% increased discomfort relative to the 60-mm width. The small-hand group reported 11.9–18.2% higher discomfort ratings, and the percent maximum voluntary exertion of their flexor digitorum superficialis muscle, pertaining to index finger flexion, was also 6.4% higher. These findings should be considered to make smartphone rear interaction more comfortable. **Practitioner Summary:** Among neutral, comfortable, maximum, horizontal, and vertical index finger strokes on smartphone rear surfaces, maximum vs. neutral strokes caused 43.8% greater discomfort. Horizontal (vertical) strokes deviated from the horizontal (vertical) axis. Discomfort increased by 12.3% with 90-mm- vs. 60-mm-wide devices. Rear interaction regions of five commercialised smartphones should be lowered 20 to 30 mm for more comfortable rear interaction.

- **Keywords:** One-handed smartphone interaction, index finger interaction, rear interaction, %MVE

Clarisse Gaudes & François Cail. *Effects of mouse slant and desktop position on muscular and postural stresses, subject preference and performance in women aged 18–40 years. Pages 1473-1486.*

This study compared muscular and postural stresses, performance and subject preference in women aged 18–40 years using a standard mouse, a vertical mouse and a slanted mouse in three different computer workstation positions. Four tasks were analysed: pointing, pointing-clicking, pointing-clicking-dragging and grasping-pointing the mouse after typing. Flexor digitorum superficialis (FDS) and extensor carpi radialis (ECR) activities were greater using the standard mouse compared to the vertical or slanted mouse. In all cases, the wrist position remained in the comfort zone recommended by standard ISO 11228-3. The vertical mouse was less comfortable and more difficult to use than the other two mice. FDS and ECR activities, shoulder abduction and wrist extension were greater when the mouse was placed next to the keyboard. Performance and subject preference were better with the unrestricted mouse positioning on the desktop. Grasping the mouse after typing was the task that caused the greatest stress. **Practitioner Summary:** In women, the slanted mouse and the unrestricted mouse positioning on the desktop provide a good blend of stresses, performance and preference. Unrestricted mouse positioning requires no keyboard, which is rare in practice. Placing the mouse in front of the keyboard, rather than next to it, reduced the physical load.

- **Keywords:** Computer mouse, muscle activity, posture, performance, subject preference

Inge Bogaert, Kristine De Martelaer, Michèle Beutels, Karolien De Ridder & Evert Zinzen. *Posture analysis among Flemish secondary school teachers: difference between the use of chalkboards and electronic school boards during classroom teaching. Pages 1487-1493.*

The aim of this study was to (i) make a posture analysis of teachers during theoretical classroom teaching; (ii) to estimate the risk for the development of musculoskeletal problems (MSP); (iii) test the hypotheses that an electronic school board (EB) has more ergonomic advantages for teachers. Thirty-five secondary school teachers, of which 15 used an EB and 20 used chalkboards, were selected by convenience sampling and filmed during 30 min of a theoretical course. Posture analysis of back, arms, legs and risk assessment was performed using the Ovako Working Posture Analysis System. Most of the teachers' postures did not indicate a higher risk for MSP. However, some postures may be harmful when accumulated for several hours of teaching a day; especially, long periods of standing and standing with a bended back. Results also indicated that currently the use of an EB does not improve teachers' posture. **Practitioner Summary:** The relationship between objectively measured physical work load and risk for injuries among teachers was not analysed so far. In this study teachers' posture was analysed using the OWAS method. Prolonged standing and forward bending were identified as risk postures. Also, using an electronic school board currently does not improve posture.

- **Keywords:** School teacher, posture analysis, electronic school board, OWAS

Simon S. W. Li & Daniel H. K. Chow. *Multi-objective analysis for assessing simultaneous changes in regional spinal curvatures under backpack carriage in young adults. Pages 1494-1504.*

Change in sagittal spinal curvature from the neutral upright stance is an important measure of the heaviness and correctness of backpack use. As current recommendations, with respect to spinal profile, of backpack load thresholds were based on the significant curvature change in individual spinal region only, this study investigated the most critical backpack load by assessing simultaneously the spinal curvature changes along the whole spine. A motion analysis system was used to measure the curvature changes in cervical, upper thoracic, lower thoracic and lumbar regions with backpack load at 0, 5, 10, 15 and 20% of body weight. A multi-objective goal programming model was adopted to determine the global critical load of maximum curvature change of the whole spine in accordance with the maximum curvature changes of the four spinal regions. Results suggested that the most critical backpack load was 13% of body weight for healthy male college students. **Practitioner Summary:** As current recommendations of backpack load thresholds were based on the significant curvature change in individual spinal region only, this study investigated the backpack load by considering simultaneously the spinal curvature changes along the whole spine. The recommendation, in terms of the global critical load, was 13% of body weight for healthy male college students.

- **Keywords:** Backpack load, spinal curvature, upright stance, postural change, goal programming

Jeevaka B. Kiriella, Carolyn J. Perry, Kara M. Hawkins, Camille J. Shanahan, William H. Gage & Anne E. Moore. *Sagittal plane lumbar loading when navigating an obstacle and carrying a load.* Pages 1505-1513.

The current study quantified lumbar loading while carrying an anterior load mass and navigating an obstacle. Eight healthy male participants walked down a walkway and crossed an obstacle under three randomised LOAD conditions; empty-box (2 KG), five kilogram (5 KG) and ten kilogram (10 KG). Each walk was assessed at two events: left foot mid-stance (LMS) and right toe-crossing (TC) to characterise any changes from approach to crossing. Measures of interest included: trunk pitch, L4/L5 joint moment, compression, joint anterior-posterior shear and erector spinae activation. Findings demonstrate that obstacle crossing extended posture by 50, 41, 44%, respectively for each carried load magnitude. Further, these results indicate that shear rather than compressive loading may be an important consideration during crossing due to increase by 8, 9, 22% from LMS to TC for each load magnitude tested. These results provide insight into sagittal lumbar loading when navigating an obstacle while carrying a load. **Practitioner Summary:** The risk of carrying while navigating obstacles on the lumbar spine is not completely understood. The forces at the lumbar spine while simultaneously carrying and obstacle crossing were analysed. Data indicate that carrying and obstacle crossing influence lumbar shear loads, thereby moderately increasing the relative risk at lumbar spine.

- **Keywords:** Carrying, anterior load carriage, obstacle crossing, lumbar loading

Oguz Akkas, Cheng-Hsien Lee, Yu Hen Hu, Thomas Y. Yen & Robert G. Radwin. *Measuring elemental time and duty cycle using automated video processing.* Pages 1514-1525.

A marker-less 2D video algorithm measured hand kinematics (location, velocity and acceleration) in a paced repetitive laboratory task for varying hand activity levels (HAL). The decision tree (DT) algorithm identified the trajectory of the hand using spatiotemporal relationships during the exertion and rest states. The feature vector training (FVT) method utilised the k-nearest neighbourhood classifier, trained using a set of samples or the first cycle. The average duty cycle (DC) error using the DT algorithm was 2.7%. The FVT algorithm had an average 3.3% error when trained using the first

cycle sample of each repetitive task, and had a 2.8% average error when trained using several representative repetitive cycles. Error for HAL was 0.1 for both algorithms, which was considered negligible. Elemental time, stratified by task and subject, were not statistically different from ground truth ($p < 0.05$). Both algorithms performed well for automatically measuring elapsed time, DC and HAL. **Practitioner Summary:** A completely automated approach for measuring elapsed time and DC was developed using marker-less video tracking and the tracked kinematic record. Such an approach is automatic, repeatable, objective and unobtrusive, and is suitable for evaluating repetitive exertions, muscle fatigue and manual tasks.

- **Keywords:** Repetitive motion, work-related musculoskeletal disorders, exposure assessment, time and motion study

Liuxing Tsao & Liang Ma. *Using subject-specific three-dimensional (3D) anthropometry data in digital human modelling: case study in hand motion simulation.* Pages 1526-1539.

Digital human modelling enables ergonomists and designers to consider ergonomic concerns and design alternatives in a timely and cost-efficient manner in the early stages of design. However, the reliability of the simulation could be limited due to the percentile-based approach used in constructing the digital human model. To enhance the accuracy of the size and shape of the models, we proposed a framework to generate digital human models using three-dimensional (3D) anthropometric data. The 3D scan data from specific subjects' hands were segmented based on the estimated centres of rotation. The segments were then driven in forward kinematics to perform several functional postures. The constructed hand models were then verified, thereby validating the feasibility of the framework. The proposed framework helps generate accurate subject-specific digital human models, which can be utilised to guide product design and workspace arrangement. **Practitioner Summary:** Subject-specific digital human models can be constructed under the proposed framework based on three-dimensional (3D) anthropometry. This approach enables more reliable digital human simulation to guide product design and workspace arrangement.

- **Keywords:** Digital human modelling, three-dimensional (3D) anthropometry, dynamic digital human models, hand motion simulation