A Computerized Approach for Improving Word Recognition in Chronic Aphasic Patients

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Reading problems are a major complaint of adult aphasic patients. However, improvement in the reading ability of these patients may be achieved through continuous stimulation. Porch (1981), among others, stated that aphasic patients should interact with a reasonably stimulating language environment in order to reach language potential. Schuell (1974) wrote of bombarding aphasic patients with auditory stimulation to maximize recovery.

Several recent studies have used microcomputer-based technology to provide intense language stimulation for aphasic patients during treatment sessions (Katz and Nagy, 1982; Mills, 1982) as well as outside treatment sessions (Colby, Christinaz, Parkison, Graham and Karpf, 1981). These studies show that computer programs can incorporate many fundamental features found in treatment tasks, such as rate and duration of stimulus presentation, complexity of response required, and meaningfulness of stimuli.

The purpose of this study was to determine the efficacy of a computer-based stimulation treatment approach for improving accuracy and recognition time for aphasic patients in reading commonly-used words. The treatment strategy was designed to enhance attention and memory, factors that are necessary to recognize words and subsequently to improve reading. The program requires the patient to maintain attention to stimulus words and then to recall the words from memory. The treatment program was developed to provide language stimulation for a period of 40-60 minutes.

METHOD

The subjects were five adult men suffering from unilateral, left hemisphere damage causing mild-to-moderate aphasia of at least two years duration. Average overall performance of the subjects on the Porch Index of Communicative Ability, (PICA) (Porch, 1981), was 75th percentile (Table 1). Subjects had completed high school and had no history of premorbid reading problems. Visual acuity was normal or corrected to normal.

Table 1. Description of subjects. (5 Men)

PICA Overall	75th percentile (65 - 85)
Reading	68th percentile (44 - 89)
RCBA Overall	88 out of 100 (77 - 98)
Raven CPM	33 out of 36 (33 - 35)
Time Post Onset	10.4 years (2.3 - 22.2)
Chronologic Age	57.2 years (40 - 67.1)
Educational Level	14.2 years (12 - 18)

A computerized reading treatment program, called FLASH, was developed for this study. The program was written by the first author in BASIC for an Apple II Plus microcomputer with two disk-drives and a television monitor. FLASH represents a computerized adaptation of the "flash card" drills commonly used in education for teaching new vocabulary. It is a tachistoscopic reading procedure which drills subjects in the recognition of 65 commonly used 1 - 5 letter words. The complexity of a subject's response (that is, whether he has to match words from multiple choice or actually type words from memory) was predetermined by the clinician, based upon the subject's level of functioning.

The program consists of drills on five different word sets -- one- and two-letter words, two-letter words, three-letter words, TH-words, and question words. The clinician selects one of the five sets to practice. The 13 words within each set are selected four times at random by the computer, totaling 52 initial stimulus presentations. Additional presentations of the words are provided as needed by the computer following error responses. All words in each set are displayed on the screen before the task begins, in order to familiarize the subject with the stimuli. Just before each word is flashed, the subject is signaled visually with a blinking message (i.e., "Are you ready?", and then, "Steady," "Ready") and with accompanying auditory tones. Then, the word is flashed in large 2-inch capital letters for an extremely brief period of time (approximately .01 sec.). The subject is asked to identify the flashed word (multiple choice or type from memory). After responding, the computer informs the subject whether or not the response was accurate. If the response was correct, the procedure then repeats, flashing another word. If the response was incorrect, the word is flashed again, but at a slower rate (approximately .2 sec.). The exposure rate is increased cumulatively by approximately .2 sec. (i.e., .4 sec., .6 sec., .8 sec., etc.) each time an error is made until the correct response is given. Then the exposure rate is reduced to .01 and a new word is presented.

Administration of a single set of 13 stimulus words for four trials results in language stimulation periods of approximately 20 minutes. In this study, an average of two or three sets was administered during a treatment session.

In order to study the effects of the computerized drill, a single-case, A-B design was used. To assess their general level of language functioning, all subjects were initially administered a PICA and a test of reading ability, the Reading Comprehension Battery for Aphasia (LaPointe and Horner, 1979).

In addition, several tests were administered to determine generalization of the treatment program. Subjects were given an experimental reading test and two other cognitive tests. Our experimental reading test was designed to assess how well individuals could recognize, read, write and understand the words in the Flash Reading Program. It consists of six subtests (Oral Reading, Writing to Dictation, Sentence Completion, Understanding Questions, Visual Matching, and Auditory-Visual Matching). Words within each reading subtest were taken from FLASH and from a generalization set of similar words. The two other measures of cognitive ability were a Math Test composed of 10 simple arithmetic problems and the Raven Coloured Progressive Matrices (Raven, 1975) which assesses visual-spatial ability. The purpose for the additional cognitive tests was to assess any nonlanguage changes that may have taken place as a result of the computerized treatment program.

At the beginning of the A-phase of the study, the first baseline measurements were administered. Then, ten to twenty sessions (approximately five weeks) of "standard" speech treatment, without any reading drills, was conducted. At the end of this phase, the reading and cognitive tests were administered for the second time.

In the B-phase, the subjects worked with the Flash Reading Program for two to five 30-60 minute sessions per week for ten weeks. In each session, the reading program either preceded or followed a 30-60 minute session of "standard speech" treatment conducted by a speech clinician. At the end of the B-phase, the reading and cognitive tests were administered for the third time.

One concern in the study was the three-time administration of the pre/post, reading and cognitive tests, introducing possible internal validity confounds. To determine if multiple-test administrations by themselves resulted in improvement in test scores, one additional chronic aphasic patient, similar to the experimental subjects, served as a control subject and took the reading and cognitive tests at the same three times as the experimental group, but did not participate in the computerized reading treatment.

RESULTS

Two different sets of data were analyzed to study the effects of the computer treatment program. Computer treatment task scores were examined to determine if performance improved with repeated practice with the computer drills. Also, pre- and post-test results were compared to ascertain if changes generalized to reading and cognitive test scores over the period of the study.

With respect to level of task performance, all experimental subjects were responding by typing from memory to all five sets of words by the end of the study. Subjects usually worked on two or three different sets of words at each session. Most practiced each set for three or four sessions. One high-level subject began the study by typing the response words. The remaining four subjects started by matching words and all gradually moved up to typing words.

The two high-level subjects performed at ceiling level for most of the computer tasks and, therefore, demonstrated little change. However, these two subjects did show improvement with practice on the two most difficult tasks, typing TH-words and question words. The first subject moved through tasks relatively quickly, completing an average of four tasks per session, while the other subject was more reflective, completing only one task per session.

The three remaining, more severely-impaired subjects, all of whom suffered from nonfluent aphasia, showed good improvement on many sets of words. Matching most words appeared easy for these subjects; their performance improved quickly and smoothly (e.g., from 50% to 92% accuracy after six sessions). When typing words, the first three sets of short words were quickly mastered (e.g., from 50% to 75% accuracy after five sessions). Performance continued to improve as difficulty increased for the 4th and 5th sets of words, but at a slower rate and it became more variable (e.g.; from 71% to 81% after five sessions).

No change was demonstrated by the subjects' pre- and post-test scores, indicating that overall reading and cognitive performance levels were stable. This suggests little generalization of improvement for any of the chronic aphasic subjects as a result of the experimental treatment. The two pre-test and the post-test scores were also stable for the control subject over the three-month period of the study.

DISCUSSION

The FLASH program provided a high level of reading stimulation for the subjects for substantial periods of time, supplementing the benefits of standard speech treatment. By working on the FLASH reading program for the better part of an hour several times a week, subjects had responded to thousands of stimulus presentations during the experimental phase of the study. The nature of the tachistoscopic procedure required substantial concentration for all subjects. It was necessary for them to focus entirely on the task and to attend carefully to the presented words. The stimulation objective of the FLASH program for the chronic aphasic patients was clearly attained.

Although no generalization was demonstrated by the pre- and post-tests, the computer performance data is encouraging, as there is evidence that all subjects improved in word recognition accuracy and recognition time. Advancements were made, however, primarily for those words that were just beyond a subject's ability to perform with little error. For words that were easily within their capacity, no new learning was demonstrated, and for words that were far above their performance level, subjects made frequent errors, progressing slowly.

The performance data provides good insight into directions for improving word recognition for aphasic patients. The FLASH program could provide a more optimal learning context if modified not only to evaluate the performance of each patient, but also to adjust the level of difficulty of stimulus words. Artificial intelligence procedures can be built into the FLASH program to monitor performance and select appropriate stimulus words. It is possible to program the computer to decide which stimulus words are within the patient's learning capability and which should be presented for additional exposure and practice. A variety of treatment tasks, such as match-to-sample, anagrams and user-controlled delayed matching, can be offered to give the patient repeated practice on target words. Learning can be maximized through frequent exposure to the words in various language contexts, modalities and cognitive sets.

Incorporating artificial intelligence functions into the program will give the computer the ability to monitor the individual's progress and to present gradually more difficult words as appropriate. Through computer control, a combination of target words and activities can be utilized that provide both general language stimulation and specific learning through drills.

The effect of adding artificial intelligence features to the FLASH program would be that, like its human counterpart, language treatment will be tailor made for each patient, regardless of severity of impairment or variability of performance. The preliminary data we have collected suggest that such changes can result in a highly effective therapy tool for the speech-language clinician.

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DISCUSSION

Q: Your task was for word recognition. Could you comment briefly on the progression you see from your task to tasks with a greater emphasis on comprehension?

A: In our paper, we mentioned additional language activities that could have a greater focus on comprehension, for example, sentence completion, etc. Through the FLASH program, we feel the computer could identify the words the patient was unable to read and then put those words through these other language tasks.

Q: What was the status of the reading comprehension of these five subjects before they entered your program?

A: Table 1 describes the means and ranges of the subjects' RCBA overall scores and the scores of the PICA reading subtests.

Q: This program does not really tap word comprehension, just word recognition. I was interested in why you chose these patients as opposed to maybe some other group; e.g. (sic), head injury patients, or even right hemisphere patients who are having attentional difficulties. You were inferring that that was a significant part of their functional reading deficit. The case might be that for some of these patients or for other left-hemisphere patients word recognition may be intact enough for functional reading comprehension and comprehension of the word *per se* may be the critical part. What use would your program have for that kind of patient?

A: First of all, all of our left-hemisphere subjects had at least some difficulty performing the task at the higher levels for whatever reason. the 65 stimulus words in the program are recognition (sight) and vocabulary words. These words are read as whole units and not letter-by-letter as other words. We felt that to be better and faster readers, the aphasic subjects should also have this ability. It appeared from their performance on this task that they did not.

Q: I would be concerned that this program did not generalize to the other tasks that seemed to tap more into the kinds of reading that people might do when they leave the computer. I am wondering what you think your program really helped those people to do when they left the computer and went home.

A: We feel there are important considerations when interpreting the results of the pre- and post-tests. The mildly-impaired patients performed at a high level initially, and all subjects performed without error on the matching tasks, leaving little or no room to demonstrate improvement. Dictation tasks were not affected, perhaps, because the computer task did not incorporate an auditory component. We felt that if subjects read a word not five or ten times but hundreds of times, they would retain a visual image of the word that would reflect in their performance. Now we feel that while much stimulation was provided, the program could be more effective if it isolated error items and presented these words in a variety of language tasks using different language modalities and cognitive sets. This is our next goal.

Q: I would like to respond a little to the last question. I am not so concerned that what you are doing does not have any direct, immediate application to the outside. I would be more concerned if you came back after five or six years and after 50 or 60 of these programs and you were not any closer to real life than you are now. I think there is a place for studies that have no immediate, direct application to the aphasic patient's real life. We have to start somewhere, and in order to control some of the variables that we cannot control in real life,we have to start with artificial situations, find out what the aphasic patient does in those situations, and then gradually extend our knowledge into more and more life-like situations. I am not particularly concerned at this point with the sort-of artificiality of this task.

Q: Can you change the amount of time that the word is flashed on the screen, depending on the patient's need?

A: The computer responds to that. If the subject misses the word, then the computer flashes the word again, but more slowly, and continues to lengthen the duration of the exposure until the subject responds correctly. Then the next word is flashed quickly, at the original rate. The speed at which the word is flashed is controlled by the program and can be adjusted if desired by the clinician. The multiple choices are not flashed; these choices stay on the screen until the patient responds correctly or incorrectly.

Q: Do you think that patients can use this program with minimal or no supervision other than getting them started?

A: Definitely. Patients were able to operate the program with minimal supervision for most of the study. However, because this was a research project, the program was altered so that the subjects could not load the program themselves as we wanted to control the order and frequency of each word set. Nevertheless, based upon pilot work with earlier versions of the FLASH program and our CATS program presented here last year, as well as experiences from our own clinic, mildly- and moderately-impaired aphasic persons have repeatedly demonstrated their ability to load and run specially designed treatment programs on our computer.

Q: In reference to my earlier comment, the artificiality of any task *per se*, is not a particular concern of mine. I do not want to criticize any kind of therapy just because it does not create a movie set of the person's real life. What I am concerned about is whether or not it has an effect.

A: The role I see the program taking in the future is to screen out those words that the patient does not know, and from there move on to other language activities that focus on those words. This program did isolate those words that the subjects could not recognize and as such, it performed what could be the first module in a series of language tasks designed to improve reading.

Q: I am interested in the patients' reaction to the concept of working with the computer.

A: First of all, only those patients who volunteered were involved in the study. Some of whom we would have liked to include were not interested in the computer. The five aphasic subjects in this study used the computer every time they were in the clinic. We did not have to encourage them to use it more often. A schedule was finally made to eliminate conflicts when two or more subjects wanted to use the computer at the same time. Experience from clinical use of the computer as well as our research projects indicates that some use the computer enthusiastically, some dutifully and some want to work only with a clinician and have nothing to do with the computer.

Q: Have you ever used a voice synthesizer with the computer?

A: Yes, but we are not satisfied with the quality of speech in terms of articulation, pausing and intonation. Specifically, we have used Handivoices with our patients and it seems that those who need auditory comprehension treatment the most understand synthesized speech poorly. We now use a Supertalker speech digitizer identical to the one used by Russ Mills in his auditory comprehension program. While digitized speech uses a great deal of the computer's memory, it can be used to provide the most natural sounding voice, preserving pausing, stress and intonation. Our patients find digitized speech easier to understand and report that it is more pleasing to listen to than synthesized speech. (In all fairness, several of our aphasic patients understand the hybrid, synthesized/digitized speech of the VOCAID better than synthesized speech alone, although neither was as well understood as digitized speech.) At some point, we will incorporate digitized speech into our reading program to provide simultaneous stimulation, crossed modality tasks and other reading activities.

Q: There is a distinction between using the computer to practice language-type tasks as opposed to having it become an integral part of a patient's communicating. A TI 99/4A computer with voice synthesizer was used with a patient with pure word blindness, where the purpose was to translate the visual signal to an auditory code, and so she would see the word and then type the key that matches the letters. The machine would then say the word out loud so she would be able to process the word that way.

A: I wonder if that had an effect on her ability to read.

Q: Was there an after image on the screen after the word was flashed? Perhaps that would provide one reason for the subjects achieving ceiling so quickly.

A: Following the exposure of the word, an extremely brief after image does appear, but its duration is much shorter than the presentation itself. The after image could be entirely eliminated by filling the screen with a color other than black after the word is flashed. The demonstration video tape presented here today was made by photographing the TV screen with a video camera and it was the camera tube that produced a lengthy after image.

Q: As you read about the use of computers in therapy as augmentative defices, it seems that reading comprehension is one area where the computer might take over a greater role. Indeed, it might become the primary means of treatment, with traditional therapy being the augmentative part. How far away from that are we?

A: This was an attempt to use the computer in a unique role, something that a clinician alone could not do. We feel that it will still be some time before the computer can plan individualized treatment for aphasic patients without some control by the clinician. As we write better treatment programs for the computer, we will probably develop a better understanding of the reading impairment as well as better strategies to treat that impairment.