Visualization, Games, Eye Data, & Extreme Expertise - VGEDEE+

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COGS-6963-01
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This is a graduate level course.

VGEDEE+ Recent Topics on Visualization, Games, Eye Data, Extreme Expertise Plus Other Issues

Description

A variety of recent topics in Cognitive Science. Some of the topics will be updates on topics covered in prior graduate seminars. A few will be papers that cite and critique work published by the CogWorks Laboratory. The rest will be recent papers on a variety of topics that help us triangulate on research issues and topics of interest.

Seminar Topics

New versions of this syllabus will be released during the semester. The new versions will reflect readings on topics and issues that arise during our in-class discussions. The readings will also reflect the new publications on topics related to this class.

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Visualization: Clear-eyed Assessments, Hypes, and Hopes


This paper reviews cognitive science perspectives on the design of visual-spatial displays and introduces the other papers in this topic. It begins by classifying different types of visual-spatial displays, followed by a discussion of ways in which visual-spatial displays augment cognition and an overview of the perceptual and cognitive processes involved in using displays. The paper then argues for the importance of cognitive science methods to the design of visual displays and reviews some of the main principles of display design that have emerged from these approaches to date. Cognitive scientists have had good success in characterizing the performance of well-defined tasks with relatively simple visual displays, but many challenges remain in understanding the use of complex displays for ill-defined tasks. Current research exemplified by the papers in this topic extends empirical approaches to new displays and domains, informs the development of general principles of graphic design, and addresses current challenges in display design raised by the recent explosion in availability of complex data sets and new technologies for visualizing and interacting with these data.

What Can You Learn from One Subject?

Proposes a theory of the processes that enable a student to learn while engaged in solving a problem. It gives a microscopic account of learning in a specific situation (the Tower of Hanoi problem) based on a detailed analysis of a single human problem-solving protocol. It proposes general mechanisms, however, that make no specific reference to an individual S or task, and it shows how these interact with specific task information gained during the problem-solving process. The adequacy of the mechanisms for producing the learning is guaranteed by a computer simulation of the process in the form of an adaptive production system. A transcript of the S’s (an adult college graduate) complete protocol is appended.


Although there are many machine-learning programs that can acquire new problem-solving strategies, it is not known exactly how their processes will manifest themselves in human behavior, if at all. In order to find out, a line-by-line protocol analysis was conducted of a subject discovering problem-solving strategies. A model was developed that could explain 96% of the lines in the protocol. On this analysis, the subject’s learning was confined to 11 rule acquisition events, wherein she temporarily abandoned her normal problem solving and focused on improving her strategic knowledge. Further analysis showed that: (1) Not all rule acquisition events are triggered by impasses; (2) Rules are acquired gradually, both because of competition between new and old rules, and because of the subject’s apparently deliberate policy of gradual generalization. (3) This subject took a scientific approach to strategy discovery, even planning and conducting small experiments.

Strategies and Decision Making – recent research we need to know about!

Ignoring irrelevant visual information aids efficient interaction with task environments. We studied how people, after practice, start to ignore the irrelevant aspects of stimuli. For this we focused on how information reduction transfers to rarely practised and novel stimuli. In Experiment 1, we compared competing mathematical models on how people cease to fixate on irrelevant parts of stimuli. Information reduction occurred at the same rate for frequent, infrequent, and novel stimuli. Once acquired with some stimuli, it was applied to all. In Experiment 2, simplification of task processing also occurred in a once-for-all manner when spatial regularities were ruled out so that people could not rely on learning which screen position is irrelevant. Apparently, changes in eye movements were an effect of a once-for-all strategy change rather than a cause of it. Overall, the results suggest that participants incidentally acquired knowledge about regularities in the task material and then decided to voluntarily apply it for efficient task processing. Such decisions should be incorporated into accounts of information reduction and other theories of strategy change in skill acquisition.


Individuals frequently make use of the body and environment when engaged in a cognitive task. For example, individuals will often spontaneously physically rotate when faced with rotated objects, such as an array of words, to putatively offload the performance costs associated with stimulus rotation. We looked to further examine this idea by independently manipulating the costs associated with both word rotation and array frame rotation. Surprisingly, we found that individuals patterns of spontaneous physical rotations did not follow patterns of performance costs or benefits associated with being physically rotated, findings difficult to reconcile with existing theories of strategy selection involving external resources. Individuals subjective ratings of perceived benefits, rather, provided an excellent match to the patterns of physical rotations, suggesting that the critical variable when deciding on-the-fly whether to incorporate an external resource is the participant’s metacognitive beliefs regarding expected performance or the effort required for each approach (i.e., internal vs. internal + external). Implications for metacognition’s future in theories of cognitive offloading are discussed.


It is known that, on average, people adapt their choice of memory strategy to the subjective utility of interaction. What is not known is whether an individual’s choices are boundedly optimal. Two experiments are reported that test the hypothesis that an individual’s decisions about the distribution of remembering between internal and external resources are boundedly optimal where optimality is defined relative to experience, cognitive constraints, and reward. The theory makes predictions that are tested against data, not fitted to it. The experiments use a no-choice/choice utility learning paradigm where the no-choice phase is used to elicit a profile of each participant’s performance across the strategy space and the choice phase is used to test predicted choices within this space. They show that the majority of individuals select strategies that are boundedly optimal. Further, individual differences in what people choose to do are successfully predicted by the analysis. Two issues are discussed: (a) the
performance of the minority of participants who did not find boundedly optimal adaptations, and (b) the possibility that individuals anticipate what, with practice, will become a bounded optimal strategy, rather than what is boundedly optimal during training.


Learning to solve a class of problems can be characterized as a search through a space of hypotheses about the rules for solving these problems. A series of four experiments studied how different learning conditions affected the search among hypotheses about the solution rule for a simple computational problem. Experiment 1 showed that a problem property such as computational difficulty of the rules biased the search process and so affected learning. Experiment 2 examined the impact of examples as instructional tools and found that their effectiveness was determined by whether they uniquely pointed to the correct rule. Experiment 3 compared verbal directions with examples and found that both could guide search. The final experiment tried to improve learning by using more explicit verbal directions or by adding scaffolding to the example. While both manipulations improved learning, learning still took the form of a search through a hypothesis space of possible rules. We describe a model that embodies two assumptions: (1) the instruction can bias the rules participants hypothesize rather than directly be encoded into a rule; (2) participants do not have memory for past wrong hypotheses and are likely to retry them. These assumptions are realized in a Markov model that fits all the data by estimating two sets of probabilities. First, the learning condition induced one set of Start probabilities of trying various rules. Second, should this first hypothesis prove wrong, the learning condition induced a second set of Choice probabilities of considering various rules. These findings broaden our understanding of effective instruction and provide implications for instructional design.

**Games**

**Overviews**


This work reviews several aspects of the growing research field interested in video games. First, the evolution of this media in the educational field is discussed. Three different fields interested in the cognitive impact playing of video games are reviewed: abilities and skills, attitudes and motivation, knowledge and content learning. However, most studies used video games as new experimental materials and tasks to contribute to their specific field (i.e., attention and perception), and not as a scientific object of interest per se. We claim that the research on video games is in need of a conceptual and methodological framework in which results and effects could be compared, interpreted and generalized. We argue that video games can have multiple effects on players and that these effects can be used as educational potentials. An empirically-based classification of games, depending on their potential effects for an educational purpose, is strongly needed. Likewise, a unified research paradigm and methodologies to carry on reliable research on video games has to be developed.

In this paper we present an analysis of the academic landscape of games research from the last 15 years. We employed a data driven approach utilizing co-word and co-venue analysis on 48 core venues to identify 20 major research themes and 7 distinct communities, with a total of 8,207 articles and 21,552 unique keywords being analyzed. Strategic diagrams and network maps are applied to visualize and further understand interrelationships and underlying trends within the field.


Movement-based digital games are becoming increasingly popular, yet there is limited comprehensive guidance on how to design these games. In this article we discuss a set of guidelines for movement-based game design that were initially presented at CHI 2014 (Mueller & Isbister, 2014). These guidelines were developed through reflection upon our research-based game development practice and then validated and refined through interviews with 14 movement-based game design experts with experience in the academic, independent, and commercial game development domains. In this article, we provide an in-depth contextualization and explanation of the research process that led to the creation of the final guidelines and discuss what human–computer interaction researchers and designers might learn from the guidelines beyond entertainment contexts. The primary contribution of this research is a body of generative intermediate-level knowledge (Hk & Lwgren, 2012) in the design research tradition that is readily accessible and actionable for the design of future movement-based games and other movement-based interfaces.


The idea that game design can inspire the design of motivating, enjoyable interactive systems has a long history in human-computer interaction. It currently experiences a renaissance as gameful design, often implemented through gamification, the use of game design elements in nongame contexts. Yet there is little research-based guidance on designing gameful systems. This article therefore reviews existing methods and identifies challenges and requirements for gameful design. It introduces a gameful design method that uses skill atoms and design lenses to identify challenges inherent in a user’s goal pursuit and restructure them to afford gameplay-characteristic motivating, enjoyable experiences. Two case studies illustrate the method. The article closes by outlining how gameful design might inform experience-driven design more generally.


Game developers have to ensure their games are appealing to, and playable by, a range of people. However, although there has been interest in the game-play experience, we know little about how learning relates to player involvement. This is despite challenge being an integral part of game-play, providing players with potential opportunities to learn. This article reports
on a multiple case-study approach that explored how learning and involvement come together in practice. Participants consisted of a mix of gamers and casual players. Data included interviews, multiple observations of game-play, postplay cued interviews, and diary entries. A set of theoretical claims representing suggested relationships between involvement and learning were developed on the basis of previous literature; these were then assessed through a critical examination of the data set. The resulting theory is presented as 14 refined claims that relate to micro and macro involvement; breakdowns and breakthroughs in action, understanding, and involvement; progress; and agency, meaning and compelling game-play. The claims emphasize how players experience learning via breakthroughs in understanding, where involvement is increased when the player feels responsible for progress. Supporting the relationship between learning and involvement is important for ensuring the success of commercial and educational games.

Crisis??!!!


Forty years have passed since video-games were first made widely available to the public and subsequently playing games has become a favorite past-time for many. Players continuously engage with dynamic visual displays with success contingent on the time-pressured deployment, and flexible allocation, of attention as well as precise bimanual movements. Evidence to date suggests that both brief and extensive exposure to video-game play can result in a broad range of enhancements to various cognitive faculties that generalize beyond the original context. Despite promise, video-game research is host to a number of methodological issues that require addressing before progress can be made in this area. Here an effort is made to consolidate the past 30 years of literature examining the effects of video-game play on cognitive faculties and, more recently, neural systems. Future work is required to identify the mechanism that allows the act of video-game play to generate such a broad range of generalized enhancements.


We are beginning to understand that the social sciences often leap beyond the data, ignore null effects and overstate confidence in cherished beliefs (Ioannidis, 2005; Pashler and Harris, 2012). When perceived health of children is involved, this general effect can be exacerbated into crusade bias; the tendency to distort, overstate, or misrepresent research findings to lend a veneer of science to a polemic social agenda. That this occurred in the field of media violence has been well established (Savage, 2004; Sherry, 2007; Ferguson, 2013). But, with media, a parallel process which we might call a savior bias also emerges in which the media are considered a remarkable game-changer for reinventing society (e.g., McGonigal, 2011).

In a few short years, research on action games and aggression has gone from an absolute truth (e.g., American Psychological Association, 2005) to a full-blown replication crisis. In this essay I examine the degree to which the field of action games and visuospatial cognition may run similar risks. I wish to be clear that, in the debate on visuospatial cognition research, I respect researchers on both sides, and I hope that my comments may be viewed as constructive suggestions for improving the field, rather than merely as criticisms. With that in mind, here are several observations
Cognitive Elements of Games

Memory Dynamics Relevant to Eye Data


Research has demonstrated that oculomotor visual search is guided by memory for which items or locations within a display have already been inspected. In the study reported here, we used a gaze-contingent search paradigm to examine properties of this memory. Data revealed a memory buffer for search history of three to four items. This buffer was effected in part by a space-based trace attached to a location independently of whether the object that had been seen at that position remained visible, and was subject to interference from other stimuli seen in the course of a trial.

Dynamic ROIs (dROI) & Eye Tracking During Dynamic Videogames


Future interactive virtual environments will be “attention-aware,” capable of predicting, reacting to, and ultimately influencing the visual attention of their human operators. Before such environments can be realized, it is necessary to operationalize our understanding of the relevant aspects of visual perception, in the form of fully automated computational heuristics that can efficiently identify locations that would attract human gaze in complex dynamic environments. One promising approach to designing such heuristics draws on ideas from computational neuroscience. We compared several neurobiologically inspired heuristics with eye-movement recordings from five observers playing video games, and found that human gaze was better predicted by heuristics that detect outliers from the global distribution of visual features than by purely local heuristics. Heuristics sensitive to dynamic events performed best overall. Further, heuristic prediction power differed more between games than between different human observers. While other factors clearly also influence eye position, our findings suggest that simple neurally inspired algorithmic methods can account for a significant portion of human gaze behavior in a naturalistic, interactive setting. These algorithms may be useful in the implementation of interactive virtual environments, both to predict the cognitive state of human operators, as well as to effectively endow virtual agents in the system with humanlike visual behavior.


Prediction of gaze behavior in gaming environments can be a tremendously useful asset to game designers, enabling them to improve gameplay, selectively increase visual fidelity, and optimize the distribution of computing resources. The use of saliency maps is currently being advocated as the method of choice for predicting visual attention, crucially under the assumption that no specific task is present. This is achieved by analyzing images for low-level features such as motion, contrast, luminance, etc. However, the majority of computer games are designed to be easily understood and pose a task readily apparent to most players. Our psychophysical experiment shows that in a task-oriented context such as gaming, the predictive power of saliency maps at design time can be weak. Thus, we argue that a more
involved protocol utilizing eye tracking, as part of the computer game design cycle, can be sufficiently robust to succeed in predicting fixation behavior of players.


Understanding players’ visual attention patterns within an interactive 3D game environment is an important research area that can improve game level design and graphics. Several graphics techniques use a perception based rendering method to enhance graphics quality while achieving the fast rendering speed required for fast-paced 3D video games. Game designers can also enhance game play by adjusting the level design, texture and color choices, and objects’ locations, if such decisions are informed by a study of players’ visual attention patterns in 3D game environments. This paper seeks to address this issue. We present results showing different visual attention patterns that players exhibit in two different game types: action-adventure games and first person shooter games. In addition, analyzing visual attention patterns within a complex 3D game environment presents a new challenge because the environment is very complex with many rapidly changing conditions; the methods used in previous research cannot be used in such environments. In this paper, we will discuss our exploration seeking a new approach to analyze visual attention patterns within interactive 3D environments.


This paper describes a study carried out in which the eye gaze data of several users playing a simple First Person Shooter (FPS) game has been recorded. This work shows the design and implementation of a simple game and how the execution of the game can be synchronized with an eye tracking system. The motivation behind this work is to determine the existence of visual psycho-perceptual phenomena, which may be of some use in developing appropriate information limits for distributed interactive media compression algorithms. Only 2 degrees of the 140 degrees of human vision has a high level of detail. It may be possible to determine the areas of the screen that a user is focusing on and render it in high detail or pay particular attention to its contents so as to set appropriate dead reckoning limits. Our experiment shows that eye tracking may allow for improvements in rendering and new compression algorithms to be created for an online FPS game.


Eye movements can be used to infer the allocation of covert attention. In this article, we propose to model the allocation of attention in a task-dependent manner based on different eye movement conditions, specifically fixation and pursuit. We show that the image complexity at eye fixation points during fixation, and the pursuit direction during pursuit are significant factors in attention allocation. Results of the study are applied to the design of an interactive computer game. Real-time eye movement information is taken as one of inputs for the game. The utility of such eye information for controlling game difficulty is shown.

Metrics of Expertise


This study introduces the Amsterdam Chess Test (ACT). The ACT measures chess playing proficiency through 5 tasks: a choose-a-move task (comprising two parallel tests), a motivation questionnaire, a predict-a-move task, a verbal knowledge questionnaire, and a recall task. The validity of these tasks was established using external criteria based on the Elo chess rating system. Results from a representative sample of active chess players showed that the ACT is a very reliable test for chess expertise and that ACT has high predictive validity. Several hypotheses about the relationships between chess expertise, chess knowledge, motivation, and memory were tested. Incorporating response latencies in test scores is shown to lead to an increase in criterion validity, particularly for easy items.

Different Strokes for Different (research communities and) Folks

The Ethnomethodologist Perspective


[from the intro] 3D video games remain a rapidly evolving new medium bringing together gameplay, narrative, architecture, computing and cinema. Correspondingly for a number of existing schools of inquiry they raise absorbing questions about game theory, storytelling, space, human-computer interaction and the moving image. In the space of this chapter our ambitions are necessarily modest, we wish to concentrate on only one of the devices that arises out of the trading between cinema, television and gameplay that is nevertheless at the heart of the video-ness of video games: the camera. How we play video games is dependent on and generated by the uses of the camera: a ‘game-camera’ that is modelled upon the optical set-ups of mechanical and digital cameras and yet, as we shall see, is distinct from them. For instance, the gamecamera is an invisible point without virtual representation. Game-cameras are central to playing 3D video games because they are a mediated view into, and perspective upon, the ‘visibility arrangements’ of the game (Watson, 1997). They are at the core of analysing, at any moment, what has just happened, what is currently happening in the game and what might happen next. The interplay between using the game camera and the ‘visibility arrangements’ of the game produce not just the experience of 3D spaces but the very play of the game.

Latham on Games


Twenty-two experienced action video-game players (AVGPs) and 18 non-VGPs were tested on a pen-and-paper line bisection task that was untimed. Typically, right-handers bisect lines 2% to the left of true centre, a bias thought to reflect the dominance of the right-hemisphere for visuospatial attention. Expertise may affect this bias, with expert musicians showing no
bias in line bisection performance. Our results show that experienced-AVGPs also bisect lines with no bias with their right hand and a significantly reduced bias with their left hand compared to non-AVGPs. Bisects by experienced-AVGPs were also more precise than those of non-AVGPs. These findings show the cognitive proficiencies of experienced-AVGPs can generalize beyond computer based tasks, which resemble their training environment.


Increasing behavioural evidence suggests that expert video game players (VGPs) show enhanced visual attention and visuospatial abilities, but what underlies these enhancements remains unclear. We administered the Poffenberger paradigm with concurrent electroencephalogram (EEG) recording to assess occipital N1 latencies and interhemispheric transfer time (IHTT) in expert VGPs. Participants comprised 15 right-handed male expert VGPs and 16 non-VGP controls matched for age, handedness, IQ and years of education. Expert VGPs began playing before age 10, had a minimum 8 years experience, and maintained playtime of at least 20 hours per week over the last 6 months. Non-VGPs had little-to-no game play experience (maximum 1.5 years). Participants responded to checkerboard stimuli presented to the left and right visual fields while 128-channel EEG was recorded. Expert VGPs responded significantly more quickly than non-VGPs. Expert VGPs also had significantly earlier occipital N1s in direct visual pathways (the hemisphere contralateral to the visual field in which the stimulus was presented). IHTT was calculated by comparing the latencies of occipital N1 components between hemispheres. No significant between-group differences in electrophysiological estimates of IHTT were found. Shorter N1 latencies may enable expert VGPs to discriminate attended visual stimuli significantly earlier than non-VGPs and contribute to faster responding in visual tasks. As successful video-game play requires precise, time pressured, bimanual motor movements in response to complex visual stimuli, which in this sample began during early childhood, these differences may reflect the experience and training involved during the development of video-game expertise, but training studies are needed to test this prediction.

**Brain Training or Strategy Acquisition?**


Adaptive computerized training has been associated with significant enhancements in untrained working memory tasks, but the nature of the cognitive changes that underpin these improvements are not yet fully understood. Here, we investigate the possibility that training stimulates the use of memory-related strategies. In a randomized controlled trial, participants completed four tests of working memory before receiving adaptive working memory training, nonadaptive working memory training with low memory loads, or no training. Open-ended interviews about strategy use were conducted after the administration of untrained working memory tasks at two time points. Those in the adaptive and nonadaptive groups completed the assessments before (T1) and after (T2) 10 training sessions. The no-training group completed the same set of tasks at T1 and T2, without any training between assessment points. Adaptive training was associated with selective improvements in untrained tests of working memory, accompanied by a significant increase in the use of a grouping strategy for visuospatial short-term memory and verbal working memory tasks. These results indicate
that training-related improvements in working memory may be mediated by implicit and spontaneous changes in the use of strategies to subsegment sequences of information into groups for recall when the tasks used at test overlap with those used during training.

**Looking at Visualizations – Eye Data**


Hierarchical graphs (e.g. file system browsers and preference trees) represent objects (e.g. files and folders) as graph nodes and relations between them (e.g. sub-folder relations) as lines. We investigated the temporal organisation of two processes that are necessary for comprehending such graphs—search for the graph nodes and reasoning about their relation. We tracked eye movements to change graphs while participants interpreted them. In Experiment 1, we masked the graph at a time when search processes had finished but reasoning was hypothetically ongoing. We observed a dramatic deterioration in comprehension compared with unmasked graphs. In Experiment 2, we changed the relation between critical graph nodes after search for them had finished, unbeknownst to participants. Participants mostly based their response on the graph as presented after the change. These results suggest that comprehension processes are organised in a sequential manner, an observation that can potentially be applied to the interactive presentation of graphs.


An eye tracking methodology can help uncover subtle cognitive processing stages that are otherwise difficult to observe in visualization evaluation studies. Pros and cons of eye tracking methods are discussed here, including common analysis metrics. One example metric is the initial time at which all elements of a visualization that are required to complete a task have been viewed. An illustrative eye tracking study was conducted to compare how radial and linear graphs support value lookup tasks for both one and two data-dimensions. Linear and radial versions of bar, line, area, and scatter graphs were presented to 32 participants, who each completed a counterbalanced series of tasks. Tasks were completed more quickly on linear graphs than on those with a radial layout. Scanpath analysis revealed that a three-stage processing model was supported: (1) find desired data dimension, (2) find its datapoint, and (3) map the datapoint to its value. Mapping a datapoint to its value was slower on radial than linear graphs, probably because eyes need to follow a circular, as opposed to a linear path. Finding a datapoint within a dimension was harder using line and area graphs than bar and scatter graphs, possibly due to visual confusion of the line representing a data series. Although few errors were made, eye tracking was also used here to classify error strategies. As a result of these analyses, guidelines are proposed for the design of radial and linear graphs.


Effective graphics are essential for understanding complex information and completing tasks. To assess graphic effectiveness, eye tracking methods can help provide a deeper understanding of scanning strategies that underlie more traditional, high-level accuracy and task completion...
time results. Eye tracking methods entail many challenges, such as defining fixations, assigning fixations to areas of interest, choosing appropriate metrics, addressing potential errors in gaze location, and handling scanning interruptions. Special considerations are also required designing, preparing, and conducting eye tracking studies. An illustrative eye tracking study was conducted to assess the differences in scanning within and between bar, line, and spider graphs, to determine which graphs best support relative comparisons along several dimensions. There was excessive scanning to locate the correct bar graph in easier tasks. Scanning across bar and line graph dimensions before comparing across graphs was evident in harder tasks. There was repeated scanning between the same dimension of two spider graphs, implying a greater cognitive demand from scanning in a circle that contains multiple linear dimensions, than from scanning the linear axes of bar and line graphs. With appropriate task design and targeted analysis metrics, eye tracking techniques can illuminate visual scanning patterns hidden by more traditional time and accuracy results.

Data Visualization and Understanding Number Sets

Comparing datasets, that is, sets of numbers in context, is a critical skill in higher order cognition. Although much is known about how people compare single numbers, little is known about how number sets are represented and compared. We investigated how subjects compared datasets that varied in their statistical properties, including ratio of means, coefficient of variation, and number of observations, by measuring eye fixations, accuracy, and confidence when assessing differences between number sets. Results indicated that participants implicitly create and compare approximate summary values that include information about mean and variance, with no evidence of explicit calculation. Accuracy and confidence increased, while the number of fixations decreased as sets became more distinct (i.e., as mean ratios increase and variance decreases), demonstrating that the statistical properties of datasets were highly related to comparisons. The discussion includes a model proposing how reasoners summarize and compare datasets within the architecture for approximate number representation.

Visual Search in Information Tasks

To support effective exploration, it is often stated that interactive visualizations should provide rapid response times. However, the effects of interactive latency on the process and outcomes of exploratory visual analysis have not been systematically studied. We present an experiment measuring user behavior and knowledge discovery with interactive visualizations under varying latency conditions. We observe that an additional delay of 500ms incurs significant costs, decreasing user activity and data set coverage. Analyzing verbal data from think-aloud protocols, we find that increased latency reduces the rate at which users make observations, draw generalizations and generate hypotheses. Moreover, we note interaction effects in which initial exposure to higher latencies leads to subsequently reduced performance in a low-latency setting. Overall, increased latency causes users to shift exploration strategy, in turn affecting performance. We discuss how these results can inform the design of interactive analysis tools. (Recommended by David Peebles based on attending the talk.)

In a simulated aircraft navigation task, a fusion technique known as triangulation was used to improve the accuracy and onscreen availability of location information from two separate radars. Three experiments investigated whether the reduced cognitive processing required to extract information from the fused environment led to impoverished retention of visual-spatial information. Experienced pilots and students completed various simulated flight missions and were required to make a number of location estimates. Following a retention interval, memory for locations was assessed. Experiment 1 demonstrated, in an applied setting, that the retention of fused information was problematic and Experiment 2 replicated this finding under laboratory conditions. Experiment 3 successfully improved the retention of fused information by limiting its availability within the interface, which it is argued, shifted participants’ strategies from over-reliance on the display as an external memory source to more memory-dependent interaction. These results are discussed within the context of intelligent interface design and effective human-machine interaction.


An important question for Human-Computer Interaction is to understand how and why visual search strategy is adapted to the demands imposed by the task of searching the results of a search engine. There is emerging evidence that a key part of the answer concerns the expected information gain of each of the set of available information gathering actions. We build on previous research to show that people are acutely sensitive to differences in the density and in the number of items returned by the search engine. These factors cause shifts in the efficiency of the available information gathering actions. We focus on an image browsing task, and show that, as a consequence of changes to the efficiency of available actions, people make small but significant changes to eye-movement strategy.


One reason that human interaction with technology is difficult to understand is because the way in which people perform interactive tasks is highly adaptive. One such interactive task is menu search. In the current article we test the hypothesis that menu search is rationally adapted to (1) the ecological structure of interaction, (2) cognitive and perceptual limits, and (3) the goal to maximise the trade-off between speed and accuracy. Unlike in previous models, no assumptions are made about the strategies available to or adopted by users, rather the menu search problem is specified as a reinforcement learning problem and behaviour emerges by finding the optimal policy. The model is tested against existing empirical findings concerning the effect of menu organisation and menu length. The model predicts the effect of these variables on task completion time and eye movements. The discussion considers the pros and cons of the modelling approach relative to other well-known modelling approaches.

*Please note that the above list of topics and papers is not the reading syllabus but is meant to be suggestive of the topics that will be covered.*
Participation

There are three parts to this course each part is associated with a weekly meeting.

Individual Session

Each enrolled student will meet once each week with the instructor for an hour-long meeting. The focus of the meeting will be the student’s current research and readings. It is expected that each week, the student will be able to discuss with the instructor new readings relevant to their research topic, discuss the design, conduct, and analysis of empirical studies, as well as the design, conduct, and evaluation of computational cognitive modeling. It is NOT expected that all three of these topics will be discussed each week.

Research Issues Session

All students will meet once each week with the instructor for an hour-long group meeting. This meeting will also include any and all undergraduate students who are engaged in collaborative research with the graduate student and/or engaged in research related to the graduate student’s. The focus of this meeting will be on methods and techniques for experimental data collection, data analysis, display of data, and modeling. On different weeks, different students will present work-in-progress to the group.

Reading Seminar Session

All students will meet together, once each week with the instructor for a 3-4 hour reading seminar discussion. This semester’s discussions will be centered around the weekly readings listed in this syllabus as well as readings that may arise during the semester as related to papers on the syllabus.

The class will be run as a graduate seminar. On some weeks, all students will be expected to read and be prepared to lead a discussion on any or all assigned readings. On other weeks, different students will read and present different papers. (On those weeks, it will not be expected that each student reads all papers but it will be expected that each presentation will be support by slides.)

All students will be expected to comment and discuss the readings based on how the author frames and presents his or her work. That is, all of our grad students are capable of free-associating and generating, at times, interesting ideas without reading the material. However, that is not acceptable. If you have not done the work expected for that week’s class, do not come to class.

PreRequisites

Permission of the instructor. This is a graduate research seminar. However, interested undergraduates are encouraged to contact the instructor to discuss their participation in the seminar. Responsibilities and assignments for undergraduates will be discussed and agreed on, in writing, by the student and the instructor.

About the Instructor

Professor Gray has been a member of the Cognitive Science Department at RPI since the Fall of 2002. For details on his research interests and activities see his homepage.

Honors Policy

My expectation is that all of the work you do for me in this class will be the work of one individual. Exceptions to this rule will be broadcast to the class by email.
As you will all find out, I explicitly encourage you to engage in public (using email and other media to broadcast a message to the entire) or private (one-to-one) discourse regarding the readings and topics raised in this class. Study groups are encouraged.

If any of you have any questions regarding current situations or future situations, remember that I am your first contact on this. Please contact me.

**Grading Policy**

**Examinations**

There are no examinations

**Active Participation**

65% For reading papers and for active participation in all discussions on all weeks in which the seminar is held. Exceptions due to professional travel or other activities need to be discussed with the instructor ahead of time.

45% Formal presentations based on assigned readings.

In general, 1-2 students will be assigned the discussion leaders for each week’s readings. The discussion leaders will prepare slides to organize and structure the discussion of their paper. All students are expected to join in the active discussion.

**References**

Please note that this listing includes both misses and false alarms! That is, it excludes some papers that will be read and discussed and includes some that will not be read and discussed. Please consider this list as representative of the types of papers that will be read and discussed.


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Yes. I expect 110% out of you!


