Understanding the Role of Presentation Pace in Learning a Time-sensitive Task

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Understanding the Role of Presentation Pace in

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To my parents, James and Ollie Hickman, your prayers, love, support, and encouragement made this moment in my life possible. I am forever indebted to you.

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SUMMARY

In developing training for new technologies, designers encounter many options in an effort to increase system knowledge and produce effective system usage. Technological advancements do, however, provide the opportunity for more dynamic and interactive training methods. Moreover, technology may require the acquisition of time-sensitive skills. Many technologies have automatic shut-off or low-power functions, like the shutting off the backlight of a cell phone after 30 seconds. These system functions may lead to errors for novice users or for infrequent tasks. To develop effective training for time-sensitive tasks, the learner needs instruction on how to accurately perform the task at a particular pace. One potentially fruitful avenue of exploration is to provide the learning goal during training through the pace of the training materials. This presentation pace is the rate at which training tasks are presented to the learner during training; this pace may be fixed or self-regulated. The goal of the current study was to examine the role of presentation in learning a complex technology using four types of pacing for younger adults (Experiment 1) and older adults (Experiment 2). The results of this study show there seems to be a benefit of self-paced training for younger adults and older adults. These findings provide insight into future studies investigating the underlying mechanisms related to the benefits of self-paced training. Additionally, the findings have implications for the development of training paradigms for time-sensitive technologies.

CHAPTER 1

GENERAL INTRODUCTION

Consider the following scenario: A husband and wife are getting settled in for the evening. The husband is just ending a cell phone conversation with his best friend who has recently moved to a new city. The husband realizes that he does not have his friend's new number programmed into his cell phone and it has been a while since he last added a number. In the dim bedroom light, he looks at the phone trying to figure out which menu option will allow him to replace the old number with the new number. The built in screen illumination stays on for 30 seconds between button presses which has never posed a time-constraint issue while doing routine cell phone tasks. However, in completing this unfamiliar task, the husband is finding the 30 seconds insufficient to allow him to complete the task.

The gentleman in the previous scenario demonstrates two aspects of operating a complex technological system: performing time-sensitive tasks effectively and within a specific time window. Many systems today are complex with multiple functions and employ a timing mechanism for reasons such as energy efficiency or sample validity in medical devices. Users of these new technologies need some form of training to operate the device efficiently and effectively (Fisk, Rogers, Charness, Czaja, & Sharit, 2009).

In developing training for new technologies, designers encounter many options in an effort to increase system knowledge and produce effective system usage. New technologies pose old challenges to the area of skill acquisition. Although in the 21st century we are faced with rapid changes in the way we perform daily tasks, understanding skill acquisition is not a new area for psychologists. Technological advancements do, however, provide the opportunity for more dynamic and interactive training methods and are bringing about renewed interest in skill acquisition (Goldman, 2003). For example, multimedia learning methods were thought to solve issues faced with unimedia methods (e.g., paper manuals), such as little or no hands-on tasks with dynamic feedback (Cognition and Technology Group at Vanderbilt, 1996). However, old issues of learning new technologies were not ameliorated by multimedia approaches. In fact, the same issues emerged. For example, the distracting combination of sound, movies, and text in the multimedia training protocol resulted in poor performance due to increases in working memory demands (Fisk, Rogers, Charness, Czaja, & Sharit, 2009). What did make a difference in learning was instruction grounded in the well-established principles of skill acquisition (Fisk et al., 2009; Mayer, 2003). Regardless of the frequency of training, the consequences of errors, or whether you are learning to play checkers or use a car navigation system, if you have never done it before, it is new to you. Therefore, the same principles of skill acquisition apply to the acquisition of technological skills. The overall goal of my dissertation was to use the foundational principles of skill acquisition to examine how individuals learn to perform time-sensitive performance skills effectively and within the allotted time window through training.

Key Concepts in the Design of Training

The term "training" can be broadly used to describe the act of teaching a particular skill or type of behavior through practice or instruction over a period of time. Determining effective training, in general, is a multi-step process that includes understanding the learner's capabilities and limitations, analyzing the to-be-learned system, and determining the learning goals (Rogers, Campbell, & Pak, 2001; Salas, Cannon-Bowers, & Kozlowski, 1997; Swezey & Llaneras, 1997).

Understand the Learner

Knowing the learner is vitally important in designing effective training. Different user groups have different system needs and may require different training. For example, a manager may need to know how to adjust complex technical settings, whereas an entry level employee may need to perform routine system tasks. There are also person characteristics about the learner that may influence skill acquisition and require a different training approach. From a cognitive perspective, cognitive abilities such as working memory capacity, perceptual speed, vocabulary, and long-term memory affect information processing.

For example, older adults experience age-related changes in cognition such as reductions in working memory and perceptual speed (Craik & Salthouse, 2000; Park & Schwarz, 2000). It is important to know how these cognitive changes influence skill acquisition; moreover, due to these changes, older adults may need different training than younger adults. Previous research on training found that, compared to younger adults, older adults take longer to complete training tasks, complete fewer tasks, make more errors, and require more help (see Czaja & Lee, 2003 for a review). However, aging research also demonstrates and endorses that these changes can be ameliorated with effective training (i.e., training that incorporates learner needs, a system analysis, and learning goals) (e.g., Hickman et al., 2007; Jamieson & Rogers, 2000; Mead & Fisk, 1998).

Analyze the System

In addition to understanding the learner population, it is also important to understand the to-be-learned system through various front-end analyses, such as a system analysis. A system analysis is a series of task analyses for an overall system. The system analysis is used to identify task components or concepts, the hierarchical organization or knowledge organization of the system, and the task demands, which are the cognitive, perceptual, and motor demands required when performing a task (e.g., Gagne & Briggs, 1974; Luczak, 1997; Mayhorn et al., 2004; Shepherd, 1985, 1998). The system analysis also aids in the identification of consistent components which are essential for learning to occur (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977).

Identify the Learning Goals

It is very hard to find your destination if you do not know where you are going. In the design of training, learning goals are the trainee's destination. There are various types of learning goals, such as a performance criterion of speed or accuracy. For training to be successful it is essential to determine the learning goals and design training that facilitates the development of skills associated with those goals (Gagne, 1970; Gagne & Briggs, 1974). Identifying learning goals not only results in more effective training but also provides the learner with task expectations and demands (Swezey & Llaneras, 1997). Matching these task expectations and demands to training type yielded improved performance for both younger and older adults (McLaughlin, Rogers, Sierra, & Fisk, 2007). Therefore, it is essential to identify the learning goals because they influence the type of training that will be presented to the user and also the level at which the user acquires knowledge.

Understanding Presentation Pace

Recall the gentleman in the introduction using the cell phone: his learning goals are not only to accurately select controls to input a new number, but also to perform each selection within a 30 second window. To develop effective training for this cell phone task, the learner needs instruction on how to accurately perform the task at a pace within the 30 seconds. However, little research has focused directly on determining how to optimize training for this specific learning goal.

One potentially fruitful avenue of exploration is to provide the learning goal context during training through the pace of the training materials. This presentation pace is the rate at which training tasks are presented to the learner during training (Mayhorn et al., 2004); this pace may be fixed or self-regulated. Fixed presentation pace is a general term used to describe pacing that is not regulated or governed by the learner. There is an external time mechanism limiting the learner on the amount of time spent on individual or overall tasks, such as a computer training module or an individual with a stopwatch. However, when the presentation pace is self-paced, participants are instructed to work at their own pace with no external timer limiting the amount of time spent on a task.

Presentation Pace and Training Younger Adults

What is the best training presentation rate for younger adults learning to perform a task that must be completed in a particular time frame? The literature provides minimal guidance on this issue. Presentation pace has only been investigated in the context of general learning such as concept mastery (Bloom, 1976; Keller, 1968), diagram comprehension (Tabbers, 2002), and verbal learning (Taub, 1967). The learning goals in these studies related primarily to the knowledge of the materials rather than the rate of responding. These studies do provide some general guidance about the importance of presentation pace, although the results are somewhat mixed.

Two opposing camps of instructional design lend support to either fixed pacing or self pacing in an educational environment. Bloom's Learning for Mastery (LFM) and Keller's Personalized System of Instruction (PSI) both focus on concept mastery through diving the learning materials into smaller units and evaluating learning through formative tests on each unit of material (Bloom, 1976; Keller, 1968). However, LFM encourages structure and teach-controlled pacing to increase learning, while PSI endorses that learner-controlled pacing increases learning.

Some studies suggest benefits of self pacing. For example, self-paced training yielded better learning for diagram comprehension (compared to a fixed paced condition) and mitigated the effects of having to integrate information across modalities (e.g., Tabbers, 2002). The author suggested that the self-pacing allowed the learners time to integrate the relevant information perhaps by minimizing working memory demands. Moreover, according to the Keller Plan, participants preferred self-paced training compared to instructor paced for learning (Kulik, Kulik, & Carmichael, 1974).

There is some evidence that fixed pacing can lead to successful learning, however the specific rate of the pacing is critical. For learning paired associates, for example, a slower presentation rate led to better learning (Taub, 1967). These data suggest that the critical variable may not be self- versus fixed-rate, per se, but the actual presentation rate may be the critical variable.

In sum, studies of presentation pace for younger adults suggest that this is an important variable that influences leaning. However, the underlying mechanisms of the effect are not clear and the specific importance of presentation pace for time-related learning goals has not been investigated.

Presentation Pace and Training Older Adults

The issue of training pace has been investigated in somewhat more depth for older adults but not necessarily with the learning goal of being able to respond within a particular time frame. In general, it has been suggested that the training for older adults be presented in a self-paced manner (e.g., Czaja, 2001) due to reductions in working memory capacity and processing speed (Salthouse, 1991) as well as learner preferences (Mayhorn et al., 2004).

A review of the literature within the domain of aging and technology skill acquisition, revealed that many studies that reported presentation pace used self-paced learning (see Table 1.1 for the list of articles).

Table 1.1

List of studies that focused on aging and technology training that indicated or manipulated presentation pace

Study	Presentation Pace
Charness, Schumann, & Boritz (1992 exp1)	self-paced
Charness, Schumann, & Boritz (1992 exp2)	self-paced v. fixed-paced
Czaja, Hammond, Blascovich & Swede (1986)	self-paced
Czaja, Hammond, Blascovich & Swede (1989)	self-paced
Czaja & Sharit (1993)	self-paced v. fixed-paced
Hickman, Rogers, & Fisk (2007)	self-paced
Echt, Morrell, & Park (1998)	self-paced
Zandri & Charness (1989)	self-paced
Sterns (2005)	self-paced

The review identified only two studies that specifically manipulated presentation pace. Charness et al. (1992) examined the effects of age and training condition on computer anxiety and performance (measured as accuracy and task completion time). The manipulation of learning pace consisted of self-paced active learning and fixed-pace passive learning. In self-paced active learning participants were engaged in an interactive word processing tutorial where they were instructed to read the computer screen and press the corresponding keys, working at their own pace. Participants in the fixed-pace passive learning condition were instructed to watch a tutorial that was presented at a set pace without performing any key presses; they were informed that they would have an opportunity to type in the next session. Data analysis revealed a significant main effect for training approach. The age x training interaction effect was not significant; however younger adults benefited more from the self-pacing than older adults. The authors conclude that the "*...failure to find that self-paced training makes more of a difference than fixed pace training in older adults implies that employers need not devise specialized training programs specifically for older workers. A good program for the older worker will be equally effective for the young one. The reverse need not be true, however.*" (p. 104).

The Charness et al. (1992) paper is often referenced as demonstrating benefits of self-pacing. However, this study is not an indication that one pace fits all, but that it needs further examination. Moreover, it may be the interaction of pacing (self vs. fixed) and training type (active vs. passive) that was beneficial and not the pacing per se. Therefore, holding constant other aspects of the training, such as type of training, and manipulating only the pacing may lead to a clearer understanding of the effects of presentation pace on learning.

The second study directly assessing pacing was an investigation of the age-related differences in the performance of computer-based tasks. Czaja and Sharit (1993) simulated three work-related tasks: data-entry, file-modification, and inventory-management. Performance was measured by response time per problem, variability in time per problem, number and type of errors for each task. In addition to these measures of performance, work load, fatigue, and task difficulty were also assessed. Training on the computer-based tasks was presented to the learner as either fixed-paced or self-paced. In the fixed-paced condition, participants were allowed 45s per problem, whereas in the self-paced condition; participants were instructed to work at their own pace. For the data-entry task there was a significant age x pacing interaction such that the age differences were reduced in response time only for the fixed-paced condition. Older adults also demonstrated greater variability when the data-entry task was self-paced. However, there was no significant interaction for type of pacing on response time or variability for either the file modification or the inventory management tasks. Czaja and Sharit conclude that "*older people prefer to work at a slower variable pace; a supposition further supported by the subjective data. The older people found the tasks more fatiguing when they were paced. These findings have important implications for job design. The data suggest that unpaced work is more suitable for older workers, which is consistent with the existing age- and work-performance literature*." (p. 66)

The Czaja and Sharit (1993) results provide mixed information about the roles of presentation pace. Sometimes, as in the data entry task, pacing improved performance and reduced age differences (in both response time and variability). For the other tasks, pacing did not influence performance or age differences. These findings suggest that the type of task interacts with presentation pace. Older adults consistently perform slower than younger (see Czaja, 2001 for a review); therefore, a fast presentation pace similar to that of younger adults may not be beneficial to older adults. However, the application of fixed-paced that is comparable to the natural learning pace of older adults found in previous research may improve performance. The pace does not have to be fast to be fixed; there may be some benefit to goal setting and time constraints that may improve task performance for older adults. Also, the nature of the task and learning outcomes may be important to consider when deciding what type of pace to use.

These studies illustrate that more research is needed in the area of pacing and more specifically, as stated by Czaja and Sharit "*…there is a need to understand the information-processing components underlying the age-performance deficits*" (p. 66, 1993). Essentially, the underlying mechanisms influencing learning pace need to be identified through theories of learning and skill acquisition and then examined empirically to understand the influence of different learning paces on learning goals. The implication that one type of learning pace is effective in all training conditions and for all learning outcomes is not supported with empirical research. It is important to understand how presentation pace influences the acquisition of different learning goals and in this specific study, performing a time-sensitive task.

Theoretical Background

Over the past 30 years a substantial effort has been aimed at understanding skill acquisition (e.g., Ackerman, 1988; Fisk & Schneider, 1983; Shiffrin & Schneider, 1977;

Whaley & Fisk, 1993). The performance level during controlled processing is qualitatively different from that during automatic processing. The transition from the slow, effortful, and error-prone performance to the quick, effortless, and accurate performance has been extensively examined.

One over-arching theme in the automatic and controlled processing literature is the importance of consistent task components and how important it is that training emphasizes these consistencies (Schneider, 1985). Learning best occurs in tasks with consistent components and those components must be identified and made relevant to the learner. Referred to as *consistent component training* (Eggemeier, Fisk, Robbins, & Lawless, 1988; Fisk & Eggemeier, 1988), the learner is exposed to the consistent relationship between components over a series of trials.

There are two areas of the automatic and controlled processing theory that may help identify the underlying mechanisms of learning that are influenced by presentation pace: comparison loads and coactivations. During initial exposures, or training trials, the learner's performance is slow, effortful and error prone. The learner has not yet internalized the task consistencies and is unable to parallel process other information. The learner needs adequate time in this controlled processing phase to make comparisons between components and identify relationships (e.g., Briggs & Johnsen, 1973; Johnsen & Briggs, 1973; Schneider & Shiffrin, 1977). In visual search studies for digits, letters, words, and semantic category, response times for variably mapped stimuli increase as the number of comparisons increase, whereas after practice consistently mapped stimuli response times are relatively independent of the number of comparisons (e.g., Fisk & Schneider, 1983; Schneider & Shiffrin, 1977). Once the relationships are identified, coactivations between associated task components can occur. Coactivation strengthening hypothesis states that because *memory is conceived to be a large collection of interassociated nodes, learning is changes in the activation strength between nodes. After the initial strengthening in short-term storage, one node will more strongly and quickly activate other nodes that were coactive with it* (Schneider & Fisk, 1984, p. 12).

Previous research suggests several reasons why automaticity may not occur. The learner is unable to make the relationships between components because the relationships are either not there (i.e., variably mapped) or incorrectly associated due to lack of time (Schneider & Fisk, 1984). Also, the learner may not been provided the appropriate amount of time to process the relationships in general therefore no relationship is formed (Schmitter-Edgecombe & Rogers, 1997). This may be the case for either too fast of a pace or too slow of a pace, such that too fast may not allow for adequate time but too slow may mask the whole-task connections between components.

OVERVIEW OF THE CURRENT RESEARCH PROJECT

The overall objective of the current project was to investigate the role of presentation pace in learning a time-sensitive complex technological system for younger and older adults. More specifically, the goals were to understand how different types of presentation pace influence learning system tasks and performing those tasks within a specific timeframe. Participants' performance was assessed for both the acquisition and execution of skills related to time-sensitive tasks in a computerized gardening system.

We assessed the influence of presentation pace on learning in two separate studies to be able to time-stress the participants; that is, to create a learning goal that required performing a task "quickly". However, what might be considered quick for younger adults is different from what older adults would consider quick. There is a wealth of data showing the age-related slowing is a common finding (e.g., see Craik & Salthouse, 2000). Therefore, Experiment 1 investigated the role of presentation pace in learning a time-sensitive task for younger adults and Experiment 2 investigated this issue for older adults.

CHAPTER 2: EXPERIMENT 1

INTRODUCTION

The learning goal of interest in this research is performing a time-sensitive task in the context of a technological system. For example, being able to add a telephone number on a cell phone or entering information into a medical device. The literature suggests that presentation pace during training may be an important variable to consider. However, there is limited guidance about which presentation pace (e.g., self or fixed) yields better learning in a time-sensitive task. The goal of the current study was to examine the effects of presentation pace on learning a time-sensitive task for younger adults.

To investigate this issue, four presentation paces were compared. First, was a self-paced condition. Self-paced training yields better learning in some contexts (e.g., Tabbers, 2002) and is preferred by the learners (e.g., Kulik et al., 1974). However, those studies did not require learners to perform tasks within a specific time limit. For that type of learning goal, fixed-paced training may be better because this type of training can be designed to match the learning goals.

Three fixed-paced conditions were included: Sequential, Static Slow, and Static Fast. In the Sequential condition participants received an increasing presentation pace – they started at a slow rate which was increased to ultimately match the target performance rate. This condition had the benefit of imposing a specific rate of responding, allowing time to link task components, and, matching the ultimate learning goal. However, the condition also required participants to monitor the presentation pace which may impose additional working memory demands.

In the Static Slow condition participants a fixed pace was used but the timing was selected (as described below) to enable the linkage and strengthening of task components (e.g., Schmitter-Edgecombe & Rogers, 1997). These participants also had to monitor their pacing during training but it was slower than the target rate.

The Static Fast condition provided a presentation pace that exactly matched the learning goal (i.e., the target performance rate). However, this pace might be too fast for the learner to be able to link the critical task components (e.g., Schneider & Fisk, 1984).

The four presentation pace conditions are summarized in Table 2.1.

Table 2.1

Presentation Pace Conditions

Pace	Need to monitor pacing?	Time for strengthening coactivations?	Match learning goals?
Self Paced	NO	YES	NO
Sequential	YES	YES?	YES*
Static Slow	YES	YES?	NO
Static Fast	YES	NO?	YES

*matched learning goal only for the final block of training

Learning was assessed through a Test Phase that consisted of trained tasks and untrained tasks which are described in the Method. Hypotheses focused on performance at test. The general pattern was expected to be similar for the trained and untrained tasks, at test, although the effects might be larger for the untrained tasks. This is expected because participants did not receive direct training on the untrained tasks and may them more difficult and may need more time to complete them. However, the general pattern is expected for untrained tasks as in trained tasks because the Self Pacing condition may facilitate better system knowledge due to improved component matching.

One general hypothesis was that self-paced training would be superior, overall, to any of the fixed-paced conditions. Therefore a planned comparison was made between the Self Paced condition and the other three conditions. In addition, each of the fixed paced conditions will be compared to one another as the relative benefits of each condition was indeterminate, based on the literature.

METHOD

Participants

There were 90 younger adults 18 to 29 years of age (*M* = 20.48, *SD* = 1.53) recruited from a local Atlanta university who received either course credit or $25 for compensation. Data from four of the participants were lost due to a computer error and the data from one younger adult were removed from the final dataset because overall accuracy at test was two standard deviations below the mean. The final dataset in the study included 85 participants (*M* = 20.44, *SD* = 1.54).

The current study was conducted through the Center for Research and Education on Aging and Technology Enhancement (CREATE). Prior to the current study, participants were prescreened, completed a 4-hour battery of ability measures and questionnaires in a 3-hour group-testing environment and a 1-hour individual testing environment (Czaja, Charness, Fisk, Hertzog, Nair, Rogers et al., 2006). The demographic and health/medication questionnaires consisted of items pertaining to age, gender, education, income, and health/medication issues. The technology and computer experience questionnaires consisted of items relating to daily computer use and device familiarity. The ability measures assessed vision, hearing, semantic knowledge, associative memory, perceptual speed, working memory, induction, short and long-term memory, reaction time, and depressive state (see Appendix A). A portion of the abilities measures collected are reported in Table 2.2. There were no statistically significant differences between conditions.

Table 2.2

Ability Test Data and Demographic Information

	Self Paced		**Sequential**		**Static Slow**		**Static Fast**		
Younger Adults	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*f*-value*
Males/Females	10/12	---	11/9	---	11/11	---	9/12	---	
Age	20.23	1.97	20.40	1.57	20.59	1.18	20.52	1.40	.88
Education [a]	4.77	.75	4.60	1.00	4.73	.88	4.57	.93	.25
Health [b]	4.18	.66	4.05	.69	3.91	.87	3.95	.74	.58
Perceptual Speed [c]	93.23	15.47	92.94	10.32	93.53	15.37	93.19	13.59	.01
Working Memory[d]	5.39	.75	5.10	.68	5.16	.75	5.10	.62	.82
Vocabulary [e]	31.68	5.80	32.30	3.67	33.41	2.32	32.30	3.67	.89
Reaction Time [f]	618.73	87.17	630.00	90.41	603.88	171.49	616.14	151.84	.12
Spatial Ability [g]	15.45	3.83	14.40	3.17	15.45	3.22	13.71	3.42	.27
Long-term Memory [h]	14.45	1.50	13.65	2.46	14.77	1.31	13.95	1.91	1.59

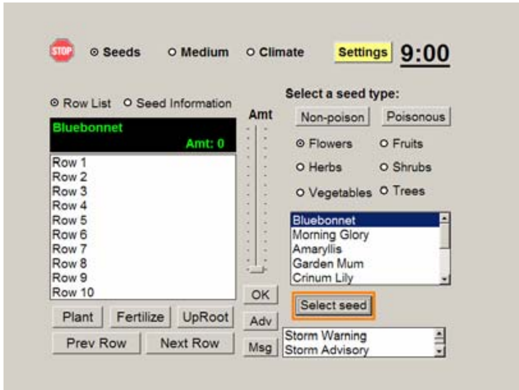
Note: *p<.05, [a] Range: 2 = less than high school, 3=High School, 4=Vocational training, 5=some college, 6=Bachelor's degree; [b]Self-rating: 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent; [c] Digit Symbol Substitution (Wechsler, 1997); [d] Alphabet Span - simple score (Craik, 1986); [e]Shipley Vocabulary (Shipley, 1986); [f] A composite score in ms of both simple RT (time to press one key) and choice RT (time to select respond to one of two keys); [g] Paper Folding Test – number correct (Ekstrom et al., 1976); [h] California Verbal Learning Test – delayed (Delis et al., 1987). All participants did not answer all questions.

Materials

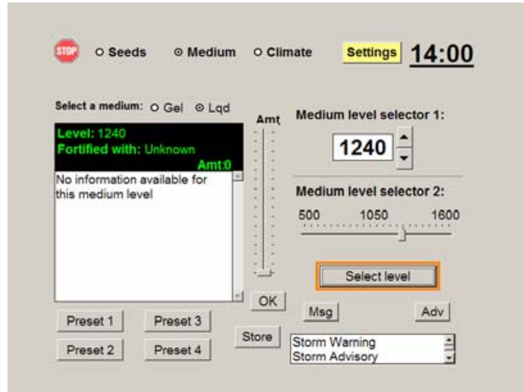
Hydroponic Garden Control

A computer simulated Hydroponic Garden Control (HGC) was designed as a training apparatus with a complex menu structure. Hydroponic gardening is gardening without soil. These types of gardens use a nutrient enriched water based medium, which flows under the roots of the plants in reservoirs causing them to grow quicker and larger.

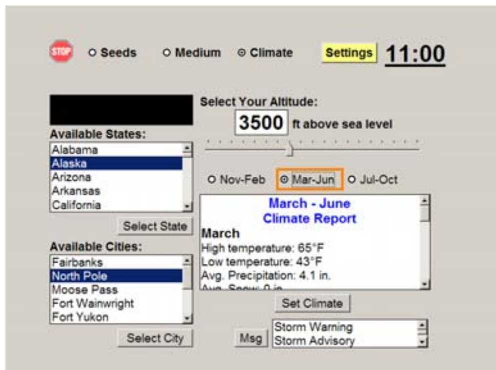
The HGC was designed using Microsoft Visual Basic 6.0 ©. The program monitored the presentation pace as well as recorded button selections, button selection time, and the time between mouse movement and button selection. By design, the system's main screens were seeds, medium, and climate and the sub-screens were advance growth controls, settings, and message history. Each main screen was designed with three primary functions that are necessary for proper system operation (see Figure 2.1). The seeds screen's primary functions were to plant a seed, adjust the amount, and view the seed information. The medium screen's primary functions were to adjust the gel medium, adjust the liquid medium, and adjust the amount. The climate screen's primary functions were to set the climate months, set the altitude, and set both the climate and altitude simultaneously.



Seeds Screen



Medium Screen



Climate Screen

Figure 2.1 Screen shots of the three main screens of the HGC.

In addition to functions of the three main screens, the HGC had three secondary screens that contained the advanced controls (i.e., calcium levels), the settings (i.e., set alarm), and the message histories (i.e., loss of power). By design, the sub-screens had supplemental functions that were not necessary for proper system operation, but enhanced system operation.

Task Environment and Experiment Procedure

During the study, the HGC was displayed on a 15” laptop monitor to the right of a presentation notebook, which displayed the directions for each task on 8 ½ x 11” paper in Times New Roman, font size 24. An external computer mouse was used in this study and a hand pointer with an extended index finger was used as a point and click aid in the navigation of the device. This task environment is shown in Figure 2.2.

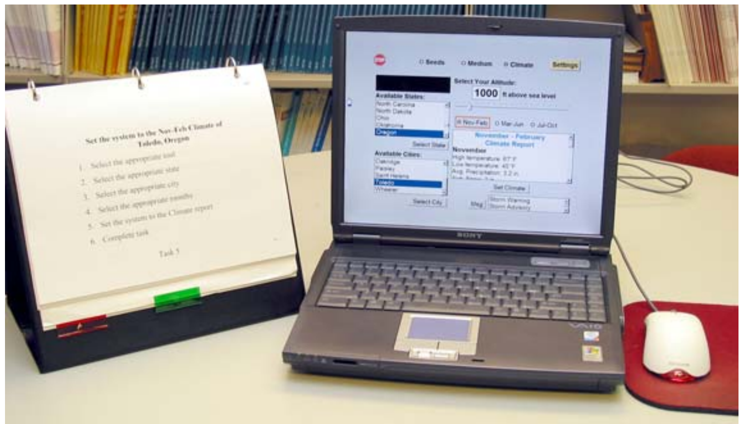


Figure 2.2. Picture of the physical setting of the computer and presentation notebook that will be used during the study.

Figure 2.3 presents the overview of the experimental procedure; the subsequent sections of this chapter will further explain each phase of the experiment. Participants began with a paper folding test, which is a measure of spatial ability, followed by mouse training. They then began the training phase of the study receiving one of the four presentation pace conditions: Self Paced, Sequential, Static Slow, or Static Fast. After training participants completed the NASA-TLX about the training followed by a test. At test, all participants were given the static fast presentation pace and completed a mixture of tasks they received during training and tasks they were not trained on. The study concluded with a questionnaire about strategy development and usage during the experiment.

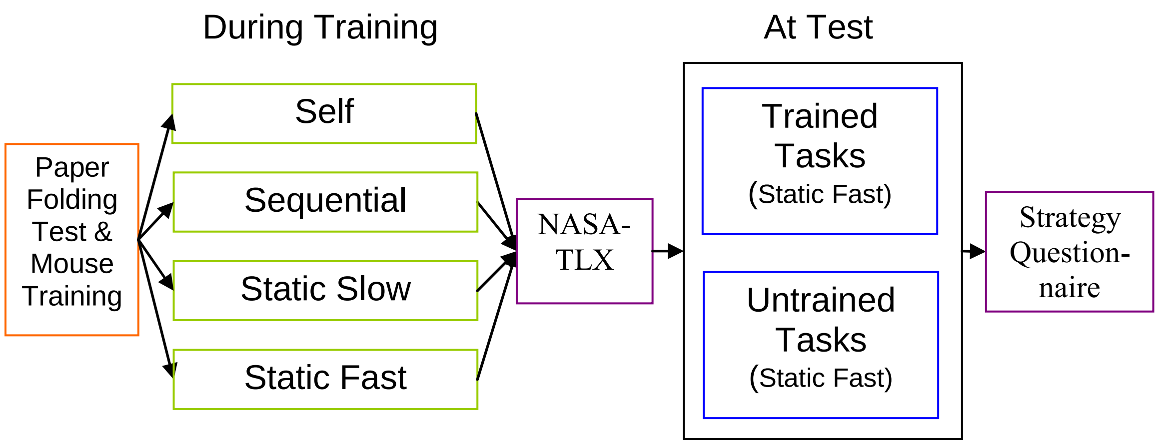


Figure 2.3. Illustration of the experimental procedure

Mouse Training

A task analysis of the general process and skills needed to complete task objectives and previous research identified that basic computer skills (mouse skills, button/slider activation) were necessary to perform tasks of the HGC. The mouse training apparatus was designed using Microsoft Visual Basic 6.0 © and recorded accuracy. The purpose of mouse training was to establish that participants had a base level of knowledge of operating controls (e.g., up/down buttons, horizontal sliders, vertical sliders, and drop down menus) that were used in the HGC in addition to increasing familiarity with primary functions of mouse usage, such as following/moving the pointer and clicking the left mouse button. Figure 2.4 shows a control in the HGC and how that control was represented during mouse training.

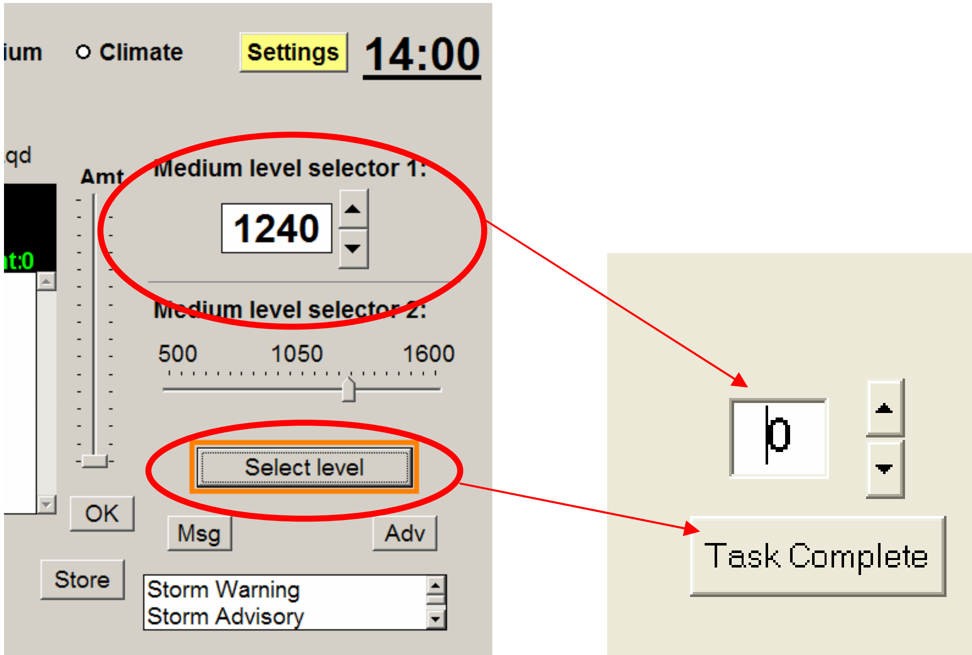


Figure 2.4. Image of a screen HGC control (left) and a similar control used during mouse training (right).

The mouse training program consisted of eight types of controls that participants used in the HGC. During mouse training, the eight controls were each paired with a "Task Complete" button. During training, a word or number was presented in the middle of the screen. Participants then selected that word or number in the control to complete the task successfully. Participants then clicked the "Task Complete" button to move on to the next control. Only one control pair was displayed at a time; participants were not being trained on how to locate or decide what control to use, the goal of mouse training was to train participants to use the system controls. The controls were positioned around the screen in one of eight places and were presented in the same place each time they were presented. The position of the control and the order of presentation were randomized and each participant received the same order of presentation.

Mouse training was completed before the HGC training session begin. It consisted of at least 10 blocks of the eight controls (80 controls). Because the controls were paired with a "Task Complete" button, participants completed at least 160 control activations (80 controls plus 80 "Task Complete" buttons). Successful mouse training was determined by a 90% accuracy criterion. This criterion was selected to ensure the successful activation of every type of control at least once. If a participant did not meet the 90% accuracy criteria this process was repeated again. Participants were given three attempts to complete mouse training with a minimum 90% accuracy. Participants who did not reach the criterion during mouse training were informed that the study was over and paid the full compensation amount for completing the study. Of the participants who did complete mouse training, obtained the 90% accuracy criterion in one attempt.

Development of Training Program

System analysis

A computerized training tutorial was designed to present the structure of the Hydroponic Garden Control. A system analysis was performed on the HGC to understand the structural design of the system (Mead & Fisk, 1998; Moray, 1999; see Appendix B for complete system analysis). From the system analysis, a task decomposition was performed for each task to identify the subtasks and the order in which they must be performed for the task to be successfully completed on the HGC. The training materials were then developed from the decomposed tasks. System training was designed to train participants on the primary operational functions of the system established in the task decompositions. The system consists of three main screens and three sub-screens. Through the training trials, participants were exposed to all six screens of the HGC; however they were not trained to operate all functions of each screen.

Training material format

The training procedure followed the guided attention training used by Hickman et al. (2007) which resulted in increased accuracy and faster task completion times for both younger and older adults at test compared guided action training. Guided attention training was designed to assist participants in properly allocating their attention but required them to actively determine what to do for each step of the task. Participants were provided with the task steps for each goal as illustrated in Figure 2.5.

Plant a Lilac flower seed

1. Select the appropriate tool
2. Select the appropriate seed type
3. Select the appropriate seed category
4. Choose the appropriate seed
5. Select the appropriate seed
6. Plant the seed
7. Complete task

Figure 2.5. Example of guided attention training

During training, participants received 36 tasks that exposed them to each screen of the system. The training included three tasks for each of the three primary functions on each screen, resulting in nine tasks per main screen and three tasks from each of the three secondary screens. In total, the training included 27 tasks from the three main screens and 9 tasks from the secondary screens.

The task presentation order was distributed in a random presentation across the six screens, such that tasks from the same screen were intermingled with tasks from the other five screens (Jamieson & Rogers, 2000). An initial presentation order was randomized then checked against the following decision rule: two tasks of the same screen type could not be in subsequent trials. Hickman et al. (2007) found no difference in the performance of the two counterbalanced presentation orders; therefore the training order was not counterbalanced. One counterbalance order was randomly selected from the two counterbalance training orders from Hickman et al.

Presentation pace

To simulate the time-sensitivity of the HGC, participants were provided an introduction to the use of HGC and told that time-sensitivity is an important function within the system due to the nature of the seeds and the chemicals used. In addition, the system had an integrated timer function that allowed participants to view the elapsed time. The 36 training tasks were presented in three blocks of 12 tasks. Participants in the Self Paced condition governed the time themselves in all three blocks. However, the presentation pace in the three remaining conditions was fixed by the training program. The goal of the fixed presentation paces was to add a time constraint, but to not overwhelm the participants in the task environment. Therefore, the various target times in fixed presentation paces were set based on the mean task completion times plus one standard deviation for younger adults reported in Hickman et al. (2007). In the Hickman et al. study, participants were trained on the same system, however they were able to work at their own pace, therefore the task completion times are good indicators of the time needed to complete the tasks when not under a time constraint. One standard deviation from the mean was selected because it covered 68% of participants' performance in Hickman et al. and two standard deviations is considered outlier performance and may have resulted in too lenient of a time constraint.

Three fixed-pace conditions were developed to examine the role of presentation pace on performance and learning: a slow condition, a fast condition, and one that progressed from the slow condition to the fast condition. Performance during training was the slowest performance reported because participants were learning the system. The slow paced condition was set at constant 28 seconds, which was based on the mean task completion time (i.e., 21.22 seconds) plus one standard deviation (i.e., 6.60 seconds) for performance during training in the Hickman et al. study. The fastest pace was set at constant 17 seconds, which was based on the mean task completion time at test (i.e., 13.99 seconds) plus one standard deviation (i.e., 3.47 seconds). In the sequential fixed-pace condition, the pace decreased with each training block, gradually reducing the time from the slowest pace of 28 seconds to a middle pace of 22 seconds, then to the fastest pace 17 seconds. The middle pace was calculated by dividing the difference between the slowest pace and the fastest pace by two, then rounding down from 22.5 seconds. Table 2.3 displays the presentation paces for each condition.

Table 2.3

Presentation Pace Times (s) During each Training Block for Younger Adults

Presentation pace	Block One	Block Two	Block Three
Self Paced	Unlimited	Unlimited	Unlimited
Sequential	28	22	17
Static Slow	28	28	28
Static Fast	17	17	17

During training, participants were presented each task one at a time. To complete each task, participants in the Self Paced condition worked at their own pace and selected the "Stop" button to signal completion. However, in the three remaining presentation pace conditions, the computer simulator ended the task based on the time allotted to complete each task. If the participant finished the task before the allotted time was completed, the participant selected the "Stop" button to indicate the task was finished, but the screen remained visible until the fixed time had elapsed. During the extra time, participants were free to view the screen, however they were not explicitly told to do so.

NASA-TLX

Immediately following training, participants completed the NASA-TLX (Hart, 2006; Hart & Staveland, 1988) (See Appendix C). The NASA-TLX was designed to measure self-reports of six workload related factors: mental demand, physical demand, temporal demand, performance, effort, and frustration level.

Test of learning

After completing the NASA-TLX, participants completed a test of learning, which consisted of 34 tasks originally used by Hickman et al. (2007). During training, participants were given the task goal and the steps to complete the task, however at test they were only given the task goal (see *Figure* 2.6). During the system performance measure, participants were assessed on their ability to perform system tasks without aid of step-by-step instructions. The tasks at test were divided into 17 tasks that participants had previous experience performing (i.e., trained tasks) and 17 were novel tasks (i.e., untrained tasks). Participants were given 17 seconds to complete each task at test. If the task was completed within 17 seconds participants were able to end the task and move on to the next task (i.e., participants did not have to wait the entire 17 seconds). Tasks that were not completed in 17 seconds were counted as incorrect.

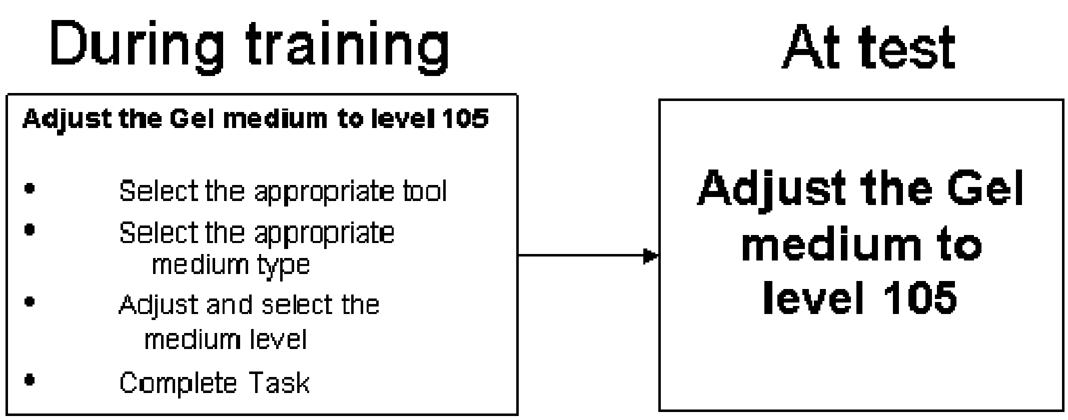


Figure 2.6. Diagram illustrating the difference between tasks during training and those during the system performance measure.

In general, the system performance measure was designed to assess participants' ability to perform system functions of both trained and untrained tasks. Performance was evaluated for accuracy, task completion time, and number of steps taken to complete each task. The trained tasks were chosen to assess participants' ability to perform the three primary functions of each of the three main screens and the supplemental functions of the sub-screens. These tasks were identical to those used during training. The untrained tasks were chosen to assess participants' ability to perform secondary functions of the main screens and supplemental functions not trained on in the sub-screens. Shown in Figure 2.7, the untrained tasks were of similar difficulty to the trained tasks because they were from the same screens and had equal number of steps. Untrained tasks were analogous to medium transfer tasks because participants were exposed to the screen during training, but were not specifically presented the task to complete during training.

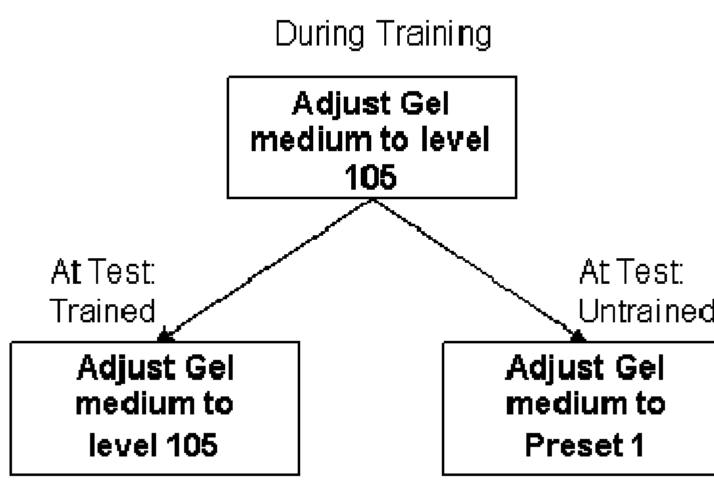


Figure 2.7. Diagram illustrating the difference between tasks shown at training and those shown at test.

The untrained tasks in the main screen consisted of one of each of the three secondary functions. From the remaining tasks of each of the sub-screens, two untrained tasks were randomly selected from the advance growth control screen, three from the settings screen, and three from the message history screen.

The order of the 34 system performance tasks was determined as follows. An initial presentation order was first randomized then checked against the following decision rules: 1) no more than two trials in a row were trained or untrained; 2) tasks of the same screen type were not in subsequent trials. All participants received the same order.

Strategy Questionnaire

At the conclusion of the study, participants completed the strategy questionnaire and exit interview that consisted of a Likert scale questionnaire as well as open ended questions (see Appendix D). The questionnaire focused on obtaining training preferences, personal performance evaluations, and strategy usage during both training and testing. The strategy options were based on pilot data and literature on learning strategies.

Design

The experiment consisted of two phases, training and test. During training the between-participant independent variable was training method (Self Paced, Sequential, Static Slow, and Static Fast). The dependent variables for performance during training were percent correct (accuracy) and time to complete correct tasks (task time). At test there was a 4 (training method) x 2 (trial type) mixed design. The between-participant independent variable was training method (Self Paced, Sequential, Static Slow, and Static

Fast). Trial type (trained or untrained tasks at test) was a within participant variable. The dependent variables for performance at test were percent correct (accuracy), time to complete correct tasks (task time), and the number of mouse clicks performed minus the minimal mouse clicks necessary to accurately complete the task (Navigational Efficiency Index). The Navigational Efficiency Index (NEI) was only measured for performance at test because during training participants are provided the exact steps. Additional subjective measures include the NASA-TLX ratings and the data from the strategy questionnaire.

RESULTS

Performance during Training

Practice Effects

There was a significant main effect of block for accuracy, $F(2, 162) = 22.05$, $p < .01$, $\eta^2 = .21$ and task time, $F(2, 162) = 110.85$, $p < .01$, $\eta^2 = .58$. The presentation pace x block interaction was also found to be significant for both accuracy, $F(6, 162) = 6.60$, $p < .01$, $\eta^2 = .20$, and task time, $F(6, 162) = 7.74$, $p < .01$, $\eta^2 = .22$.

The means and standard deviations for accuracy across the three training blocks are reported in Table 2.4 and graphically represented in Figure 2.8 for accuracy and in Table 2.5 and Figure 2.9 for task time. Simple effects analysis of accuracy and task time indicated that not all the conditions changed at the same rate. Comparing the beginning of training to the end, only participants in the Static Fast condition had significantly higher accuracy; however there was no change in how fast they completed the tasks. The opposite was the case for participants in the Self Paced, Sequential, and Static Slow conditions. There was no significant change in accuracy from the beginning of training and at the end of training, but participants did perform tasks significantly faster at the end of training. An analysis of performance at the end of training indicated that participants in the Self Paced condition had higher accuracy, but slower task completion times than those in the Sequential, Static Slow, and Static Slow conditions.

Table 2.4

Descriptive Statistics: Accuracy by Training Block

		Block 1		Block 2		Block 3	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	22	91.08	13.19	96.65	5.41	86.74	10.50
Sequential	20	81.25	13.75	84.17	13.76	75.83	9.71
Static Slow	22	81.82	13.27	92.42	8.49	78.03	12.21
Static Fast	21	62.30	18.74	78.97	15.73	78.57	8.96

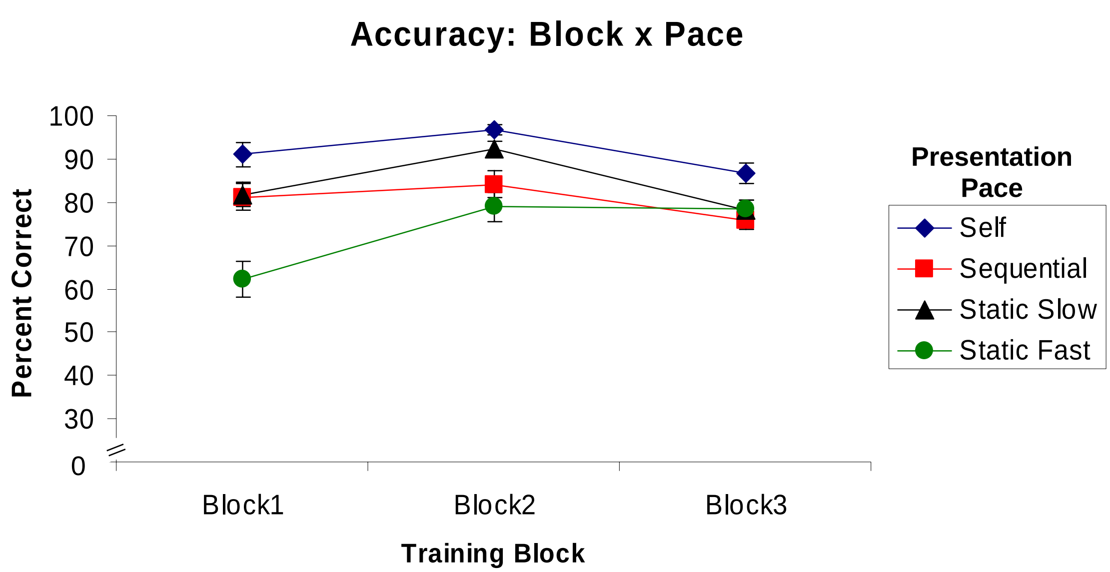


Figure 2.8. Accuracy by block and presentation pace; error bars represent standard deviations.

Table 2.5

Descriptive Statistics: Task Time(s) by Training Block

		Block 1		Block 2		Block 3	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	22	16.55	3.63	12.91	3.00	13.06	4.37
Sequential	20	15.04	2.32	11.71	1.68	9.26	1.62
Static Slow	22	15.99	2.66	12.83	2.29	10.78	2.32
Static Fast	21	10.80	1.61	9.90	1.21	9.40	1.29

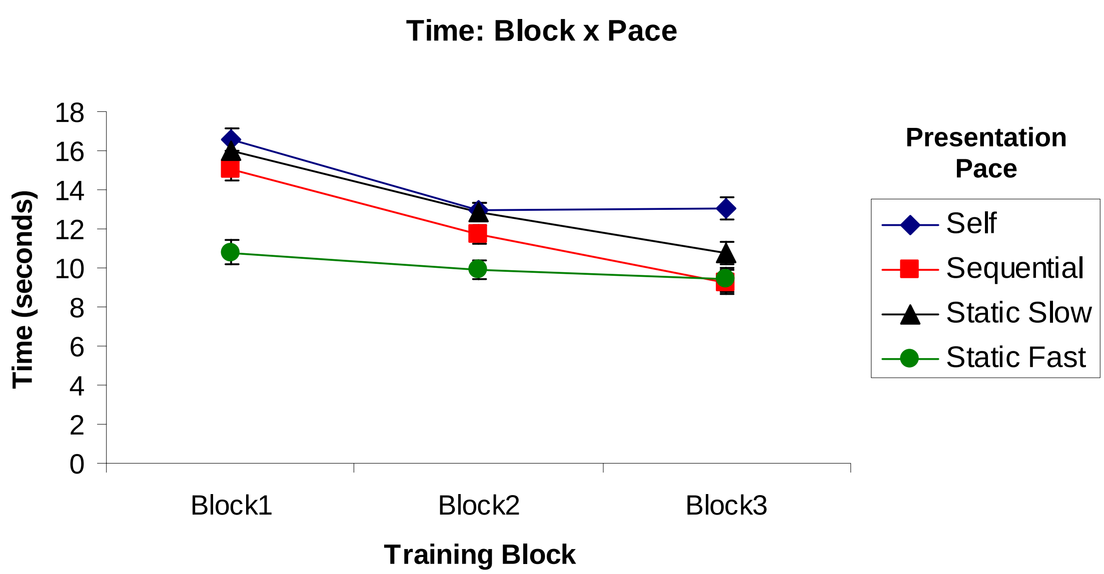


Figure 2.9. Task completion time by block and presentation pace; error bars represent standard deviations.

Subjective Measure: NASA-TLX

The NASA-TLX assessment provided a subjective report of the perceived workload during training. Participants rated the training on a scale of 0-100 for each of six factors. The means are presented in Figure 2.10 (for means and standard deviations see Appendix E).

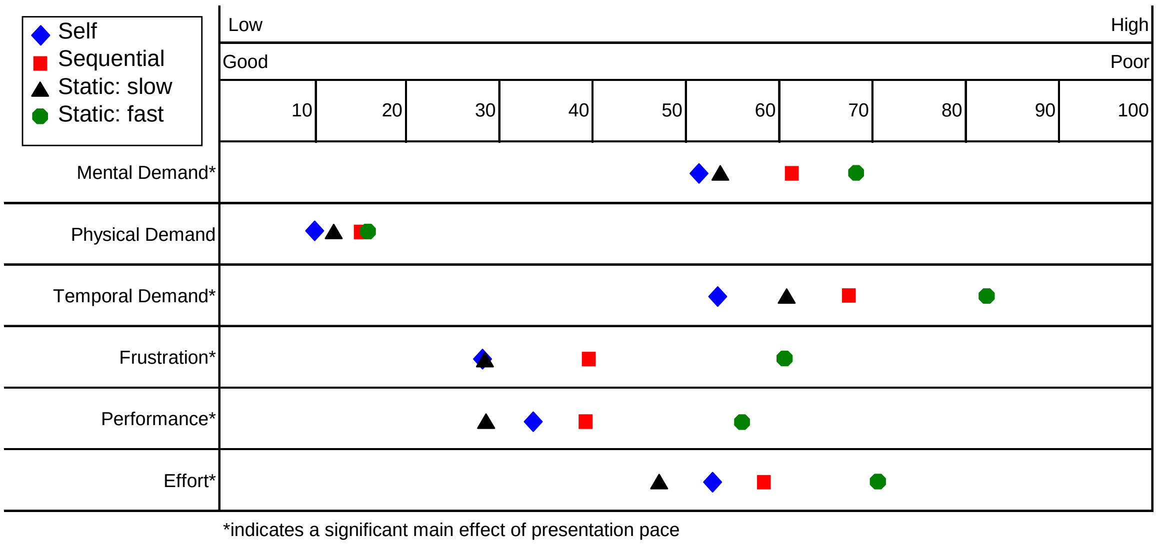


Figure 2.10. Mean NASA-TLX ratings by factor and presentation pace condition.

There was a main effect of presentation pace for mental demand, $F(3, 81) = 3.13$, $p < .05$, $\eta^2 = .10$, temporal demand, $F(3, 81) = 8.65$, $p < .01$, $\eta^2 = .25$, frustration level, $F(3, 81) = 8.55$, $p < .01$, $\eta^2 = .24$, performance, $F(3, 81) = 6.08$, $p < .01$, $\eta^2 = .18$, and effort, $F(3, 81) = 4.61$, $p < .01$, $\eta^2 = .15$. On the NASA-TLX the physical demand scale refers to physical activity such as pushing or pulling. The HGC task was not physically demanding, therefore there were low mean ratings for this measure and there was no significant difference between the groups ($p = .55$). Further analyses of the subjective workload measures followed a similar trend as the performance analyses. Participants in the Static Fast condition rated the training as more mentally demanding than those in the

Self Paced condition, $t(81) = -2.71$, $p < .01$, and Static Slow condition, $t(81) = 2.34$, $p < .05$. They also found the task to have a higher time pressure than participants in all the other conditions (Self Paced: $t(81) = -4.90$, $p < .01$; Sequential: $t(81) = -2.40$, $p < .05$; Static Slow: ,$t(81) = 3.66$, $p < .01$). This is an especially important finding as it also serves as a manipulation check. The Static Fast condition was designed to be faster than the other conditions and therefore should be perceived that way. The fastest pace also lead to significantly higher feelings of frustration compared to the ratings of participants in the Self Paced condition, $t(81) = -4.45$, $p < .01$, Sequential, $t(81) = 2.86$, $p < .01$, and Static Slow, $t(81) = 4.40$, $p < .01$. Additionally, participants in the Static Fast condition reported significantly poorer performance ratings of participants in the three other conditions. And, those participants reported significantly higher effort to achieve this level of performance compared to those in the Self Paced condition, $t(81) = -2.69$, $p < .01$, and the Static Slow condition, $t(81) = 3.58$, $p < .01$.

Performance at Test

At test, participants were assessed on their ability to perform system tasks without aid of step-by-step instructions. Participants received 34 tasks in which they were presented the goal, but not the steps to accomplish the goal. The tasks at test were divided into 17 tasks that participants had previous experience performing (i.e., trained tasks) and 17 were novel tasks (i.e., untrained tasks). Participants were given 17 seconds to complete each task at test. If the task was completed within 17 seconds participants were able to end the task and move on to the next task (i.e., participants did not have to wait the entire 17 seconds). Tasks that were not completed in 17 seconds were counted as incorrect.

Performance at test: Trained tasks

For performance at test on trained tasks, the main effect of presentation pace was not significant for accuracy, $p = .61$, but was for task time, $F(3, 81) = 3.68$, $p < .01$, $\eta^2 = .12$ and NEI, $F(3, 81) = 7.09$, $p < .01$, $\eta^2 = .21$. The means and standard deviations for performance at test on trained tasks are presented in Table 2.6. The descriptives for task time and NEI are for correct trials only. Planned contrasts revealed no difference in accuracy between conditions, but there was a performance advantage of task time for participants in the Self Paced condition only. Participants in the Self Paced condition performed correct tasks significantly faster than participants in the three remaining conditions: Sequential ($p < .01$), Static Slow ($p < .05$), and Static Fast ($p < .01$). Participants in the Self Paced condition also performed those tasks with greater navigational efficiency than those in the Sequential condition ($p < .05$) and Static Slow ($p < .01$).

Table 2.6

Descriptive Statistics: Performance at Test - Trained Tasks

		Accuracy		Task Time (s)		NEI	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	22	87.70	5.71	9.31	1.13	1.67	.46
Sequential	20	84.41	11.65	10.84	1.81	2.26	.61
Static Slow	22	85.03	8.65	10.44	1.61	2.82	1.35
Static Fast	21	86.27	7.74	10.76	2.14	2.12	.57

Self Paced vs. Fixed Analysis

The performance on trained tasks of participants in the Self Paced condition was compared to performance of the three fixed-paced conditions combined. When comparing the performance of participants who worked at their own pace to those who were paced in general, there was no difference in accuracy (p = .25), however there was a significant difference found for task time, $t(81) = -3.24$, $p < .01$ and NEI, $t(81) = -3.54$, $p < .01$. On trained tasks, participants who worked at the own pace were faster and more navigationally efficient than participants who were paced by the system.

Performance at test: Untrained tasks

The means and standard deviations for performance at test on untrained tasks is presented in Table 2.7. For performance at test on untrained tasks, an ANOVA revealed there was not a main effect of presentation pace for accuracy (p = .18), task time (p = .30), or NEI (p = .59). Planned follow-up contrasts revealed a no difference between conditions in task time or NEI, but there was a performance advantage of accuracy for participants in the Self Paced condition only. Participants in the Self Paced condition had higher accuracy in performing untrained tasks than participants in the Static Fast condition (p = .058). However, note that although not significant at the .05 level, directionally, participants in the Self Paced condition also tended to be faster and more efficient than those in the other conditions.

Table 2.7

Descriptive Statistics: Performance at Test - Untrained Tasks

		Accuracy		Task Time (s)		NEI	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	22	83.42	8.64	9.98	1.24	.81	.52
Static Fast	21	78.43	9.18	10.46	1.31	.72	.33
Sequential	20	78.82	7.73	10.09	1.44	.62	.28
Static Slow	22	78.88	8.45	10.68	1.36	.67	.59

Self Paced vs. Fixed Analysis

The performance on untrained tasks of participants in the Self Paced condition was compared to performance of the three fixed-paced conditions combined. When comparing the performance of participants who worked at their own pace to those who were paced in general, there was a significant difference in accuracy $t(81) = 2.23$, $p < .05$, but not task time ($p = .20$) or NEI ($p = .22$). On untrained tasks, participants who worked at the own pace were more accurate than participants who were paced by the system.

Subjective Measure: Strategy Questionnaire

The strategy questionnaire focused on obtaining training preferences, personal performance evaluations, and strategy usage during both training and testing.

Likert Scale: Training preferences and performance

The Likert scale portion of the questionnaire focused on obtaining training preferences and personal performance evaluations. The means for the Likert scale responses are graphically reported in Figure 2.11 (for means and standard deviations, see Appendix F).

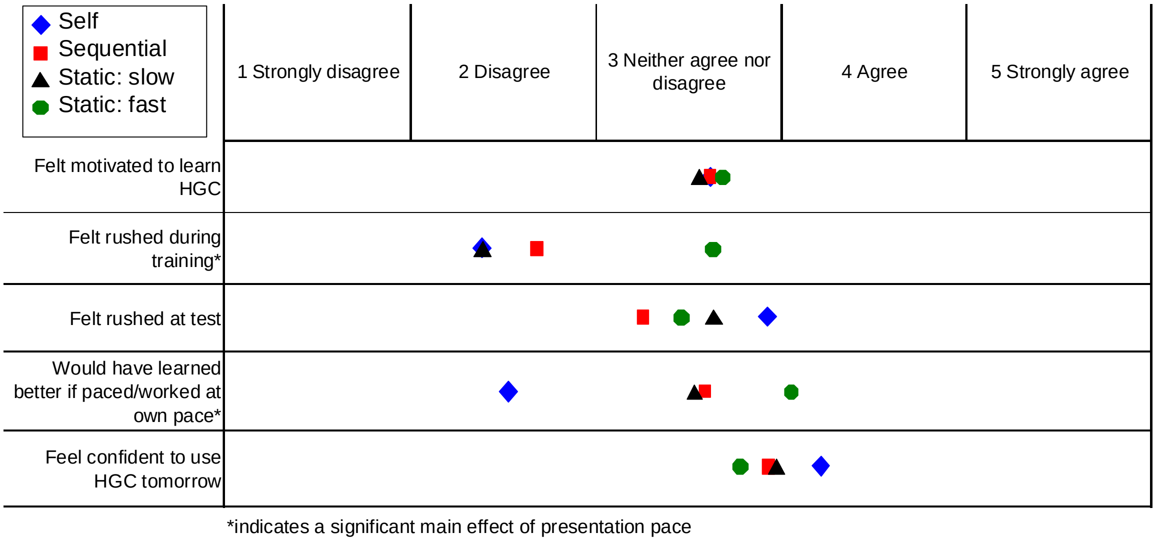


Figure 2.11. Mean Likert scale reports by statement and presentation pace condition.

There was a main effect of presentation pace when questioned about feeling rushed during training, $F(3, 81) = 5.91$, $p < .01$, $\eta^2 = .18$, and when questioned about presentation pace preference, $F(3, 81) = 7.78$, $p < .01$, $\eta^2 = .22$. Participants in the Static Fast condition reported significantly higher feelings of being rushed during training compared to participant reports in the Sequential, Static Slow, and Static Fast conditions (all ps < .01).

When asked if they would have learned better if they received the presentation pace opposite of that which was given during training, participants in the Self Paced condition disagreed with that statement. They did not believe that a working at a fixed-pace would have helped them learn the task better. There was no statistically significant difference between the three fixed paced conditions (p > .05). However, participants in the Static Fast condition had a mean ranking of agreeing with the statement that they would have learned better if they were able to work at their own pace (M = 4.1, SD = .62).

Open-ended Questions: Strategy usage

The main purpose of the strategy usage portion of the questionnaire was to determine what strategy was used during training and at test. Participants were specifically asked, in an open-ended format, what type of strategy was employed. If a participant did not state a strategy in the open-ended section, two reviewers examined the additional questions pertaining to strategy usage to determine strategy usage.

Prior to data collection, an initial coding scheme was developed based on a review of literature on learning strategies. The coding scheme was then later revised based on participants' responses to account for unanticipated responses that were given (e.g., "I didn't really read the steps. I just looked at the task and tried to complete it"). This coding scheme was then revised a final time by combining specific strategies into higher-level categories based on four main strategy purposes, during training (see Table 2.8) and at test (see Table 2.9).

The open-ended responses were then coded by two research assistants using MAXqda. MAXqda is a software package that assists in qualitative data analysis by helping to systematically evaluate and interpret text, and unify coding segments. After the transcripts were segmented, two coders independently coded eight transcripts (two from each condition). The interrater reliability was 88%. After coding the remaining transcripts, the two coders reconvened and then established 100% agreement on all coded segments.

Table 2.8

Type of Strategies During Training

Specific Strategy Type	Higher-Level Strategy Goal
Read goal - follow steps/followed directions	Procedural-focused
Read instructions prior to beginning task	Procedural-focused
Read goal - ignored steps all or majority of the time	Goal-focused
Screen/button familiarization	Memorization-focused
Visual Association and Imagery	Memorization-focused
Memorized/remembered - nonspecific	Memorization-focused
Clustering strategies	Memorization-focused
Focused on speed	Speed-focused

Table 2.9

Types of Strategies at Test

Specific Strategy Type	Higher Level Strategy Goal
Plan ahead before beginning task	Procedural-focused
Read goal and perform steps simultaneously	Procedural-focused
Just focused on the goal/read directions	Goal-focused
Memorized/remembered - nonspecific	Memorization-focused
Screen/button familiarization/key words	Memorization-focused
Visual Association and Imagery	Memorization-focused
Paying attention/Keeping focused	Memorization-focused
Focused on speed/fast task completion	Speed-focused

The percentages of strategies employed during training and at test are reported in Table 2.10. A Chi-Square analysis revealed that participants in the Self Paced condition were more likely to report memorization-based strategies over the other three types of strategies during training, $X^2(3) = 9.64$, $p < .05$. Although not significant, there were interesting trends in the tops strategies reported by participants in each condition. During training, procedure-focused strategies were the top choice of participants in the Sequential condition (40%), while those in the Static Fast condition focused more on memorization-focused strategies (38%). The participants in the Static Slow condition had a tie for the top strategy at 36% for procedure-focused and goal-focused. Although the importance of speed was indicated to participants in all conditions, there was very little focus on speed-related strategies during training.

Table 2.10

Reported Strategies During Training and at Test by Type and Presentation Pace

	During Training				At Test			
	Procedure	Goal	Memory	Speed	Procedure	Goal	Memory	Speed
Self Paced	23%	32%	45%	0%	41%	4%	46%	9%
Sequential	40%	30%	25%	5%	25%	25%	30%	20%
Static Slow	36%	36%	23%	5%	36%	4%	46%	14%
Static Fast	33%	24%	38%	5%	29%	14%	43%	14%

Note: The percentages are mutually exclusive. For participants reporting more than one strategy, the first strategy recorded was chosen as their selection. All percentages are based on within condition totals.

A Chi-Square analysis was conducted to determine the most commonly reported strategy within each pacing condition. The analysis revealed that memorization-based strategies were more likely to be reported by participants in the Self Paced and Static Slow conditions over the other three types of strategies at test, $X^2(3) = 11.82$, $p < .01$ and $X^2(3) = 9.64$, $p < .05$, respectively. The remaining conditions had trends in the top strategies reported by participants although they were not significant. The top strategy of participants in the Sequential condition switched from focusing on procedures during training to focusing on memorization at test (30%). The participants in the Static Slow condition changed from mixture of procedure- and goal-focused strategies during training to predominately using strategies that focused on memorization at test (46%). There was also an overall increase in the number of reported strategies that focused on speed at test compared to during training.

DISCUSSION

The main research question was to determine which presentation pace led to the best learning of a time-sensitive task in a technological system. All of the training conditions resulted in participants being able to perform the task by the end of the 17 second deadline. However, Self Paced training was superior to the other pacing conditions. For the test of trained tasks, Self Paced training yielded faster performance than the fixed-paced conditions. For the test of untrained tasks, Self Paced training yielded more accurate performance (numerically better than all the fixed-paced condition and statistically faster than the Static Fast condition).

The learning benefits of Self Paced training were further supported by the results of the NASA-TLX subjective workload measure. Self Paced training was reported as less mentally demanding, requiring less effort to complete, and a less frustrating form of training compared to the fixed-paced trainings. In Self Paced training, tasks were still performed at a relatively fast pace, yet the feeling of being pressured to work at a fast pace was not present. The added demand of working at a fast pace may have led to detrimental instructional consequences to the fixed-paced training, especially for the Static Fast condition.

The perceived lower workload demands and additional time used during training may have also allowed for participants working their own pace to have more effective learning strategies during training and develop effective strategies to be applied at test. The majority of Self Paced learners used techniques to help them memorize the tasks during training instead of focusing on just getting through the task's procedures and completing the goal as with most of the fixed-paced learners. At test the participants' main strategy was memorization-focused (i.e., strategies related to recalling information from training). The decrease in performance at test, especially for untrained tasks, of the fixed-paced conditions may be due to the fact that they were attempting to draw upon information at test they did not memorize during training. They were not focused on memorizing the task or the system during training. However, the self-pacing strategy during training aided them in memorizing the tasks and the system, therefore at test these participants were recalling the information that that had learned and excelling at tasks they did not have previous experience on.

Younger adults were able to arrive at the target learning goal in all conditions. However, Self Paced training had clear performance benefits over the fixed-paced training and the findings suggest that the benefits may be due to reduced workload demands and more time to develop effective learning strategies. Will the same hold true for older adults? Will Self Paced training continue to result in increased learning over fixed-paced training for older adults? Are older adults going to be able to benefit from Self Paced training when learning a time-sensitive task?

CHAPTER 3: EXPERIMENT 2

INTRODUCTION

Recall the husband who ended his cell phone conversation with his best friend who recently moved to a new city. The lights are dim, the cell phone is complex, and task of adding a new number is becoming increasingly difficult as the backlight on the phone continues to go out every 30 seconds. The 70 year old husband whispers to his wife, “Right now, I really want my Rolodex back”.

The 30 second backlight of this cell phone is just one example of time-sensitive technologies that older adults encounter everyday. So how do you design training for older adults that results in learning to perform the task accurately and within the specific timeframe? The literature suggests that presentation pace may be an important variable to consider, but it is limited. Therefore the purpose of this study was to examine the effects of presentation on learning a time-sensitive task for older adults.

Using the same experimental protocol in Experiment 1, Experiment 2 compared the same four presentation pace types but the rates used were adjusted to accommodate age-related changes in speed of processing. The first condition was Self Paced. Due to decreases in working memory capacity and processing speed, older adults may be at a disadvantage when presented tasks at an accelerated rate. Also, older adults have reported increased frustration when performing tasks that are given a pre-determined presentation rate (i.e., Czaja & Sharit, 1993). Therefore it has been suggested that to increase performance older adults progress through training tasks at their own rate. However, Hickman et al. (2007) concluded that it is inappropriate to have a one-size fits all approach to training or a simplistic view of training older adults. The design of training should be determined by not only the capabilities and limitations of the user group but also the learning goals. With the current learning goal of performing a task within a specific timeframe, three fixed-paced conditions were included. The rationale of the pros and cons of the three fixed-paced conditions are the same in Experiment 2 as they were in Experiment 1 (see Table 2.1). The hypothesis are also the same, however, with the age-related cognitive changes in older adults, the effects may be larger.

METHOD

Participants

There were 77 older adults 65-83 years of age (M = 74.91, SD = 5.27). Ten older adult participants failed to successfully complete mouse training, therefore they did not continue to the training portion of the study. Two older adults experienced difficulty using the mouse due to arthritis and a decision was made by the experimenter to not proceed further through the study. The final dataset in the study included 65 older adults (M = 74.65, SD = 5.28). Older adults received $36 for their participation in this study (i.e., 3 hours at $12 an hour) for compensation.

Just as in Experiment 1, the current experiment was conducted through the Center for Research and Education on Aging and Technology Enhancement (CREATE). A portion of the abilities measures collected are reported in Table 3.1. There were no statistically significant differences between conditions.

Table 3.1

Ability Test Data and Demographic Information

	Self Paced		**Sequential**		**Static Slow**		**Static Fast**		
Older Adults	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*f*-value*
Males/Females	6/11	---	8/8	---	9/7	---	6/10	---	
Age	74.06	5.34	76.88	4.59	72.38	5.78	75.31	4.71	2.21
Education[a]	5.00	2.03	5.25	1.71	5.82	1.32	5.40	1.58	.51
Health[b]	3.82	.81	3.08	.52	3.67	.99	3.80	.92	2.23
Perceptual Speed[c]	66.07	24.97	64.20	13.29	57.58	11.48	65.35	19.52	.53
Working Memory[d]	3.63	.72	3.64	.87	3.96	.69	3.95	.72	.76
Vocabulary[e]	34.12	3.22	35.00	3.19	35.58	2.54	35.20	2.57	.63
Reaction Time[f]	812.42	140.34	885.40	195.53	807.17	310.41	807.44	200.49	.31
Spatial Ability[g]	6.24	2.88	6.62	3.63	5.88	2.83	5.56	2.16	.40
Long-term Memory[h]	10.47	3.13	9.58	3.00	10.00	3.74	9.80	2.49	.21

Note: *p<.05, [a] Range: 2 = less than high school, 3=High School, 4=Vocational training, 5=some college, 6=Bachelor's degree; [b]Self-rating: 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent; [c] Digit Symbol Substitution (Wechsler, 1997); [d] Alphabet Span - simple score (Craik, 1986); [e]Shipley Vocabulary (Shipley, 1986); [f] A composite score in ms of both simple RT (time to press one key) and choice RT (time to select respond to one of two keys); [g] Paper Folding Test – number correct (Ekstrom et al., 1976); [h] California Verbal Learning Test - delayed (Delis et al., 1987). The CREATE assessment battery was completed by 59 of the 65 participants; all participants did not answer all questions.

Materials

Participants in Experiment 2 were presented the same computer simulated Hydroponic Garden Control (HGC), task environment, experimental procedure, and design as participants in Experiment 1. The only difference across the experiments was the presentation pace.

As in Experiment 1, there was a Self Paced condition and three fixed-pace conditions. Because pacing was designed to impose a timing-constraint but not tax the learners' cognitive resources, the pacing was based on the older adult task completion time data from Hickman et al. (2007) as opposed to the younger adult data. The Static

Slow condition was set at constant 120 seconds, which was based on the mean task completion time (i.e., 92.28 seconds) plus one standard deviation (i.e., 27.35 seconds) for performance during training. The Static Fast condition was set at constant 70 seconds, which was based on the mean task completion time at test (i.e., 53.13 seconds) plus one standard deviation (i.e., 16.70 seconds). In the Sequential condition, the pace decreased with each training block, gradually reducing the time from the slowest pace of 120 seconds to a middle pace of 95 seconds, then to the fastest pace 70 seconds. The middle pace was calculated by dividing the difference between the slowest pace and the fastest pace by two, then rounding down. Table 3.2 displays the presentation paces calculated for each condition.

Table 3.2

Presentation Pace Times (s) During each Training Block for Older Adults

Presentation pace	**Block One**	**Block Two**	**Block Three**
Self Paced	Unlimited	Unlimited	Unlimited
Sequential	120	95	70
Static Slow	120	120	120
Static Fast	70	70	70

RESULTS

Performance during Training

Practice Effects

Practice effects were also examined. There was a significant main effect of block for accuracy, $F(2, 122) = 7.85$, $p < .01$, $\eta^2 = .11$, and task time, $F(2, 122) = 23.95$, $p < .01$, $\eta^2 = .28$. The presentation pace x block interaction was also found to be significant for both accuracy, $F(6, 122) = 3.31$, $p < .05$, $\eta^2 = .09$, and task time, $F(6, 122) = 2.82$, $p < .01$, $\eta^2 = .12$.

The means and standard deviations for accuracy across the three training blocks are reported in Table 3.3 and graphically represented in Figure 3.1 for accuracy and in Table 3.4 and Figure 3.2 for task time. Simple effects analysis of accuracy and task time indicated that not all the conditions changed at the same rate. Participants in both the Self Paced and the Sequential conditions had a significant change in accuracy and task time from the beginning of training to the end (*p*s < .01). Interestingly, participants in both conditions had lower accuracy and faster task completion times. Participants in the Static Slow condition also experience a significant increase in task speed ($p < .01$) and although their accuracy decreased, it was not significant. The Static Fast condition resulted in no improvement in performance for either accuracy or speed. At the end of training all participants were performing at a similar speed and the only difference in accuracy was between participants in the Static Slow and Static Fast conditions, where the Static Slow condition resulted in higher accuracy.

Table 3.3

Descriptive Statistics: Accuracy by Training Block

		Block 1		Block 2		Block 3	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	17	81.37	13.35	82.84	15.44	68.71	28.90
Sequential	16	73.44	21.13	69.27	22.51	59.90	21.99
Static Slow	16	80.21	17.45	83.85	13.77	74.48	17.87
Static Fast	16	52.60	26.30	59.05	23.48	58.00	21.40

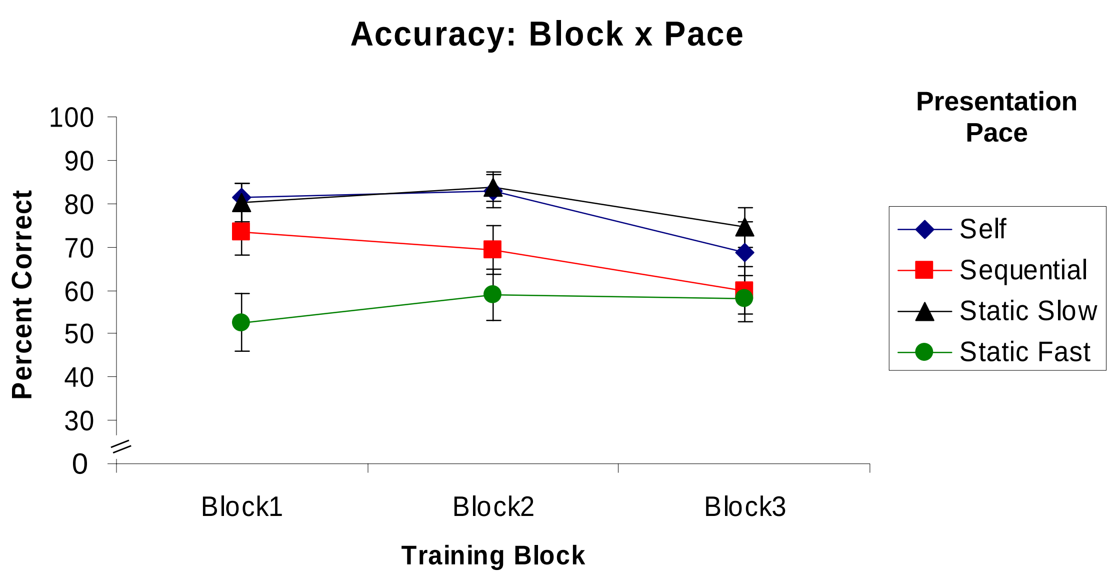


Figure 3.1. Accuracy by block and presentation pace; error bars represent standard deviations.

Table 3.4

Descriptive Statistics: Task Time(s) by Training Block

		Block 1		Block 2		Block 3	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	17	59.76	27.88	52.87	29.59	46.63	22.40
Sequential	16	59.20	11.62	48.21	16.62	36.99	10.37
Static Slow	16	55.74	18.53	50.27	14.83	42.10	16.68
Static Fast	16	40.52	14.81	41.45	10.17	39.31	12.10

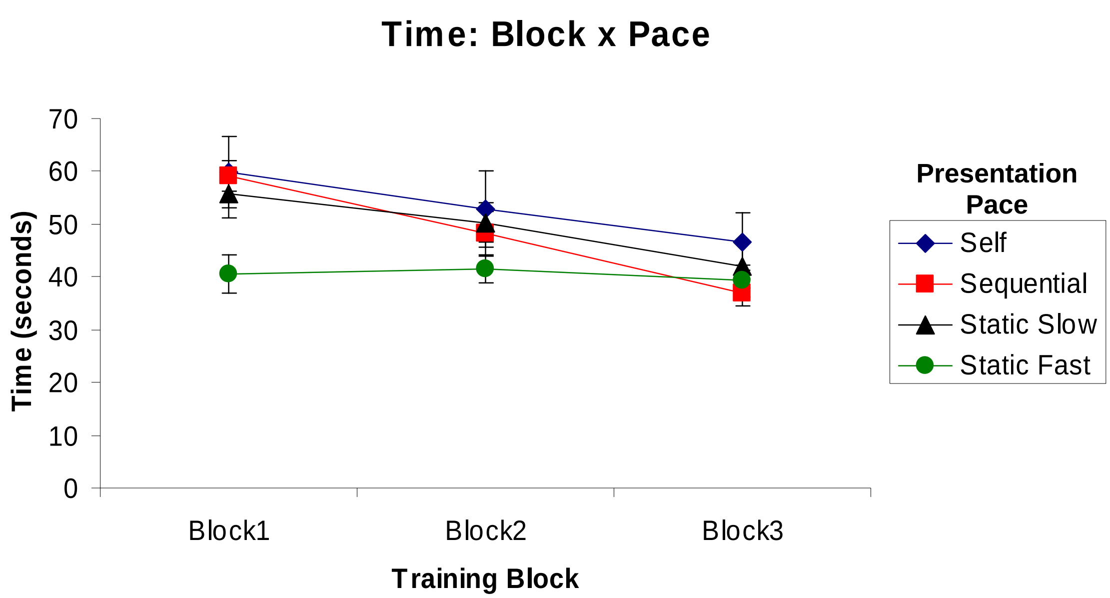


Figure 3.2. Task completion time by block and presentation pace; error bars represent standard deviations.

Subjective Measure: NASA-TLX

The means are graphically presented in Figure 3.3 (for means and standard deviations, see Appendix G). There was no main effect of presentation pace for There was not a main effect of presentation pace for any of the subjective workload measures (all *ps* > .05) and there were no significant differences between conditions for any of the subjective workload measures (all ps > .05). Because of the non-physical nature of the HGC task, this was expected for the physical demand factor. The lack of significance for the remaining factors may help in understanding performance during training and at test.

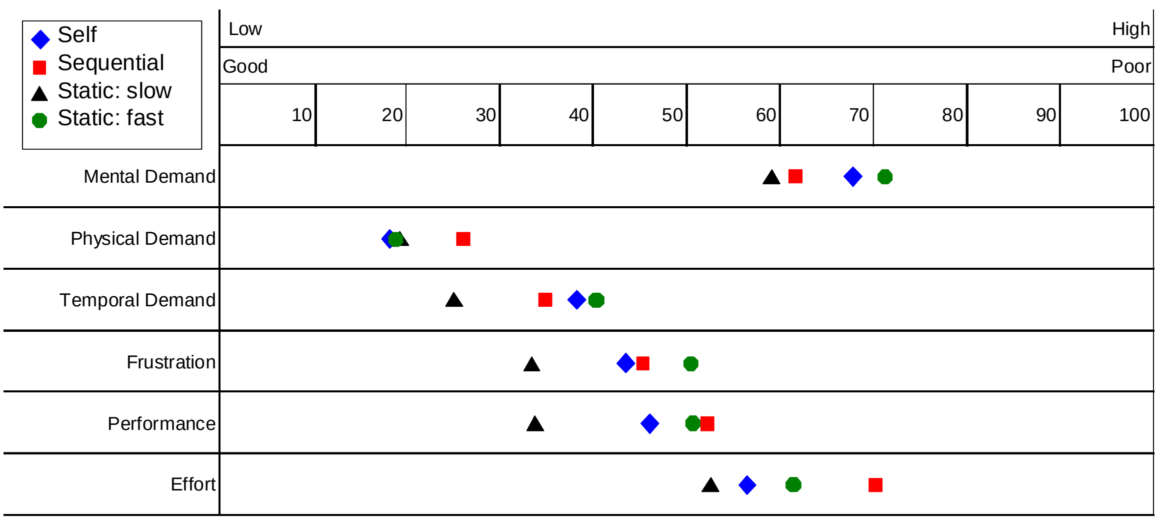


Figure 3.3. Mean NASA-TLX ratings by factor and presentation pace condition.

Performance at Test

Performance at test: Trained tasks

For performance at test on trained tasks, there was not a main effect of presentation pace for accuracy, $p = .42$, task time, $p = .19$ or NEI, $p = .20$, note the high variability for accuracy. The means and standard deviations are reported in Table 3.5. The descriptives for task time and NEI are for correct trials only.

Table 3.5

Descriptive Statistics: Performance at Test - Trained Tasks

		Accuracy		Task Time (s)		NEI	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	17	60.90	21.41	29.58	8.33	2.50	1.22
Sequential	16	61.40	22.63	34.84	8.15	2.98	1.60
Static Slow	16	68.75	20.00	32.13	9.07	3.85	2.48
Static Fast	16	55.88	22.93	35.47	8.86	3.12	1.66

In an analysis of simple effects revealed several performance benefits of the Self Paced condition. Participants in the Self Paced condition performed tasks significantly faster than participants in the Static Fast condition ($p < .05$). Also, participants in the Self Paced condition performed tasks at test with greater navigationally efficient than those in the Static Slow condition ($p < .05$). There were no other significant differences between conditions for accuracy, task time, or NEI (all ps > .05). However, note the SDs were quite high indicating a lot of between participant variability in task time.

Self Paced vs. Fixed Analysis

When comparing the performance of participants who work at their own pace to participants who are paced in general, there was no difference in accuracy (*p* = .86), task time (*p* = .06), or NEI (*p* = .11). Although task time was not significant at the traditional .05 level, the effect was in the predicted direction whereas the participants in the Self Paced condition were faster on correctly completed tasks compared to the other three fixed-paced conditions.

Performance at test: Untrained tasks

For performance at test on untrained tasks, there was not a main effect of presentation pace for accuracy, *p* = .43, task time, *p* = .63 or NEI, *p* = .98. The means and standard deviations are reported in Table 3.6. The descriptives for task time and NEI are for correct trials only.

Table 3.6

Descriptive Statistics: Performance at Test - Untrained Tasks

		Accuracy		Task Time (s)		NEI	
Pacing	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
Self Paced	17	59.86	21.83	35.20	10.21	1.37	.62
Sequential	16	60.29	23.87	34.72	8.19	1.26	.65
Static Slow	16	56.25	23.33	34.41	10.96	1.30	.67
Static Fast	16	48.53	21.10	38.50	10.37	1.34	.98

An analysis of the simple effects revealed there were also no significant differences between conditions for accuracy, task time, or NEI (all ps > .05). However, note the SDs were quite high indicating a lot of between participant variability in task time. Because of this additional analyses were computed and are reported in the following sections.

Self Paced vs. Fixed Analysis

When comparing the performance of participants who work at their own pace to participants who are paced in general, there was no difference in accuracy (p = .45), task time (p = .81), or NEI (p = .76).

Subjective Measure: Strategy Questionnaire

Likert Scale: Training preferences and performance

The Liket scale portion of the questionnaire focused on obtaining training preferences and personal performance evaluations. The means for the Likert scale responses are graphically reported in Figure 3.4 (for means and standard deviations, see Appendix H).

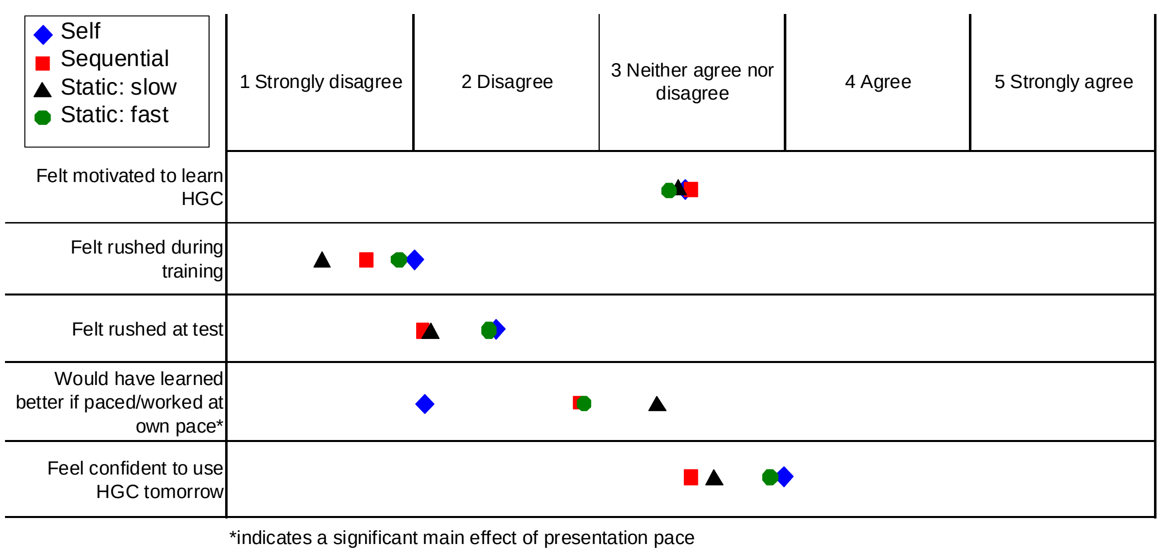


Figure 3.4. Mean Likert scale reports by statement and presentation pace condition.

There was only a main effect of presentation pace when questioned about presentation pace preference, $F(3, 61) = 2.64$, $p < .05$, $\eta^2 = .11$. The participants in the

Self Paced condition did not believe that a working at a fixed-pace would have helped them learn the task better (*M* = 2.12, *SD* = .70) and their rankings was statistically different than the Static Slow and Static Fast conditions (*p*s < .05). There was no difference between the rankings of the three paced conditions (*p* > .05), however their reported means indicate they did not believe working at their own pace would have improved their learning or had no opinion either way (Sequential: *M* = 2.81, *SD* = 1.17; Static Slow: *M* = 3.12, *SD* = 1.26; Static Fast: *M* = 2.88, *SD* = 1.15).

Open-ended Questions: Strategy usage

The strategies were analyzed the same way as reported in Experiment 1. The percentages of strategies employed during training and at test are reported in Table 3.7. A Chi-Square analysis revealed several significant trends in reported strategies during training. Memorization-focused strategies were the likely choice for participants in the Self Paced condition, $X^2(3) = 18.06$, $p < .01$. While participants in the Sequential, Static Slow and Static Fast conditions reported procedure-focused strategies as their top choices, $X^2(3) = 15.50$, $p < .01$; $X^2(3) = 24.00$, $p < .01$; $X^2(3) = 16.50$, $p < .01$, respectively.

Table 3.7

Reported Strategies During Training and at Test by Type and Presentation Pace

	During Training				At Test			
	Procedure	Goal	Memory	Speed	Procedure	Goal	Memory	Speed
Self Paced	41%	0%	59%	0%	0%	23%	65%	12%
Sequential	63%	0%	31%	6%	38%	31%	31%	0%
Static Slow	75%	0%	25%	0%	8%	33%	59%	0%
Static Fast	56%	0%	44%	0%	0%	21%	72%	7%

Note: The percentages are mutually exclusive. For participants reporting more than one strategy, the first strategy recorded was chosen as their selection. The percentages at test exclude 9 who reported no strategy. All percentages are based on within condition totals.

A Chi-Square analysis revealed again several significant trends in strategies reported at test. The top strategy of participants in the Self Paced condition remained focused on memorization, $X^2(3) = 16.18$, $p < .01$. Although not significant, participants in the Sequential condition maintained procedural-focused strategies as their top strategy (38%). While participants in the Static Slow and Static Fast conditions changed from procedural-focused during training to memorization-focused at test, $X^2(3) = 10.00$, $p < .05$ and $X^2(3) = 17.43$, $p < .01$, respectively. Note that although the importance of speed was indicated to participants in all conditions, there was very little focus on speed-related strategies reported during training and at test. However, speed was sometimes mentioned as a secondary strategy.

Error Analysis

The current study was focused on the role of presentation pace in learning a time-sensitive task. With the high error rate in Experiment 2 it was important to determine if timing out was a major contributor to those errors. When a task was computed as "incorrect" participants did not perform the steps necessary to complete the task. The error analysis explores why the necessary steps were not completed. Based on participant data, why the task was not complete was extrapolated as the number of time-outs (i.e., participants ran out of time when trying to complete the task). The analysis of the time-out data was computed for all participants and was comprised of incorrect responses where the task time reached the maximum time allowed for tasks at test, 70 seconds. The data were categorized as percentage of time-out errors for both trained and untrained tasks (for mean and standard deviations, see Table 3.8).

Table 3.8

Descriptive Statistics: Percentage of Time-out Errors at Test

		Trained Tasks		Untrained Tasks	
Pace	N	*M*	*SD*	*M*	*SD*
Self Paced	17	12.45	14.84	13.15	16.96
Sequential	16	12.13	12.24	18.75	20.17
Static Slow	16	8.09	8.82	13.60	14.04
Static Fast	16	13.97	11.34	18.75	14.92

Note: These percentages are computed out of all 17 tasks.

There was not a main effect of presentation pace for trained tasks, p = .56 or untrained tasks, p = .64. There were also no significant differences between conditions for trained or untrained tasks (ps > .05). An additional analysis of Self Paced versus fixed-pace (i.e., Sequential, Static Slow, and Static Fast combined) revealed no difference for trained or untrained tasks (ps > .05).

DISCUSSION

In trying to understand the role of presentation pace in learning a time-sensitive task, four presentation paces were examined: Self Paced, Sequential, Static Slow, and Static Fast. The goal was to determine which presentation pace led to the best learning. Performance was relatively poor and had high variability for all conditions, however the only benefit of pace came from self-pacing. Self Paced yielded faster performance on trained tasks compared to the Static Fast condition and better navigation compared to the Static Slow condition. Although not always significantly different, the Static Fast condition consistently had the lowest accuracy and the slowest task completion times compared to the other conditions. However, it is important to note that when participants did perform a task correctly, they did so quickly thus achieving the learning goal of fast performance. The benefit of one pacing over another may have been diminished by everyone receiving the same learning goal of going fast. Older adults may have fixated on that goal regardless of the presentation pace condition.

The lack of difference among conditions was also a theme in the results of the NASA-TLX subjective workload measure. All conditions were ranked similarly in terms of mental demand, frustration, and effort. One interesting finding is that there was no difference in the perceived temporal demand of the training. Participants who worked at their own pace felt the same time pressure as those who were in the fixed-paced conditions. This further supports that the learning goal of going 70 seconds at test may have been the focus during training instead of just focusing on the training task at hand.

Older adults' strategy selections during training and at test provide further explanation as to why performance between the conditions was similarly poor in terms of accuracy, but relatively fast. During training, participant who received Self Paced training relied on memorization-focused strategies, but at test they switched to goal focused strategies. Thus, they may have been more focused on getting the task done, not on recalling knowledge acquired during training. During training their combined accuracy was approximately 80 percent, so they were doing the tasks correctly but that information did not transfer at test. It may be that those participants never learned the task, but it is also possible that they selected an ineffective strategy at test. The fixed-paced conditions reported predominately procedure-focused strategies at test; essentially, they were going through the motions of getting the task done. At test, the majority of the fixed-paced participants relied on memory for knowledge they did not acquire during training which may have yielded low accuracy. In looking at the strategy data, one cannot ignore that very few strategies focused on speed. If there such an emphasis on getting the task done and there is the suggestion that older adults were motivated by the learning goal of 70 seconds, why were there very little reports of speed-focused strategies? It may be that the underlying intention of procedure-focused strategies was to get the task done quickly, therefore participants may not have explicitly expressed that they were rushing through the training because they were unaware of the intention. Societal pressures may have also swayed them to not indicate to the experimenter that they were rushing through the study; they did not want to appear rude or disinterested in the research.

With so many errors being made at test, examining the time-out data provided insight into what was happening on incorrect trials. Only 12-18% the errors were due to running out of time. Participants are doing something wrong, but it is not known what.

They are consciously ending the task by selecting the stop sign, the motivation for ending the task may be that the participants gave up or they thought they had completed the task accurately. The data files do not provide insight into the participant's motivation.

CHAPTER 4: GENERAL CONCLUSIONS

Many technologies have timing mechanisms that require some type of input from the user to maintain the current system state (e.g., the cell phone light turning off within 30 seconds if no button is pressed). The objective in these types of tasks is to not only perform the task accurately, but to do so within a specific amount of time. The question is, "How do you design training that facilitates learning the task and developing fast performance?" There is no research that specifically addresses this issue, but previous research on learning and skill acquisition provides guidance on how to design training.

Designing training is a multi-step process that includes understanding the learner's capabilities and limitations, analyzing the to-be-learned system, and determining the learning goals. The current study focused on examining the influence of presentation pace on learning a time-sensitive task by first isolating pacing from other variables of training; second, disentangling the relative benefits of self-paced and fixed-paced training from the relative benefits of various rates of fixed-paced training; and third, determining if there were differential benefits of presentation pace. The presentation pace was either set by the learner (Self-paced), set by the system at a pace that progressed from fast to slow over the course of training (Sequential), set by the system at a consistent slow pace (Static Slow) or set by the system at a consistent fast pace (Static Fast). The goal of the study was to understand the role of presentation pace for a time-sensitive task that was challenging for each age group: younger adults in Experiment 1 and older adults in Experiment 2.

Summary of Key Findings

In Experiment 1, younger adults in all conditions were able to complete the tasks within the 17 second target time and with reasonably high accuracy. However, Self Paced training was superior to all the other training conditions. Participants in Self Paced training were significantly faster at completing trained tasks and were more accurate at completing untrained tasks. This benefit of self pacing may in part be related to the types of strategies used during training and at test. Participants in self-paced training may have had more time to develop effective strategies or self-paced training may have encouraged different strategy usage. In fact, the strategy analysis was suggestive of different strategies being used in the different pacing conditions.

In Experiment 2, older adults in all conditions were able to complete tasks within the 70 second target time; however accuracy across conditions was relatively low. Self Paced training resulted in faster task completion than Static Fast training at test on trained tasks, however there was no other statistically significant benefit of any presentation pace over the others. Although not significantly different, participants in the Static Fast condition were consistently slower and less accurate than participants in the other conditions. The lack of statistical differences may have been due to very high variability between participants, which may have masked the relative benefits of the different presentation paces. Although there was no significant difference in performance, the findings do lend support for recommendations of self-pacing for training older adults. Older adults' subjective "liking" ratings were higher and had lower subjective workload demand ratings for the Self Paced condition than the fixed-paced conditions.

Benefits of Various Pacing

The overall results of the current study suggest that when designing training for learning a time-sensitive task working at one's own pace may be more effective than training at a fixed-pace. This is not to say that fixed-pacing does not have its place in training protocols, as seen in the current study, not all fixed-paces influence learning in the same way. Being trained at the fast target pace was not beneficial to the learners in either experiment, however Sequential and Static Slow paces were not as detrimental and at times, not significantly different than the Self-paced condition. Moreover, there may be circumstances where fixed-pace training is beneficial, such as when the rhythm of performing a task is necessary for effective product usage.

Nonetheless, the benefits of self-pacing in the current study were evident and there are several possibilities as to why. Self-paced training may provide more time to explore the system during training, as seen in Experiment 1 where younger adults were significantly slower but more accurate at completing tasks. In self-paced training, learners do not have to monitor the time during training which may allow them to dedicate more cognitive resources toward learning the task. This increase in time on task may have also allowed for time to make accurate associations between task components, resulting in the performance benefit seen at test for those in the self-paced training. The Self-paced condition did not directly provide training with the learning goal; however at test those participants were faster than those in the fixed-pace conditions. Although the full extent of knowing the learning goal was not examined in the current study, it appears to be a critical factor in training.

Understanding the Importance of Learning Goals

Learning goals are an important component in the multi-step process of designing training. The current study added further support to importance of knowing the learning goal and how that influences learning. To further explore the influence of learning goals on learning, the performance of the Self-paced condition in the current study was compared to that of the performance of participants in Hickman, Rogers, and Fisk (2007). Participants in the Hickman et al. study received the same training and test as the participants in the current study; however they were all self-paced and they were not given the learning goal of fast task performance.

The accuracy and task time for overall performance during training and at test for Experiment 1 was compared to the performance of younger adults in Hickman et al. (2007). The means and standard deviations are reported in Table 4.1.

Table 4.1

Descriptive Statistics: Accuracy and Task Time (s) of Younger Adult Participants in Hickman et al (2007) Compared to the Current Study

	During Training				At Test							
					Trained Tasks				Untrained Tasks			
	Accuracy		Task Time		Accuracy		Task Time		Accuracy		Task Time	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Hickman et al	93	4.9	21.2	6.60	97	4.3	13.99	3.47	93	5.9	16.65	3.58
Current Study	92	7.1	14.4	2.99	88	5.7	9.31	1.13	83	8.64	9.98	1.24

The participants in both studies achieved similarly high levels of accuracy during training, but participants in the current study performed the tasks faster. The Hickman et al. (2007) participants had higher accuracy at test, but that same trend of fast task completion was maintained by the participants in the current study. Thus, achieving the learning goal of completing a task within a specific timeframe appears to have come at the cost of accuracy.

For older adults, across conditions, performance also appeared to suffer for participants given a speed-related learning goal, as evidenced by the comparison to the Hickman et al. (2007) data shown in Table 4.2. The goal of going fast may have taken precedence over learning the system, even for participants in the Self Paced condition. When given the time to learn the system, internalize task consistencies, and build relationships between components, older adults still may have focused on the speed goal which may have inhibited their learning.

Table 4.2

Descriptive Statistics: Accuracy and Task Time (s) of Older Adult Participants in Hickman et al (2007) Compared to the Current Study

	During Training				At Test: Trained Tasks				At Test: Untrained Tasks			
	Accuracy		Task Time		Accuracy		Task Time		Accuracy		Task Time	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Hickman et al	79	15.6	92.28	27.35	75	17.4	53.13	16.70	69	19.7	64.51	20.82
Current Study	80	12.9	54.75	25.93	61	21.4	29.58	8.33	60	21.8	35.20	10.21

Older adults in the current study performed at similar accuracy levels during training as the participants in the Hickman et al. study, but their speed was substantially faster in the current study. The benefits of self-pacing did not transfer to test. Although the task completion times were almost half, accuracy was reduced.

For both younger and older adults there may have been a speed-accuracy trade-off at test when given the learning goal of fast task completion. These findings suggest that participants in the Self-paced condition in the current study were focused on the learning goal which may have decreased their accuracy. However, with such substantial decreases in task completion times, the learning goal of being fast was met.

Research Contributions

Theoretical Contributions

When designing training for a time-sensitive task, providing self-paced training with a focus on the learning goal proved most beneficial in the current study. In line with these results, previous research supports and encourages self-paced training as well (e.g., Czaja, 2001; Keller, 1968). There are various domains where self-pacing improves learning or improves the quality of the learning environment, such as in concept mastery, diagram comprehension, and technology usage. However, understanding the reasons why is an ongoing research question where the current results add to the existing body of literature. For example, there was some evidence in the present study that participants in the Self-paced conditions focused more on memory-based strategies during training which may have enable them to better link the related components in the system they were learning.

In addition, there is an apparent benefit, overall, to being given the learning goal of performing the task quickly. Both younger and older adults were able to achieve that target performance level, although accuracy rates may have suffered as evidenced by the comparison to the Hickman et al. (2007) data. These interactive effects of training pace and learning goals will have to be investigated further in future research.

Lastly, the specific type of pacing that is optimal for a given task, task, context, and user population is likely to be a combination of self-paced and some variety of fixed-paced training. The present findings support the relative benefits of self-paced training for novices but future research will be required to determine how pacing conditions should be sequenced for more experienced users of a technology, for more complex tasks, and for tasks that truly require a pacing (rather than performance by a deadline).

Practical Contributions

Companies spend countless person-hours designing new technologies and modern conveniences that are often accompanied by some type of training materials. Cell phones, medical devices, and ATMs are all examples of technologies wherein the system will shut down or blackout after a certain amount of time. For those tasks when training is needed to facilitate learning in a time-sensitive environment, the current research suggests that self-paced training that emphasizes the learning goal of speed may be beneficial. Additionally, self-paced training may also allow for the development of effective strategies during training that improve performance in the task environment. Providing learners with strategies aimed at increasing memorization of task components may be helpful prior to beginning training and reinforced in the task environment. Importantly, there were no costs to Self-paced training for either younger adults or older adults.

Future Research

This research study is one step in the process of understanding various elements of training and how they interact to influence learning. The results of the current study open the door for further exploration. Knowing the learning goal of having a limited amount of time to perform the task may have played a major role in increasing the speed in all the conditions, especially the Self Paced condition. New questions regarding learning goals emerge from these results. First, there are the individual assessments of the learning goal; that is, does each participant view the learning goal the same way? In the current study, participants may have interpreted the learning goal as a "deadline", whereas others may have seen it as a pace to help structure and distribute task procedures over the entire allotted time. This difference in learning goal assessment may influence time needed to develop task associations and develop strategies, thereby affecting learning.

Second, does the application of knowing learning goals generalize to other types of learning goals? Time-sensitive performance may not always be an aspect of the task and these results may not be applicable. Will the same results hold true if participants are instructed of an accuracy criterion in the task environment, but during training there is no accuracy criterion to meet? For example, during training participants are given feedback on their accuracy and told during training they do not have to meet a specific accuracy criterion. Participants in the fixed-accuracy conditions would have accuracy criterions to meet throughout training. All participants are informed that they must achieve a specific accuracy level at test. In the current study there was a benefit of Self Paced training, however these results may or may not generalize to other learning goals.

Results from the current study also shed light on the need to disentangle self and fixed-pace training various forms of fixed-pace training. All fixed-paces did not influence learning the same way. The Static Fast condition resulted in consistently slower and less accurate performance across both experiments; however Sequential and Static Slow conditions resulted in mid-range performance and at times was no different than Self-paced training. There may be circumstances where one will be better than the other. The goal of future research will be to determine when and where it is appropriate and effective to use each type of pacing, whether self-paced or various forms of fixed-pace.

The benefits of self-paced were evident in the current study and support previous research that demonstrates or encourages the use of self-paced training, especially for older adults. One of the possible benefits of self-paced training is that it does not increase cognitive demands resulting in more cognitive resources to allocate towards learning task procedures. Both younger and older adults benefit from this freeing of cognitive resources due to self-paced training (e.g., Czaja, 2001; Tabber, 2002). However, direct assessment of the level of cognitive demand imposed by self-paced training has not been studied. To truly begin to understand why self-paced training is beneficial across learning domains and age groups, the underlying mechanisms need to be clearly identified and isolated.

Conclusions

To summarize, the goal of the present study was to understand the role of presentation pace in learning a time-sensitive task. Although there was a qualitative and quantitative benefit of self-paced training, the findings suggest that the bigger picture of self-paced and fixed-paced training is not a good versus bad comparison, but rather a when and where application. When training for a time-sensitive task, providing self-paced training while emphasizing the learning goal of the target pace may be sufficient for effective performance. However, all forms of fixed-pace training were not detrimental to learning. Therefore, it is critical to understand the task environment and its relationship to different forms of presentation pace.

APPENDIX A

CREATE Ability Measures

Background Questionnaire

- Demographics
- Health
- CES-D
- Computer Questionnaire 1
- Computer Questionnaire 2
- Medication Usage Details

Technology Experience Questionnaire

- Technology and Computer Experience Questionnaire
- Internet Questionnaire

Group Testing

- California Verbal Learning Test (CVLT) - Immediate
- Letter Sets (ETS)
- Number Comparison Test
- California Verbal Learning Test (CVLT) - Delayed
- Alphabet Span
- Comprehensive Ability Battery - Study List
- Information (WAIS-III)
- Comprehensive Ability Battery - Meaningful Memory
- Shipley Institute Of Living Scale

Individual Testing

- Near Vision
- Far Vision
- Earscan Audiometer
- Mini Mental State Examination (MMSE)
- Trailmaking Test
- Digit Symbol (WAIS – III)
- Simple Reaction Time Task
- Choice Reaction Time Task

Added measure: Paper Folding Test

APPENDIX B

Hydroponic Garden Control System Analysis

Figure A. Overall General System Structure.

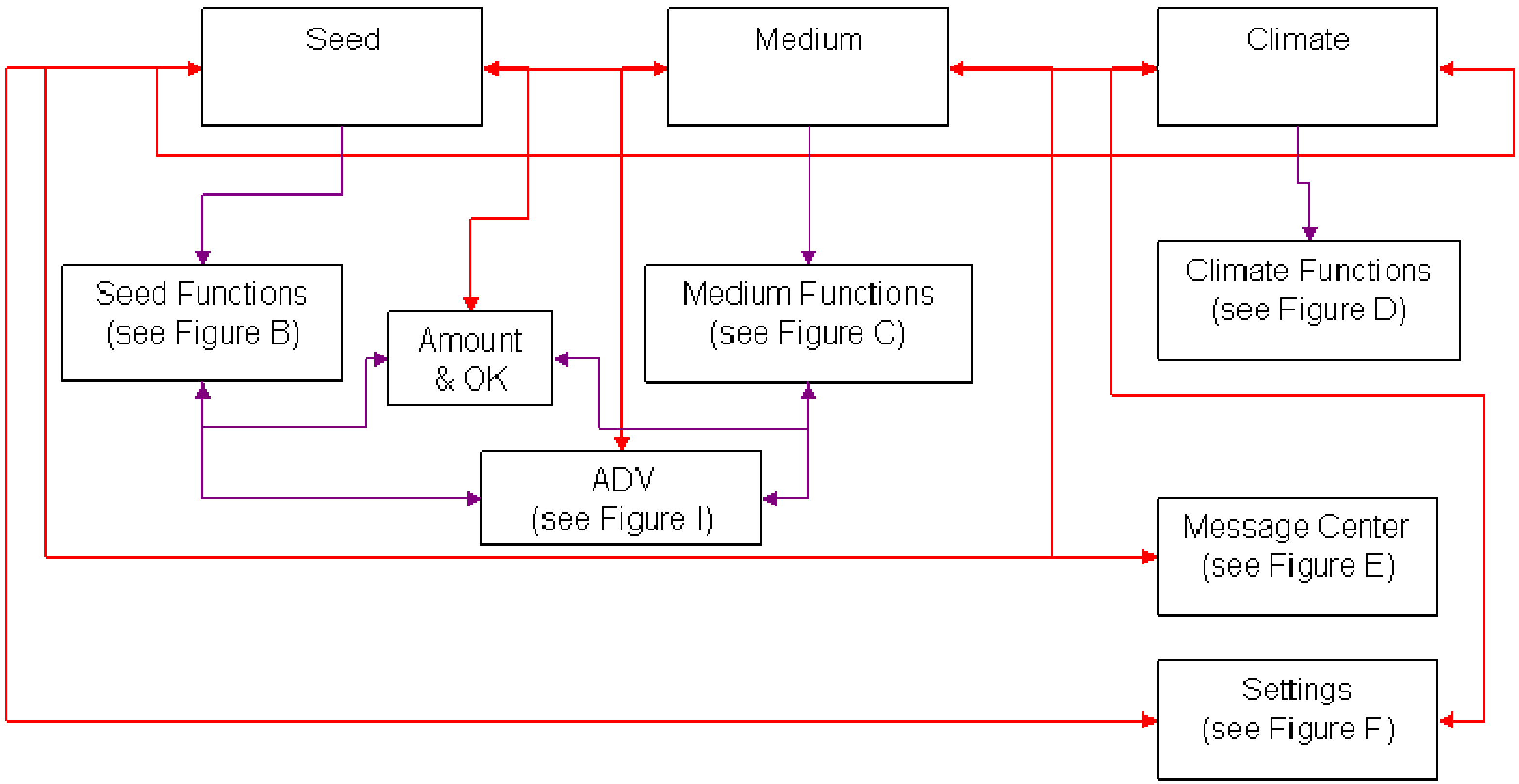


Figure B. Seed Screen Functions

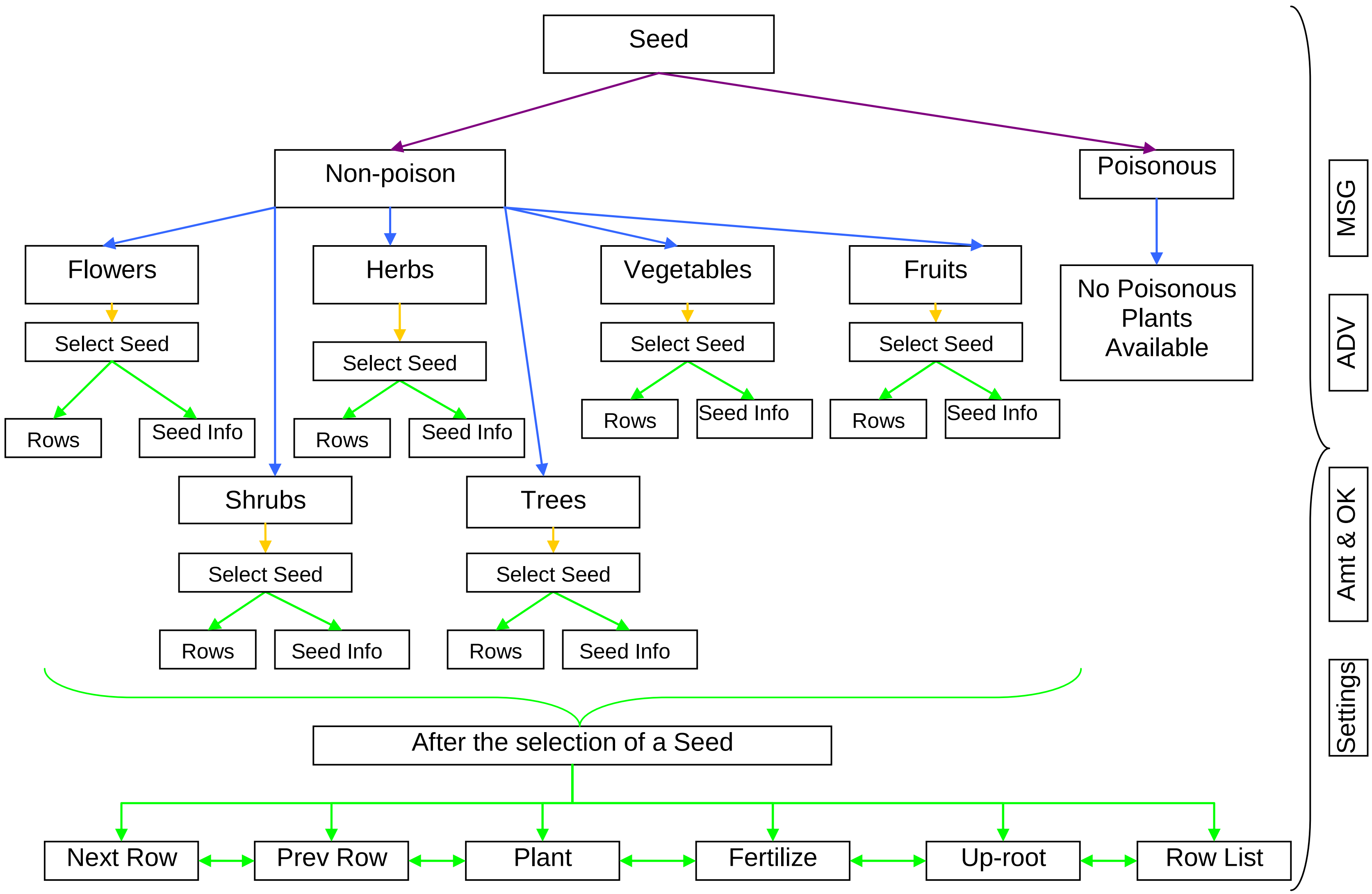


Figure C. Medium Screen Functions

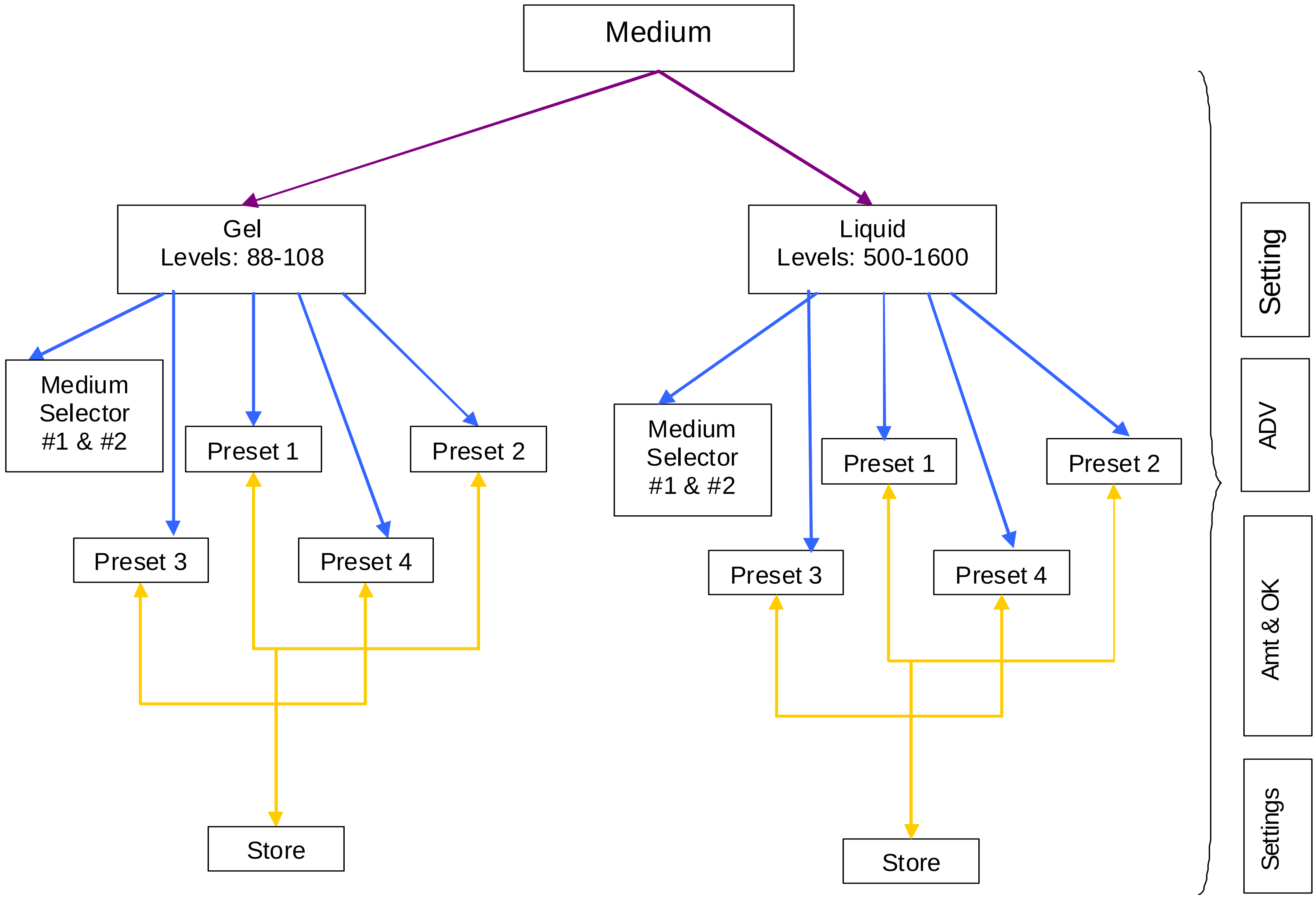


Figure D. Climate Screen Functions

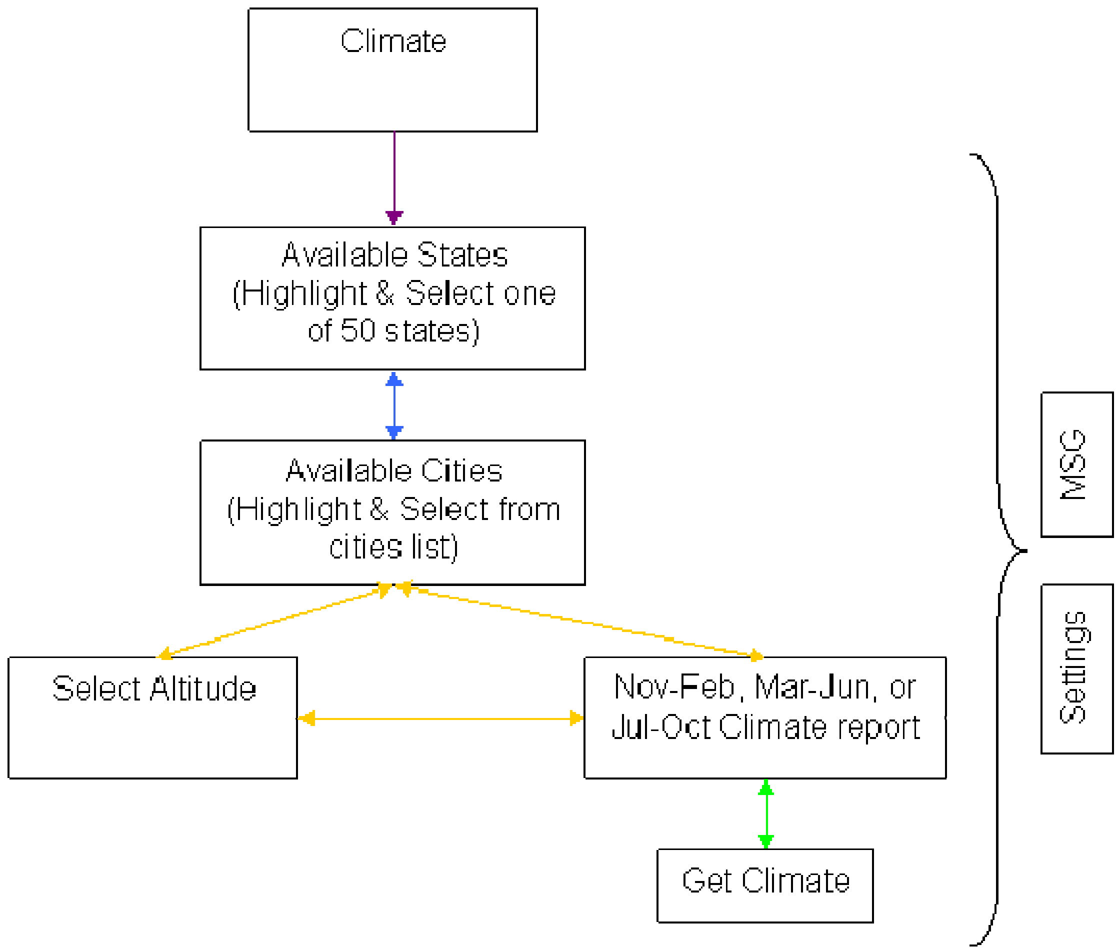


Figure E. Message Center Screen Functions

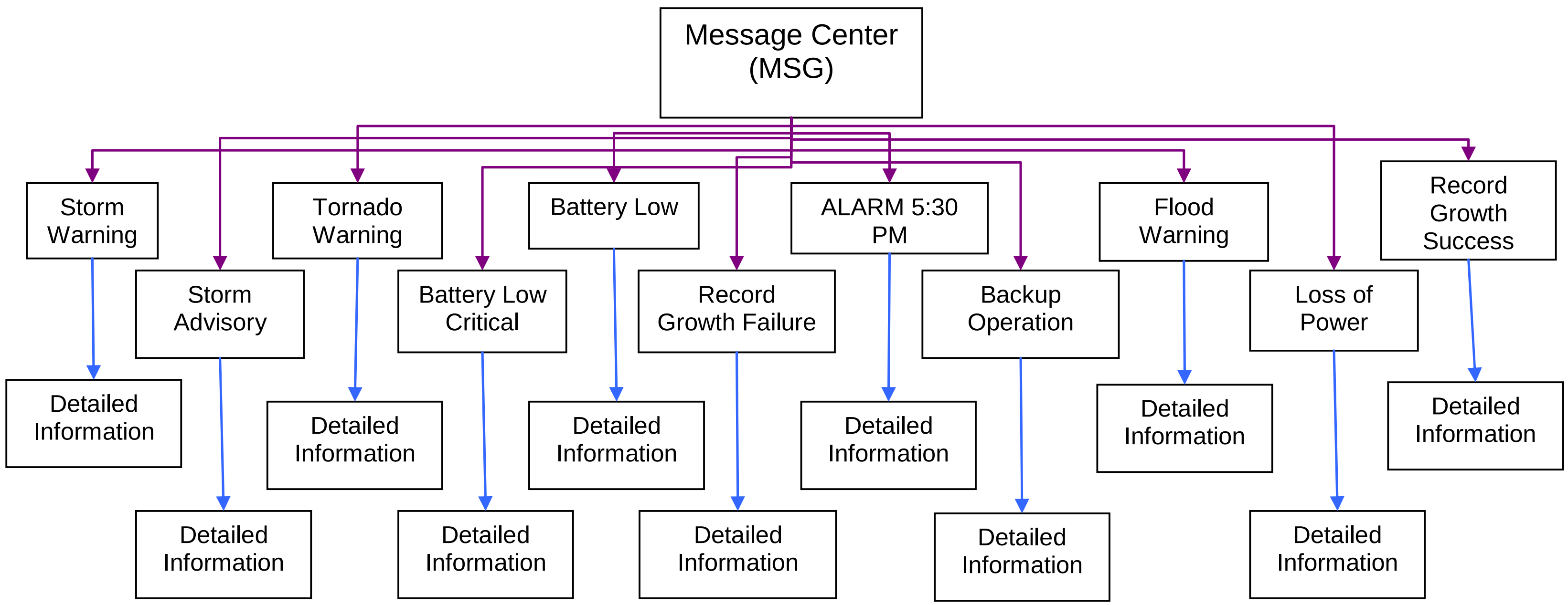


Figure F. Settings Screen Functions

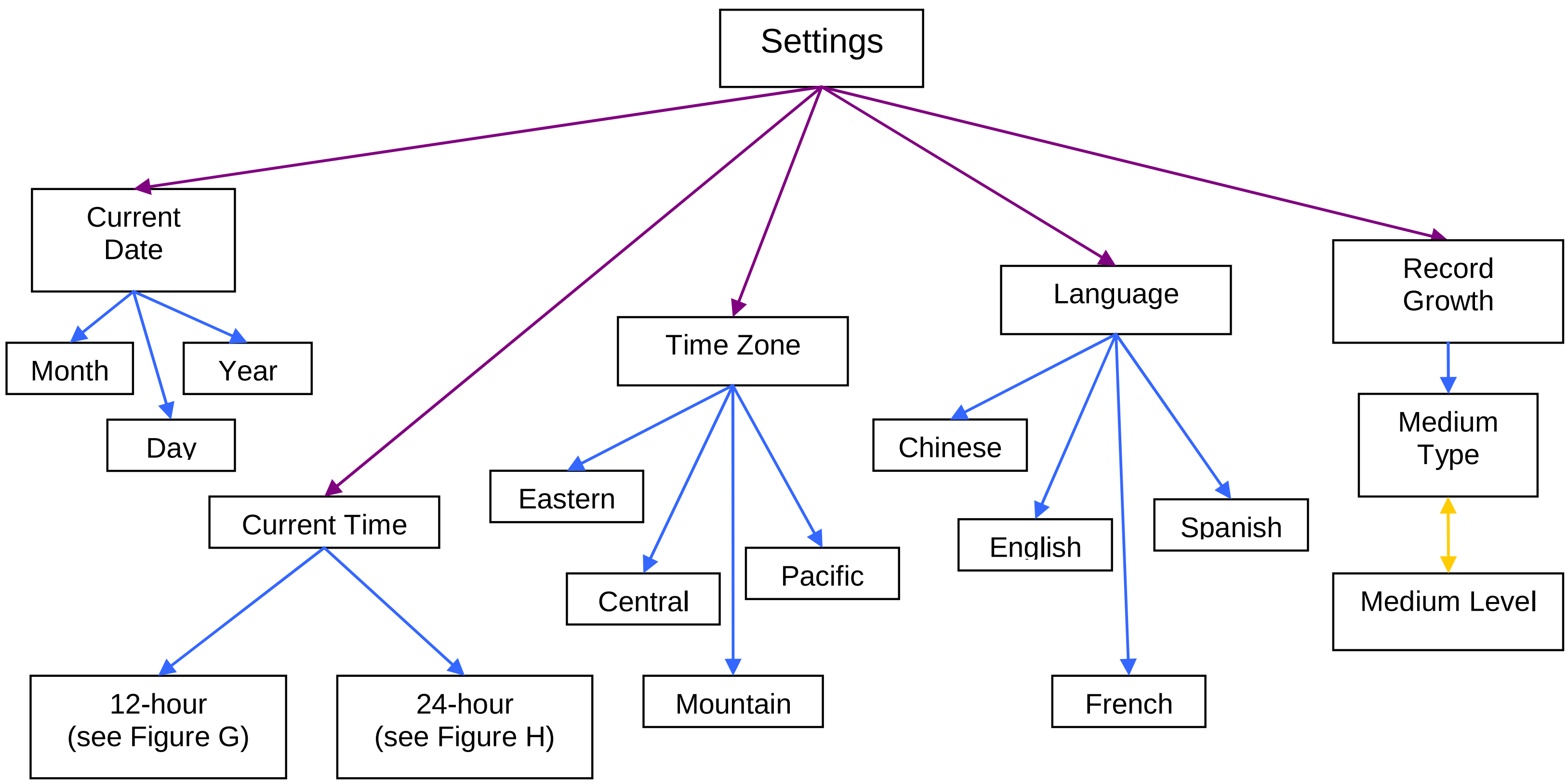


Figure G. 12-hour Settings Screen Functions

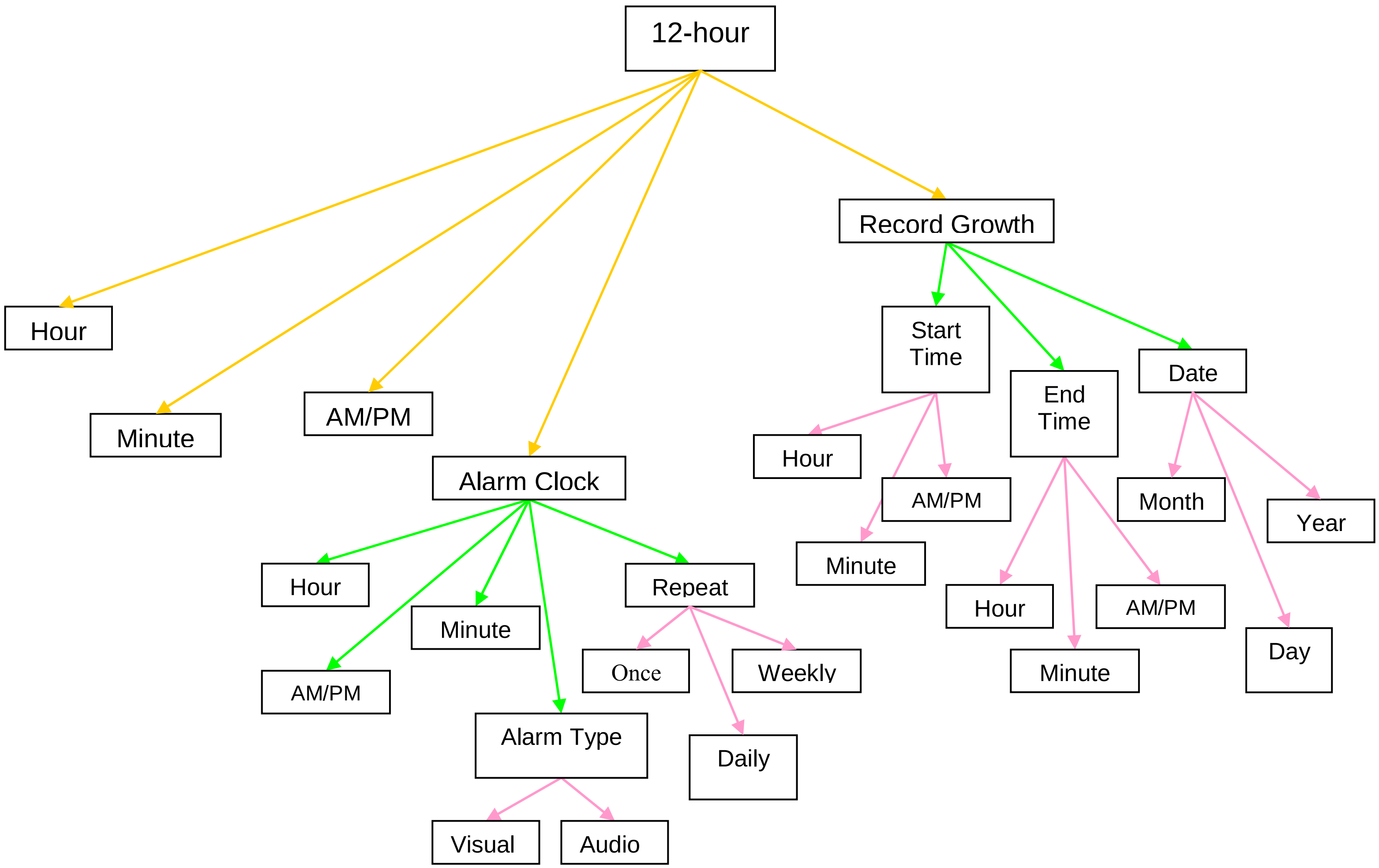


Figure H. 24-hour Settings Screen Functions

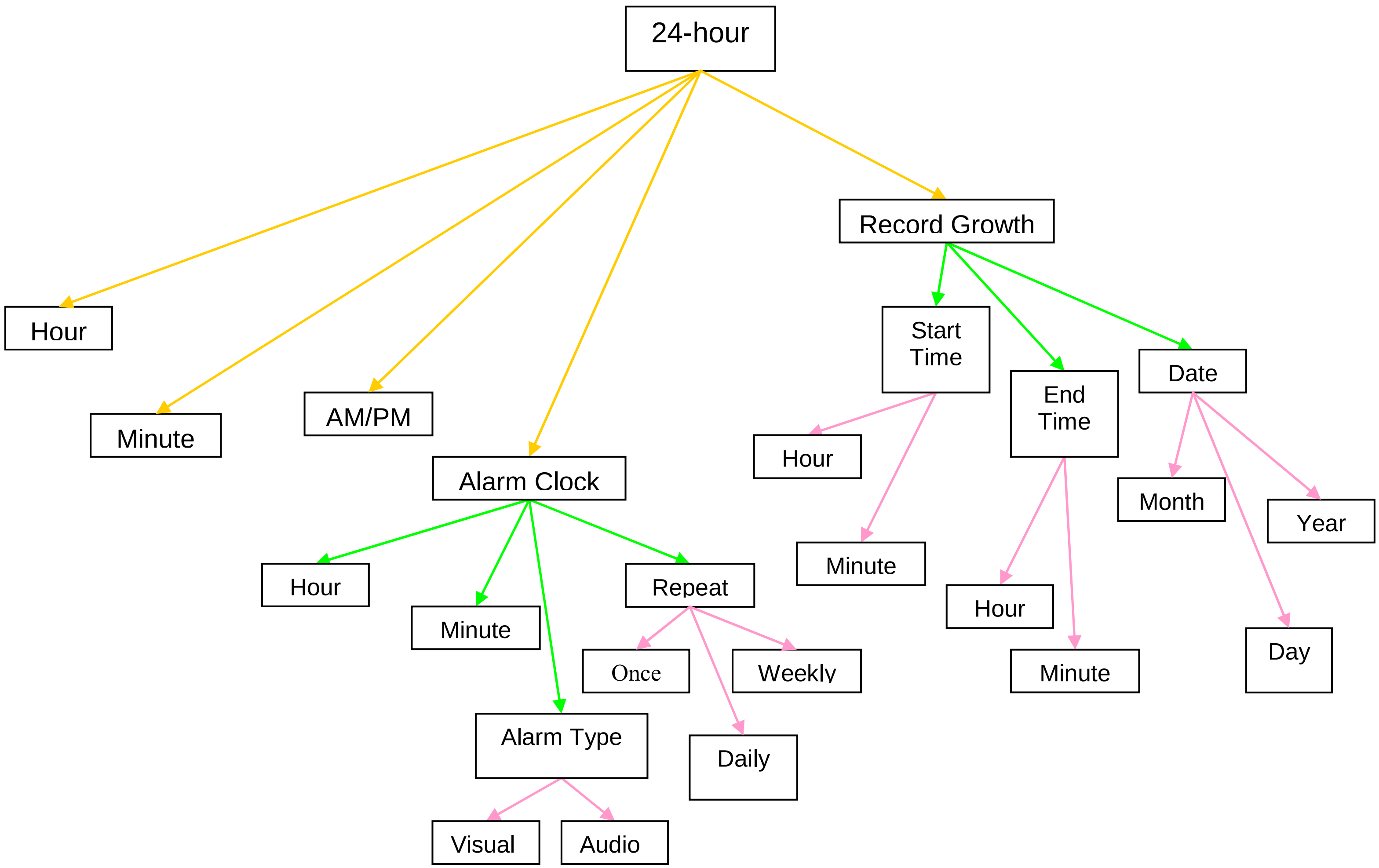
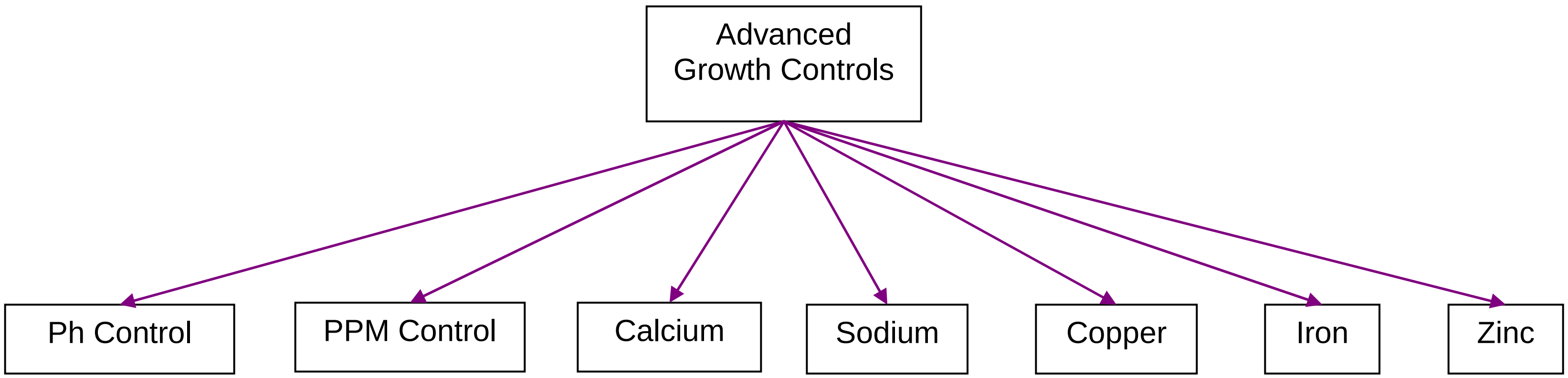


Figure I. Advance Growth Control Screen Functions



APPENDIX C

NASA-TLX

Please complete the following items to the best of your ability by circling one line on each scale:

MENTAL DEMAND

How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**

PHYSICAL DEMAND

How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?

Low **High**

TEMPORAL DEMAND

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was that pace slow and leisurely or rapid and frantic?

Low **High**

PERFORMANCE

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Good **Poor**

EFFORT

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**

FRUSTRATION LEVEL

How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**

APPENDIX D

Exit Interview Survey

Project title: Training Complex Technologies

Now that you have completed the study, we would like you to answer a few questions about your experience during the study. There are no right or wrong answers please just provide your opinion.

For the following questions, please circle the appropriate response.

1. I was motivated to learn the Hydroponic Garden Control.

1	2	3	4	5
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

2. I felt rushed during the <u>training</u> portion of the study.

1	2	3	4	5
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

3. I felt rushed during the <u>testing</u> portion of the study.

1	2	3	4	5
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

4. I would have learned the system better if I had been [given a time limit during training] OR [able to work at my own pace during training]

1	2	3	4	5
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

5. I feel confident that if I had to use the Hydroponic Garden System tomorrow, I could.

1	2	3	4	5
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree

6. **Describe to me the approach (e.g., a strategy, trick, or technique) you used during <u>TRAINING</u> to help you complete each task in the allotted amount of time and learn the system:**

____

____

____

____

____

____

7. **Describe to me the approach (e.g., a strategy, trick, or technique) you used during <u>TESTING</u> to help you complete each task accurately and within the allotted amount of time:**

____

____

____

____

____

____

Please read each item and then indicate how often this statement applied to you during this study.

- Check **1** if the statement never applied to you,
- Check **3** if the statement sometimes applied to you,
- Check **5** if the statement always applied to you, or
- Check **2** or **4** to indicate that the statement is closer to either end of the range of responses.

Think about what you did DURING TRAINING when answering these questions.

	Never		Sometimes		Always
	1	2	3	4	5
Did you try to focus your attention on each step as you read it?					
Did you read through all the steps for each task before clicking the start button?					
Did you mentally picture performing each step before clicking the start button?					
Did you verbally rehearse the steps before clicking the start button?					
Did you verbally rehearse the steps while performing the training task (after clicking the start button)?					
Did you use a combination of techniques? Describe:________________________ ________________________________ ________________________________					
Other? Describe:________________________ ________________________________ ________________________________					
Other? Describe:________________________ ________________________________ ________________________________					

Did your strategies or techniques change throughout TRAINING (think about early in training, mid-training, and the end of training)?

Circle one: YES NO

If yes, describe how:

____

____

____

Now think about the TEST portion of this study, were your strategies or techniques:

The SAME as during training
Describe:

____

____

____

DIFFERENT from training
Describe:

____

____

____

Do you think being aware of these types of strategies or techniques before beginning training may have improved your performance?

Circle one: YES NO
If yes, describe how:

____

____

____

APPENDIX E

Means and standard deviations on the NASA-TLX for Experiment 1 (younger adults)

	Self Paced		Sequential		Static Slow		Static Fast	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Mental	52.07	20.76	61.88	15.66	53.98	19.36	67.25	16.62
Physical	10.32	8.44	15.88	18.08	13.86	16.49	16.13	15.65
Temporal	54.13	22.48	67.88	20.83	61.02	15.99	82.25	14.07
Performance	34.78	21.65	39.88	28.06	27.61	16.54	56.50	23.72
Effort	53.26	23.54	58.62	17.83	47.27	24.78	70.75	16.86
Frustration	28.80	23.19	39.50	25.13	28.86	18.85	60.75	26.46

APPENDIX F

Means and standard deviations on the Likert scale responses in the Strategy Interview for Experiment 1 (younger adults)

	Self Paced		Sequential		Static Slow		Static Fast	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Felt motivated to learn HGC	3.55	1.01	3.55	.10	3.36	1.00	3.71	0.78
Felt rushed during training	2.41	1.22	2.70	1.13	2.41	0.91	3.62	1.07
Felt rushed at test	3.86	0.83	3.25	1.12	3.64	0.90	3.48	1.33
Would have learned better if pace/worked at own pace	2.55	1.37	3.65	1.04	3.59	1.18	4.10	0.62
Feel confident to use HGC tomorrow	4.23	0.87	3.9	0.91	3.95	0.79	3.57	1.08

APPENDIX G

Means and standard deviations on the NASA-TLX for Experiment 2 (older adults)

	Self Paced		Sequential		Static Slow		Static Fast	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Mental	66.91	22.94	62.03	23.51	59.69	24.10	71.72	24.34
Physical	18.09	13.27	26.41	20.61	19.69	14.97	19.03	23.72
Temporal	38.97	24.09	35.00	23.77	25.31	23.47	40.94	28.66
Performance	46.03	21.85	53.44	26.91	34.69	27.88	50.31	23.82
Effort	57.79	22.08	70.31	20.77	53.13	23.74	62.19	22.89
Frustration	44.26	21.93	45.63	26.42	34.38	27.85	50.94	27.57

APPENDIX H

Means and standard deviations on the Likert scale responses in the Strategy Interview for Experiment 2 (older adults)

	Self Paced		Sequential		Static Slow		Static Fast	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Felt motivated to learn HGC	3.47	0.94	3.50	1.03	3.44	0.96	3.38	0.89
Felt rushed during training	2.00	1.00	1.75	1.06	1.50	0.52	1.94	1.00
Felt rushed at test	2.47	1.12	2.13	1.09	2.19	0.91	2.44	1.09
Would have learned better if pace/worked at own pace	2.12	0.70	2.81	1.17	3.13	1.26	2.88	1.15
Feel confident to use HGC tomorrow	4.00	0.87	3.50	0.82	3.63	1.26	3.94	1.06

REFERENCES

Ackerman, P. L. (1988). Determinants of individual differences during skill acquisition: Cognitive abilities and information processing. *Journal of Experimental Psychology: General, 117*, 288-318.

Baddeley, A. (1992). Working memory. *Science, 255*, 556-559.

Bloom, B. S. (1976). *Human characteristics and school learning*. New York, NY: McGraw-Hill.

Briggs, G. E., & Johnsen, A. M. (1973). On the nature of central processing in choice reactions. *Memory & Cognition, 1*, 91-100.

Charness, N., Schumann, C. E., & Boritz, G. M. (1992). Training older adults in word processing: Effects of age, training technique, and computer anxiety. *International Journal of Technology & Aging, 5*, 79-106.

Cognition and Technology Group at Vanderbilt (1996). Looking at technology in context: A framework for understanding technology and education research. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology.* (pp. 807-840). New York, NY: Macmillan.

Craik, F. I. M., & Salthouse, T. A. (2000). *The handbook of aging and cognition (2nd ed.)*. Mahwah, NJ: Lawrence Erlbaum.

Czaja, S. J. (2001). Technological change and the older worker. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging (5th ed.)* (pp. 547-568). San Diego, CA: Academic Press.

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., et al. (2006). Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging, 21*, 333-352.

Czaja, S. J., & Lee, C. C. (2003). Designing computer systems for older adults. In J. A. Jacko & A. Sears (Eds.), *The human-computer interaction handbook: Fundamentals, evolving technologies, and emerging applications* (pp. 413-427). Mahwah, NJ: Lawrence Erlbaum.

Czaja, S. J., & Sharit, J. (1993). Age differences in the performance of computer-based work. *Psychology and Aging, 8*, 59-67.

Delis, D. C., Kramer, J. H., Kaplan, E. & Ober, B. A., (1987). *California Verbal Learning Test (CLVT) Manual*. New York, NY: Psychological Corporation.

Eggemeier, F. T., Fisk, A. D., Robbins, R. J., & Lawless, M. T. (1988). Application of automatic/controlled processing theory to training tactical command control skills: II. Evaluation of a task-analytic methodology. *Proceedings of the Human Factors Society 32nd Annual Meeting* (pp. 1232-1236). Santa Monica, CA: Human Factors Society.

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D. (1976). *Manual for Kit of Factor Referenced Cognitive Test.* Princeton, NJ: Educational Testing Service.

Fisk, A. D., & Eggemeier, F. T. (1988). Application of automatic/controlled processing theory to training tactical command and control skills: I. Background and task analytic methodology. *Proceedings of the Human Factors Society 32nd Annual Meeting* (pp. 1227-1231). Santa Monica, CA: Human Factors Society.

Fisk, A. D., Rogers, W. A., Charness, N., Czaja, S. J., & Sharit, J. (2009). *Designing for Older Adults: Principles and Creative Human Factors Approaches*. New York, NY: CRC Press.

Fisk, A. D., & Schneider, W. (1983). Category and word search: Generalizing search principles to complex processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9*, 177-195.

Gagne, R. M. (1970). *The conditions of learning* (2nd ed.). New York, NY: Holt, Rinehart, & Winston.

Gagne, R. M., & Briggs, L. J. (1974). *Principles of instructional design*. New York, NY: Holt, Rinehart & Winston.

Ginns, P. (2005). Meta-analysis of the modality effect. *Learning & Instruction, 15*, 313-331.

Goldman, S. R. (2003). Learning in complex domains: When and why do multiple representations help? *Learning & Instruction, 13*, 239-244.

Hart, S. G. (2006). NASA-Task Load Index (NASA-TLX): 20 years later. *Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting* (pp. 904-908). Santa Monica, CA: Human Factors and Ergonomics Society.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), *Human mental workload.* (pp. 139-183). New York, NY: North-Holland.

Hickman, J. M., Rogers, W. A., & Fisk, A. D. (2007). Training older adults to use new technology. *Journals of Gerontology Series B: Psychological Sciences & Social Sciences, 62B*, 77-84.

Jamieson, B. A., & Rogers, W. A. (2000). Age-related effects of blocked and random practice schedules on learning a new technology. *Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 55*, P343-P353.

Johnsen, A. M., & Briggs, G. E. (1973). On the locus of display load effects in choice reactions. *Journal of Experimental Psychology, 99*, 266-271.

Keller, F. S. (1968). "Good-bye teacher…". *Journal of Applied Behavior Analysis, 1*, 79-89.

Kulik, J. A., Kulik, C. L., & Carmichael, K. (1974). The Keller plan in science teaching. *Science, 183*, 379-383.

Luczak, H. (1997). Task analysis. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (2nd ed., pp. 340-416). New York, NY: John Wiley.

Mayer, R. E. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning & Instruction, 13*, 125-139.

Mayhorn, C. B., Stronge, A. J., McLaughlin, A. C., & Rogers, W. A. (2004). Older adults, computer training, and the system approach: A formula for success. *Educational Gerontology, 30*, 185-203.

McLaughlin, A. C., Rogers, W. A., Sierra, J. E. A., & Fisk, A. D. (2007). The effects of instructional media: Identifying the task demand/media match. *Learning, Media, & Technology, 32*, 381-405.

Mead, S. E., & Fisk, A. D. (1998). Measuring skill acquisition and retention with an ATM simulator: The need for age-specific training. *Human Factors, 40*, 516-524.

Morrell, R. W., & Echt, K. V. (1996). Instructional design for older computer users: The influence of cognitive factors. In W. A. Rogers, A. D. Fisk & N. Walker (Eds.), *Aging and skilled performance: Advances in theory and applications.* (pp. 241-265). Mahwah, NJ: Lawrence Erlbaum.

Paas, F., Camp, G., & Rikers, R. (2001). Instructional compensation for age-related cognitive declines: Effects of goal specificity in maze learning. *Journal of Educational Psychology, 93*, 181-186.

Park, D., & Schwarz, N. (2000). *Cognitive aging: A primer*. Philadelphia, PA: Taylor & Francis.

Rogers, W. A., Campbell, R. H., & Pak, R. (2001). A systems approach for training older adults to use technology. In N. Charness, D. C. Parks & B. A. Sabel (Eds.), *Communication, technology and aging: Opportunities and challenges for the future.* (pp. 187-208). New York, NY: Springer Publishing.

Salas, E., Cannon-Bowers, J. A., & Kozlowski, S. W. (1997). The science and practice of training: Current trends and emerging themes. In J. K. Ford, S. W. Kozlowski, K. Kraiger, E. Salas & M. S. Teachout (Eds.), *Improving effectiveness in work organizations* (pp. 357-367). Mahwah, NJ: Lawrence Erlbaum.

Salthouse, T. A. (1991). *Theoretical perspectives on cognitive aging*. Hillsdale, NJ: Lawrence Erlbaum.

Sanderson, P. M. (1990). Knowledge acquisition and fault diagnosis: Experiments with plault. *IEEE Transactions on Systems, Man, and Cybernetics, 20*, 225-242.

Schmitter-Edgecombe, M., & Rogers, W. A. (1997). Automatic process development following severe closed head injury. *Neuropsychology, 11*, 296-308.

Schneider, W. (1985). Training high-performance skills: Fallacies and guidelines. *Human Factors, 27*, 285-300.

Schneider, W., & Fisk, A. D. (1984). Automatic category search and its transfer. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*, 1-15.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. *Psychological Review, 84*, 1-66.

Shepherd, A. (1985). Hierarchical task analysis and training decisions. *Programmed Learning and Educational Technology, 22*, 162-176.

Shepherd, A. (1998). HTA as a framework for task analysis. *Ergonomics, 41*, 1537-1552.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84*, 127-190.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*, 185-233.

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*, 251-296.

Swezey, R. W., & Llaneras, R. E. (1997). Models of training and instruction. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (2nd ed., pp. 514-577). New York, NY: John Wiley.

Tabbers, H. K. (2002). The modality of text in multimedia instructions: Refining the design guidelines. Unpublished doctoral dissertation. Open University of the Netherlands, Heerlen.

Taub, H. A. (1967). Paired associates learning as a function of age, rate, and instructions. *Journal of Genetic Psychology, 111*, 41-46.

Whaley, C. J., & Fisk, A. D. (1993). Effects of part-task training on memory set unitization and retention of memory-dependent skilled search. *Human Factors, 35*, 639-652.