Research Statement
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My research investigates the cognitive mechanisms and processes of learning and skill acquisition. Toward this end, I have developed three inter-related lines of research that investigate learning—one, involving surveys and field studies regarding the acquisition of methods and strategies associated with efficient use of computer software, another in a more traditional classroom-learning environment, and the third in the laboratory with a non-traditional task of interpreting auditory graphs. By studying the learning principles and processes for diverse topics, my research ultimately focuses on building the knowledge base regarding how skill and knowledge acquisition occurs and what influences that process.

My three areas of research include:

1. Efficient Strategy Selection: The investigation of the cognitive mechanisms associated with the acquisition and selection of efficient strategies with software.
2. Simulations and Teaching Statistics: When teaching statistics, when is the integration of animations and simulations into the classroom most beneficial and for whom?
3. Auditory Displays: What dimensions of sound should be used in the auditory display of quantitative data and how does the integrality of these dimensions impact their effectiveness? What effects does a divided attention environment have on interpreting auditory graphs? Should training for these types of displays be focused on the display or the underlying task?

Efficient Strategy Selection:

On the surface, the utilization of new software tools in the workplace would seem to be a cost effective method of improving productivity. However, research indicates that many, if not most, people do not utilize these tools effectively. For instance, Napier, Batsell, Lane & Guadagno, (1992) found that most people only use a small portion of the available commands in a spreadsheet program. The common assumption of many software developers seems to be that people's expertise with software programs will improve as a function of the amount of time they have used that software. However, there have been several studies indicating that this is not the case (Bhavnani & John, 1996; Lane, Napier, Peres, & Sándor, 2005). Bhavnani investigated how architects use computer aided drafting (CAD) programs and found that most of the architects were not utilizing some of the most powerful features of the programs. Furthermore, he found that some architects were so inefficient with the program that it took just as much time to make a drawing using the CAD as it would to make the same drawing by hand.

In a study on the use of the keyboard to issue commands (KIC), we found this same pattern of use—regardless of age, experience with computers, number of hours spent at the computer, or professional position, most people did not use the keyboard to issue commands (Lane *et al.*, 2005). Indeed, even though it takes approximately 50% more time, to issue a command, the most experienced users move the mouse to the icon or the menu at the top of the Graphical User Interface (GUI) instead of using a keyboard shortcuts (Lane *et al.*, 2005). This contradicts the current assumption of many software designers that users will become more efficient with a software program over time. These findings led me to the question: What factors are associated with the efficient and effective use of software?

Some of my initial work in this area has identified that the observation of efficient users, often termed peer learning is related to the use of KIC {Peres, 2004 #306; Peres, 2005 #304}.

This finding is not new and there are reports of this type of learning in several studies (Carroll & Rosson, 1987; Chadwick-Dias, Tedesco, & Tullis, 2004). Indeed, in his work on architects using CAD software, Bhavnani reported this type of learning being associated with knowledge of efficient strategies (Bhavnani & John, 1996). However, Bhavnani's and other's findings are usually reported as an aside and the effects of learning from peers has not yet been systematically investigated.

My continued work in this area has provided evidence that the use of efficient strategies is associated with a higher weighting of the benefits of using that strategy (Peres, Fleetwood, Tamborello II, Yang, & Paige-Smith, 2005). When considered in conjunction with my previous findings, these results suggest that peer learning may be involved an individual's perception of the benefits of using the efficient technique sufficiently enough to outweigh the costs of learning and adopting a new strategy. The next study in this line of research will be a lab experiment designed to manipulate someone's observation of another using an efficient strategy and then measure the person's subsequent use of that strategy and their weightings of the costs and the benefits of using the strategy. The behavioral data from this study will be used to develop a cognitive model for evaluating different hypotheses regarding the cognitive mechanisms associated with the impacts of peer learning.

I expect that one of the findings from this line of research will be that people do not start using an efficient strategy after first learning about it, but rather after subsequent exposure to the strategy. Through cognitive modeling (ACT-R) and observations of brain activity (either fMRI or ERPs), I will test the theory that when people first learn of an efficient strategy, procedural knowledge is established, but that the base activation level of that procedure is not sufficiently high for it to be accessed in the future when it is applicable. However, when people are "re-exposed" to this strategy in an environment with very strong contextual cues, the base activation level of the procedure is increased to a sufficient level that it will be selected in the future. Moreover, I propose that environments with the strongest contextual cue are those where someone observes another person using the strategy. For example, if someone who know about but does not use Ctrl+C to copy information to the clipboard observes someone else using this technique, the base level activation of that technique will be sufficiently increased so the observer will use that technique to copy information to the clipboard in the future. Furthermore, I think that the relevant components of the contextual cues can be identified and manipulated, i.e. that strong contextual cues includes those that influence the cost/benefit analysis and that provide task relevance for the technique.

I would like to ultimately apply this theoretical position to classroom learning. Very often when learning complex subjects, a single exposure to the material is not sufficient for the material to be well enough learned that it will be available when necessary at a later time—one exposure does not often ensure transfer. I submit that in learning about the cognitive mechanisms associated with the acquisition of efficient strategies, the theories of the processes associated with classroom learning will be furthered as well—particularly with regard to the impact of contextual cues in the learning environment to subsequent knowledge transfer. Indeed, it may be that it is when students are attempting to retrieve and apply procedures/knowledge in an environment with contextual relevance (e.g., engineering internship for Physics and Geometry or

a summer trip to France for French) that knowledge acquisition is firmly established. It may be that once this process is completely understood (i.e., the impacts of contextual cues on the transfer of existing knowledge) that the structured learning that occurs in the classroom can be best designed to facilitate this process.

Simulations and Teaching Statistics:

I am pursuing this line of research in collaboration with David Lane from Rice University. With this research, we are investigating when and for whom the integration of animations and simulations into the classroom is most beneficial particularly for teaching statistics. Much of the simulations and multimedia we are using in this research are associated with "Online Statistics: A Multimedia Course of Study" (http://psych.rice.edu/online_stat/). This is an online statistics textbook that contains written and multimedia presentations of the material covered in an undergraduate statistics course. This website includes interactive simulations and demonstrations, self-testing questions, data analysis capabilities, and case studies with real data. The book is designed to support a face-to-face statistics course by providing the professor and student access to (a) real data analysis, (b) simulations that make abstract concepts more concrete, and (c) interactive activities.

Currently, I am investigating the impacts of integrating a multimedia presentation of the statistics material, particularly on retention and motivation. This investigation involves conducting an experiment that will compare students' performance on statistics quizzes when they are exposed to a statistics module in different formats—html text, a multimedia format, and a combination of the two.

Regarding the use of simulations in teaching, previous work suggests that statistical training using computer simulations may be beneficial, particularly for students with lower cognitive skills (Lane & Tang, 2000). The mechanisms of this benefit are still not clearly understood though. Nor is it clear what type of preparation is necessary for the students to benefit from the interaction with the simulation. My own experience with using simulations for teaching suggests that if students do not have sufficient academic training before using the simulation, it can prove to create more confusion than clarity. This may also influence students' motivation and attitude toward learning. A technique used in the Online Stats for preparing students to learn from the simulations is the "query first" method. This involves having the student answer questions about the material presented in the simulation before interacting with it. These questions are meant to guide the learning experience by providing the learner with a "preview" of what they are going to learn.

My future research in this area will focus on identifying and isolating the mechanisms associated with any benefits found from using the query first method. This research will apply the knowledge gained from my work on the acquisition of efficient strategies to learning statistics.

Auditory Displays:

My research on auditory displays has focused primarily on the sonification of statistical graphs and how the dimensions of sound used in those graphs impacted user's performances. Sonification is a method of presenting information using sound. A Geiger counter is a good

example of this as it represents the level of radioactivity using sound. This display directly represents the data and does not attempt to summarize the radioactivity readings. There are situations where a summary of the data is more beneficial than a direct representation. A sonified graph is appropriate in this situation and my research has been focused on how performance differs for sonified graphs (specifically boxplots) when different dimensions of sounds are used for the graphs. I have found that performance is superior with a design using some element of time to represent the values of the graph (Peres, 2004; Peres & Lane, 2003; Sándor, 2004). I have also conducted some research investigating the effects of dimensions of sounds on displays designed to represent hold time for someone calling into a call center. Similar to the work on auditory box plots, these findings too indicate that individual's performance is impacted by the dimension of the sound used in the display (Kortum, Peres, Knott, & Bushey, 2005).

There is also some reason to believe that designs using multiple dimensions of sound may have benefits over those using single dimensions (Kramer, 1994). In my research on auditory graphs, I have found a redundancy gain when the integral dimensions of sound used are loudness and pitch (Peres, 2004) while other research no redundancy gain for other integral dimensions of sound (Sándor, 2004). Another element associated with auditory displays that I have investigated is how performance is affected when the auditory task is being done concurrently with a visual task. I found that, while there was an initial decrement in performance for a divided attention environment, ultimately, participants were able to evaluate the auditory graph equally well in single and dual task situations (Peres, 2004).

The next step in this research is to apply the principles of learning and training developed primarily on visual tasks to auditory tasks. Bjork and Schmidt (1992) found that initial performance levels after training did not necessarily correlate positively with later performance levels. However, subsequent research has been mixed on this topic and primarily differs for the type of task being taught. There is little research on how different methods of training people to use auditory displays impacts performance. I plan to continue my research on auditory graphs by exploring how the training methodology effects performance and transfer for the task of interpreting auditory graphs. I am particularly interested in following up on some of my findings that suggest that those who have had statistical training perform better on the task using the auditory box plot. These findings suggest that training for auditory displays may need to be focused on the task rather than the display. I would also like to investigate whether and how the mechanisms of learning associated with the utilization of efficient strategies are associated with learning to perform a task using an auditory display.

In summary, for my research, I utilize different methods and topics to investigate and discover the cognitive mechanisms and processes associated with learning and skill acquisition. Because my research is designed to allow for the testing of theories of learning across different types of task and perceptual domains, I will be able to develop theories that generalize across these dimensions. Thus allowing me to identify mechanisms of learning that are basic to human learning and not domain specific.

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