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Accidents, Safety, and Human Error

Amy Irwin, Kathryn Mearns, Margaret Watson, and Jim Urquhart. *The Effect of Proximity, Tall Man Lettering, and Time Pressure on Accurate Visual Perception of Drug Names.* S. 253-266.

Objective: The aim of this study is to assess the effect of proximity and time pressure on accurate and effective visual search during medication selection from a computer screen. **Background:** The presence of multiple similar objects in proximity to a target object increases the difficulty of a visual search. Visual similarity between drug names can also lead to selection error. The proximity of several similarly named drugs within a visual field could, therefore, adversely affect visual search. **Method:** In Study 1, 60 nonpharmacy participants selected a target drug name from an array of mock drug packets shown on a computer screen, where one or four similarly named nontargets might be present. Of the participants, 30 completed the task with a time constraint, and the remainder did not. In Study 2, the same experiment was repeated with 28 pharmacy staff. **Results:** In Study 1, the proximity of multiple similarly named nontargets within the specified visual field reduced selection accuracy and increased reaction times in the nonpharmacists. Time constraint also had an adverse effect. In Study 2, the pharmacy participants showed increased reaction times when multiple nontargets were present, but the time constraint had no effect. There was no effect of Tall Man lettering. **Conclusion:** The presence of multiple similarly named medications in close proximity to a target medication increases the difficulty of the visual search for the target. Tall Man lettering has no impact on this adverse effect. **Application:** The widespread use of the alphabetical system in medication storage increases the risk of proximity-based errors in drug selection.

- **Keywords:** pharmacy, Tall Man, time pressure, proximity, drug name similarity

Aerospace Systems

Suzanne K. Kearns and Jennifer E. Sutton. *Hangar Talk Survey: Using Stories as a Naturalistic Method of Informing Threat and Error Management Training.* S. 267-277.

Objective: The current study developed an online hangar talk survey (HTS) to solicit narratives describing challenging scenarios that professional pilots encountered during the hours-building phase of their career. **Background:** The predicted pilot shortage will effectively reduce the minimum flying hours required for pilots to be hired at an airline, resulting in less opportunity to develop nontechnical skills naturalistically. To

compensate, threat and error data from the hours-building phase of a pilot's career are required to inform training development. Pilots often share stories of such experiences, colloquially termed "hangar talk." **Method:** The HTS gathered 132 narrative descriptions of general aviation (GA) events from pilots along with the event's impact and whether the pilots would react differently if the scenario were encountered again. **Results:** The distribution of threats reported by GA pilots was similar to that reported at the airline level. Logistic regression analysis revealed that decision-making errors were associated with recognition of the need to react differently in the future, and decision-making errors and proficiency errors were associated with greater perceived impact on skill development. **Conclusion:** The current HTS solicited an array of data similar to the findings of airline-based threat and error observations. Pilots perceive decision-making and proficiency errors as impactful on skill development. **Application:** An HTS can be used to gather naturalistic threat and error data and to create a database of operational stories that can be used to develop nontechnical training based on narrative thought.

- **Keywords:** hours-building phase, narrative thought, nontechnical skills, pilot training

Aging and Individual Differences

Matthew R. E. Romoser. *The Long-Term Effects of Active Training Strategies on Improving Older Drivers' Scanning in Intersections.* S. 278-284.

Objective: To determine the long-term effects of active training on older drivers' scanning in intersections, the present article reports the results of a 2-year follow-up with drivers who had previously participated in the older driver training study reported in Romoser and Fisher. **Background:** Customized feedback coupled with active learning in a simulator has been shown to be an effective means of significantly improving the intersection scanning behavior of older drivers. However, the long-term effect of such training has not been established. **Method:** Older drivers from the active learning and control groups from Romoser and Fisher were invited to participate in a 2-year follow-up field drive in their own vehicle starting at their home. Secondary looks, defined as looking away from the path of the vehicle while entering the intersections toward regions to the side from which other vehicles could appear, were recorded. **Results:** Two years after their training, older drivers in the active learning group still took secondary looks more than one and a half times as often as 2009 pretraining levels. Control group drivers saw no significant change in performance over the 2-year period. **Conclusion:** Customized feedback and active learning in a simulator is an effective strategy for improving the safe driving habits of older drivers over the long term. It provides drivers a means by which to reincorporate previously extinguished behaviors into their driving habits. **Application:** These results can guide the development of older driver retraining programs that could have the potential to reduce intersection crashes.

- **Keywords:** aging, driver behavior, surface transportation systems, training technologies, training, education, instructional systems, older drivers, situation awareness, attentional processes, older driver performance, road scanning, intersection crashes, training strategies, simulator training

Attentional Processes

Rachel A. Weatherless, Paul D. Fedele, Kathy L. Kehring, and Tomasz R. Letowski. *The Effects of Simulated Hearing Loss on Speech Recognition and Walking Navigation.* S. 285-297.

Objective: The objective was to assess whether a concurrent but independent navigation task exacerbates the effects of hearing loss on speech recognition and whether hearing loss degrades performance of the navigation task during the concurrent but independent listening task. **Background:** Navigation performance and speech comprehension both decrease when a driver follows hard-to-hear concurrent verbal instructions. It remains unknown how much both tasks would be affected when performed concurrently, if tasks were independent. **Method:** Participants performed a listening task by responding to Callsign Acquisition Test (CAT) stimuli at three simulated hearing levels. For each hearing level, one trial was performed with the participant standing still and another trial was performed while navigating a path in a virtual environment using a handheld map. In one more trial, participants navigated a path with no CAT. The proportion of call signs correctly repeated and the total time required to walk the path were measured. **Results:** CAT scores showed an expected negative effect of hearing loss. Concurrent navigation produced an even larger decrease in CAT score. Hearing loss caused a slight but not significant decrease in navigation task performance. **Conclusion:** A person with hearing loss may communicate less effectively while walking than predicted on the basis of hearing loss alone. The hearing loss, however, does not significantly decrease walking performance in a simple navigation task. **Application:** Obtained results may guide soldier performance modeling and requirements for communication systems used during physical activity when a soldier's hearing becomes compromised during dismounted combat operations.

- **Keywords:** speech, hearing, walking, navigation, hearing loss, executive attention, task interference, dual independent tasks

Biomechanics, Anthropometry, Work Physiology

Chia-Hsiung Chen, Yu Hen Hu, Thomas Y. Yen, and Robert G. Radwin.
Automated Video Exposure Assessment of Repetitive Hand Activity Level for a Load Transfer Task. S. 298-308.

Objective: A new method is described for automatically quantifying repetitive hand activity with the use of digital video processing. **Background:** The hand activity level (HAL) is widely used for evaluating repetitive hand work. Conventional methods involving either a trained observer on- or off-site or manual off-site video analysis are often considered inaccurate, cumbersome, or impractical for routine work assessment. **Method:** A cross-correlation-based template-matching algorithm was programmed to track the motion trajectory of a selected region of interest across successive video frames for a single camera to measure repetition frequency, duty cycle, and HAL. A simple, paced, load transfer task was used to simulate a repetitive industrial activity. A total of 12 participants were videoed performing the task for varying HAL conditions. The automatically predicted HAL was compared with the manually measured HAL with the use of frame-by-frame video analysis. **Results:** Predicted frequency, duty cycle, and HAL were in concert with the manually measured HAL conditions. The linear regression slopes of the automatically predicted values with respect to the manually measured values were 0.98 ($R^2 = .79$), 1.27 ($R^2 = .63$), and 1.06 ($R^2 = .77$) for frequency, duty cycle, and HAL, respectively. **Conclusion:** A proof-of-concept for automatic video-based direct exposure assessment was demonstrated. **Application:** The video assessment method for repetitive motion is promising for automatic, unobtrusive, and objective exposure assessment, which may offer broad availability with the use of a camera-enabled mobile device for helping evaluate, prevent, and control exposure to repetitive motions related to upper-extremity injuries in the workplace.

- **Keywords:** biomechanics, hand activity level, repetitive motion, upper extremity injuries, work-related musculoskeletal disorders

Vincent M. Ciriello, Rammohan V. Maikala, and Niall V. O'Brien. *Maximal Acceptable Torques of Six Highly Repetitive Hand-Wrist Motions for Male Industrial Workers*. S. 309-322.

Objective: The purpose of the study was to quantify maximum acceptable torques (MATs) in 16 healthy male industrial workers while performing six motions: screw driving clockwise with a 40 mm handle and a 39 mm yoke handle, flexion and extension with a pinch grip, ulnar deviation with a power grip (similar to knife cutting), and a handgrip task (similar to a pliers task). **Background:** Psychophysical studies on repetitive motions of the wrist and hand were previously reported on women; however, it is not clear how men will psychophysically respond to similar motions. **Method:** A psychophysical methodology was used in which the participant adjusted the resistance on the handle. Repetition rates for these tasks were 15 and 25 per minute. Participants performed the tasks for 7 hours per day, 5 days per week, and for 12 days. Symptoms were recorded by the subjects at the end of each hour. **Results:** The mean MATs ranged from 1.15 Nm to 1.88 Nm for screw driving, 2.26 Nm to 3.71 Nm for pinch flexion and extension, 3.88 Nm to 4.07 Nm for ulnar deviation, and 11.47 Nm to 13.98 Nm for the handgrip task. The higher the repetition rate, the lower the MAT. Depending on the type of task and repetition rate, these values represented 15% to 35% (median of 23%) of their maximum isometric torque. **Application:** Based on aforementioned findings, a table of MATs and derived acceptable forces for six tasks at different percentage capabilities of the male industrial populations is formulated.

- **Keywords:** upper extremity, maximum acceptable torques, maximum isometric torque, screw driving, supination, ulnar deviation, pinch extension and flexion, handgrip

Cognitive Processes

Deia Ganayim and Raphiq Ibrahim. *How Do Typographical Factors Affect Reading Text and Comprehension Performance in Arabic?* S. 323-332.

Objective: The objective of this study was to establish basic reading performance that could lead to useful design recommendations for print display text formats and layouts for the improvement of reading and comprehension performance of print text, such as academic writings, books, and newspapers, of Arabic language. **Background:** Readability of English print text has been shown to be influenced by a number of typographical variables, including interline spacing, column setting and line length, and so on. Therefore, it is very important to improve the reading efficiency and satisfaction of print text reading and comprehension by following simple design guidelines. Most existing research on readability of print text is oriented to build guidelines for designing English texts rather than Arabic. However, guidelines built for English script cannot be simply applied for Arabic script because of orthographic differences. **Method:** In the current study, manipulating interline spacing and column setting and line length generated nine text layouts. The reading and comprehension performance of 210 native Arab students assigned randomly to the different text layouts was compared. **Results:** Results showed that the use of multicolumn setting (with medium or short line length) affected comprehension achievement but not reading and comprehension speed. Participants' comprehension scores were better for the single-column (with long line length) than for the multicolumn setting. However, no effect was found for interline spacing. **Conclusion:** The recommendations for appropriate print text format and layout in Arabic language based on the results of objective measures facilitating reading and comprehension performance is a single-column (with long line length) layout with no relevance of the interline spacing.

- **Keywords:** text, reading, comprehension, typography

Robert Earl Patterson, Byron J. Pierce, Alan S. Boydston, Lisa M. Ramsey, Jodi Shannan, Lisa Tripp, and Herb Bell. *Training Intuitive Decision Making in a Simulated Real-World Environment*. S. 333-345.

Objective: We investigated whether naturalistic, intuitive (pattern recognition-based) decision making can be developed via implicit statistical learning in a simulated real-world environment. **Background:** To our knowledge, no definitive studies have actually shown that implicit learning plays a causal role in the development of intuitive decision making when the latter is defined as pattern recognition of real-world, or simulated real-world, environmental situations. **Method:** The simulated environment was presented dynamically so as to induce a sense of simulated locomotion through the scene and over sequences of objects on the ground. During training, participants passively viewed the objects sequences; during test, participants made intuitive decisions about related or unrelated sequences. **Results:** Intuitive decision making can be developed via implicit learning. Articulatory suppression, which affects working memory, exerted a significant inhibitory effect on the training of intuitive decision making. Intuitive decision making trained in the simulated environment fully transferred to a flat display (but not vice versa). **Conclusion:** Intuitive decision making is developed by an implicit learning process that is engaged by the meaning inherent in naturalistic scenes. **Application:** Implicit learning can be used for training intuitive decision making.

- **Keywords:** intuitive decision making, pattern recognition, implicit learning, artificial grammar learning, immersive environment

Displays and Controls

Misty Blue, Maranda McBride, Rachel Weatherless, and Tomasz Letowski. *Impact of a Bone Conduction Communication Channel on Multichannel Communication System Effectiveness*. S. 346-355.

Objective: In this study, the impact of including a bone conduction transducer in a three-channel spatialized communication system was investigated. **Background:** Several military and security forces situations require concurrent listening to three or more radio channels. In such radio systems, spatial separation between three concurrent radio channels can be achieved by delivering separate signals to the left and right earphone independently and both earphones simultaneously. This method appears to be effective; however, the use of bone conduction as one channel may provide both operational and performance benefits. **Method:** Three three-channel communication systems were used to collect speech intelligibility data from 18 listeners (System 1, three loudspeakers; System 2, stereo headphones; System 3, stereo headphones and a bone conduction vibrator). Each channel presented signals perceived to originate from separate locations. Volunteers listened to three sets of competing sentences and identified a number, color, and object spoken in the target sentence. Each listener participated in three trials (one per system). Each trial consisted of 48 competing sentence sets. **Results:** Systems 2 and 3 were more intelligible than System 1. Systems 2 and 3 were overall equally intelligible; however, the intelligibility of all three channels was significantly more balanced in System 3. **Conclusion:** Replacing an air conduction transducer with a bone conduction transducer in a multichannel audio device can provide a more effective and balanced simultaneous monitoring auditory environment. **Application:** These results have important design and implementation implications for spatial auditory communication equipment.

- **Keywords:** multichannel radio communication, bone conduction, speech intelligibility

Petr Janata and William H. Edwards. *A Novel Sonification Strategy for Auditory Display of Heart Rate and Oxygen Saturation Changes in Clinical Settings*. S. 356-372.

Objective: The aim of this study was development of a sonification scheme to convey deviations in heart rate and oxygen saturation from a desired target level. **Background:** Maintaining physiologic parameters, such as oxygen saturation, within desired ranges, is challenging in many clinical situations. High rates of false positive alarms in clinical settings limit the utility of the alarms that trigger when thresholds are exceeded. Auditory displays that consider the semantic connotations of sounds and the processing limitations of human perception and cognition may improve monitoring. **Method:** Across two experiments, clinical practitioners were tested on their ability to (a) discriminate pairs of sounds (two-note discrimination task), (b) infer and discern the intended physiological connotation of each acoustic attribute (name-the-variable task), and (c) categorize the amount of change in an implied physiological variable into three levels of change: none, small, and large (change-magnitude task). **Results:** Considerable variation in performance was observed across the set of practitioners, ranging from near-perfect performance on all tasks, even with no prior exposure to the stimuli, to failure to reach a target accuracy criterion of 87.5% after ~80 min of training. On average, performance was well above chance on the name-the-variable and change-magnitude tasks during initial exposure and reached criterion within ~20 min of training on each task. **Conclusion:** The described sonification strategy may effectively communicate information about current heart rate and oxygen saturation status relative to desired target levels. **Application:** The results can be applied to clinical monitoring settings in which a stream of discrete auditory informational items is indicated.

- **Keywords:** patient monitoring, vital statistics, timbre, alarms, decision making

Joshua Shive and Gregory Francis. *Choosing Colors for Map Display Icons Using Models of Visual Search*. S. 373-396.

Objective: We show how to choose colors for icons on maps to minimize search time using predictions of a model of visual search. **Background:** The model analyzes digital images of a search target (an icon on a map) and a search display (the map containing the icon) and predicts search time as a function of target-distractor color distinctiveness and target eccentricity. **Method:** We parameterized the model using data from a visual search task and performed a series of optimization tasks to test the model's ability to choose colors for icons to minimize search time across icons. Map display designs made by this procedure were tested experimentally. In a follow-up experiment, we examined the model's flexibility to assign colors in novel search situations. **Results:** The model fits human performance, performs well on the optimization tasks, and can choose colors for icons on maps with novel stimuli to minimize search time without requiring additional model parameter fitting. **Conclusion:** Models of visual search can suggest color choices that produce search time reductions for display icons. **Application:** Designers should consider constructing visual search models as a low-cost method of evaluating color assignments.

- **Keywords:** quantitative modeling, optimization, histogram backprojection, interface design, CIELAB

Health and Medical Systems

Jonathan D. Jolly, Emily A. Hildebrand, and Russell J. Branaghan. *Better Instructions for Use to Improve Reusable Medical Equipment (RME) Sterility*. S. 397-410.

Objective: The objective was to evaluate human-factors-based instructional aids on endoscope reprocessing. **Background:** The project stems from recent failures in reprocessing (cleaning) endoscopes, contributing to the spread of harmful bacterial and viral agents between patients. A previous study discovered three themes that represent a majority of problems: (1) lack of visibility (parts and tools were difficult to identify), (2) high memory demands, and (3) insufficient feedback. **Method:** In an effort to improve completion rate and reduce error, the authors designed instructional aids utilizing human factors principles that would replace existing manufacturer-provided visual aids. Then, they conducted a usability test, which compared the endoscope reprocessing performance of novices using the standard manufacturer-provided visual aids and the new instructional aids. **Results:** Participants in the experimental group successfully completed 87.1% of the reprocessing procedure with the use of the instructional aids, compared to 44.7% in the control group using only existing support materials. Of 60 subtasks, 27 showed significant improvement in completion rates. **Conclusion:** When given an instructional aid designed with human factors principles, participants were able to more successfully complete the reprocessing task. This resulted in an endoscope that was more likely to be safe for use on patients. **Application:** The human factors design elements utilized to create the instructional aids could be transferred to a dynamic electronic-based system to improve patient safety.

- **Keywords:** human factors, patient safety, instructions for use, IFU, reusable device sterility, reusable medical equipment, RME, infection, outbreak

Macroergonomics and the Environment

Lakhwinder Pal Singh, Arvind Bhardwaj, and Kishore Kumar Deepak.
***Occupational Noise-Induced Hearing Loss in Indian Steel Industry Workers: An Exploratory Study.* S. 411-424.**

Objective: The present study focused on exploring the current level of hearing protection and subsequently determined the prevalence of occupational noise-induced hearing loss among casting and forging industry workers. **Background:** The casting and forging industry provides employment to a significant portion of the population. **Method:** The level of hearing protection was assessed through questionnaire survey of 572 workers. Out of these workers, 165 and another control group of 57 participants were assessed by formal audiometry. Audiometric tests were conducted at frequencies of 1.0 KHz to 8.0 KHz. The occurrence of hearing loss was determined on the basis of a hearing threshold level with a low fence of 25 dB. Student's test and ANOVA were used to compare the various groups; a p value <.05 was considered statistically significant. **Results:** More than 90% of the workers sampled showed significant hearing loss at medium and high frequencies. The analyses revealed a higher prevalence of significant hearing loss among the forging workers compared with the workers associated with the other activities. **Conclusions:** The workers of the Indian steel industry are highly exposed to occupational noise. The majority of workers are not protected from noise-induced hearing loss. There is a need to provide special ear protectors for workers engaged in forging. A complete hearing protection program, including training, audiometry, job rotation, and the use of hearing protection devices, needs to be introduced.

- **Keywords:** occupational noise-induced hearing loss

Psychomotor Processes

Amity Campbell, Andrea Roelofs, Paul Davey, and Leon Straker. *Response Time, Pistol Fire Position Variability, and Pistol Draw Success Rates for Hip and Thigh Holsters*. S. 425-434.

Objective: The aim of this study was to investigate the effect of pistol holster position on pistol draw time and performance of police officers. **Background:** Proficient use of the lethal force option is critical to an officer's ability to survive. Traditionally, pistols were worn in hip holsters; however, recently, thigh holsters have also become popular. The effect of holster position on pistol draw performance has not been investigated. **Method:** For this study, 27 police officers, representing a range of holster familiarity, years of service, and gender, were assessed drawing a training pistol from both the thigh and hip holster positions via a 3-D motion analysis system. Participants were required to draw and fire toward a target as quickly and accurately as possible following a visual stimulus, three times successfully. Temporal characteristics, accuracy variability, and draw success rate were compared between the thigh and hip holster with repeated-measures ANOVA both unadjusted and adjusted for familiarity, years of service, and gender ($p < .05$). **Results:** No differences in the temporal variables, accuracy variability, or success rate were detected between the hip and thigh holster positions, either adjusted or unadjusted. Holster familiarity was found to significantly affect draw success rate, with participants more successful when drawing from their familiar holster. **Conclusion:** Hip and thigh holster positions are both viable options in terms of draw time and accuracy. However, draw success rate will be negatively affected during initial use of an unfamiliar holster position. Further research should address the effect of familiarization on draw performance.

- **Keywords:** movement time, response time, lethal weapon draw time, police officers, pistol holster position

Training, Education, Instructional Systems

Vanessa Loh, Sally Andrews, Beryl Hesketh, and Barbara Griffin. *The Moderating Effect of Individual Differences in Error-Management Training: Who Learns From Mistakes?* S. 435-448.

Objective: We investigated the effectiveness of error-encouragement training and the influence of ability and personality attribute-treatment interactions using a dynamic decision-making task. **Background:** Error-encouragement training is said to be more effective than error-avoidance training because active exploration and error encouragement promote better learning and transfer. Past research, which is limited by confounded experimental designs involving simple tasks with little consideration of individual differences, provides evidence for the value of active exploration but less so for error encouragement. **Method:** We randomly allocated 164 participants to receive error-encouragement, error-avoidance, or no error-related instructions in training on ATC-lab, a dynamic computer simulated air traffic control task. Active exploration and task information were controlled, and ability and personality were assessed. **Results:** Error encouragement yielded better transfer performance than did error avoidance but was no better than the control training. Higher- rather than lower-ability trainees benefited from training with an error orientation (positive or negative), suggesting that learning from errors in training requires greater cognitive resources. Trainees higher in openness to experience and agreeableness performed more poorly with error-avoidance training than with error-encouragement and control training. **Conclusion:** Error-avoidance training had a detrimental effect especially for those less open to experience, lower in agreeableness, and of lower ability. The significant benefits of error-encouragement training reported in previous research were probably attributable to confounding factors, such as active exploration and differential task information. **Application:** Although errors

and active exploration can be useful learning tools in training, trainers should be mindful that focusing on errors, whether positively or negatively, may not suit everyone.

- **Keywords:** error encouragement, active exploration, cognitive ability, personality, dynamic decision making, transfer of training, attribute-treatment interaction effects

Joey C. Y. So, Robert W. Proctor, Phillip S. Dunston, and Xiangyu Wang. *Better Retention of Skill Operating a Simulated Hydraulic Excavator After Part-Task Than After Whole-Task Training. S. 449-460.*

Objective: We examined whether part-task training produces better learning and retention than whole-task training of a trench-and-load task performed on a hydraulic excavator simulator. **Background:** For complex perceptual-motor tasks that involve several components and require spatial awareness of the environment, part-task training will be effective if the benefit of being able to focus attention on each component outweighs the cost of integrating the components. We predicted that such would be the case for learning to operate an excavator. **Method:** A part-task training group practiced separate Carrier Positioning, Trenching, and Truck Loading modules, whereas a whole-task training group practiced the Trench and Load module, which combines elements from the other modules. The latter module, involving different scenarios, was performed by both groups immediately after training and following a 2-week retention interval. **Results:** Production rate on the trench-and-load task was better overall on the retention test than on the immediate test. The part-task group showed improvement on the retention test compared with the immediate test, whereas the whole-task group did not. The part-task group showed higher productivity rates than did the whole-task group on the retention test. **Conclusion:** Part-task training on the excavator simulator results in better skill retention than does whole-task training. The benefit of part-task training is likely to be found for other tasks requiring control of implements in various environments. **Application:** Part-task training can result in better retention of complex perceptual-motor skills involving several components, even when immediate transfer to the whole task does not show better performance than whole-task training.

- **Keywords:** part-whole training, part-task practice, whole-task practice, simulator training, hydraulic excavator simulator

Christopher D. Wickens, Shaun Hutchins, Thomas Carolan, and John Cumming. *Effectiveness of Part-Task Training and Increasing-Difficulty Training Strategies: A Meta-Analysis Approach. S. 461-470.*

Objective: The objective was to conduct meta-analyses that investigated the effects of two training strategies, increasing difficulty (ID) and part-task training (PTT), on transfer of skills and the variables that moderate effectiveness of the strategies. **Background:** Cognitive load theory (CLT) provides a basis for predicting that training strategies reducing the intrinsic load of a task during training avail more resources to be devoted to learning. Two strategies that accomplish this goal, by dividing tasks in parts or by simplifying tasks in early training trials, have offered only mixed success. **Method:** A pair of complementary effect size measures were used in the meta-analyses conducted on 37 transfer studies employing the two training strategies: (a) a transfer ratio analysis on the ratio of treatment transfer performance to control transfer performance and (b) a Hedges' *g* analysis on the standardized difference between treatment and control group means. **Results:** PTT generally produced negative transfer when the parts were performed concurrently in the whole transfer task but not when the parts were performed in sequence. Variable-priority training of the whole task was a successful technique. ID training was successful when the increases were implemented adaptively but not when increased in fixed steps. Both strategies provided evidence that experienced learners benefited less, or suffered more, from the strategy, consistent with

CLT. **Conclusion:** PTT can be successful if the integrated parts are varied in the priority they are given to the learner. ID training is successful if the increases are adaptive. The fundamental elements of CLT are confirmed.

- **Keywords:** training strategies, transfer of training, cognitive load theory, part-task training, adaptive training, meta-analysis