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A Comparison of Four Types of Feedback During Computer-based Training (CBT)

Michael Cowen

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Navy personnel often have difficulty operating the state-of-the-art programmable equipment employed in radar systems, communication systems, and transportation systems. These types of devices tend to be designed without adequate consideration of the user interface. Computer-based training (CBT) systems have been developed to help users overcome difficulties associated with learning how to operate complex devices. An important capability of CBT is feedback that informs users about the correctness of their knowledge of device procedures. Current research in CBT provides little guidance as to when feedback should be provided and how to design feedback content. An experimental CBT lesson on how to operate a military phone system was administered to 80 Navy students. The lesson was presented individually on a microcomputer and consisted of an introduction, a practice, and performance test. During practice, each treatment group received one of four types of feedback. The computer provided feedback either immediately following an error or at the end of the button-pushing of the to-be-learned sequence. Feedback consisted of the correct response or a "wrong" indication. All the CBT treatment groups outperformed a no-treatment control group. The treatment group who received delayed feedback performed significantly better on the performance test than those who received immediate feedback. Delaying the feedback was beneficial during CBT because it aids in the development of a usable device schema.

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FOREWORD

The experimental study of the role of feedback in computer-based training was conducted within the independent research program (Program Element 0601152N, Work Unit R0001.01) under the sponsorship of the Chief of Naval Research. The goal of this study was to determine the relative effectiveness ot different types of feedback in learning how to operate a program entry panel using computer-based training. The success of future Navy computer-based teaching systems hinges on effective employment of feedback during computer-based instruction. This report provides preliminary results on the benefits of different types of feedback employed during computer-based training.

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SUMMARY

Problem

Navy personnel often have difficulty operating the state-of-the-art programmable equipment employed in radar systems, communication systems, and transportation systems. These types of devices are often designed without adequate consideration of the user interface. Computer-based training (CBT) systems have been developed to help users overcome difficulties associated with learning to operate complex devices. An important capability of CBT is feedback that informs users about the correctness of their knowledge of device procedures. Current research in CBT provides little guidance as to when feedback should be provided and how to design feedback content.

Objective

The objective of this study was to determine the relative effectiveness of different types of feedback in learning how to operate a program entry panel during computer-based training.

Approach

An experimental CBT lesson on how to operate a military phone system was administered to 80 Navy students. The lesson was presented individually on a microcomputer and consisted of an introduction, a practice, and a performance test. During practice, each treatment group received one of four types of feedback. The computer provided feedback either immediately following an error or at the end of the button-pushing of the to-be-learned sequence. Feedback consisted of the correct response or a "wrong" indication.

Results

All the CBT treatment groups outperformed a no-treatment control group. The treatment group who received delayed feedback performed significantly better on the performance test than those who received immediate feedback. Delaying the feedback was beneficial during CBT because it aids in the development of a usable device schema.

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INTRODUCTION

The Problem

Navy personnel often have difficulty operating the state-of-the-art programmable equipment employed in radar systems, communication systems, and transportation systems. These complex devices "often contain internal mechanisms that obscure the relationship between the user's input and the device's behavior" (Shrager & Klahr, 1986, p. 153). These types of devices tend to be designed without adequate consideration of the user interface. Indeed, conceptual models of how the device works are used in the engineering of the device (Norman, 1988), but engineers often seem to give little thought on how the user will make it work (e.g., pushing buttons, flipping switches).

Computer-based training (CBT) systems have been developed to help users overcome the learning difficulties associated with operating these types of complex devices. CBT systems are used extensively at many industrial and military installations. Computers are used to teach operation of the device because they provide users with a safe environment in which to learn how to operate equipment without endangering themselves and others or harming the equipment. Also, CBT systems can be easily programmed to simulate faults. Consequently, CBT is more flexible than using the actual equipment for training.

Capabilities of CBT systems include the use of sound, animated graphics, and video and the presentation of information in a linear or interactive mode. Feedback for student responses is also an important capability of CBT. In order for CBT to be effective, it must use feedback strategies that allow the student to learn device procedures. Feedback is important for learning how to operate a complex device, in that it informs the student about the correctness of his or her knowledge of the device procedures.

Instructional designers implement feedback in current CBT systems in many ways. Feedback is typically provided immediately after a student responds to an inquiry from the training system, but feedback has also been provided at some later point during the instruction. For example, some CBT systems such as the H-53 helicopter training system (Cowen, 1989) provide feedback only after three errors in the practice of a single subtask. In contrast, the E-2C radar training system (Stern & McCabe, 1987) provides feedback immediately after the completion of every subtask. Another training system, the ECM/ECCM radar jamming training system (Cowen, 1985), provides feedback only after the completion of the entire radar jamming procedure.

The effectiveness of feedback hinges on the suitability of its content to the learning task. The two most common types of feedback used in CBT are confirmatory feedback and corrective feedback. Confirmatory feedback provides an indication of correctness of input such as the presentation "right" or "wrong" as the computer's response to the student's input. Corrective feedback presents the correct answer for the student's incorrect response. For example, if the student answered "gas" to the question, "What liquid do you put in the radiator?" the computer would respond, "The radiator should be filled with water."

Although meta-analyses have demonstrated that computerized instruction can improve student achievement (Bangert-Drowns, C. C. Kulik, & J. A. Kulik, 1985; J. A. Kulik, & C. C. Kulik, 1988;

Kulik, Kulik, & Bangert-Drowns, 1985; Niemiec & Walberg, 1987; Roblyer, 1990), there is no clear indication in the literature as to when feedback should be provided during a CBT lesson and what its content should be. An important question is how to use feedback most effectively in a computerized lesson on how to operate the program entry panel (PEP) for a complex device.

The purpose of this study was to investigate the relative effectiveness of different types of feedback in learning how to operate a PEP device using CBT.

Background

Operating a Program Entry Panel (PEP) Device

The knowledge of how to operate a PEP device has been described as a synthetic construction of familiar items (e.g., buttons, switches) in a novel fashion (Moran, 1981). The student's knowledge of how to perform a device's unique sequence of operations is called a task/action mapping (Young, 1981). Task/action mappings have been used to describe the operation of the standard four-function calculator (Young, 1983). This representation accurately describes not only the procedures for basic calculations such as 2 + 3 = 5, but also for special calculations such as cumulative calculations, constant calculations, and upside-down division. For instance, the quotient 8 / (4 + 6) can only be evaluated by pushing the button sequence, 4, +, 6, ÷, =, 8, =. The user's task/action mapping of the device helps the user retrieve the sequences of push buttons operation needed to perform certain types of calculations.

Shrager and Klahr (1986) called this representation a device schema and they proposed three subclasses of knowledge that characterize how a device works: syntactic knowledge, semantic knowledge, and device model knowledge. Syntactic knowledge is the grammar of the sequence. The user must understand what constitutes a "legal" sequence of buttons and switches. For instance, to compute a basic calculation on the four-function calculator, a user must always push a number button followed by an operation button, followed by a number button, followed by an operation button.

Semantic knowledge is knowing the results of pushing an individual button or flipping a particular switch. For example, when performing a basic calculation on the four-function calculator, the meaning of the 5 button is the integer five and the meaning of the = button is equals. The function of a button, however, may change with the type of calculation to be performed. During a cumulative calculation the = may also mean addition as in the sequence 4, +, 6, =, =. When a button or a series of buttons represents more than one function, the user may become confused and consequently will have difficulty operating the device.

Device model knowledge is the user's understanding of the interrelationships among the internal mechanisms of the device. For example, a user's device model of a four-function calculator consists of a vague notion that pushing number buttons puts integers into number registers inside the calculator and that pushing operation buttons affects the contents of these internal registers and of the numbers that appear in the external display. A user's device model can mediate the recall of syntactic and semantic knowledge. For instance, the user executes his or her device model of the four-function calculator and knows that in order to enter a number into an internal register of the calculator he or she must push an operation button after entering the numerals of the first operand. Thus, the device model of how the user thinks the device works has helped in remembering the syntax of how to perform a basic calculation. Shrager and Klahr (1986) report that some subjects in their experiment were successfully able to operate the "BigTrak" programmable toy tank using a device schema of how the toy works.

Using Computers to Teach Device Operation

CBT "generally refers to the use of computers to accomplish a specific training objective" (Willis, 1987, p. 80). There are CBT systems at industrial and military installations that teach operation of complex physical devices such as radar equipment, communication systems, and military vehicles (Cowen, 1985; Malec & Luszczak, 1987; Stern & McCabe, 1987).

Computerized instruction is a convenient way to present consistent information to students at different training sites. Other advantages of computerized instruction include standardizing course materials, matching materials to the ability of the student, and automated scoring of performance tests. Computers also provide a safe environment in which to operate potentially dangerous equipment. Procedures can be attempted which, if done incorrectly, would endanger the student or the instructor and harm the equipment. For example, CBT could provide a student with opportunities to practice the adjustment of temperature settings during a power plant operation lesson. Coleman (1988) reported student achievement using CBT equals that achieved using the actual complex device. As a result, CBT is cost effective because it typically costs much less than the actual equipment. Coleman also reported that CBT "consistently took less time to deliver course material than the same course taught conventionally, generally 30 per cent less time" (p. 44).

Feedback in Computer-based Training

Feedback for student responses is a key design feature of CBT systems. Most researchers and practitioners agree that feedback is an important factor in learning (Annett, 1969; Gagne, 1977; Kulhavy, 1977). A meta-analysis of 15 studies (Schimmel, 1983) indicates that using feedback in computer-based instruction is more effective than not using feedback. Schimmel located 15 studies that investigated both feedback and no-feedback conditions in administering an adult lesson involving meaningful verbal material. Schimmel reported that subjects receiving feedback on average scored .47 standard deviations higher than those receiving no feedback. However, this analysis did not show how the timing and content of feedback in computer-based instruction may be related to learning and retention of the device procedures.

Feedback For Correct Responses

The purpose of providing feedback for correct answers is to help the student perceive that his or her understanding of the subject matter is correct. Kulhavy and others (Kulhavy & Anderson, 1972; Kulhavy & Parsons, 1972; Kulhavy & Swenson, 1975) found that correct responses were repeated whether or not feedback was provided. These findings are consistent with the results of earlier studies (Krumboltz & Kiesler, 1965; Oppenheim, 1964) which investigated feedback for correct responses during verbal learning. These studies found that confirmation did not affect student achievement. Steinberg (1984) believed that there is no need to provide extensive feedback after a correct response: "It serves no useful purpose, and the students will not read it" (p. 86).

In contrast, feedback for incorrect responses is highly important to learning. Buss (Buss & Buss, 1956; Buss, Weiner, & Buss, 1954) found that subjects who were informed only of their errors performed better than subjects who received feedback only for correct responses. Although feedback for correct responses can be helpful in some settings, this investigation focused on the effects of providing feedback for student errors. The effectiveness of feedback for student errors during CBT may be related to when it is provided and the suitability of its content.

Timing of Feedback

A literature review of the results comparing immediate to delayed feedback in the education literature (Wager & Wager, 1985) indicates that both types of feedback are effective in promoting learning. The feedback content in most of these studies was confirmatory and the feedback delay was typically a day after the lesson examination. For example, Robin (1978) found no differences in achievement or study time between immediate and delayed feedback conditions during a self-paced section of a college-level abnormal psychology course. The feedback in this study was a grade of "correct" or "incorrect" by the class proctor, and the proctor did not provide correct answers for incorrect responses. During the delayed condition, this feedback was not provided until the beginning of the next class period.

A recent meta-analysis by (J. A. Kulik & C. C. Kulik, 1988) of 53 studies on feedback timing and verbal learning also found mixed results. The analysis indicated that immediate feedback was more effective than delayed feedback for applied studies using actual classroom quizzes. However, they also found that delayed feedback was superior to immediate feedback for experimental studies involving the learning of multiples-choice items or lists of words. It is difficult to draw conclusions from this study because many of the journal articles cited in the meta-analysis sometimes classify after-test feedback as immediate feedback and sometimes as delayed feedback. The inconsistent use of the terms immediate and delayed has made it difficult to generalize research results on feedback (Dempsey & Wager, 1988).

Nevertheless, there is strong evidence that, at least for some paradigms, delayed feedback for student errors is more effective than immediate feedback. Delayed feedback groups consistently outperformed no-delay feedback groups in paired-associate tasks, lessons with multiple-choice items, and learning prose passages (Kulhavy, 1977). Kulhavy and Anderson (1972) argued that delayed feedback is more effective because an interval between response and feedback reduces the strength of the memory trace for the incorrect response. They argued that, when feedback is provided immediately, the wrong response will interfere with the correct response (i.e., pro-active interference). They found that subjects spend significantly more time attending to delayed feedback. Kulhavy and Parsons (1972) found that delayed feedback was most effective when the level of the instructional material was appropriate for the student and the student could relate the material to some previously acquired knowledge.

Content of Feedback

As previously mentioned, a meta-analysis was performed by Schimmel (1983) on the educational effectiveness of feedback in computerized instruction. Although feedback treatment groups generally outperformed their respective control groups, this study found no significant advantage for one feedback content type over another. For example, the effect size for a study

(Kulhavy, Yekovich, & Dyer, 1976) which administered review-type feedback was .71 while the effect size for a study (Roper, 1977) that provided "right/wrong" feedback was .69. Moreover, studies providing the correct response as feedback yielded effect sizes ranging from -1.25 to 1.10. Schimmel (1988) concluded that the empirical research on the content of feedback provides little guidance: "Providing learners with extensive information about why their answers are correct or incorrect has proven, on the whole, no more useful than offering minimal information" (p. 186). Anderson, Kulhavy, and Andre (1971) found similar results when college students were required to learn about heart disease using a 112-frame computer-based lesson. The college students were provided feedback either after right answers or wrong answers but not both. Result showed that, although both groups committed about the same number of errors during the lesson, the wrong-only condition had higher performance test scores. Kulhavy (1977), after reviewing the literature on feedback in written instruction, concluded that feedback works best when its content "identifies and corrects errors--or allows the learner to correct them" (p. 229). However, Kulhavy noted that this content is only effective if the correct answer is not blatantly available before the student response (so it will not be copied) and only if the lesson subject matter can be comprehended by the student.

The research suggests that instruction can be effective with feedback that is confirmatory or the corrective, and immediate or delayed. All the while, there is some indication that delayed feedback may be may be slightly more effective than immediate feedback. However, most of the research studied feedback in the learning of factual or declarative knowledge and not procedural knowledge. These studies examined feedback in instruction to perform tasks that are different than operating the PEP devices which are of interest here. In fact, no research exists on the role of feedback in learning how to operate PEP devices such as automated bank tellers, telecommunications equipment, or avionics consoles.

The only research which investigated the role of feedback in learning similar procedures was done by Lewis and Anderson (1985). They compared the effectiveness of immediate and delayed feedback in learning the rules in a computerized adventure game. In this experiment, subjects would attempt to move from room to room in search of treasures by activating objects in each room (e.g., waving a wand, rubbing the lamp). In the delayed feedback condition, subjects were allowed to move into the next room by activating the wrong object but could not move into a third room until the correct object was activated in the first room. In the immediate feedback condition, subjects were informed immediately of an error. Results showed that the immediate feedback subjects performed more accurately during the performance test than the delayed feedback subjects. However, the subjects in the delayed feedback group tested more hypotheses and were better at recognizing dead ends. The authors of the study concede that "subjects in the immediate feedback condition, although significantly more accurate at selecting forward moves, might flounder if allowed to move off of the correct solution path" (p. 63). In short, the issue of immediate versus delayed feedback is "controversial" (Anderson, 1987).

Hypotheses

The key dimensions of CBT feedback to student errors are content and timing. The content of feedback in CBT is typically either an indication of right or wrong (i.e., confirmatory feedback) or the presentation of the correct response (i.e., corrective feedback). It was hypothesized that (1) feedback in CBT for operating a PEP device is more effective when it is confirmatory than when it is corrective and (2) feedback in CBT for operating a PEP device is more effective when it is delayed than when it is immediate. Users successfully operate PEP devices by retrieving their mental representation (i.e., device schema) of how to make the device work. They construct a device schema by formulating hypotheses about how to make the device work and then by testing those hypotheses. During CBT, subjects can test hypotheses by interacting with a simulation of the device. Feedback during CBT is most important when it assists the user in confirming or rejecting hypotheses. When proposed hypotheses are wrong, the user will search the problem space and formulate and test new hypotheses. Accordingly, feedback in the form of a "you are wrong" statement in response to a student error (when compared to feedback in the form of the correct response) leads to active hypothesis testing which produces a rich device schema which leads to better learning. Lewis and Anderson (1985) found that subjects who actively tested hypotheses were better performers. Users are unlikely to formulate and test new hypotheses if provided with the correct response.

During CBT, feedback can be provided immediately after an error or at the end of the practice for a specific task. Delaying the feedback until after the end of practice for each task will allow the student to formulate and refine hypotheses. Users who formulate and test hypotheses in the learning of a PEP procedure will generate device schema that will help them recall device procedures. Consequently, it was predicted that (1) subjects provided with confirmatory (e.g., "you are wrong") feedback for errors they made during practice of a to-be-learned sequence will learn how to perform more device procedures than those provided with corrective feedback and (2) subjects provided with feedback at the end of practice of a to-be-learned sequence will learn how to perform more device procedures than those provided with feedback immediately after every error during practice of a to-be-learned sequence.

In short, it was predicted that subjects provided with confirmatory or delayed feedback during CBT will outperform those provided with corrective or immediate feedback. The users provided with confirmatory or delayed feedback will have a better understanding of the relationship among device buttons and will perform better on a performance test administered immediately following the CBT.

METHOD

Subjects

The subjects in this study were 53 Navy students awaiting instruction for Sonar Technician (ST) "A" school at the Fleet Anti-submarine Warfare (ASW) Training Center, Pacific and 27 Navy students awaiting instruction for Apprenticeship Training at the Recruit Training Command (RTC) in San Diego. More than one sample was tested because the number of students at the ST "A" school available for testing was small. The students enrolled at the ASW Training Center (henceforth, referred to as the ASW sample) generally score between the 65th and 99th percentile on the Armed Forces Qualification Test (Monzon & Foley, 1988). The mean enlisted rank of the ASW sample was E-3 (rank ranges from E-1 to E-9) and the mean age was about 21 years. The ASW subjects had been in the Navy approximately 11 months and at the ASW training center about 3.5 months.

Students enrolled at RTC Apprenticeship Training school (henceforth, referred to as the RTC sample) generally score between the 10th and 30th percentile on the Armed Forces Qualification Test (Monzon & Foley, 1988). The mean enlisted rank of the RTC sample was E-2 and the mean age was about 21 years. These subjects had been in the Navy approximately 7.5 months and at the RTC about 3.5 months.

Procedure

The study consisted of three phases. First the subjects were required to fill out the pre-questionnaire, which included consent forms. Next, they were administered the experimental CBT lesson. Lastly, they were required to fill out the post-questionnaire. All phases were administered individually and were self-paced.

Pre-questionnaire

The pre-questionnaire (see Appendix A) asked about the subject's mood, experience with telephones, microcomputers, and video games and for biodemographic information. In addition, each subject was required to sign a consent form to act as a subject for scientific research. The consent form described the to-be-performed task and the objective of the study.

Computer-based Training

Each subject was seated in front of an Apple MacIntosh Model SE/30 microcomputer.[1] The microcomputer presented a CBT lesson on how to operate the Consolidated Area Telephone System (CATS). The objective of the lesson was to learn how to activate and employ eight features of the Navy's CATS using the AT&T Model 2500 Telephone (AT&T Technologies Inc., 1987). The nucleus of the lesson consisted of a computerized graphic simulation of the Model 2500 Telephone (see Figure 1). The simulation was displayed on the 9-inch (diagonal) monochrome monitor of the SE/30. The subjects interacted with the simulation by "clicking" a mouse on the computerized graphics, listening to simulated device sounds, and observing changes to the simulation. The remaining lesson materials consisted of computer frames of text and graphics which were linked to the simulation. The lesson had three parts: introduction, practice, and performance test.

Introduction. The introduction (see Appendix B) presented frames of information on how to use the mouse, the objective of the CBT lesson, the locations of the Model 2500 Telephone buttons (i.e., click areas), and a sample practice item. The introduction did not present any information on how to use the phone. To start the practice, the subjects entered the last four digits of their social security number (see Figure 2).

Practice. Practice consisted of activating each of the features of CATS by clicking the mouse on 16 active buttons or click areas located on the computerized graphic representation of the CATS phone (see Figure 1). For example, if instructed to make a call on the CATS phone, the subject would click the mouse on the Lift Receiver button, then on the Listen For Tone button, and then

[1]Identification of equipment is for documentation only and does not imply endorsement.

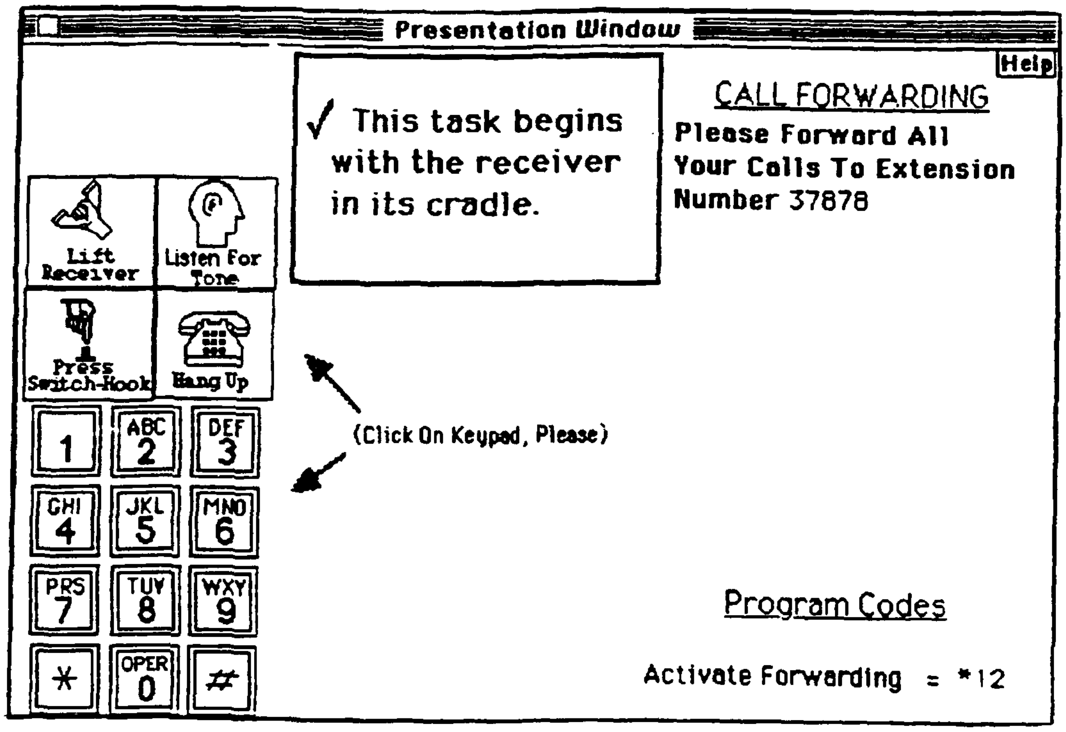


Figure 1. Screen of AT&T Model 2500 Telephone and example of task.

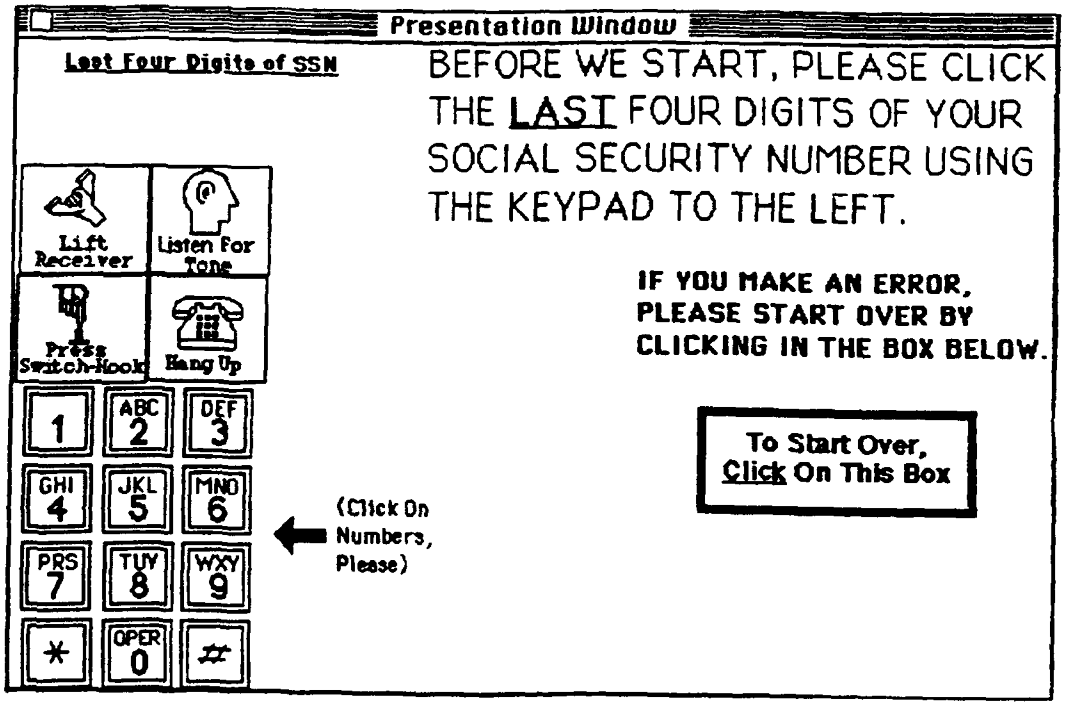


Figure 2. Sample screen of entering identification for practice.

seven times on the number buttons. If the subject made an error during practice, the CBT system provided feedback. The type of feedback provided will be described later.

Before the practice of each task, the subject was provided with a general description of the purpose of the task (Figure 3), but not how to do it. During practice, the subject could access the information presented during the introduction by clicking with a mouse on a help button. The practice contained eight tasks presented in the following order: Program Call Forwarding, Cancel Call Forwarding, Call Pickup, Program Abbreviated Dialing, Use Abbreviated Dialing, Call Transfer, Conference Calling, and Call Hold. Table 1 lists the number of steps required to activate and use each of these tasks on the simulated CATS system.

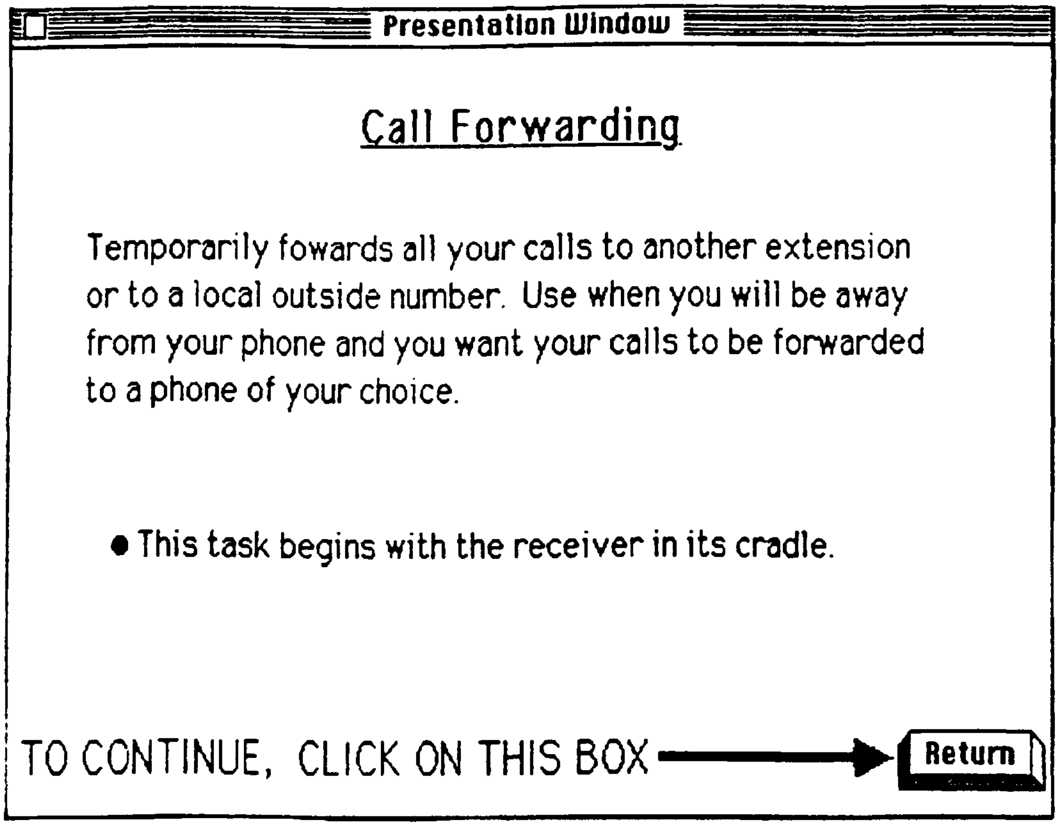


Figure 3. Sample screen of description of practice task.

Table 1

Steps Required To Operate Consolidated Area Telephone System (CATS) Features

Feature	Number of Steps	Number of Clicks of Mouse
Call Forwarding, Program	7	13
Call Forwarding, Cancel	5	7
Call Pickup	3	5
Abbreviated Dialing, Program	11	20
Abbreviated Dialing, Use	4	7
Call Transfer	4	8
Conference Calling	7	13
Call Hold	10	18

Note. Listed in order of presentation in computer-based training.

Call Forwarding sends all of the user's calls to another extension or to a local outside number. Call Forwarding is activated by entering a program code (e.g., *12) followed by the extension or outside telephone number. Program Call Forwarding requires the user to enter 7 steps (e.g., Lift Receiver, Enter *12) or 13 clicks on the simulated CATS system. Cancel Call Forwarding requires 5 steps or 7 clicks.

Call Pickup allows the user to answer another phone on his or her phone. It allows the user to handle somebody else's calls without having to leave his or her space. Call Pickup is activated by entering a program code and requires 3 steps or 5 clicks.

Program Abbreviated Dialing creates a personal list of phone numbers which can be accessed by dialing only two numbers. It is used to save time for dialing frequently called, lengthy, or important numbers. Both Program and Use Abbreviated Dialing are activated by entering several program codes and/or list numbers. Program Abbreviated Dialing requires 11 steps or 20 clicks; Use Abbreviated Dialing, 4 steps or 7 clicks.

Call Transfer moves a call from the user's phone to another extension or a local outside number. It is used mainly when the caller needs to speak with someone else. Call Transfer is activated by pushing the switch-hook and entering another number (4 steps or 8 clicks).

Conference Calling adds a third party to a call and results in a three-way conversation. It is activated by pushing the switch-hook, entering another number, and pushing the switch-hook again (7 steps or 13 clicks).

Call Hold temporarily disconnects a call so that the user can place another call or activate another feature. The Call Hold task requires the user to activate Call Hold, dial another number, and deactivate Call Hold (10 steps or 18 clicks).

CATS represents a complex PEP device since it has multiple features. Some CATS features require simple procedures for correct operation while other CATS features require complex procedures. The more complex features require the user to perform multiple functions and enter many operational steps.

Performance Test. The performance test consisted of performing the eight tasks in the practice. There was only one performance item per task. Before each item, as in the practice, the subject was provided with a general description of the task's purpose but no information on how to do it. Each performance item required the subject to click the buttons in the correct sequence. No feedback was provided. The performance tasks required the same steps as the practice tasks, but the extension numbers were different.

Post-questionnaire

The post-questionnaire (see Appendix C) consisted of questions about the subject's mood, understanding of CATS's procedures, and use of the experimental CBT. In brief, subjects were asked which of CATS features they felt comfortable using and to describe the purpose of various CATS elements such as the dial tone and the switch-hook. In addition, they were asked to rate the friendliness of the CBT and to comment on the feedback provided during CBT. They were also asked whether or not they would recommend using CBT to teach control panel procedures and for any comments.

Experimental Design

Subjects were randomly assigned to the control group or to one of four treatment groups. The control subjects were administered the pre-questionnaire, the CBT lesson introduction, the CBT performance test, and the post-questionnaire. They were not provided with CBT practice.

The four treatment groups were provided all phases of the CBT. During CBT practice, each group received one of four types of feedback: Immediate confirmatory feedback, immediate corrective feedback, delayed confirmatory feedback, and delayed corrective feedback.

Immediate feedback was feedback provided the instant the subject made an error. In the immediate confirmatory feedback condition, feedback for an error consisted of a a flashing box containing the words "Incorrect... Try Again." An example of this presentation is shown in Figure 4.

In the immediate corrective feedback condition, feedback for an error contained the correct response. This presentation (see Figure 5) consisted of a hand pointing to the correct response and a flashing box containing the words "Incorrect....The Hand Points to the Correct Response. (Click on the Hand)." In these two conditions, the subjects had to repeat missed steps until they performed them correctly. After all the correct steps had been entered for that task, subjects received the message "You Have Correctly Entered the Steps For...." and proceeded to the next task.

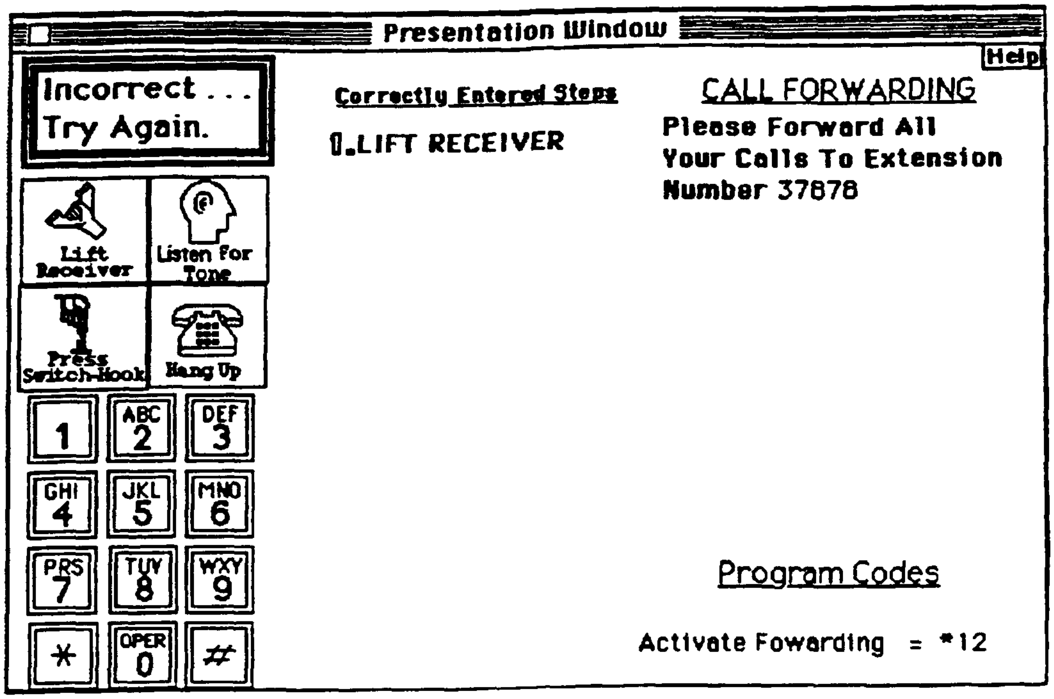


Figure 4. Sample screen of immediate confirmatory feedback.

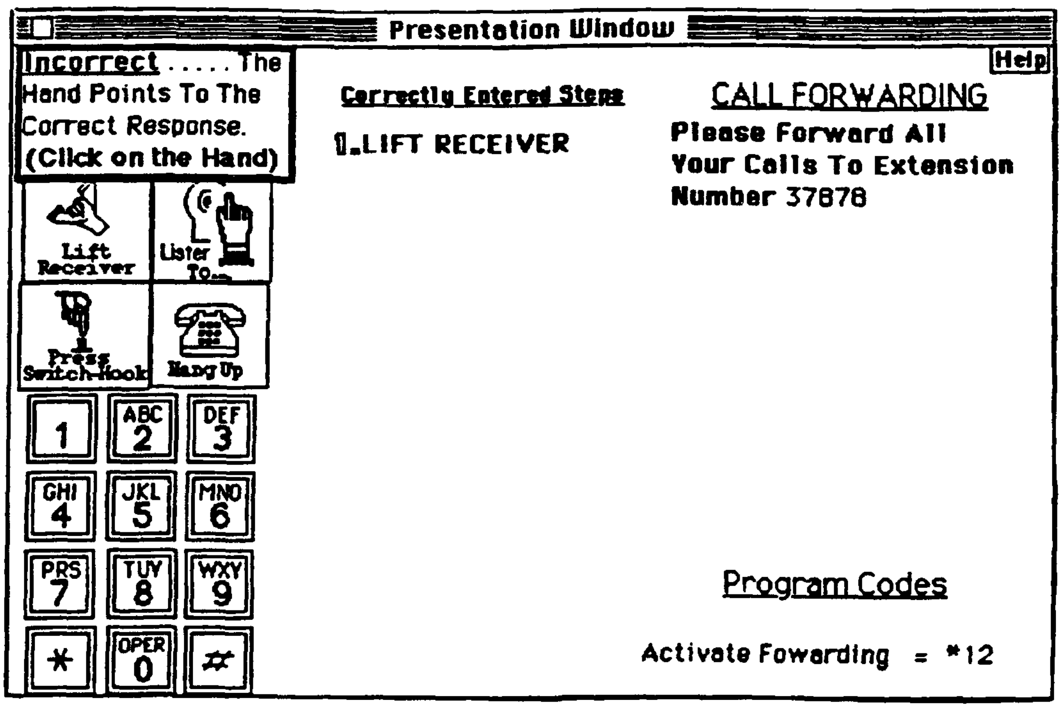


Figure 5. Sample screen of immediate corrective feedback.

In the delayed feedback conditions, subjects performed the task by first clicking the buttons sequentially and then clicking the "when-done" button (see Figure 6). The buttons pushed were displayed on the screen and this listing was erased when the when-done button was clicked. Subjects could also restart the task by clicking the "start-over" button. Feedback was provided only after a click on the when-done button. The subjects could not proceed to the next task until the sequence of steps had been entered without errors.

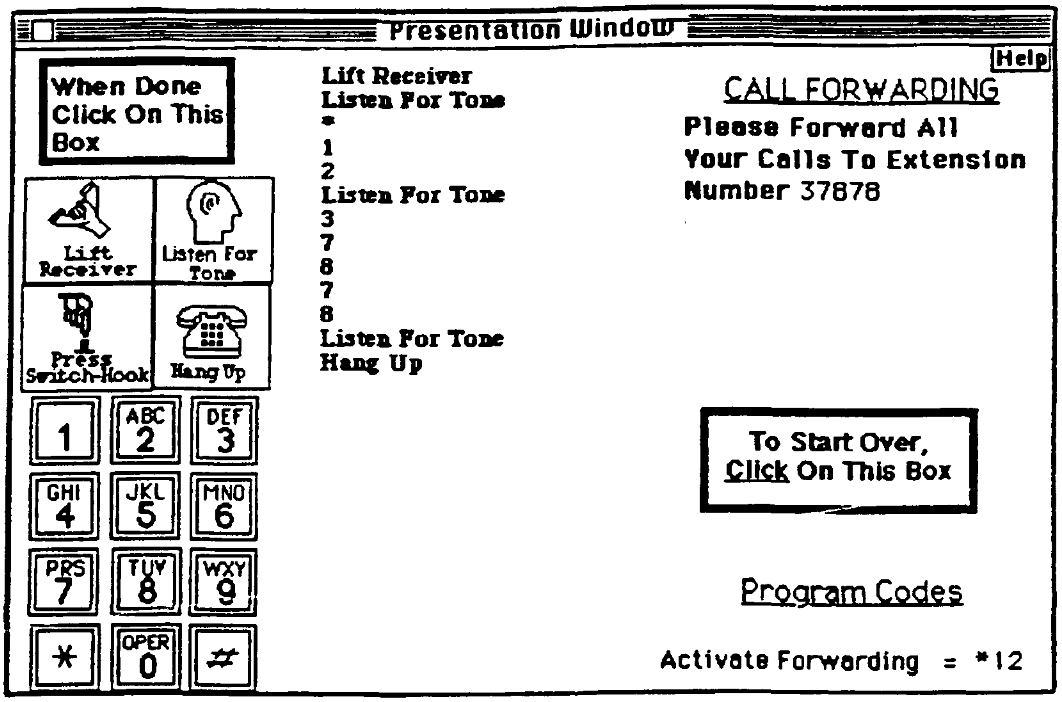


Figure 6. Sample screen of practice item from delayed feedback conditions.

In the delayed confirmatory feedback condition, the subjects were shown two lists (see Figure 7) of the correct steps: (1) in the correct order and (2) in the incorrect order. The example in Figure 7 shows that the subject performed Call Forwarding Program steps 1, 2, 6, and 7 correctly and steps 3, 4, and 5 incorrectly. The last column on the right of the display presents subject entries that are correct responses entered in the wrong order such as Touch *12 and Listen For Tone. The feedback was erased and the subject was asked to try the task again.

In the delayed corrective feedback condition, feedback for errors consisted of a presentation of the entire correct sequence of steps for that task. When a subject made an error, the feedback consisted of a hand pointing to the correct sequence of steps. Figure 8 shows an error the subject made while performing the Call Forwarding Program task. After clicking the when-done button, an animated hand shows the subject the entire sequence of correct steps.

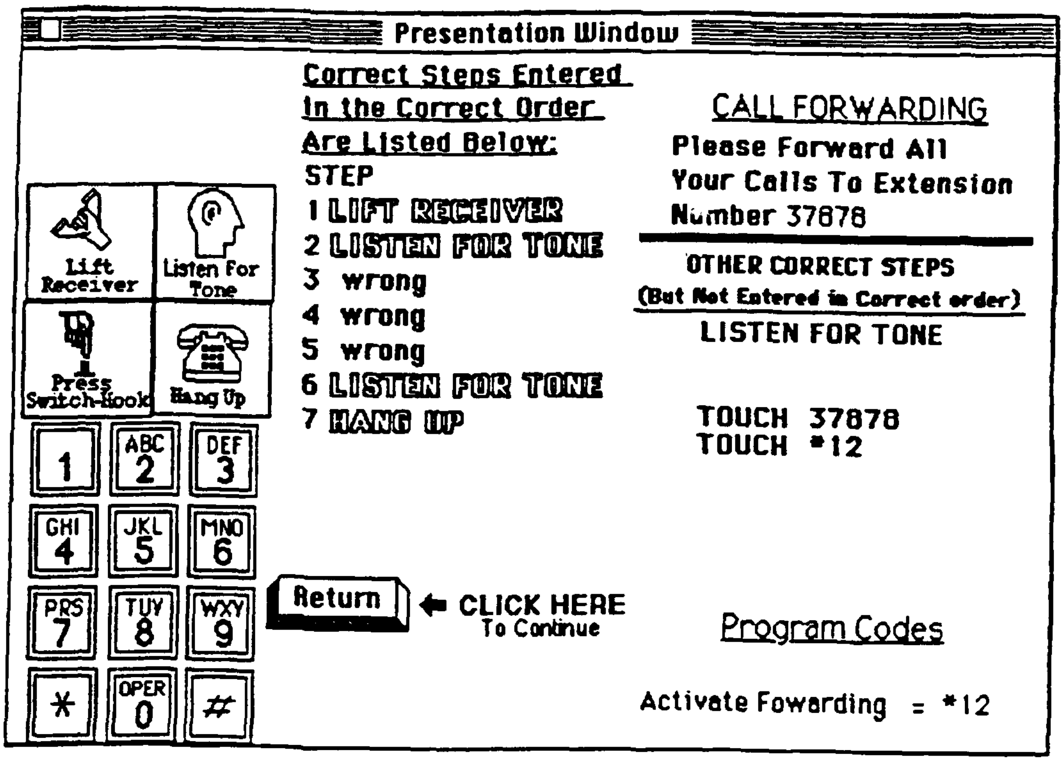


Figure 7. Sample screen of delayed confirmatory feedback.

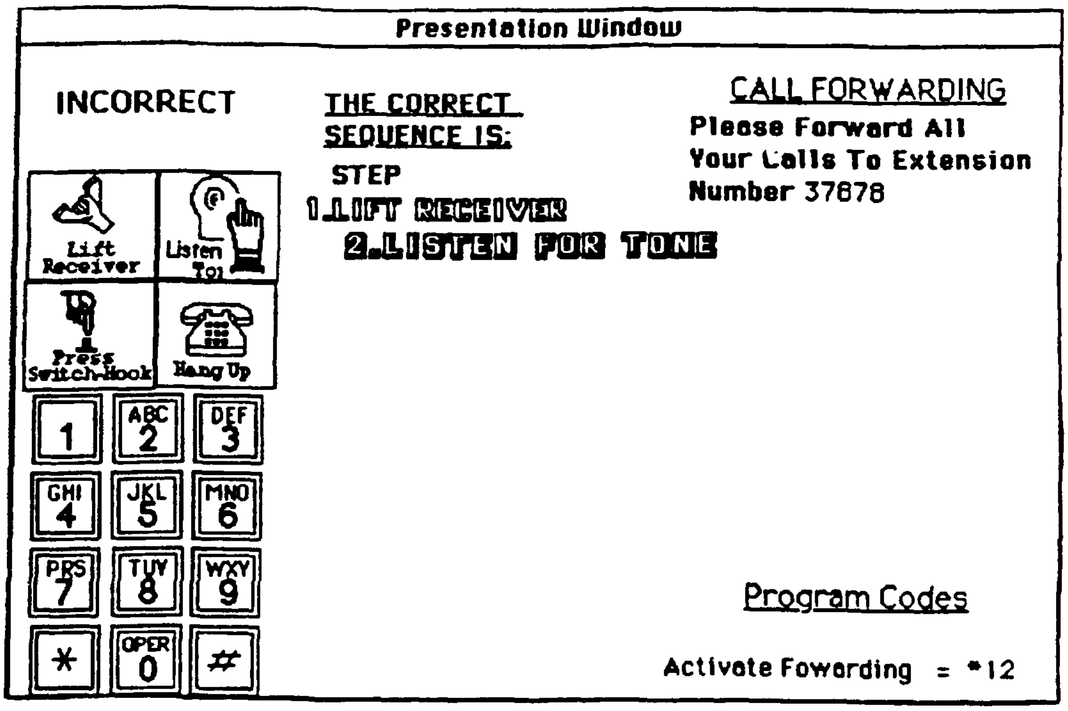


Figure 8. Sample screen of delayed corrective feedback.

Analysis

Five subjects were excluded from the analysis of data; three, because of computer failures; and two, because they did not complete the CBT. Four of these subjects were from the delayed confirmatory conditions, and the other was from the delayed corrective condition.

Pre-questionnaire

The variables analyzed from the pre-questionnaire included age, rank, months in the Navy, months in the present assignment, microcomputer experience, video game experience, mood, the number calls made or answered per day, and the number of CATS features the subject knew how to use. Rank ranged from one to nine where one equals the military rank of E-1 and nine equals the military rank of E-9. Microcomputer and video game experience was rated on a 5-point scale where 1 = none and 5 = much. Mood was rated on a 5-point scale where 1 = tired and 5 = alert. These variables were analyzed using a one-way analysis of variance (ANOVA) comparing all five groups. A priori contrasts were performed for the main effects (i.e., immediate vs. delayed, confirmatory vs. corrective, treatments vs. control). Post-comparisons among the five group means were performed using *t* tests.

Computer-based Training Performance

During the CBT practice, the computer recorded the number of errors and the time used for each task. In the delayed feedback conditions, the computer also recorded the number of clicks on the when-done and start-over buttons. The time to perform all the tasks was totaled and converted to seconds for each subject.

During the performance test, the computer recorded every response (i.e., any clicks on the graphic simulation of the phone) and created a protocol for each subject. The protocol was a chronological listing of which button was clicked, when it was clicked, and the number of the test item. A response to a test item was scored as correct if it matched the sequence to perform the task specified in that test item. The performance test score was the number of correct responses. The time to complete all items was totaled and converted to seconds.

An additional measure of performance, a modified performance test score, was generated by giving credit for nearly correct responses. For all test items, a response was re-scored as correct if the error involved listening for a tone. In addition, responses to test items for Program Call Forwarding, Use Call Forwarding, and Program Abbreviate Dialing were re-scored as correct if the subject forgot to hang up the phone. These particular errors were re-scored as correct because, if they occurred during the operation of the actual CATS equipment, these procedures might still work.

The CBT performance variables were analyzed using a one-way ANOVA. The contrasts and the range tests were the same as those used with the pre-questionnaire variables. Performance test means were compared for all groups. CBT practice means were compared for only the treatment groups.

Post-questionnaire

Answers to the open-ended questions about the purpose of CATS elements (e.g., dial tone, switch-hook) were scored on a 3-point scale. Incorrect or blank answers received 1 point; answers that were specific to just one of the CATS features received 2-points; answers that described a purpose that could apply to all the CATS features received 3-points. Answers to the open-ended comments question were scored as either positive or negative.

The quantitative variables analyzed from the post-questionnaire included the number of CATS features the subjects thought they knew, and the number of features which caused frustration. Other variables included self-ratings of mood (on a 5-point scale) where 1 = tired and 5 = alert, CBT ease of use where 1 = easy and 5 = difficult, and CBT satisfaction where 1 = miserable and 5 = enjoyable. Responses to general questions about CATS procedures, CBT feedback, and using CBT to teach control panel operation were scored as yes or no. Again, group means of these variables were compared using a one-way ANOVA.

RESULTS

Total Sample

Pre-questionnaire

Table 2 summarizes the biodemographic and self-rating variables from the pre-questionnaire for the total sample by experimental group. Means are presented for age, rank, months in the Navy, months at the present assignment, microcomputer experience, video game experience, and mood. The mean number of times a day that subjects answered or made a call and the mean number of CATS features that subjects knew how to use are also shown. No statistically significant differences among the experimental groups were found.

Overall, these subjects can be described as young and inexperienced with electronic devices. Most of the subjects were under 22 years of age and had been in the Navy less than a year. Although most of the subjects were familiar with video games, they had limited experience with microcomputers. These subjects reported little phone use and most of them reported knowing how to activate only one CATS feature.

Table 2

Total Sample: Means of Biodemographic and Self-rating Variables

	Feedback Group				
	Confirmatory		Correct Response		
Variable	Immediate	Delayed	Immediate	Delayed	Control
Age (years)	21.2	20.7	22.4	20.0	20.7
Rank	2.6	2.5	3.0	2.8	2.5
Months in the Navy	8.6	10.0	12.3	8.6	9.8
Months at Present Assignment	4.4	2.6	3.7	3.4	3.0
Microcomputer Experience	2.2	2.1	2.1	2.1	2.1
Video Game Experience	3.9	4.2	3.4	3.9	3.4
Mood	3.8	4.0	3.5	4.0	3.4
Number of Times a Day Makes a Call	0.9	0.8	1.1	1.6	1.3
Number of Times a Day Answers a Call	2.1	1.8	1.9	4.8	4.3
Number of CATS Features Subject Knows	0.9	0.6	0.6	0.9	1.0
n	16	13	16	14	16

Note. Scores for those who completed the performance test (N = 75). Rank ranges from one to nine where 1 = E-1 and 9 = E-9. Computer and video game experience are on a 5-point scale where 1 = none and 5 = much. Mood is on a 5-point scale where 1 = tired and 5 = alert. Number of possible CATS features is eight.

Computer-based Training Performance

Table 3 presents the means and standard deviations for performance test score by experimental group and shows a main effect for timing of feedback: The delayed feedback groups significantly outperformed the immediate feedback groups on the performance test score ($t(70) = 4.58, p < .01$) and on the modified performance test score ($t(70) = 3.65, p < .01$). Likewise, the delayed feedback groups significantly outperformed the control group on the performance test score ($t(70) = 5.76, p < .01$) and on the modified performance test score ($t(70) = 7.94, p < .01$). The immediate feedback groups significantly outperformed the control group only for the modified performance test score ($t(70) = 5.07$, $p < .01$). No effects were found for content of feedback (i.e., confirmatory vs. corrective).

Table 3

Total Sample: Means and Standard Deviations of Performance Test

	Feedback Group				
	Confirmatory		Corrective		
Variable	Immediate	Delayed	Immediate	Delayed	Control
Performance Test Score	1.4	3.1	1.4	2.9	0.6
	(1.3)	(1.4)	(1.3)	(1.9)	(0.8)
Modified Performance Test Score[a]	4.4	6.1	4.1	5.9	1.4
	(1.9)	(1.6)	(2.2)	(2.0)	(1.3)
Time to Complete Performance Test	729	573	712	529	680
(seconds)	(172)	(127)	(223)	(129)	(226)
n 16	13	16	14	16	

Note. Maximum score = 8. Standard deviations are given in parentheses.

[a]*Errors involving Listen for Tone and hanging up the receiver at end of task are ignored.*

Table 3 also presents the means and standard deviations for time to complete the performance test by experimental group. Again, a main effect was found for timing of feedback but not for content: The delayed feedback groups took significantly less time to complete the performance test than the immediate feedback groups ($t(70) = 3.52, p < .01$). Moreover, the delayed feedback groups used significantly less time than the control group ($t(70) = 2.22, p < .05$).

Table 4 presents the means and standard deviations for the time to complete practice. In the confirmatory conditions, the immediate feedback group used 19.4 minutes compared to 42.1 minutes used by the delayed group. In the corrective conditions, the immediate feedback group used 16.4 minutes compared to 28.4 minutes used by the delayed group. The difference between the immediate and the delayed feedback groups was significant ($t(55) = 9.70, p < .01$). In addition, the confirmatory delayed feedback group used significantly more time than the corrective delayed feedback group ($t(55) = 5.21, p < .01$). Table 4 also presents the means and standard deviations for the number of errors committed during practice. Table 4 also indicates that the delayed groups committed significantly more errors than the immediate groups ($t(55) = 9.36, p < .01$).

Table 4

Total Sample: Means and Standard Deviations of Practice Variables

	Feedback Group			
	Confirmatory		Correct	
Variable	Immediate	Delayed	Immediate	Delayed
Practice Time	1164	2528	982	1703
(seconds)	(231)	(639)	(263)	(443)
Practice Errors	44.9	151.5	25.8	122.2
	(22.3)	(66.9)	(11.7)	(49.2)
n	16	13	16	14

Note. Standard deviations are given in parentheses.

Post-questionnaire

The post-questionnaire consisted of open-ended questions about the purpose of CATS elements and self-ratings of mood, CBT ease of use, and CBT satisfaction. The open-ended questions were designed to elicit the subjects' semantic understanding of the CATS buttons and switches. Semantic knowledge is knowing the purpose of pressing an individual switch or button. The subjects were asked to describe the purpose of the switch-hook, dial tone, the * button, and the # button. The scores for these questions were totaled; the means and standard deviations are shown in Table 5. Although the immediate corrective feedback group appears to have the lowest understanding, no significant differences were found for understanding the purpose of CATS elements.

Generally, no significant differences were found for the self-rating items, for mood, and for the number of CATS features that caused subjects to feel mastery or frustration. However, significant differences were found for CBT satisfaction. Table 5 shows the means and standard deviations for CBT satisfaction, and indicates that the subjects in the confirmatory feedback groups enjoyed the training significantly more than the subjects in the corrective feedback groups ($F(1,53) = 8.00, p < .01$). Yet, no significant differences were found among the feedback groups for how easy the CBT was to use (see Table 5).

The post-questionnaire also contained a few open-ended questions about employing CBT to teach how to operate a PEP device. The answers to these questions were generally positive. Approximately 93 percent of the subjects were happy with the feedback, 93 percent recommended that CBT be used to teach control panel operation, and 73 percent wrote positive comments (while only 5 percent wrote negative comments) to the open-ended asking for comments question. Again, no significant differences were found among the feedback groups for these measures.

Table 5

Total Sample: Means and Standard Deviations of Post-questionnaire Items

	Feedback Group			
	Confirmatory		Corrective	
Item	Immediate	Delayed	Immediate	Delayed
Understanding CATS Elements	10.12	9.92	9.00	10.07
	(1.33)	(1.71)	(2.22)	(1.77)
CBT Satisfaction	4.19	4.17	3.75	3.46
	(0.65)	(0.72)	(0.77)	(0.88)
CBT Ease of Use	2.00	2.46	2.56	2.57
	(1.15)	(1.45)	(1.09)	(0.94)
n	16	13	16	14

Note. For understanding CATS elements, minimum rating score = 4 and maximum rating score = 12. For CBT satisfaction and CBT ease of use, minimum rating score = 1 and maximum rating score = 5. Standard deviations are given in parentheses.

Moderator Variables

Ability Level

The subjects were drawn from two populations of Navy students, those attending ASW training at the Fleet ASW Training Center Pacific and those attending apprenticeship training at the RTC. Since the ASW students generally have higher achievement scores than the RTC students, it was expected that the ASW students would perform better on the CBT tasks than the RTC students. A 2 X 2 X 2 ANOVA (sample by timing by content) was performed on the performance measures. Table 6 presents the means and standard deviations for performance test score, and time to complete performance test, and practice time by sample. The ASW sample significantly outperformed the RTC sample on the performance test ($F(1,51) = 16.18$, $p < .01$), and used significantly less time to complete it ($F(1,51) = 7.64$, $p < .01$) and the practice ($F(1,51) = 8.39$, $p < .01$). However, in spite of this strong main effect for ability level (i.e., ASW sample vs. RTC sample), there were no significant interactions for sample by timing, sample by content, and sample by timing by content. Thus, ability level appears to have little impact on the relationship between type of feedback and CBT performance.

Table 6

Means and Standard Deviations of Performance by Sample

Sample	Performance Test Score		Performance Test Time		Practice Time		
	M	*SD*	*M*	*SD*	*M*	*SD*	*n*
Immediate Feedback Conditions							
ASW Students	1.7	1.3	655	161	972	206	22
RTC Students	0.7	0.8	864	196	1293	235	10
Delayed Feedback Conditions							
ASW Students	3.6	1.5	539	95	1996	665	19
RTC Students	1.6	1.3	576	190	2347	696	8

Note. Maximum test score = 8. Time is in seconds.

The finding that ability level does not affect the role of feedback can be illustrated by examining the significant differences among the treatment groups for the ASW sample. The means and standard deviations for the performance test score for the ASW sample (Table 7) and for the total sample (Table 3) show a similar main effect for timing of feedback. The delayed feedback groups for the ASW sample significantly outperformed the immediate feedback groups on the performance test score ($t(46) = 4.78, p < .01$), and on the modified performance test score ($t(46) = 3.95, p < .01$). Likewise, the delayed feedback groups significantly outperformed the control group on the performance test score ($t(46) = 6.21, p < .01$), and on the modified performance test score ($t(46) = 9.15, p < .01$). Again, no effects were found for content of feedback.

Table 7

Means and Standard Deviations of Performance Test Scores: ASW Sample

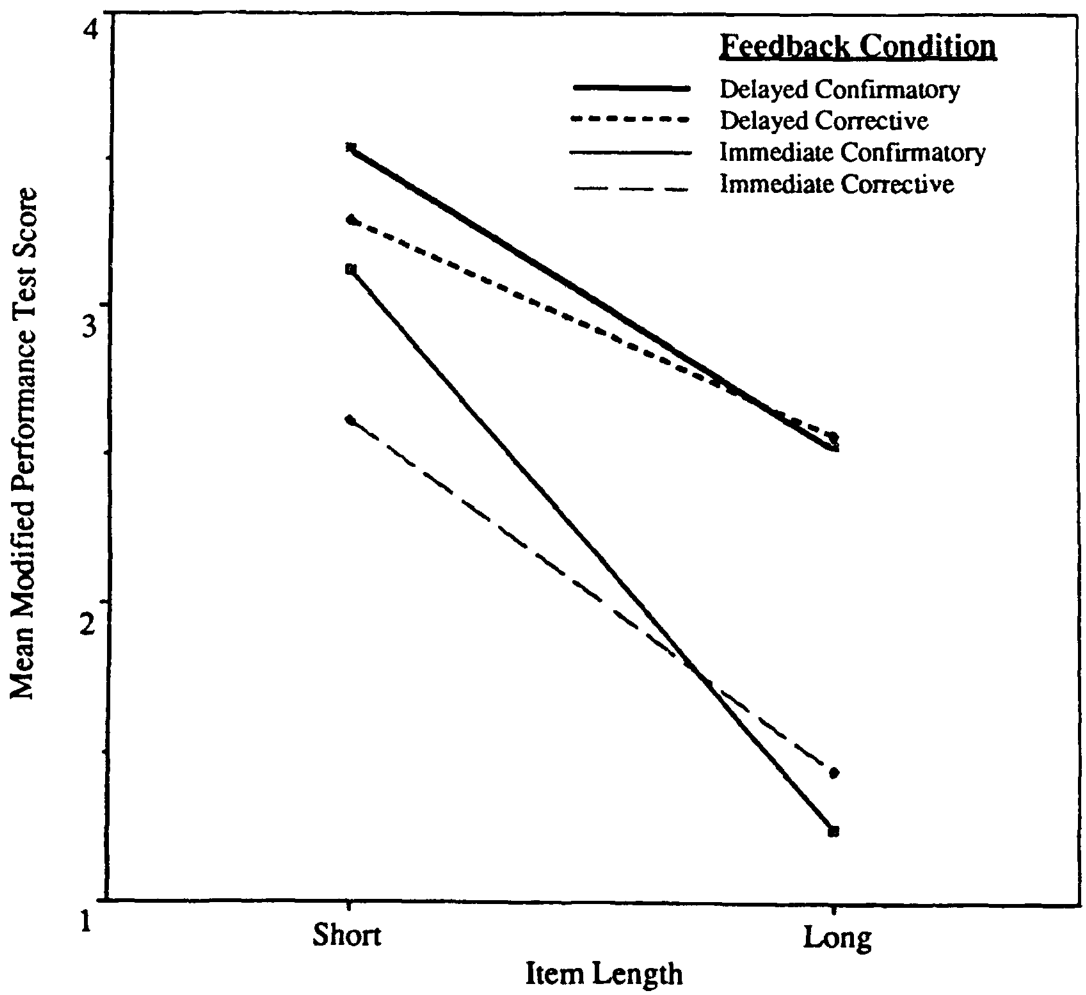
Variable	Feedback Group: Confirmatory		Feedback Group: Corrective		
	Immediate	Delayed	Immediate	Delayed	Control
Performance Test Score	1.7 (1.3)	3.8 (1.2)	1.7 (1.3)	3.5 (1.7)	0.5 (0.7)
Modified Performance test Score[a]	4.7 (1.8)	6.9 (0.9)	4.7 (1.9)	6.4 (1.4)	1.1 (1.3)
n	11	9	11	10	10

Note. Maximum score = 8. Standard deviations are given in parentheses.

[a]Errors involving Listen for Tone and hanging up the receiver at end of task are ignored.

Practice Time

Since the subjects in the delayed feedback conditions took longer to complete the practice than the subjects in the immediate feedback conditions, it is possible that the strong performance effects found for delayed feedback could be moderated by practice time. A 2 X 2 (timing by content) analysis of covariance (ANCOVA) (with practice time as the covariate) was performed on the modified performance test score. After accounting for the covariate, significant main effects were still found for the timing of feedback ($F(1,54) = 11.24$, $p < .0)1$, and no significant effects were found for content. The correlation between practice time and performance was not significant, ($r = .216$, $t(57) = 1.67$). The mean modified performance test scores and the mean modified performancetest scores adjusted for practice time are summarized by timing of feedback in Figure 9. The pattern of results for the means adjusted by the covariate is very similar to that obtained with the mean modified performance test score. The difference between the performance of the subjects who received immediate and delayed feedback seems to be slightly larger when the means were adjusted by the covariate. This would suggest that practice time and performance are negatively correlated within each feedback timing group, and, in fact, the correlation between practice time and performance is -.207 for the immediate feedback subjects and -.132 for the delayed feedback subjects.

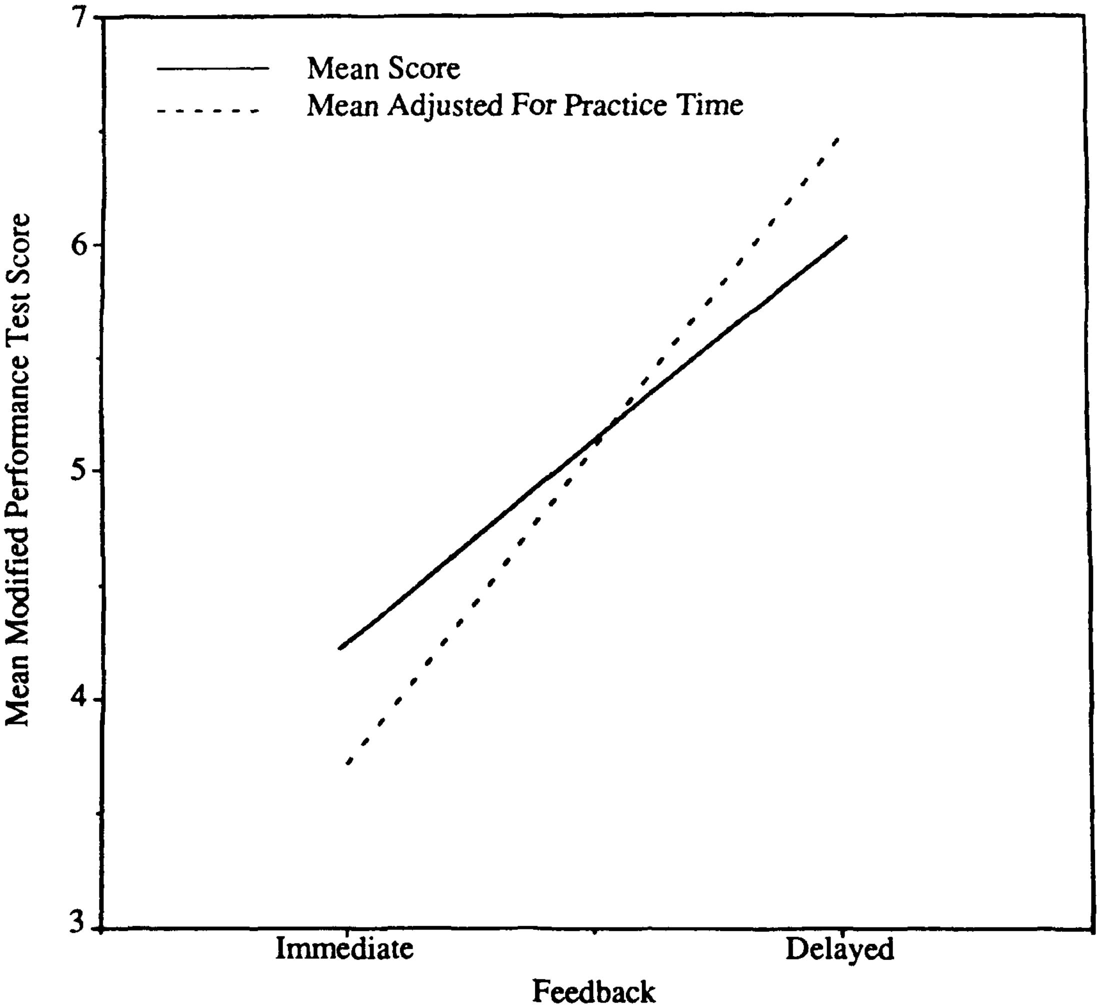


Note. Errors involving Listen for Tone and hanging up the receiver at end of task are ignored.

Figure 9. Mean modified performance test score by feedback treatment.

Task Difficulty

The eight to-be-learned tasks presented by the CBT varied in difficulty. The length of the tasks ranged from 3 to 11 steps (see Table 1). The performance test, which comprised these eight tasks, was divided into two subscales: long items and short items. Long items had seven or more steps while short items had fewer than seven steps. Each of these subscales contained four items. A 2 X 2 X 2 ANOVA was performed. The between-subject factors were feedback timing and feedback content, and the within-subject factor was item length (long vs. short). Figure 10 presents the modified performance test mean scores for all conditions and indicates that the delayed feedback groups significantly outperformed the immediate feedback groups on both the long and short items ($F(1,55) = 22.36, p < .01$). However, a significant interaction was found between feedback timing and item length ($F(1,55) = 4.11, p < .05$). The advantage found for the delayed feedback groups is much stronger for the long items than the short items.



Note. Errors involving Listen for Tone and hanging up the receiver at end of task are ignored.

Figure 10. Mean modified performance test score: Long vs. short items.

DISCUSSION

General

It was hypothesized that, when using CBT to learn a PEP task, subjects provided with confirmatory feedback will outperform those provided with corrective feedback, and subjects provided with delayed feedback will outperform those provided immediate feedback. On the surface, these results provide little support for the first hypothesis. No performance effects were found when the content of CBT feedback was manipulated. However, these results indirectly support the use of confirmatory feedback over corrective feedback. Both confirmatory feedback and corrective feedback were equally effective because both showed students the results of their actions. It appears that providing an indication that a response is wrong is central to learning procedures. This research suggests that just adding the correct-response to the student's knowledge of results does not improve learning device sequences. In other words, these results provide little support for including the correct-response as part of the feedback provided for student errors.

Strong support was found for the second hypothesis. Delayed feedback increased learning as measured by the performance test scores. Moreover, the delayed feedback groups completed the performance test significantly faster. The delayed feedback was particularly effective for subjects learning the conceptually complex features. Delayed feedback may have created an instructionless learning environment which increased learning. The subjects in the delayed feedback conditions performed better because they had acquired a richer device schema of how to operate the PEP device.

Shrager and Klahr (1986) found that during instructionless learning, subjects formed a conceptual model or a device schema of a PEP device. Their learners acquired a schema for operating a programmable toy tank which consisted of knowledge about "the syntax of interaction, the semantics of various functions, and the contents of the device which mediate interaction" (p. 176). A highly developed device schema is one which contains both syntactic knowledge and semantic knowledge. However, none of the results from this research provide any evidence that the delayed feedback subjects acquired a more highly developed device schema.

Consequently, the data were reanalyzed to identify the sequences of steps indicative of either syntactic knowledge or semantic knowledge. Sequences of steps which implied syntactic knowledge were defined as those that were highly associated in time and space. The CATS tasks were analyzed step by step and the probabilities of how often one step followed another were calculated. The two most highly associated sequences in the eight CATS tasks were Lift Receiver followed by Listen For Tone and Press Switch-hook followed by Listen For Tone. Listen For Tone always follows Lift Receiver, and Listen For Tone follows Press Switch-hook in five out of six occurrences. These steps have a high probability of occurring one after the other.

Steps which represent a single function imply the acquisition of semantic knowledge. For example, the concept of programming is implied when the # button follows the extension number in the Abbreviated Dialing Program task. It was predicted that subjects in the immediate feedback groups would acquire only syntactic knowledge while subjects in the delayed feedback groups would acquire both syntactic and semantic knowledge.

The performance test protocols for each feedback group were reexamined for highly associated steps. The targeted sequences were the Lift Receiver followed by Listen For Tone in the Call Pickup and Abbreviated Dialing Use tasks, and the Press Switch-hook followed by Listening for Tone in the Call Transfer task. Table 8 presents the response frequencies for the targeted sequences. Table 8 indicates that the subjects in both the immediate and delayed feedback groups almost always remembered that Listen For Tone follows Lift Receiver, and that 20 of the immediate feedback subjects (63%) and 19 of the delayed feedback subjects (70%) remembered that Listen for Tone follows Press Switch-hook during the Call Transfer task. This difference was not significant.

It can be argued that the sequences in Table 8 are also semantically related. That a tone follows either Lift Receiver or Press Switch-hook may imply the concept of securing an open phone line. Therefore, remembering that a tone follows lifting the receiver or pressing the switch-hook may indicate either syntactic or semantic knowledge or both.

Table 8

Response Frequencies for Highly Associated Steps

Steps/Feedback Group	Response Frequency		
	Correct	Incorrect[a]	*n*
Lift Receiver before Listen For Tone (In Call Pickup)			
Immediate	32	0	32
Delayed	27	0	27
Lift Receiver before Listen For Tone (In Abbreviated Dialing Use)			
Immediate	31	1	32
Delayed	26	1	27
Press Switch-hook before Listen for Tone (In Call Transfer)			
Immediate	20	12	32
Delayed	19	8	27

[a]Includes responses where first step is omitted.

The performance test protocols were then reexamined for semantically related steps that are not highly associated. Two sequences were targeted: Enter program code *17 (i.e., activate abbreviated list) followed by enter 19 (i.e, the list number) in the Abbreviated Dialing Program and Abbreviated Dialing Use tasks, and enter 35656 (i.e., an extension number) followed by the

button in the Abbreviated Dialing Program task. The most probable step following a program code is Listen For Tone which occurs 50 percent of the time for all tasks. The probability of a number following a program code is only 25 percent. The most probable steps following an extension number are either Press Switch-hook or Listen For Tone, which occurs about 67 percent of the time. The probability of the # button following an extension number is only about 16 percent.

Table 9 presents the frequencies of correct responses, high probability errors, and low probability errors for these semantically related steps. Low probability errors are any errors not described (above) as the most probable. Only 12.5 percent of the immediate feedback subjects remembered that step 19 follows step *17 during the Abbreviated Dialing Program task. Most of the subjects in this group followed the program code with a high probability error steps (i.e., Listen For Tone). In contrast, over 59 percent of the delayed feedback subjects remembered the sequence correctly, which is significantly higher than the frequency reported for the immediate feedback group ($\chi^2(2) = 14.90, p < .01$).

Table 9

Response Frequencies for Semantically Related Steps

Steps/Feedback Group	Response Frequency			
	Correct	High Probability Error	Low Probability Error[a]	*n*
Step *17 before Step 19 (In Abbreviated Dialing Program)				
Immediate	4	17	11	32
Delayed	16	5	6	27
Step *17 before Step 19 (In Abbreviated Dialing Use)				
Immediate	7	16	9	32
Delayed	19	5	3	27
Step 35656 before Step # (In Abbreviated Dialing Program)				
Immediate	12	13	7	32
Delayed	22	2	3	27

[a]Includes responses where first step is omitted.

During the Abbreviated Dialing Use task, 22 percent of the immediate feedback subjects correctly remembered that a list number follows the activate Abbreviated Dialing List Program code. Most of the subjects in the immediate feedback conditions followed the program code with a high probability error. In contrast, 70 percent of the subjects in the delayed feedback conditions remembered this sequence correctly. This difference was significant ($\chi^2(2) = 13.98, p < .01$).

Similar results were found for the other semantical sequence occurring during the Abbreviated Dialing Program task. Significantly more subjects in the delayed feedback conditions remembered that the # button follows the extension number than did those in the immediate feedback conditions ($\chi^2(2) = 12.27, p < .01$). Again, the most likely response for the immediate feedback subjects was to commit a high probability error. Thus, subjects in the immediate feedback conditions tended to provide the syntactically probable response even when it might be incorrect while subjects in the delayed feedback conditions provided the syntactically probable response only if the steps were semantically consistent. Moreover, subjects in the delayed feedback conditions provided semantically accurate responses even when it was not probable syntactically.

In summary, subjects in both feedback timing groups learned steps that were related syntactically, but only the subjects in the delayed feedback conditions remembered steps that were related semantically. These results suggest that subjects in the delayed feedback conditions acquired both syntactic and semantic knowledge about the PEP device while subjects in the immediate feedback conditions acquired only syntactic knowledge. This analysis provides additional evidence that delaying the feedback for student errors during CBT practice was beneficial in the development of a usable device schema.

Implications

The results of this study seem to run counter to the role of feedback in computerized instruction promoted by many instructional design textbooks. Instructional designers generally believe that feedback in computerized instruction should be immediate. In their *Handbook of Computer-Based Training*, Dean and Whitlock (1983) state that "once the learner has made his response, he should receive feedback on the adequacy of his performance" (p. 58). This belief is based on research in animal behavior (Skinner, 1968; Thorndike, 1911) and in programmed instruction (Bullock, 1978; Hartley, 1972; Taber, Glasser, & Schaefer, 1965). Proponents of this research argue that immediate feedback serves to modify or maintain the learner's actions and that delayed feedback may result in little or no learning.

However, in this study of CBT for complex tasks, immediate feedback was not found to be better than delayed feedback. In fact, as the conceptual complexity of the CBT task increased, immediate feedback groups performed considerably worse than the delayed feedback groups. Immediate feedback did not seem to encourage the development of a usable device schema for complex tasks. Immediate feedback may be adequate for learning tasks with short to-be-learned sequences that activate only one function. Yet, this form of instruction "does not result in meaningful learning, but only rote recall of information presented" (Jonassen, 1988; p. 151). Training approaches such as drill and practice that feature rote recall of information have been found not to be an effective form of instructional delivery (Kulik, Schwalb, & Kulik, 1982) and have been reported to be "dry, boring, and unpleasant" (Salisbury, 1988; p. 103).

Moreover, instructional designers also believe that content of feedback in CBT should be the correct response: "When an answer is incorrect, feedback should not only inform learners that they are wrong but should also provide corrective information" (Steinberg, 1984; p. 86). They maintain that computerized instruction "should do more than simply say your answer is incorrect" (Willis, 1987, p. 163). However, this study found no particular advantage in using correct response feedback in learning how to operate a complex device and no evidence to support the widely accepted belief that CBT should provide corrective feedback for student errors.

CONCLUSIONS

The CBT developed in this study was an effective form of instruction, which is consistent with the results found in meta-analyses of computerized instruction (Bangert-Drowns, C. C. Kulik, & J. A. Kulik, 1985; C. C. Kulik, J. A. Kulik, & Bangert-Drowns, 1985; J. A. Kulik, & C. C. Kulik, 1988; Niemiec & Walberg, 1987; Roblyer, 1990). Each CBT group outperformed the control group, which received no CBT. The experimental computerized training was enjoyable and easy to use. Moreover, this research has provided information on the relative effectiveness of various feedback designs. Feedback was found to be the most effective when it was delayed until the end of the button-pushing task. Delaying the feedback was particularly effective when the to-be-learned tas:· consisted of more than four steps and involved more than one function.

FUTURE EFFORTS

Research

Retention

Since the strong advantage found for delayed feedback may only apply for short term retention (i.e., recalled immediately after the practice), future studies should investigate the long term effects of delayed feedback. For example, a performance test could be administered 24 hours after the CBT. Since delayed feedback encourages the development of device schema, the effects found for delayed feedback should endure for more than just the training session.

Practice Time

Although the advantage found for delayed feedback was unrelated to the amount of time used during practice, subjects spent significantly more time in practice in the delayed feedback conditions. Indeed, increased practice time may be a desired characteristic in the design of CBT. However, an experiment in which the subjects in all the conditions have equal practice time may provide a more appropriate test of feedback in CBT. Future studies should increase the practice time for the immediate feedback conditions. The practice time could be increased by increasing the number of trials for the immediate feedback conditions. Conversely, practice time for the delayed feedback conditions could also be reduced. In particular, subjects could be shown how to do the task before they practice the task. Other experimental variations could include not requiring subjects to start at the beginning of the task each time they make an error and not erasing the subjects' responses from the screen during feedback.

Applications

Computers have become an important tool in helping us plan, communicate, and calculate. Computers are also becoming important in helping us learn because they can present a body of knowledge consistently and conveniently. These findings should be useful to those who design computerized instruction because it describes the benefits of different types of feedback designs.

The lesson developer must consider other factors besides effectiveness when designing CBT. The CBT must also be affordable, cost less than the actual equipment, use less training time than normal classroom instruction, and be easy to use. For instance, delayed confirmatory feedback during CBT may not be desirable because it would be the most expensive of the feedback strategies to develop. It requires additional computer programming to understand partially correct sequences. Delaying feedback during a CBT lesson may also not be desirable because it might increase the length of the lesson beyond the time allowed for training. In addition, corrective feedback must be employed carefully because it may bore some users.

These circumstances must be weighed in conjunction with effects on performance when deciding what type of feedback to implement. For a simple to-be-learned device, using feedback which consists of the correct response or is provided immediately will not significantly reduce the effectiveness of CBT. If CBT is being developed for a device that is as complex as CATS, then delaying the feedback is recommended. These findings along with cost and feasibility data should help the lesson developer design feedback which is sensitive to both the training requirements and the instructional setting.

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APPENDIX A

PRE-QUESTIONNAIRE

PRE-QUESTIONNAIRE

Last Four Digits of Social Security Number:________ Date:______________ Time:____________

Rating:________ Age:_____ Years in Navy:_____ Months at NTC (or present assignment):_____

Previous Duty Station:__________________ Number of Months at Previous Duty St[illegible]n:_______

1. How many times a day do you make a call on a Navy Phone? ___________

2. How many times a day do you answer a Navy Phone? ___________

3. Please place a check mark next to those features of the Navy phone system you know how to use:

   Abbreviated Dialing_____ Call Forwarding_____ Call Pickup_____ Call Waiting_____

   Conference Calling_____ Transferring a Call____ Last Number Redial____ Call Hold____

The following questions are on a five point scale: (Please Circle)

		Tired				Alert
4.	How do you feel right now?	1	2	3	4	5
		None				Much
5.	How much experience do you have with microcomputers?	1	2	3	4	5
		None				Much
6.	How much experience do you have with video games?	1	2	3	4	5

PRIVACY ACT STATEMENT

The Privacy Act of 1974 (Public Law 93-579) implements 5 U.S.C. 552A (Privacy Act of 1974) and DOD Directive 5400.11 (Personal Privacy and Rights of Individuals Regarding Their Records) and is published in Title 32 C.F.R., Part 701, subparts F and G. This Act requires us to provide you with certain information about the research before we ask you to give us information about yourself. You must be told the following:

1. SECNAV Instruction 5211.5C, "Personnel privacy and rights of individuals regarding records pertaining to themselves," is available for you review.

2. The brief title of this research project is: "The Role of Feedback in Computer-Based Training."

3. The primary purpose of this research is to improve computer-based training systems in teaching control panel operation.

4. The following personal information will be requested: age, rank, time at current duty station, time in service, and the last four numbers of your social security number. The last four numbers of your social security number is needed only for matching questionnaire data to experimental data and it will not be used to obtain information about your service record.

5. The information collected during this study will be used for research purposes only. It will not be given to anyone outside this center, and it will not be used for anything besides scientific study. The information you give will not help or hurt you personally in any way during your tour with the Navy.

6. Your participation in this study is entirely voluntary. Nothing will happen to you if you decide against participating in this study.

CONSENT TO ACT AS A SUBJECT FOR SCIENTIFIC RESEARCH

(1) I ______________________________ voluntarily agree to serve as a subject for scientific research involving the following:

Learning how to operate the program entry panel (PEP) for the Navy's Consolidated Area Telephone System (CATS). I understand I will perform PEP tasks using a PEP simulated on a computer monitor.

(2) The procedure outlined in in paragraph (1) has been explained to me.

(3) I understand that the procedure outlined in paragraph (1) may involve the following risks and discomforts:

There are no known risks in this procedure.

(4) I understand that this research will not benefit me directly. My participation in this project will increase scientific understanding of how people learn how to operate control panels. This research is intended to be of benefit to others and to the Navy.

(5) I understand that any questions I may have during the experiment will be answered, and that I may end my participation in this study at any time.

(6) I have read the attached Privacy Act Statement, and I understand that giving information about myself is entirely voluntary and that the uses of that information will be only for scientific purposes.

______________________________ ______________________________

Signature Date

APPENDIX B

CBT INTRODUCTION SCREENS

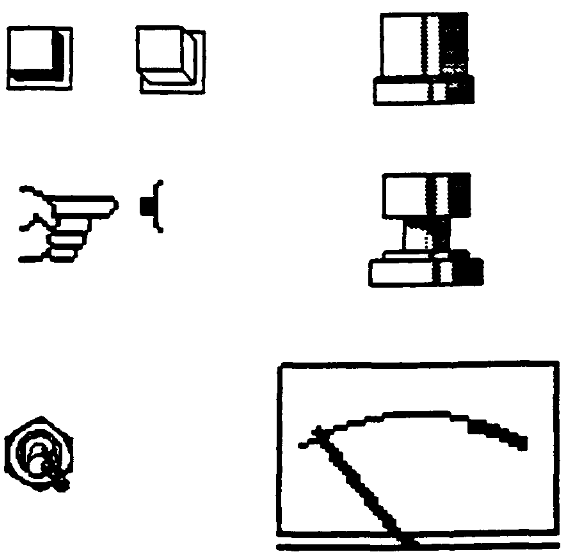
Presentation Window

Navy Personnel

Introduction

R & D Center

Presentation Window



How To Operate A Program Entry Panel (PEP)

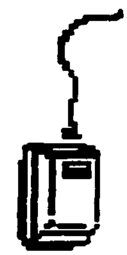
An Independent Research Project Sponsored By The Navy Personnel Research And Development Center

Principal Investigator and Author: Michael B. Cowen

Presentation Window

USING THIS LESSON REQUIRES
THAT YOU KNOW HOW TO:

A. **Point** The Mouse
B. **Click** The Mouse



The Mouse Pictured To The Right
Should Be Sitting On The Right
Side Of The Computer

Presentation Window

TO <u>POINT</u> THE MOUSE, JUST
MOVE THE MOUSE ON THE PAD.
YOU'LL SEE THAT A POINTER
MOVES ON THE SCREEN.

TO <u>CLICK</u> THE MOUSE, POINT TO
AN OBJECT AND PRESS AND
RELEASE THE MOUSE BUTTON.

TO CONTINUE, CLICK ON THIS BOX → ☐

Presentation Window

GOOD....YOU HAVE LEARNED HOW TO POINT AND CLICK THE MOUSE.

THE OBJECT OF THIS LESSON IS TO TEACH YOU HOW TO USE THE NAVY'S CONSOLIDATED AREA TELEPHONE SYSTEM (CATS).

SPECIFICALLY YOU WILL LEARN HOW TO OPERATE THE KEYPAD FOR THE AT&T MODEL 2500 TELEPHONE.

TO CONTINUE, CLICK ON THIS BOX → **Return**

Presentation Window

YOU WILL LEARN HOW TO USE SIX DIFFERENT FEATURES OF THE NAVY'S PHONE SYSTEM:

1. **Abbreviated Dialing**
2. **Call Forwarding**
3. **Call Pickup**
4. **Conference Calling**
5. **Hold**
6. **Call Transfer**

TO CONTINUE, CLICK ON THIS BOX → **Return**

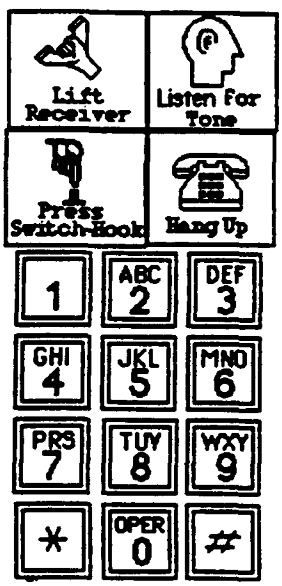
Presentation Window

THE LESSON CONSISTS OF PRACTICE ITEMS WHERE YOU ARE REQUIRED TO ENTER KEYPRESSES ON A SIMULATION OF A TELEPHONE KEYPAD USING A MOUSE.

IN A MOMENT YOU WILL SEE THE SIMULATED KEYPAD. THEN, A PRACTICE ITEM WILL BE PRESENTED

TO CONTINUE, CLICK ON THIS BOX → Return

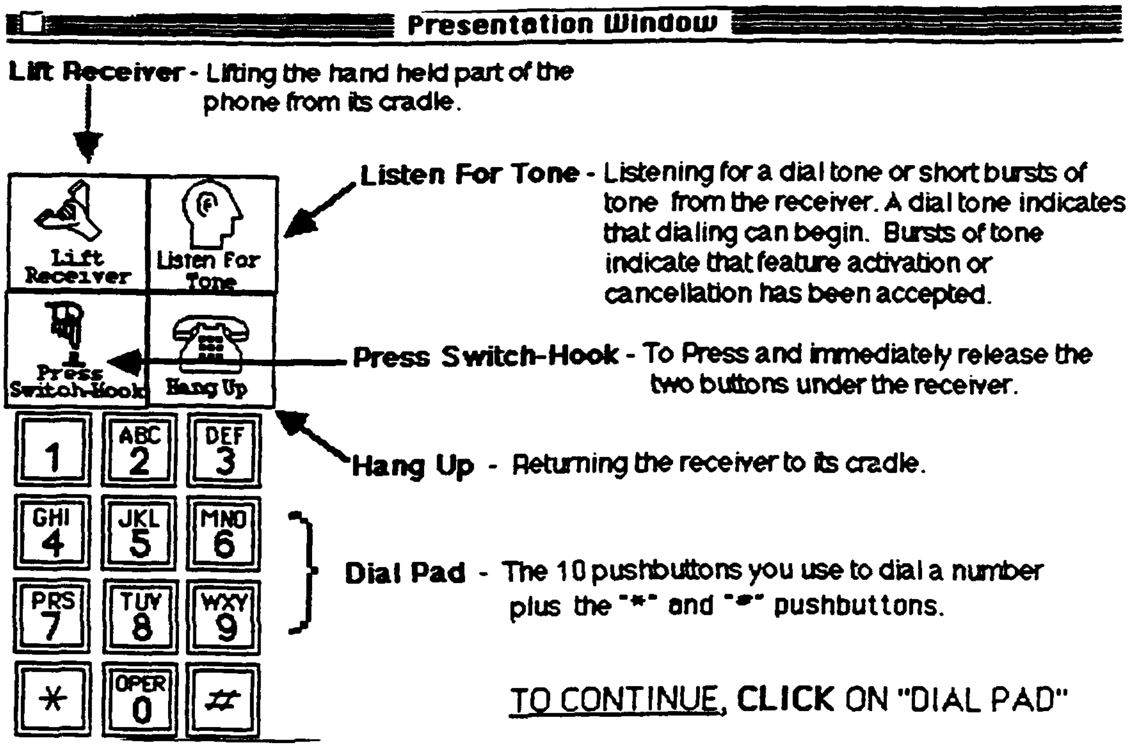
Presentation Window

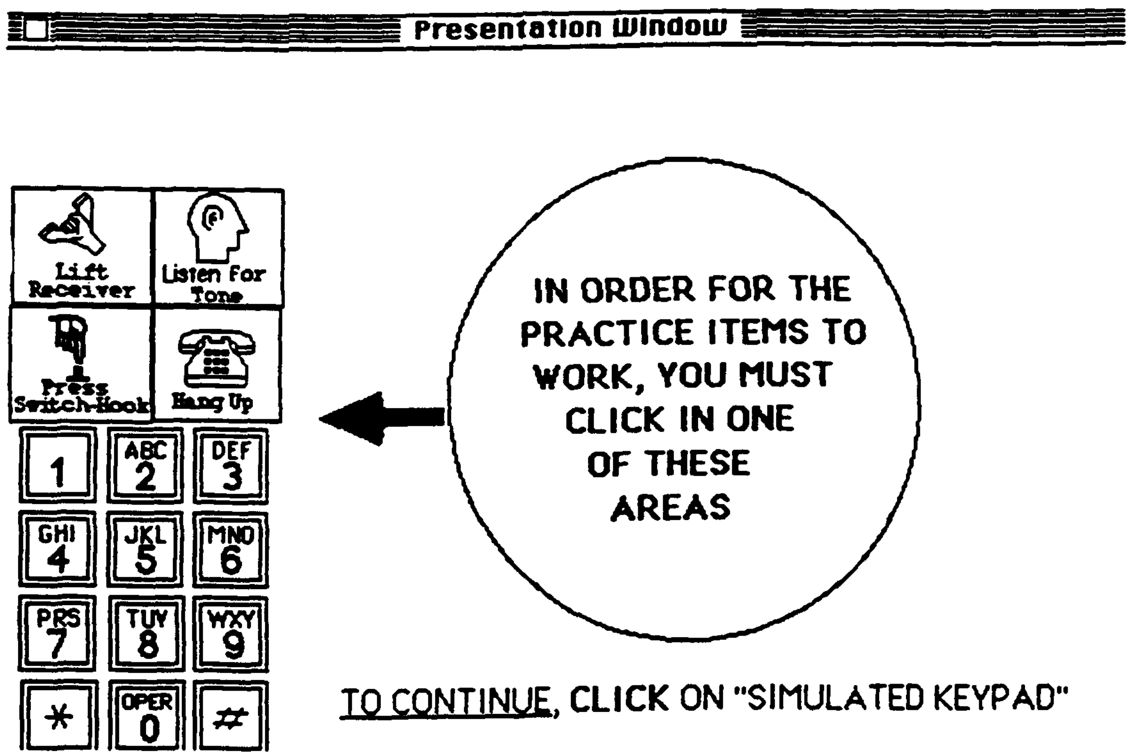


HERE IS THE SIMULATED KEYPAD.

THE SIMULATED KEY PAD HAS 16 CLICK AREAS.

TO CONTINUE, CLICK ON THIS BOX Return


Presentation Window
Lift Receiver - Lifting the hand held part of the phone from its cradle.
Listen For Tone - Listening for a dial tone or short bursts of tone from the receiver. A dial tone indicates that dialing can begin. Bursts of tone indicate that feature activation or cancellation has been accepted.
Press Switch-Hook - To Press and immediately release the two buttons under the receiver.
Hang Up - Returning the receiver to its cradle.
Dial Pad - The 10 pushbuttons you use to dial a number plus the "*" and "#" pushbuttons.
Lift Receiver
Listen For Tone
Press Switch-Hook
Hang Up
1
ABC 2
DEF 3
GHI 4
JKL 5
MNO 6
PRS 7
TUV 8
WXY 9
*
OPER 0
#
TO CONTINUE, CLICK ON "DIAL PAD"

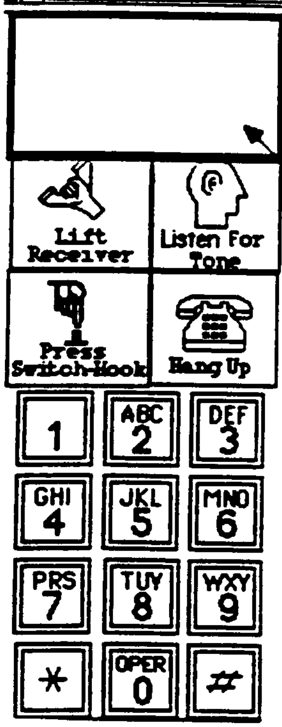

Presentation Window
Lift Receiver
Listen For Tone
Press Switch-Hook
Hang Up
1
ABC 2
DEF 3
GHI 4
JKL 5
MNO 6
PRS 7
TUV 8
WXY 9
*
OPER 0
#
IN ORDER FOR THE PRACTICE ITEMS TO WORK, YOU MUST CLICK IN ONE OF THESE AREAS
TO CONTINUE, CLICK ON "SIMULATED KEYPAD"

Presentation Window

IN THE NEXT FRAME YOU WILL SEE AN EXAMPLE OF A PRACTICE ITEM:

TO CONTINUE, CLICK ON THIS BOX → Return

Presentation Window



Your assignment will be to **read** the task to the **right** and **perform** the task on the simulated keypad on the **left**. For example, to dial a number click on "LIFT RECEIVER", then click on "LISTEN FOR TONE", then click on the extension number (e.g. click on '3' then '4' then '5' and so on). After each click appropriate feedback will be provided in this box.

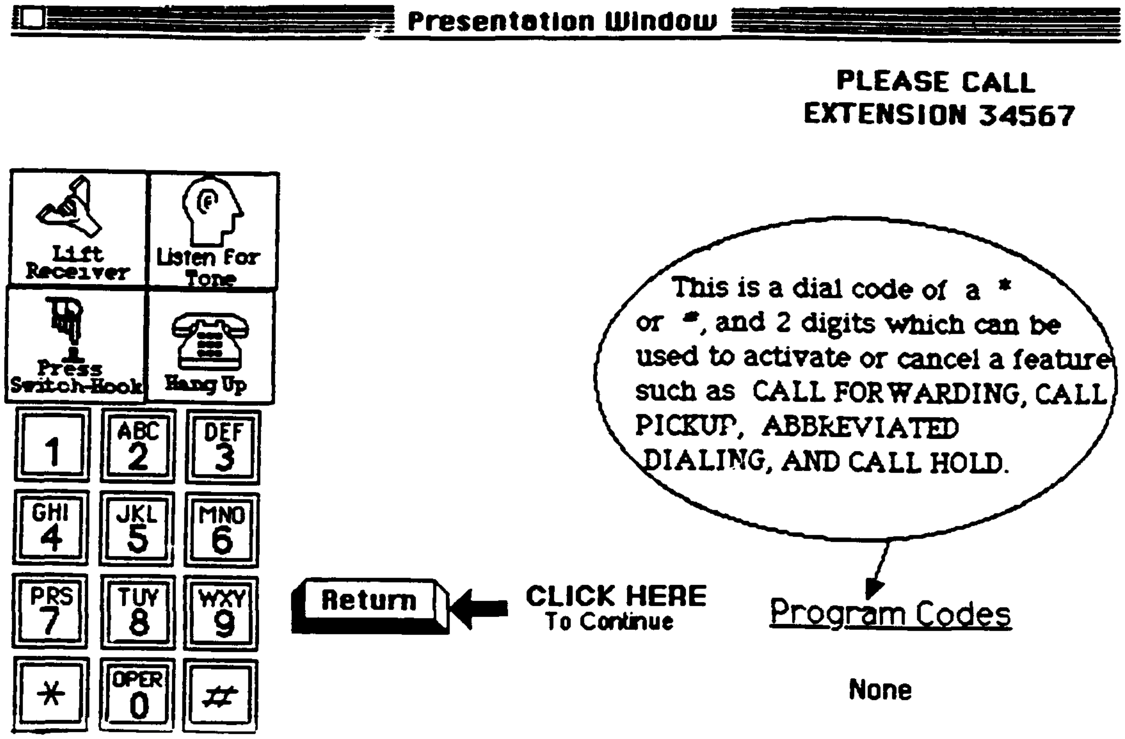
PLEASE CALL EXTENSION 34567

PLEASE CLICK BELOW TO CONTINUE...

Return ← CLICK HERE To Continue

Program Codes

None



Presentation Window

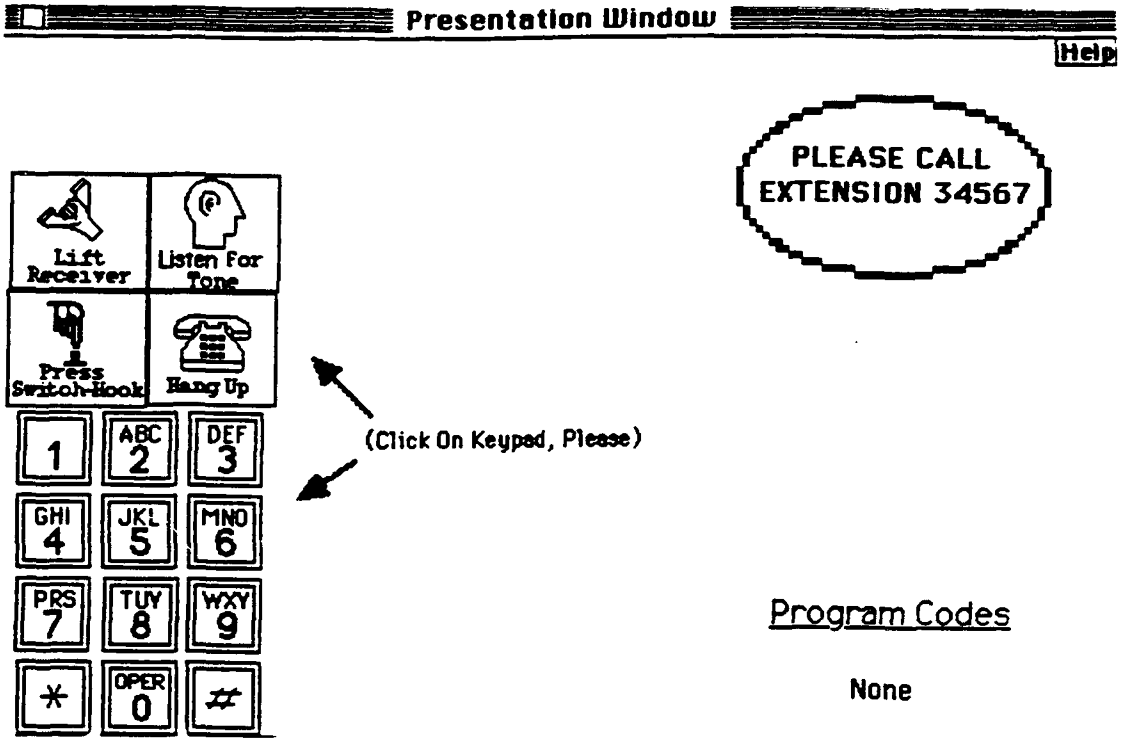
Help

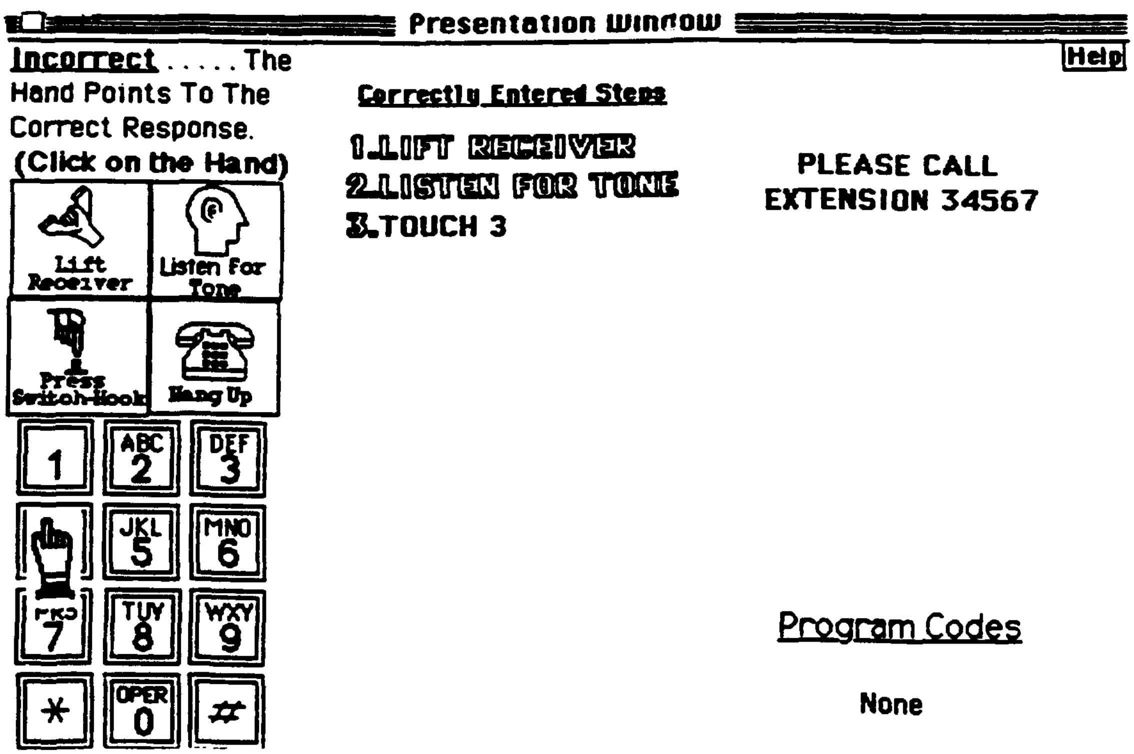
NEXT, YOU WILL BE ASKED TO DO THE SAMPLE ITEM. IF THE ITEM DOES NOT MAKE SENSE TO YOU, PLEASE CLICK ON THE HELP ICON.

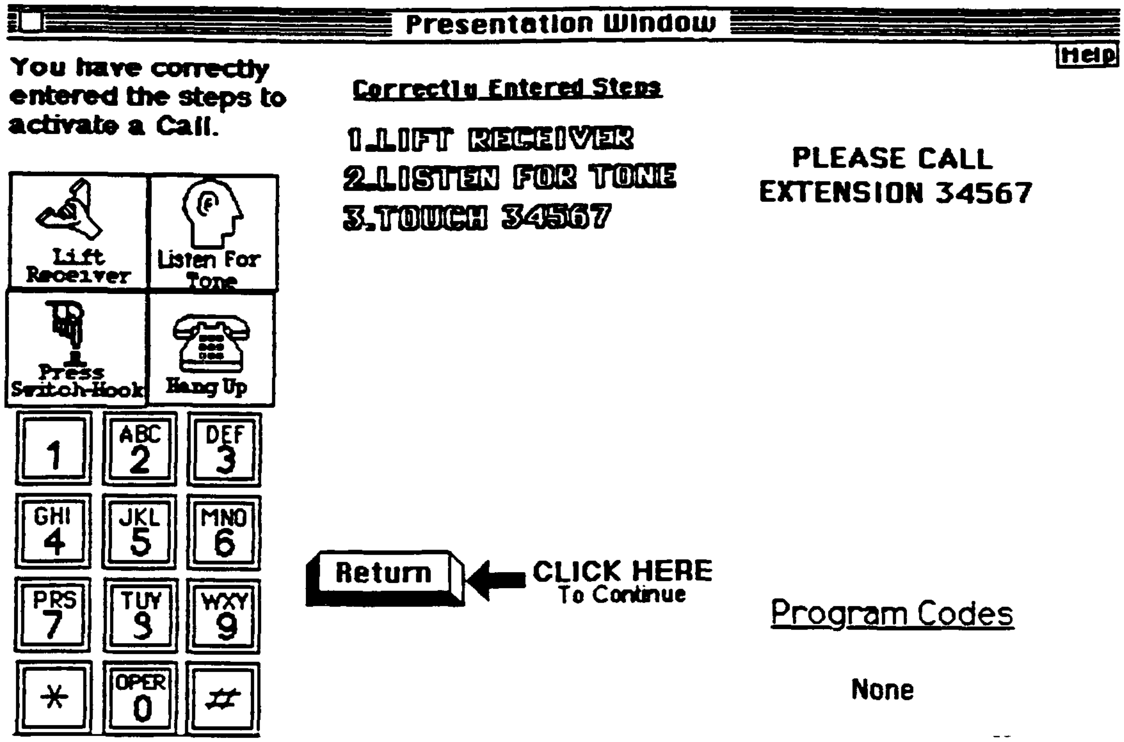
PLEASE CLICK ON THE HELP ICON NOW.

GOOD... YOU HAVE SUCCESSFULLY ASKED FOR HELP. IF, AFTER YOU CLICK ON "HELP", THE SAMPLE ITEM STILL DOES NOT MAKE SENSE TO YOU, PLEASE ASK THE INSTRUCTOR OR RESEARCH ASSISTANT FOR HELP.

TO CONTINUE, CLICK ON THIS BOX → Return


Presentation Window
Help
PLEASE CALL EXTENSION 34567
Lift Receiver
Listen For Tone
Press Switch-Hook
Hang Up
(Click On Keypad, Please)
1
ABC 2
DEF 3
GHI 4
JKL 5
MNO 6
PRS 7
TUV 8
WXY 9
*
OPER 0
#
Program Codes
None


Presentation Window
Help
Incorrect . . . . . The Hand Points To The Correct Response.
(Click on the Hand)
Correctly Entered Steps
1.LIFT RECEIVER
2.LISTEN FOR TONE
3.TOUCH 3
PLEASE CALL EXTENSION 34567
Lift Receiver
Listen For Tone
Press Switch-Hook
Hang Up
1
ABC 2
DEF 3
JKL 5
MNO 6
7
TUV 8
WXY 9
*
OPER 0
#
Program Codes
None



Presentation Window

GOOD....YOU HAVE SUCCESSFULLY COMPLETED THE SAMPLE ITEM.

NOW, PLEASE <u>TELL</u> THE RESEARCH ASSISTANT OR THE INSTRUCTOR THAT YOU HAVE COMPLETED THE INTRODUCTION. HE OR SHE WILL LOAD THE PRACTICE ITEMS.

AFTER YOU HAVE COMPLETED THE PRACTICE ITEMS, YOU WILL BE GIVEN A PERFORMANCE TEST.

PLEASE. DO NOT CLICK THE MOUSE

APPENDIX C

POST-QUESTIONNAIRE

POST-QUESTIONNAIRE

Last Four Digits of Social Security Number:________ Date:______________ Time:____________

The following question is on a five point scale: **(Please Circle)**

	Tired				Alert
1. How do you feel right now?	1	2	3	4	5

2. Please place a check mark next to those features of the Navy phone system that you would now feel comfortable using:

Abbreviated Dialing______ Call Forwarding______ Call Pickup______ Call Waiting_____

Conference Calling______ Transferring a Call____ Last Number Redial____ Call Hold____

3. In your own words, what do you feel is the purpose of the "dial tone" when using the Navy phone system?____

____

____

4. In your own words, what do you feel is the purpose of the "switch-hook" on a Navy phone?_________

____

____

____

5. In your own words, what do you feel is the purpose of the "*" button on a Navy phone?_________

____

____

____

6. In your own words, what do you feel is the purpose of the "#" button on a Navy phone?_________

____

____

____

Last Four Digits of Social Security Number:______ Date:__________ Time:__________

1. Do you think the Navy's Consolidated Area Telephone System is difficult to use?_____

The following questions are on a five point scale: (Please Circle)

		Easy to Use				Difficult to Use
2. Did you find the **computerized lesson**:	a.	1	2	3	4	5
		Miserable				Enjoyable
	b.	1	2	3	4	5

3. Were you **frustrated** at any time during the computerized lesson? If so, please place a check mark next to those Navy's phone system features which were presented in a confusing or unsuitable manner:

   Abbreviated Dialing_____ Call Forwarding_____ Call Pickup_____ Call Waiting_____

   Conference Calling_____ Transferring a Call_____ Last Number Redial_____ Call Hold_____

4. Were you happy with the feedback provided by the microcomputer during the practice portion of the lesson?_____ If not, how do you think the feedback could be improved?

   ____

   ____

5. Would you recommend computer-based training for the teaching of control panel operation? ______

6. Any other comments? ____________________________

   ____

   ____

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