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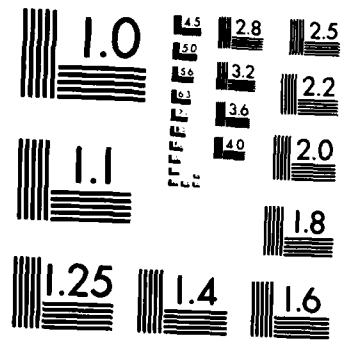
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**EDUCATIONAL OPPORTUNITIES ASSOCIATED WITH
COMPUTER-ASSISTED INSTRUCTION AND
COMPUTER-GENERATED SPEECH**

Daniel L. Collins, Maj, USAF

**TRAINING SYSTEMS DIVISION
Brooks Air Force Base, Texas 78235-5601**

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SUMMARY

Computer-assisted instruction (CAI) has traditionally used the visual display terminal (VDT) as the medium to convey information to the subject. The present experiment explored the possibility of using computer-generated speech (CGS) with, and without, the VDT to convey information to the subject. The two CGS conditions were contrasted with more traditional teaching methods (i.e., human narrative, and narrative with a script). Using the four different methods described above, a total of 160 subjects were presented identical instructions to a cognitive task. Significant differences existed on task restarts and persistence among the conditions. Significant gender differences also occurred in the time taken to make the initial move on the cognitive task. The results suggest that CGS can be a viable alternative to traditional teaching methods, and the CGS has potential to be incorporated as another dimension of CAI.

TABLE OF CONTENTS

	Page
I. INTRODUCTION.	1
II. METHOD.	2
Subjects.	2
Manipulation Check.	2
Procedure	2
III. RESULTS	3
Dependent Variables	3
Discussion.	4
REFERENCES.	5

EDUCATIONAL OPPORTUNITIES ASSOCIATED WITH
COMPUTER-ASSISTED INSTRUCTION AND
COMPUTER-GENERATED SPEECH

I. INTRODUCTION

Many articles have been written that suggest computers are likely to have a major impact on society in general and on the behavioral sciences in particular (Bartram & Bayliss, 1984; Bennett & Maher, 1984; Brady & Hill, 1984; Mathews, 1980; Rind & Solity, 1984; Szyperski, Grochla, Richter, & Weitz, 1983; Zajonc, 1984). Behavioral scientists are expected to play an ever-increasing role in proactive evaluations of how new technology impacts on human behavior (Elwork & Gutkin, 1985). This proactive concept can be traced back to the early seminal work of computer-assisted instruction (CAI) which began in 1926, when Pressey designed a mechanical device that could automatically provide drill and practice items to students (Pressey, 1926).

The early contribution Pressey made by integrating the notions of machines and learning, and his introduction of a mastery paradigm into his "teaching machines," are important concepts (Pagliaro, 1983). Pressey used state-of-the-art equipment, during his era, to construct the forerunner of CAI as we know it today. The present experiment also uses state-of-the-art equipment to explore the logical use of computer-generated speech (CGS), with the microcomputer, to investigate its potential use within the realm of CAI.

A discussion of the evolution of CAI or teaching machines would be incomplete without mentioning Skinner's IBM Teaching Machine Project from the 1950's, which set the stage for advances that were made in the 1960's, (e.g., IBM 1500 Instructional System and PLATO) (Rath, Anderson, & Brainerd, 1959; Skinner, 1958; Suppes & Morningstar, 1969). The 1970's saw further gains in both CAI theory (e.g., TICCIT) and in hardware, as new state-of-the-art microcomputer equipment was developed.

In the recent past, CAI has been largely restricted to visual-only presentations using the visual display terminal (VDT). However, since the evolution of CGS into a high-quality, affordable product, it is logical to examine how CGS could be adapted for CAI or other training purposes. If CGS was found to be as understandable as the more traditional methods of conveying knowledge (i.e., human voice and/or human voice plus script), then considerable cost savings could be realized in the education and training communities of industry, academia, and the military.

Considering the multimillions of dollars spent annually on training costs in an attempt to convey knowledge in an accurate manner, any cost saving can have major economic implications for financial planners. This economic concept becomes even more dramatic when the portability of microcomputers is coupled with CGS. This logical marriage of technology results in a unique, exportable education and training package that provides additional reinforcement to the trainee by using another of the body's senses (i.e., hearing) to augment the three modes of the CAI instructional paradigm: rule, example, and practice.

CGS is rapidly finding more uses in society as computer technology continues to make people's lives more efficient. CGS is currently being used in numerous cost-saving ways throughout the United States and in other modern societies. For example, the banking industry is using computer-generated speech for their automated banking tellers, which were nonexistent only 5 years ago. Supermarket registers are using CGS to "electronically verbalize" the item prices to their customers. "Electroverbalization" is being used in shopping malls at the computerized information/directory stations. Airport terminals and subways are also using CGS for their passengers' convenience and safety by informing travelers of departure and arrival information, and when shuttle bus doors will be closing.

These examples demonstrate the current uses of CGS to convey accurate and timely information to people in their daily transactions, while simultaneously reducing the workload of service providers (e.g., businessmen and merchants). It appears that CGS will continue to influence society in ever-increasing ways - from recreation (childrens toys), and daily business transactions, to innovative uses for the handicapped.

One fundamental, often-unstated premise in any learning or training scenario is whether or not the student comprehends the information or instructions that have been transmitted. If different techniques or methods of presenting the desired information would result in a more rapid comprehension of the material, then training cost savings (time and money) could be realized. Furthermore, if one of these different methods of instructional presentation used CGS, and resulted in similar (or even better) student comprehension than does the traditional teacher-student interaction, personnel costs associated with training could also be reduced. A proactive behavioral science question arises: How can computer-generated speech best be used to assist in education and training domains? In order to investigate differences in performance associated with different methods of instructional presentation (i.e., computer-generated speech versus human voice), the following experiment was conducted.

II. METHOD

Subjects

One hundred sixty male and female subjects were presented with four different experimental manipulations. Male and female subjects were equitably distributed across each of the four experimental conditions. All subjects were randomly selected from the Air Force Basic Military Training School at Lackland AFB, Texas, and were randomly assigned to one of the four experimental conditions.

Manipulation Check

A check was made to ensure that the four experimental manipulations would not be compromised by subjects' having prior knowledge of the conceptual task. As the subject was seated, the experimenter asked the subject if he/she was familiar with the "Pyramid Task" or (as it is also referred to in the literature, "The Towers of Hanoi" Game) (Baum, Shaeffer, Lake, Fleming, & Collins, 1985). The two subjects that were familiar with the task were thanked for their willingness to participate and excused from testing.

Procedure

The subjects were assembled in one building and informed consent was obtained. The test administrator, in turn, escorted each subject to an adjacent building where specific details of the project were explained to each individually. Upon arrival in the testing room, subjects were seated in front of the Pyramid Task, and a Koss K/6X stereophonic headset was placed over their ears. All further instructions were received through the headset to ensure an analogous environment existed across all four conditions. Each of the four experimental conditions used different methods to present the following Pyramid Task instructions to the subjects:

In front of you is a Pyramid Task. This task consists of a wooden board with three pegs placed in a row. The object of this task is to move all seven blocks of wood from the peg on one side of the board, to the peg on the other side of the board. However,

and this is important, you may never place a larger block on top of a smaller block as you attempt to move all seven blocks from one side of the board to the other. You may restart from the beginning as often as you wish. You may stop this task at any time by telling the experimenter you wish to stop. There is no penalty for stopping or for starting over. Once again, you may only place a smaller block on a larger block. Good luck. Are there any questions?

The first experimental condition consisted of the experimenter reading the Pyramid Task instructions to the subject. Following this instructional presentation and after the subject indicated that he/she understood the instructions, the experimenter instructed the subject to begin.

The second experimental condition followed the same experimental procedure of the previous condition, but employed one subtle change: While the experimenter read the instructions aloud to the subject, the subject followed along using his or her typed copy of the instructions. The instructions were typed on white bond typing paper (8 1/2 X 11 inches). All other aspects of the study remained the same.

Thus, in the first condition, the experimenter merely read the typed instructions to the subject, whereas, in the second condition, the instructions were read by the experimenter to the subject, while the subject followed along on the typed copy of the instructions placed in front of him/her.

The third condition was conceptually and procedurally analogous to the first condition except that instead of using the experimenter's voice, the subject was "electrophonically" presented with the same task instructions using CGS. The CGS used in this project was electrophonically presented using Digital Equipment Corporation's DECtalk, which produces unusually high-quality speech by using a unique three-level processing approach that avoids the monotone, robot-like voices of lower-quality systems.

The fourth condition was procedurally and conceptually similar to the third condition except that an 11-inch monochrome VDT was provided for the subject to follow along as the task instructions were presented to the subject using CGS. An Alcyon microcomputer was used to generate black letters against a white background on the 480- by 530-pixel VDT.

Thus, the same instructions were presented using four different methods of presentation: (a) human voice, (b) voice plus paper script, (c) computer-generated speech, and (d) CGS combined with VDT script. Consequently, the first and third conditions are conceptually similar, as are the second and fourth conditions. At the conclusion of the experiment, each subject was debriefed and escorted to a casual area to prevent contact with other subjects awaiting the experiment.

III. RESULTS

Dependent Variables

The dependent variables in this project were the number of times the subject started over, the persistence exhibited by the subjects on the task, and gender differences associated with the time taken to make the initial move.

A one-way analysis of variance (ANOVA) was conducted to investigate differences between the four conditions in the number of times the subjects started over on the pyramid task. The ANOVA

revealed that the subjects in the second condition (i.e., paper script plus experimenter's voice) had significantly more restarts ($M = 1.18$) than did the subjects in the voice-only condition ($M = 0.63$), the CGS condition ($M = 0.78$), or the CGS with VDT condition ($M = 0.63$), $F(3, 156) = 2.84$, $p < .05$.

An additional analysis was performed to determine if any differences in persistence existed across the experimental conditions. A lack of persistence was measured by counting the number of subjects who quit working on the task before their time limit had expired. A complex Chi-Square analysis revealed significant differences between conditions ($\chi^2(3, N = 47) = 8.14$, $p < .05$), with more people quitting when they were in the voice plus paper script ($n = 19$) or CGS plus VDT ($n = 18$) conditions than when they were presented the instructions using only voice ($n = 6$) or only CGS ($n = 4$).

A final analysis was performed to investigate for gender differences in the time it took to actually perform the first move. Collapsing across all four conditions revealed that a significant difference existed between genders (with males moving sooner ($M = 9.52$ seconds) than females ($M = 15.05$ seconds), $t(149) = 12.75$, $p < .001$). Those subjects who made their initial move before the instructions were completed were eliminated from the analysis and account for the different degrees of freedom between this t-test and the ANOVA above.

Discussion

A reason for these findings could be that a considerable amount of information is conveyed without the added requirement of attending to a script or a VDT during its presentation. When this dual requirement for one's attention exists, it may be that certain aspects of one's social background cause timesharing of one's concentration between the visual and hearing senses. This sharing of attention may contribute to a deficit in concentration, or performance, and could explain the lack of persistence in the instructional conditions that used both an aural and a visual method of presentation.

It may be that the greater number of restarts in the paper script plus human voice condition could be explained by: the subjects' having a social desire to make eye contact with the experimenter (who was verbalizing the script to them), plus also dividing their concentration between the experimenter's voice and the script in front of them. This timesharing may have resulted in either not understanding the instructions as well as their peers did in the other conditions, or in not being able to begin formulating a strategy while the instructions were being presented, or prior to beginning the task.

Implications exist for any test that uses a test proctor to read the instructions to the test taker. Numerous examples of this testing procedure (i.e., where the proctor reads instructions to the test taker while he/she follows along) exist in both commercial and military aptitude tests. The evidence obtained during this project suggests that this procedure may not be needed, and in fact, could be detrimental to individual performance during the test.

As the popularity of computers increases, the gender differences noted in this project may decrease over time. However, until computer familiarity across genders and different socioeconomic groups is established and computer fear is eliminated, the societal implications associated with computer-based testing and education remain largely unknown. The challenge that faces behavioral scientists is to pursue proactively and shape equitably, when possible, the questions and answers to this burgeoning new field of technology between man and machine.

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