The following abstracts are selected from the research presented at the 48th annual conference of Human Factors and Ergonomics Society that was held from Sept 20 to Sept 24 In New Orleans, LA, USA.

A COGNITIVE ANALYSIS OF EQUATION READING APPLIED TO THE DEVELOPMENT OF ASSISTIVE TECHNOLOGY FOR VISUALLY-IMPAIRED STUDENTS
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The purpose of this research was to investigate the perceptual and cognitive processes involved in equation reading to apply that knowledge to the development of assistive technology for blind equation readers. The research used a process tracing observational study, three experiments, and an eye-tracking study to examine several hypotheses about equation reading: people (1) read equations from left to right, one element at a time, (2) back scan when reading equations, (3) substitute the outcome of a parenthetical expression for the initial elements, and (4) scan the entire equation before element by element reading to create a schematic structure. The process tracing study provided evidence for all of the hypotheses, with the experiments supporting the first three hypotheses, but not the fourth. These results have been implemented in assistive software for visually-impaired users, the Math Genie --an auditory browser.

A comparison of Internet connection troubleshooting strategies by experts and novices
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This paper compares the strategies used by experts and novices in troubleshooting complex systems. As an example, we consider the case of establishing an Internet connection. The complexity of modern systems, such as the Internet, makes troubleshooting a very difficult task. Because many users experiencing trouble turn to the call-center, traffic loads are always heavy. This loads cost the company dearly to maintain adequate user support quality. We need to incorporate effective approaches to tackling the problems into self-service systems. Moreover, such knowledge is useful for FAQ design and creating response methods for call-center agents that can well support the troubleshooting process. Both are expected to greatly reduce call-center loads.
To elucidate effective troubleshooting techniques, we compare the troubleshooting strategies of novices to those of experts. As a result, we showed that given an initial goal constraint, the experts try to eliminate modules unambiguously and so find the fault while novices remain stuck with their first guess.

A COMPARISON OF THREE-LEVEL WEB MENU NAVIGATION STRUCTURES
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This research addresses the topic of three-level menu structures, now commonly found in ecommerce web sites, by measuring the performance and preference effects of different menu location combinations. Two studies were conducted, each using 16 different participants. The first study compared combinations of left and top menu positions across three menu levels. The results indicated a benefit when the first (primary) menu level was located on the left side of the screen, and when second and third menu levels were grouped in the same plane, opposite from the primary menu. The second study included a comparison of right-side menus. The results confirmed the benefit of grouping the second and third menu levels in the same plane, and suggest the value of locating the primary menu level on the right side. Finally, users preferred primary menus that were located in the left or right planes rather than the top plane. The results have important implications for the design of multi-level web site menu structures and represent a first-step towards providing empirical-based guidelines to site designers.

A PERSONA-CENTRIC APPROACH TO DEVELOPING COMPLEX COMPUTER SYSTEMS: LESSONS FROM THE FIELD
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Enterprise server systems, such as e-mail servers, database servers, and e-commerce servers, are the heart and soul of businesses throughout the world. They are complex back-end systems that typically fall under the realm of system administrators and developers, and drive many of the front-end client applications used by the billions of end-users in businesses on a regular basis. It is critical that these complex systems be easy to learn, install, use, troubleshoot, maintain, and upgrade. This paper describes our experience using a persona-based approach to develop complex e-business server systems. It provides an overview of personas and their benefits, the approach we took to create them and enable their adoption, and the lessons we learned that may be adapted by human factors professionals in different industries. The personas we created increased the product team's awareness of our target server audience, as well as their needs, skill levels and goals. The adoption of our personas has been fairly widespread, influencing everything from feature-based user-interface design decisions to far-reaching strategic planning for our next major product release.

A QUEUING NETWORK MODEL FOR VISUAL SEARCH AND MENU SELECTION
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Random menu search is a task component involved in many human-machine interfaces and has been modeled with various cognitive models including ACT-R and EPIC. Based on a review of empirical data in menu search and strengths and
limitations of existing models, this article proposes a model that is based on the queueing network approach, which has been successfully applied in some other task domains (e.g., response time, driver performance). The queueing network model for random menu selection was implemented and evaluated through model simulation. In contrast to existing models that rely on multiple task-specific strategies to account for performance and eye movement data, the queueing network model uses only one strategy already employed in an existing cognitive model to account for the same data. The value of this “minimal task strategy” approach for modeling complex menu search tasks is discussed, based on the reported findings of the queueing network model and a comparison to existing models.

A SURVEY OF ONLINE READING HABITS OF INTERNET USERS
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This study evaluated the reading habits of Internet users across five document types. Internet users completed an online survey indicating whether they were likely to read a document online or on paper using five possible choices. Document types evaluated included journal articles, news, newsletters, literature, and product information. Results revealed differences in the reading habits based on document type. Journal articles were reported to be primarily printed while documents such as online news, newsletters, and product reviews were reported to be read mainly online. Users tended not to use online sources for reading literature. Primary factors determining whether a document was printed or read online were size, importance, and intended purpose of document.

ADVANCED TECHNOLOGY MASTER CAUTION PANEL (ATMCP):
TRACKING TASK STATUS BY MONITORING INFORMATION
TECHNOLOGY (IT) RESOURCES
Andrea L. Pacley
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Computers are increasingly becoming a part of society's everyday life and can cause a wide variety of impacts when they fail. For example, during a military exercise, Expeditionary Force Experiment (EFX) 98, it was found that operators were losing hours of work and data because they were unaware that essential systems had failed. This illustrated the need for a system that provided system situation awareness (SA) to the operator that rapidly disseminated information
and responded quickly to connectivity and system failures. To fulfill this need, we created the Advanced Technology Master Caution Panel (ATMCP); analogous to an aircraft master caution panel. This system offers a unique approach to providing system SA that allows the operators to workaround system failures by mapping information technology (IT) resources to crew tasks as a method of monitoring task status. ATMCP offers unlimited flexibility and can be applied to multiple domain areas.

APPLICATION OF HUMAN-COMPUTER INTERACTION THEORIES TO IDENTIFY USER REQUIREMENTS FOR INTERNET PORTAL DESIGN
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This paper describes the first of two parts of a research study. The overall objective of the research was to determine the effects of tailoring Internet portal content and presentation style to user requirements according to either or both of two HCI theories. This study involved user requirements gathering by using a portal containing hyperlinks as the test bed. Participants rated the hyperlinks according to importance and the descriptions of each hyperlink according to intuitiveness. Results are discussed in terms of user search behavior and specific search requirements.

APPLICATION OF UNIVERSAL DESIGN PRINCIPLES IN THE DESIGN OF A SELF-CHECKOUT SYSTEM
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A study was conducted to explore the use of universal design principles in the redesign of a grocery store self-checkout system - focusing on the accessibility for wheelchair users. Two checkout stations were built: one was a dimensionally accurate model of an existing system and the other was a redesign of this system, using universal design principles. Five wheelchair users and ten non-wheelchair users performed simulated self-checkout activities, using both checkout stations. The dependent variables were productivity, shoulder and torso posture, and users' subjective assessment. Results indicated that productivity was not significantly affected by checkout station type and posture was significantly improved - peak shoulder angle was reduced by 64% in wheelchair users and by 69% in the non-wheelchair group, and peak sagittal angle (forward lean) of the torso was reduced by 66.5% for wheelchair-users. Subjective feedback from both user groups showed a preference for the redesigned checkout station.

Applying the Proximity Compatibility and the Control-Display
Compatibility Principles toward Engineering Design Using Configural Interfaces
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This paper presents a study to investigate the applicability of two display design principles toward the development of interfaces for engineering design. The first principle, called the Proximity Compatibility Principle, specifies that displays relevant to a common task or mental operation should be rendered close together in perceptual space. The second principle, called the Control-Display Compatibility Principle, stipulates that the spatial arrangement and manipulation of controls should be easily distinguishable. We conducted an experiment comparing the ability of subjects to search for effective designs using a separable versus two configural interfaces in a multiple-objective engineering design task. Results suggest that the Proximity Compatibility Principle is an effective indicator of task performance. Moreover, we found that the Control-Display Compatibility Principle can be used as an indicator of performance efficiency.

COMPARISON OF MOBILE TEXT ENTRY METHODS
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In this preliminary study, we tested a small group of users on their ability to perform common text input tasks using both standard and unfamiliar input devices: the standard QWERTY keyboard, an onscreen QWERTY keyboard on a Pocket PC, a letter recognition system on a Pocket PC, and a T9 text-input system on a cellular phone. We examined user performance, accuracy, and overall preference for the four input methods, and compared these results to the values predicted by Fitts’ Law. Our findings suggest that the cognitive effort loads for each device had a strong impact on the amount of time required by users to input text, and that Fitts’ Law methods do not accurately account for or predict values including cognitive load or skill transfer.

CREATING USABLE WORDLESS INSTRUCTIONS FOR PERFORMING COMPLEX ONE-TIME TASKS: EFFECTS OF VIOLATING THE RULES
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We have developed design rules for diagrammatic instructions for initial setup, basic maintenance and troubleshooting (i.e., clearing paper jams) tasks. The study reported here evaluated these rules. Four groups of novice users cleared paper jams in a laser printer using one of four different diagrammatic instructions. Diagrams presented to the first two groups all followed the rules but differed in the number of actions per diagram (one verses 3-4). The remaining groups’ instructions contained diagrams that violated one or more rules. Instructions that followed the diagram design rules resulted in no errors. Diagrams that prevented users from correctly identifying the location of a subtask resulted in the most severe errors. Other rule violations resulted in fewer errors of lesser severity so if users were shown the general location of the problem they could perform a subtask. Times to complete each subtask were similar unless the location rule was violated.

DESIGNING A USER INTERFACE FOR A PDA-BASED CAMPUS NAVIGATION DEVICE
Brian Dorn, Daniel Zelik, Harisudhakar Vepadharmalingam, Mayukh Ghosh, S.
University campuses, like many other public and private institutional settings, pose challenges to visitors and newcomers finding their way from place to place. In some cases, such campuses have grown to the size of a small town. Maps and tour guides have traditionally been the means used to assist visitors find their way; however, the recent development of high-power, low-cost mobile computing opens the door to portable electronic navigational aids. This paper focuses on user interface concerns in a personal digital assistant (PDA) based campus guide. Cognitive and visual display engineering principles are used to develop a preferred preliminary design. Subjective feedback and quantitative data on the user interface are gathered in a small pilot study. The appropriateness of the design and its implications for future work are also discussed.

**EFFECTS OF MENU FORESIGHT ON INFORMATION ACCESS IN SMALL SCREEN DEVICES**
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An experiment was conducted to evaluate the effects of menu foresight (the number of menu items visible at a time on the display) on the usability of small screen devices. Cognitive factors (field dependency, locus of control and mental rotation ability) mediating the effects were assessed in order to identify the underlying processes of accessing information. Thirty-nine participants processed tasks on a simulated cellular phone where one, three or seven menu items were presented on the display. Search time, executed steps as well as ratings of the ease of use were collected. Results show that intermediate foresight (three items) led to the best performance. Highly field dependent users showed to have extreme difficulties when only one function was seen on the display whereas low spatial ability participants had most trouble with seven items displayed at a time. These findings suggest that cognitive processes of prestructuring information account for the effects of menu foresight.

**EFFECTS OF SCREEN ORIENTATION AND MARGIN ON READING WITH A HANDHELD COMPUTER**
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Although the small size of handheld computers increases portability and mobility, it causes difficulty reading information displayed on a small screen. In an attempt to improve text readability of handheld computers, this study investigated the effects of screen orientation and margin on reading speed, comprehension, and subjective ease of reading with a handheld computer. A 2x2 within-subject factorial design was conducted with 16 participants reading text from a PDA. In addition users' preference for the two factors and their experiences with reading with the PDA were elicited in a post-experiment questionnaire. Finally usability problems encountered were discussed in the interview. The results of this study indicated that neither screen orientation nor margin had a significant influence on reading performance. No prevailing preferences for screen orientation and margin were found. Invaluable qualitative information regarding usability problems was identified, which, in turn, supports several recommendations to improve reading from small screens of handheld computers.

**EFFICIENCY ASSESSMENT OF AN E-COMMERCE DATA MANAGEMENT TOOL USING LEARNING CURVES**
Learning curves for e-commerce data management tasks were computed to assess UI efficiency. Participants were asked to update product information using an ecommerce data management tool. Mean time on task over 20 trials of the same task was fit using a power function. Learning curves of 92.7% to 97.6% were found for two product update tasks. The results obtained indicate that making efficiency judgments based on the first few trials will produce higher learning coefficients that actually exist, and suggest that practitioners should not assume that time on task will always decrease significantly with increased practice. It also shows how properties of learning curves can help in the analysis of UI efficiency.

EMERGENCY AUTOMATED RESPONSE SYSTEM (EARS)
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This paper presents a comparison of two versions of an Emergency Automated Response System (EARS), a fully manual version and a partially automated version. User evaluations involving both versions of the system were conducted using a low workload task and a high workload task. The results indicate that the automation employed by the partially automated system decreased overall response time and perceived workload for both tasks, but accuracy decreased and response times increased from low workload to high workload with both versions.

EMPIRICAL TESTS OF THE HUMAN-WEB INTERACTION CYCLE
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J. Shawn Farris
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Farris (2003) proposed the Human-Web Interaction (HuWI) cycle, which predicts that 1) system knowledge (i.e., one's knowledge base) will direct interaction with a website, 2) system knowledge will be modified by the user's interaction with the website, and 3) only goal-relevant information should be attended to during these interactions. This paper describes two experiments that tested these three predictions. In Experiment 1, performance was worse when participants’ system knowledge was inconsistent with a website, which suggests that system knowledge was directing interaction with the website. In addition, participants tested for knowledge of the content before and after interacting with the website demonstrated higher posttest scores than pretest scores, which indicates that system knowledge was modified by interacting with the website. In Experiment 2, participants attended primarily to goal-relevant information, if the goal pertained to content. These findings generally support the validity of the HuWI cycle.

ENHANCING ROBOFLAG USERS’ SITUATIONAL AWARENESS
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The RoboFlag system was designed as a testbed to study distributed control of multiple vehicle teams with humans in the loop. This work analyzed the RoboFlag version 2.0 interface to identify existing issues with the users’ Situational Awareness (SA). The existing interface for RoboFlag was modified to create two new interfaces. The first interface focused on improved usability, while the second focused on improved Situation Awareness. A user evaluation was conducted to determine if the new interfaces improved the users' SA over the original interface. Twenty-four participants completed the evaluation. This paper reports the design of the task environment, the evaluation method, and the statistical analysis. The results indicate that both new interfaces provide improved SA over the RoboFlag version 2.0 interface.

Evaluating the Effectiveness of Automated Assistance for Web Searching
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Web search engines offering personalized automated assistance have the potential to improve the searching process. We report the results of a within subjects, counter balanced empirical evaluation to determine whether automated assistance improves searching performance. Thirty subjects interacted with two fully functional, information retrieval systems. The systems were identical in all respects except that one offered automated assistance while the other did not. The study used a client side automated assistance application, a 2G Text REtrieval Conference document collection and six topics. Results from the empirical evaluation indicate that automated assistance can statistically improve searching performance; however, the improvement is not as dramatic as one might expect, with an approximately 20% performance increase, as measured by number of relevance documents retrieved. We discuss the implications for Web systems and future

EXPECTED USABILITY MAGNITUDE ESTIMATION
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Usability measures typically focus on actual user experiences while largely ignoring the impact of user expectations. User expectations provide insight into overall usability, user satisfaction, and priority of usability problems. Beyond test results, communicating user expectations can offset the negative connotation many development teams have of usability by showing examples where expectations are exceeded. This paper describes the expected Usability Magnitude Estimation (UME) method to assess user expectations in usability tests. The method is more valid, robust, and theoretically based than existing methods. It allows measurement of expectations that is easy to administer, simple to analyze, and provides actual and expected usability ratings along the same ratio scale of usability. Expectation data is used to classify tasks into empirically derived design strategy groupings based on refined theory. Overall, the method positively contributes to usability results and development team relationships.
EYE MOVEMENT AND REACTION TIME ARE BOTH IMPORTANT IN ASSESSMENT OF DIALOG BOX USABILITY
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Traditional usability metrics (accuracy and reaction time) were combined with eye movement patterns to study button placement and highlighting in dialog boxes. Participants made buttonclick responses based on the contents of the dialog box text. Traditional measures and eye movement patterns yielded different results: Reaction time analyses suggested placing the correct button to the left; eye movement patterns suggested placing the correct button on the right. This study demonstrated that eye movements are a rich source of information for usability research, provided theoretical guidelines for future research, and showed the strengths and weaknesses of eye tracking in comparison to more traditional usability metrics. In addition, it provided empirical support for eye movement heuristics that are often implemented in visual interface design, showing that the search patterns for dialog boxes follow a reading pattern.

EYE MOVEMENT MEASURES OF PERFORMANCE ON VISUAL SEARCH TASKS: EQUATING THE BASELINES OF TASK PERFORMANCE
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Previous research suggests that eye measures can indicate decrements in performance on a visual tracking task due to increased difficulty in task execution from fatigue-induced conditions (Van Orden, 2000). In order to examine the sensitivity of eye movement to increased cognitive workload as indicated by difficulty of task, we chose a visual search paradigm. Using a basic visual search task, we studied the effects of increased task difficulty on subject performance and their corresponding eye measures. Results show a decrease in performance as the number of objects on the screen increase. What results could be expected if differences in individual abilities to perform visual search were controlled? This experiment looks at one method that can be used to control for individual differences in visual search abilities.

HEURISTIC AUTOMATION FOR DECLUTTERING TACTICAL DISPLAYS
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Tactical displays can quickly become cluttered with large numbers of symbols that can compromise effective monitoring. Here, we studied how heuristic automation can aid users by intelligently “decluttering” the display. In a naval air defense task, users monitored a cluttered airspace and executed defensive responses against significant threats. An algorithm continuously evaluated aircraft for their levels of threat and decluttered the less threatening ones by dimming their symbols. As expected, 27 Navy experts appropriately distrusted and spot-checked the automation’s assessments, and decluttering did not affect which aircraft were judged significantly threatening. Nonetheless, decluttering improved response timeliness to threatening aircraft 25% compared with a baseline display with no decluttering, it increased attention to threats, and 25 of 27 participants preferred decluttering. Heuristic automation, when properly
designed to guide users’ attention by decluttering less important objects, should prove valuable in many

**IMPROVING USER SEARCH WITH EMBEDDED BOOLEAN SEARCH HINTS**

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Because of the extensive use of search engines on the Internet, even small improvements in usability can lead to huge benefits in productivity and effectiveness. Unfortunately, Internet users have consistently shown that they are unable or unwilling to use Boolean operators effectively. This paper presents an investigation of the use of embedded Boolean search hints to improve user search query construction. These hints consist of short, targeted in-line messages that present task-focused instruction on the use of Boolean operators. Three types of help content were studied: semantic, syntactic, and exemplar. The results indicate that inline help can significantly improve performance. However, the improvement was produced only when the content specifically matched the users' needs. Furthermore, some unexpected results suggest that users' experience with other Boolean interfaces can impair performance. Implications for search interface design are discussed.

**INPUT RATES FOR A ONE-HANDED INPUT DEVICE (OHAI) FOR CHINESE TEXT ENTRY**

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As computer technology has become ubiquitous in nature, designers must develop text-entry methods that can accommodate a variety of devices, cultures, and languages. This paper presents a study evaluating a One-HAnded Input (OHAI) device developed for mobile text-entry in Chinese. The device is a chorded keyboard system on which text is entered in Chinese using the pinyin system. Participants trained with the device for 10, 1-hour sessions. Their text-entry rates and their rate of input for individual chords were measured after each session. The Power Law of Practice was used to predict input rates after 100 hours of training. Predicted input rates approach 16 characters per minute, approaching pinyin input rates on conventional keyboards. Input rates for individual chords were also measured in order that future iterations of the software may associate the most commonly used characters with the fastest-to-execute chords. The study also suggests several potential future improvements to the OHAI system, such as augmenting the software with an autocompletion system.

**IS PRACTICE NECESSARY TO SPEED THE SELECTION OF WEB BROWSER CONTROLS THAT HAVE IMPENETRABLE BORDERS?**

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Previous research demonstrated that interface elements could be selected faster when placed against the edge of the screen. Doing so creates an impenetrable border between the element and the edge of the screen that the mouse cursor cannot penetrate. This changes how users move the mouse, so that selection quickens. This study investigated the effect of practice on the acquisition of targets with and without impenetrable borders. Ten participants selected targets that varied in Target Type (with or without impenetrable borders), and Distance
(.5, 3.5, 6.5, 9.5, and 12.5cm) across five Practice Sessions. The results confirmed that targets with impenetrable borders were selected faster than targets without impenetrable borders and that participants demonstrated consistent reductions in selection time over sessions, regardless of the target type. In addition, excessive practice was not necessary to demonstrate target type differences; thus the advantage of having impenetrable borders seems to be relatively instantaneous.

KEYBOARD SHORTCUT USAGE: THE ROLES OF SOCIAL FACTORS AND COMPUTER EXPERIENCE
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Previous research (Lane, Napier, Peres, & Sandor, in press) has shown that despite the fact that it typically takes half as much time to issue a command to a computer application using that command's keyboard shortcut, most people issue a particular command by clicking an icon on a toolbar or by selecting the command from a pull-down menu. This study examined reasons why that might be the case with a web survey that focused on demographic characteristics of people who do and do not use keyboard shortcuts, as well as social factors of computer use that might influence use of keyboard shortcuts. Participants' shortcut usage was influenced by social factors, such as working in an environment with other shortcut users and experiential factors, primarily the hours spent using a computer per week.

LOCAL DENSITY GUIDES VISUAL SEARCH: SPARSE GROUPS ARE FIRST AND FASTER
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Visual search is an important aspect of many tasks, but it is not well understood how layout design affects visual search. This research uses reaction time data, eye movement data, and computational cognitive modeling to investigate the effect of local density on the visual search of structured layouts of words. Layouts were all-sparse, all-dense, or mixed. Participants found targets in sparse groups faster, and searched sparse groups before dense groups. Participants made slightly more fixations per word in sparse groups, but these were much shorter fixations. The modeling suggests that participants may have attempted to process words within a consistent visual angle regardless of density, but that they were more likely to miss the target if the target was in a dense group. Furthermore, it was found that the participants tended to search sparse groups before dense groups. When combining densities in a layout, it may be beneficial to place important information in sparse groups.

MODELING USER SATISFACTION, FRUSTRATION, AND USER GOAL / WEBSITE COMPATIBILITY
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Users often come to websites with a specific type of purpose or goal, which defines how the user interacts with the site. Two types of task-goals addressed in this study include general browsing and specific information seeking. Likewise, the design and organization of different websites can facilitate different user...
goals. User satisfaction and frustration from interacting with a particular website depends on the compatibility between the website design and the user's type of goal. This study applies simulation techniques to investigate how the compatibility between user goals and website design impacts user satisfaction and frustration levels. The simulation results show that navigation tools that increase compatibility versus attractiveness (the increased likelihood of use) have a greater impact on customer satisfaction and could in turn maximize the effectiveness of website usage.

MULTIMODAL, MULTITASK INTERACTION DESIGN: A FOLLOW UP STUDY TO CHALLENGE UNIMODAL DESIGN ASSUMPTIONS
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Advances in technology are enabling multiple sensory channels to be utilized in presenting information. Nevertheless, the human operator can become easily overwhelmed if an overabundance of information is presented in a non-systematic manner. Current design guidelines are primarily tailored towards unimodal or at most bimodal systems. Thus, the question becomes how to coordinate multiple sources of information in multimodal multitasking environments, and what design guidelines are needed to direct development of such interactive systems. The current study builds on a previous study and seeks to extend unimodal design theories to multimodal principles; it identifies some interesting differences in unimodal vs. multimodal multitask interaction.

PERSUASIVE DESIGN THROUGH INTELLIGENT RECOMMENDATION SYSTEMS
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Collaboration between human factors and marketing can have a significant impact on the profitability of retail, particularly on the Internet where comprehensive information systems can be used to model customer and product relationships. This paper presents a case study through which the capabilities of intelligent recommendation systems to achieve persuasive design are demonstrated. A web site for a department store was created that provides targeted recommendations to customers based on functional relationships between products and customer profile information where available. The site was designed to present only recommendations that closely match the needs of the customer and establish a trusted relationship. An empirical study was conducted to verify that the goals of the site were attained. Participants rated the recommendations as relevant, unobtrusive, and reported an enhanced shopping experience. Privacy requirements were also maintained. This case study demonstrates that understanding and designing for the needs of the customer can significantly enhance the opportunity to increase sales to online retail customers.

PSYCHOMOTOR EFFICIENCY IN USERS OF NOTEBOOK INPUT DEVICES: CONFIRMATION AND RESTRICTIONS OF FITTS’ LAW AS AN EVALUATIVE TOOL FOR USER-FRIENDLY DESIGN
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On the basis of Fitts’ law the present study examined the psychomotor efficiency for 20 experienced users of force- (trackpoint) and motion-input (touchpad) devices in clicking and dragging tasks. Beyond task difficulty the impact of input
modality, practice, and task type was investigated. On the one hand, the results support Fitts’ law since performance data of both input devices fitted satisfyingly with Fitts’ predictions. Motion-input was found to be very robust towards task difficulty, especially in dragging tasks. On the other hand, the results were incompatible to Fitts’ assumptions as target size and distance did not equally contribute to task difficulty but rather target size was a stronger contributor. Thus, the effective task difficulty in small targets was notably underestimated. For user-friendly interfaces, button widths of over 0.5 cm should be provided, especially when distances farther than 7.5 cm are inevitable.

SELECTION ACCURACY WITH PEN SELECTION SLOTS
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This paper describes three selection accuracy experiments with the selection slot, a new menu selection device for pen-based computer systems. A selection slot is a slot into which a user places the tip of a pen or stylus for the purpose of selecting an item from a list of items. The results of the first experiment, using a prototype slot for notebook name selection with 3 mm per notebook name, indicated 100% selection accuracy. In a second experiment, the results indicated that with as little as 1.1 mm per notebook name, users could select notebook names with 100% accuracy. A third experiment evaluated page selection accuracy for 55- and 99-page slots using a 73 mm slot (0.74 mm per page for 99 pages). Participants in the 55-page condition used a single-page advance control to reach target pages greater than 55. Considering all targets, participants were slightly but consistently less accurate with the 99-page slots, but their within-slot selection accuracies were equal. All participants preferred the 99-page slot due to the inconvenience of acquiring pages greater than 55 with the single-page advance control.

Semantic information influences the degree to which human observers perceive detail and intricacy within an icon.
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Following the Boucart & Humphreys (1995) method, this paper reports a study in which response time to three groups of semantically related icons were examined. This study was used as a model by which to examine the ability of human observers to attend solely to one icon property without being influenced by other salient icon information. Humans are easily influenced by their experience of an icon: they tend to judge very simple, but unfamiliar icons (as defined by an automated analysis) as complex (Forsythe et al., 2003). This means that when humans are unreliable judges about the degree of detail or intricacy in an icon. The degree of detail or intricacy in an icon is one property that lends itself to automation (Forsythe et al., 2003). As a decision-making aid, an automated system would make the process of icon development and modification a less speculative, more cost-effective activity.

STRATEGIES FOR MAINSTREAM CELLULAR PHONE USE BY INDIVIDUALS WITH MODERATE TO SEVERE COGNITIVE IMPAIRMENTS
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A population often overlooked in the design of cellular phones is people with cognitive disabilities. This study evaluated the ability of persons with moderate to severe cognitive impairments to use mainstream cellular phones programmed
with experimental interface features that allowed operation with minimum cognitive ability. Two modes were tested. The first allowed an individual to place calls by simply opening a flip phone. The second displayed four pictures on the touchscreen and allowed a call to be made by touching one of the pictures. Sixteen individuals with Mini-Mental State Examination (MMSE) scores from 6 to 19 participated. There was a 100% success rate using the flip mode in both Instruction and Carryover conditions and a 100% success rate in Instruction and 81.3% success in Carryover for the picture mode. This was compared to standard 'touchtone' dialing mode success rate of 12.5% in the Instruction condition and 6.3% in Carryover condition.

SUPPORTING SYNCHRONOUS DISTRIBUTED COMMUNICATION AND COORDINATION THROUGH MULTIMODAL INFORMATION EXCHANGE
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Increasingly, operators in complex event-driven domains, such as the military, need to coordinate their goals and activities with numerous co-located and distributed human and machine agents. One promising way to support this requirement is the introduction of multimodal interfaces that afford functions such as increased bandwidth, complementarity, redundancy, and substitution. To inform the design of a robust multimodal system, the present study explored natural tendencies for, and the role of context in, modality usage in the context of simulated battlefield operations. Three groups of three ROTC cadets/officers each completed a set of 30-minute scenarios. The within-subject variables included participant location, the availability of radio communication, the amount of coordination required by the scenario, and the tempo of operations. Our findings show that participants were highly selective in their use of multiple modalities. Multimodal interaction was observed primarily in the context of spatial tasks and for the purpose of supporting grounding, complementarity, and disambiguation. Joint modality usage patterns evolved over time within groups and varied as a function of factors such as scenario and interface management demands. The findings from this study provide important guidance for the design of multimodal combined HCI and CSCW interfaces and show that multimodal information exchange is a highly effective means of coordination.

THE EFFECT OF TARGET POSITION AND TACTUAL RECOGNITION FIELD SIZE ON TOUCH BIAS
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Past studies have shown that touchscreen display angles other than those that perpendicularly bisect the operator's line of sight cause the operator to touch slightly below the target. The amount of bias created from this misjudgment fluctuates according to the target’s position on the screen. Additionally, the percentage of touches that activate a specific target varies according to the size of the tactual recognition field. This study sought to match three square tactual recognition field sizes with the amount of touch bias occurring in each location. The results showed that although bias differed according to location, the tactual recognition fields did not vary enough in size, nor were they large enough to find a significant difference between them in the number of touches captured according to the location of the target. The tactual recognition field that optimally captures responses varies in size over display position and is non-square in shape.

THE EFFECTS OF SEMANTIC AND SYNTACTIC INSTRUCTION ON USER PERFORMANCE AND SATISFACTION IN SEARCH USER INTERFACE DESIGN
Search engines have the potential to assist users in a variety of information retrieval tasks. Unfortunately, field studies show that they consistently fail to meet the usability goals of effective and efficient performance. Two of the primary drawbacks are that users do not apply correct semantic logic and syntax in their queries. This study investigates the use of targeted search hints, a form of in-line help, to improve query construction. The results show that search hints can improve performance, but with interactions that designers must consider. Some hints increase the time required to construct queries. Compound hints can also lead to reduced performance. The implications of these findings are discussed.

THE HUMAN-WEB INTERACTION (HUWI) CYCLE: A FRAMEWORK OF USERS’ PERCEPTION, ACTION, AND COGNITION ON THE WEB
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Since its inception, the World Wide Web has flourished. While advances have been made in the general area of web usability, little attention has been paid to developing theories of human-web interaction. Accordingly, Neisser's (1976) perceptual cycle, which unifies research on action, perception, and cognition, is used as a framework for a human-web interaction (HuWI) cycle. The HuWI cycle assumes that while users interact with a website, in order to locate certain pieces of information, they sample only goal-relevant information from the website. Users then modify their knowledge of the system, based on the goal-relevant information that was acquired. This newly modified system knowledge then directs their interaction further.

The Influence of Mere Exposure on Web Based Breadcrumb Navigation
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Recent studies have shown that while the use of breadcrumb trails to navigate a website can be helpful, few users choose to utilize this method of navigation. This study investigates the effects of "mere exposure" and training on breadcrumb usage and satisfaction. Participants were randomly assigned to one of three conditions. Condition I participants received both exposure and instruction to use breadcrumb navigation. Condition II participants received only mere exposure to the use of breadcrumb navigation and Condition III participants received neither exposure nor instruction to use breadcrumb navigation. Upon completing a list of search tasks, Condition I participants spent less time, visited fewer web pages, and relied less on other methods of navigation. The mere exposure group, Condition II, did not produce significantly faster search times or visit fewer web pages than the participants in Condition III.

UNDERSTANDING THE USABILITY CONSTRUCT: USER-PERCEIVED USBILITY
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The usability profession has seen success in industry and academia, as well as recognition in the popular press. However, inconsistent measurement, unreliable problem identification, inappropriate high-level goals, and a lack of valid metrics highlight recent usability literature. Rather than support or refute these findings, we offer a research introspection that we hope contributes to all of these issues by improving our basic understanding of the construct of usability. A Usability Concept Survey (UCS) containing 64 potential usability characteristics was created and administered to 46 users who rated how integral each characteristic was to usability. Multivariate analyses of these user perceptions were used to construct: 1) a taxonomy of usability to classify usability characteristics, 2) data-driven general dimensions of usability, 3) a map of usability space showing specific usability characteristics within the general dimensions; and, 4) a definition of usability. We believe this better understanding of the construct of usability can contribute directly to improving usability objectives, measures, and practice.

**Usability Evaluation of Concentric Rings in Relationship Graphing**

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A usability evaluation was conducted of a prototype radial graph visualization tool, to better understand whether concentric rings are useful for navigation and comprehension. Nodes represented sales representatives and contacts, and edges represented specific types of relationships. Double-clicking a graph node caused slow-in, slow-out, animated reorganization of the network about that node. Ten sales managers completed tasks ranging from graph comprehension to strategic analysis. Eye tracking was also used to address specific usability questions. Tasks were generally completed in 1-3 minutes, but assists revealed significant confusion with relationship concepts and terminology. Specific difficulties were related to filtering the graph and with occlusion of specific nodes. Eye tracking confirmed that concentric rings are used while searching nodes within the same level. Subjective assessments were quite positive compared with presently-used enterprise sales network analysis tools.

**USER-CENTERED DESIGN OF A CUSTOMIZED INTRANET PORTAL FOR A LARGE PUBLIC UNIVERSITY**

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Intranet portals can provide a centralized source of company information, web applications, and external links that are customized for the needs of each employee, increasing employee productivity and effectiveness. However, they are only effective when they support user needs in an effective and usable fashion. In 2003, Florida International University (FIU) began the process of creating an intranet portal for use by its 34,000 students. The portal would provide web-based email functionality along with profile-driven University information and preference-based external links. This is expected to increase student use of the FIU email system, facilitate dissemination of FIU information to students, improve achievement of educational goals, streamline university processes such as registration, provide cost savings to the university, and increase student satisfaction. This paper describes the user-centered design process that was used to create the MyFIU portal and provides guidance for the development of Intranet portals.

**USER-CENTERED SYMBOL DESIGN THROUGH HUMAN-COMPUTER COLLABORATION**

Brian Carnahan and Nathan T. Dorris
The purpose of this research was to develop a new approach to symbol development that used an interactive evolutionary computation (IEC) algorithm to expand end-user participation in the design process. IEC iteratively employs subjective assessment and parameter recombination to create a population of anthropomorphic symbols that "evolve" based on user input. Three design groups, comprised of both student and industrial subjects, used the IEC algorithm to develop 60 symbols for awkward posture, a risk factor for work-related musculoskeletal disorders. Factor analysis was used to reduce the nine design parameters (i.e., limb angles) to a three-factor structure. Analysis of variance revealed that student generated symbols differed significantly from those created by industrial participants in terms of two of the three factor scores. Actual or potential applications of this research include a new approach to creating symbols that encourages end-user input into their design.

VISUALIZATIONS TO FACILITATE ONLINE TABULAR PRESENTATION OF PRODUCT DATA
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In a growing number of domains, users are presented with huge volumes of data that they are required to parse in order to accomplish their goals. Interface designers are experimenting with a variety of design manipulations to facilitate user's identification and analysis of these data. Many domains present information in grids, such as the side-by-side comparison of products prevalent at many ecommerce web sites. Further assistance can be provided by using color-coding, ranking systems and other visualization techniques. This study investigates the use of color-coding and ranking on tasks that require either focused or integrative analysis of tabular data. The results show that each provides some benefit, but color-coding is superior. The presence of both manipulations degrades performance, suggesting some degree of information overload. Furthermore, despite the prevalence of these techniques, instructions that explained how they were relevant to the task were necessary to achieve the performance improvement. The implications of these results are discussed.

WHY A CONSUMER ELECTRONIC DEVICE IS DIFFICULT TO USE
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This paper describes a cognitive usability analysis of a home stereo as well as an experiment that tests the predictions borne out of that analysis using the RAFIV method of cognitive usability analysis (Sherry, Polson, Fennell, & Feary, 2002). At the heart of this method is a five-stage model that describes a user's cognitive steps as they perform a task. This model provides a framework for analyzing an interface by asking whether or not each stage can be accomplished purely through label-following. The results suggest that the RAFIV technique can be used to predict which tasks might prove difficult for users. Furthermore, it suggests that the number of recall steps within a task can play a negative role in a user's ability to complete that task.