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ABSTRACT

The paper describes the development of a computerized symbol processing system which allows nonspeaking severely handicapped persons to create communication electronically. Two pilot studies investigated the use of Rebus and Bliss Symbols with either an Apple Graphics Tablet or the Power Pad, a peripheral which allowed users to activate the computer by touching the board with their fingers. Positive results included improved speed and accuracy of performance, enhanced motivation, and reported teacher and parent satisfaction. Three case studies illustrate the ability of multiply handicapped students to learn the use of the symbol processing systems in a relatively short time. (CL)

Computerized Symbol Processing For Handicapped Persons

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Several research studies have documented the benefits of using alternate symbol systems, such as Rebus and Blissymbolics, with persons who have severe communication disorders (Carrier, 1974; Clark, 1981; 1984; Sailor & Guess, 1983). These logographic symbol systems have increased in usage so much in recent years that some believe that they will soon be as common as manual signing for nonspeaking severely handicapped individuals (Clark, 1984). However, while the popularity of symbol systems is increasing, handicapped persons still have no way of using the systems to produce written communication. Like sign language, logographic symbols are strictly transitory, providing users with the ability to express themselves, but no with the ability to preserve their communications.

But what if a computerized system were developed which would allow users to create communication electronically, much the same as nonhandicapped people user word processors? Such a system would need to be easy to operate, flexible (allowing users to print their communications in English or in the picture symbols), and low in cost. The system obviously would need to include an alternative to the traditional computer keyboard which requires too much motor control to be of value to most Rebus and Bliss users.

Although several adaptive keyboard devices have been developed, each one has certain characteristics which make the device less than ideal for severely and multiply handicapped users. Peripherals presently on the market are either very limited in the types and numbers of available symbols, are inflexible as to the size of each symbol, are difficult to operate, or are prohibitive in cost (Osguthorpe, Li & Applegate, 1985). Due to these findings, a project was launched to

develop a symbol processing system that would be more flexible and cost-effective than those presently available. The purpose of this article is to describe a study in which a newly developed system was evaluated. Because of the newness of the system, the study was formative in nature, focusing on the useability of the system and the uniqueness of each user's performance.

Method

Development of the Computerized System

Two different types of peripherals for the Apple II computer have been used in the symbol processing research. In the initial stages of the project, an Apple Graphics Tablet, measuring 11 inches square was used. Software was written allowing the user to select from among 110 (one inch square) Bliss symbols from the board by touching an electronic pen to the tablet. A plastic overlay was placed on the tablet to show the location of each symbol. During the initial experimentation with this system, the user could print out communications on a Prowriter printer, but only in the symbols themselves, English equivalents had not yet been added to the software.

Later in the project the software was expanded to include either Rebus or Bliss symbols and the English equivalents of those symbols. This allowed the user to print out communications in either English or in the symbols, depending upon the intended receiver. In addition, a new type of communication board was used which allowed users to activate the computer by touching the board with their finger, rather than with the electronic pen. This peripheral, called the Power Pad, provided a similar size of activating area, but was much less expensive

than the Graphics Tablet. Figure 1 shows the hardware configuration using either the Power Pad or the Graphics Tablet.

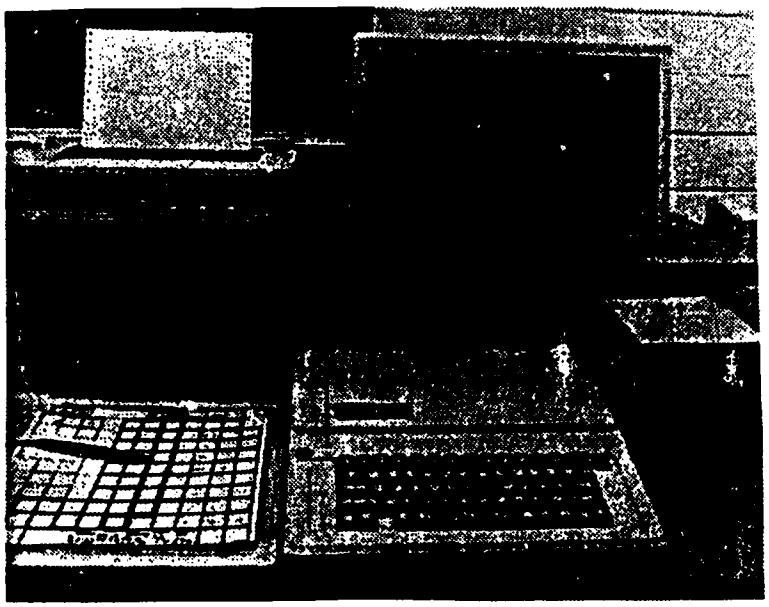

FIGURE 1 The hardware configuration of the System Processors.

Continual refinements are being made in the software to allow users to customize their computer boards more easily, making the resulting board as much as possible like the regular one they normally use.

Pilot Study

Prior to conducting the current study, a two week pilot project was launched to investigate the effectiveness of the Apple Graphics Tablet configuration with Bliss users. The study involved 10 severely and multiply handicapped residents at a state residential facility for the mentally retarded. The results of this initial study indicated that after only 2 hours of practice severely disabled nonspeaking

individuals:

1) were able to produce understandable communications using the computerized system,
2) improved significantly both their accuracy and speed in using the computerized board,
3) had a positive attitude toward using the system, but
4) had difficulty using the electronic pen attached to the tablet.

Rebus Symbol Study

In the second study Rebus symbols were used rather than Bliss symbols and the Power Pad peripheral was included with the Apple Graphics Tablet for comparison purposes.

Method

Setting

The second study was conducted at a self-contained day school for the mentally handicapped. The school enrolls approximately 100 students, ages 5 to 21 who have been recommended by parents and school personnel for placement in a full-time special education setting. The school serves the needs of students with moderate to profound retardation, with many of the students having additional handicapping conditions. While all of the students live at home, the severity of ndicapping conditions is similar to that of residential students prior to the mainstreaming movement.

Students

A total of 12 moderate to profoundly retarded students, ages 7 to 16, participated in this study. Each student was referred by a home-

room teacher as someone who might benefit from training in symbol processing. Of the 12 students, 6 did not use intelligible speech; 2 used extremely limited speech, 3 had two or three-word-phrase and 1 had 9 or 10 word sentence expression. Their experience with Rebus symbols ranged from 0 to 50 symbols. With regard to their motor control, 3 had cerebral palsy and 3 used a wheelchair. Among the 12 subjects, 4 had very poor or poor gross or fine motor control but could point with their fist or finger; 1 had limited motor control, 4 had fair gross and fine motor control and 3 had good fine and gross motor ability.

System Implementation

In order to measure the relative merits of both the Graphics Tablet and the Power Pad systems, two groups of handicapped users were formed. To control for nonequivalency between the two groups, both systems were used by both groups. During the first 7 weeks of the project, Group I used the Graphics Tablet and Group II used the Power Pad. During the final two week period, the groups exchanged communication boards.

For the first 6 weeks, each child spent an average of 20 minutes each session 3 times a week to work on the Symbol Processor system. At least twice a week the children were encouraged to write what they felt and thought to whomever they wished to write. After introducing the system to the users, each student received two or three training sessions individually prior to the free-expression writing. During the training the proctor vocalized the symbols row by row to enhance students' understanding of each symbol.

Students were tested on their speed and accuracy in mastering the Rebus symbols and using the board during the third session of each week. During the tests, the proctor arranged flash cards into meaningful sentences and showed them to students. Each flash card has a Rebus symbol and its corresponding English word. After each student composed these sentences by pressing the appropriate symbols on the board, the student's time and error rate were recorded. The fixed sentences in Test A had 10 Rebus symbols which were "Hello I ride bus. I like [to] see television." Test B had 25-symbol sentences which were "Yes give me money. I want big ice-cream and cookie. I like my mother. I want [to] kiss my father and mother."

The students used the system more frequently during the last three weeks -- as often as four or five times a week to determine if they might lose interest from intensive involvement with the system.

Parent/Teacher Questionnaires

At the conclusion of the study, the 5 teachers whose students participated in the study provided feedback to project staff by filling out a questionnaire. The questionnaire asked for teachers' perceptions regarding the effects of the symbol processing program on each student. The same questionnaire with slight modifications was presented to the parents or guardians through telephone interviews.

Results

In this section of the article a description will first be given of how the two groups performed on each of the symbol processors. Results from the parent and teacher questionnaires will then be discussed. Because each student possessed such a unique array of personal

characteristics, more detailed case descriptions will be given of selected students from each group.

Group Performance

Figures 2 & 3 show how each group improved in both speed and accuracy on each of the two boards. Of special interest is the ease with which students adjusted to the other board

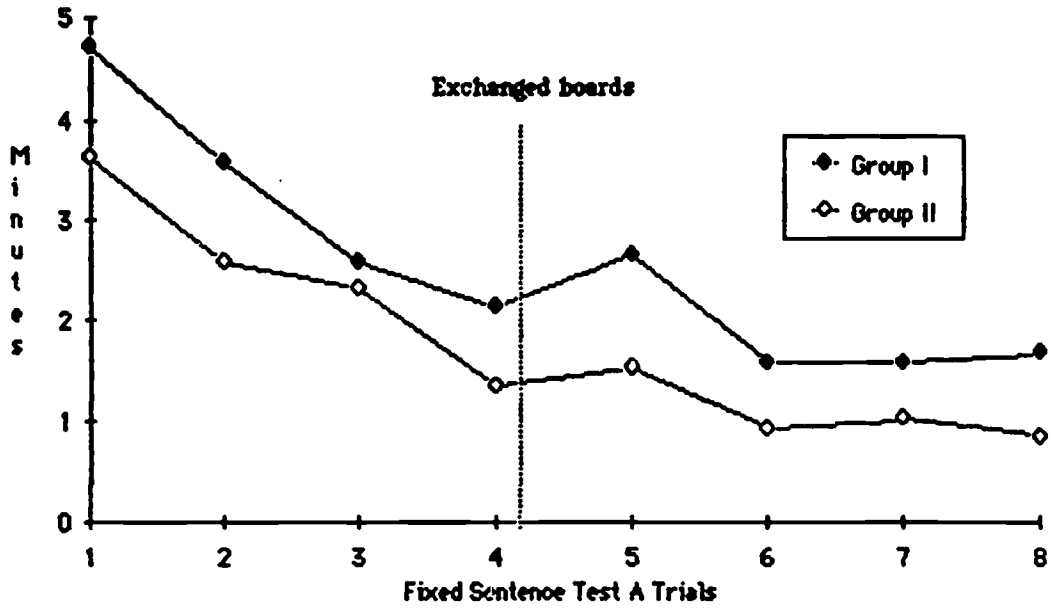

FIGURE 2 The speed of each group using both boards.

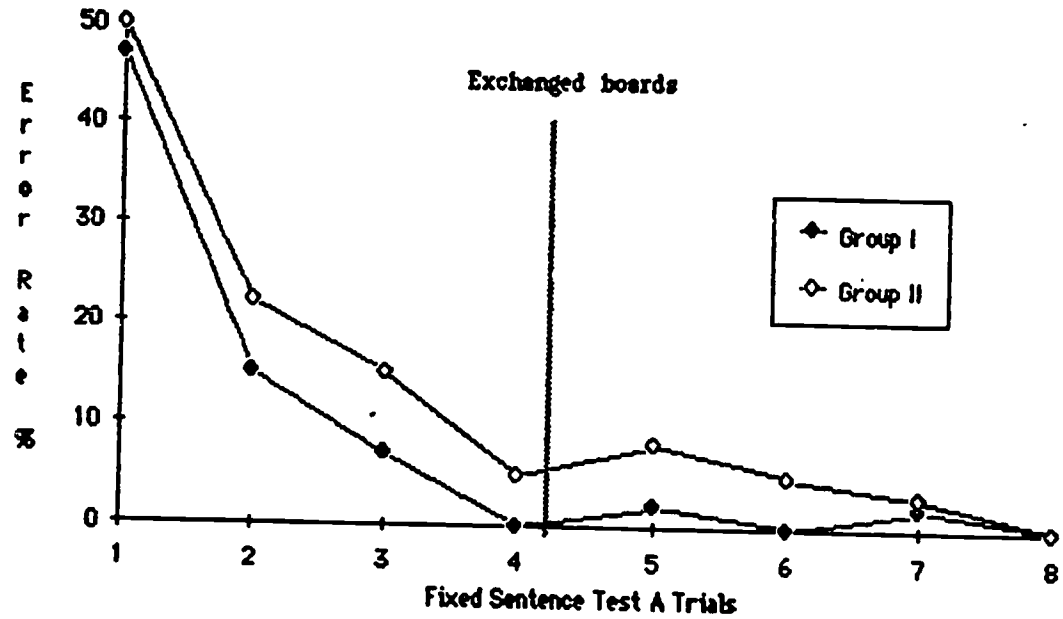

FIGURE 3 The error rate of each group using both boards.

When the exchange was made. As seen in Figures 2 & 3, rather than hampering student performance, the introduction of a different symbol board actually improved both speed and accuracy for most students, regardless of which board came first. During the first set of trials, Group I tended to perform more accurately than Group II, yet took longer to complete the task than Group II. However, when changing to the second board, both groups became more similar in speed and accuracy. For instance, Group I achieved a 2% error rate on the third trial, while Group II had an average error rate of 3%. During the fourth trial, both groups performed virtually error free.

All subjects showed great enthusiasm during free expression trials. Students commonly did not want to quit and would go beyond their scheduled time. Most of them made understandable expressions after a few sessions of practice. The content of their writing varied, including mention of family, friends, food, clothes, TV, swimming,

riding the bus, pets, their wheelchair, and personal activities.

Teachers' Questionnaire

All teachers said that the system was beneficial to their students, mentioning the following effects: increased self-confidence, self-esteem and self-image, improved use of symbols, and the improved communication skills. They suggested that the nonvocal, the socially reserved, and the students with limited writing skills gained most from the system.

All five teachers said that their students retained high interest in the symbol processors. The most frequent comments included: "The student always seemed to be excited, when it was time to work with the computer," "The students took greater pride in their work and shared their work with classmates;" "They [the students] always wanted to show their printouts to me [the teacher] and point each symbol." Four out of five teachers would like to see the project continue next year. One did not respond to this question. However, they all believed that the system could, in the long term, be beneficial to students. When asked to cite specific benefits of symbol processing, teachers said that they believed that it helped students organize their thoughts better, communicate more effectively with others, improve their writing skills, and become generally more expressive.

None of the five teachers responded with negative comments regarding the effects of the symbol processing experience on their students.

Telephone Interviews with Parents

A total of 11 of the 12 parents were interviewed by telephone regarding their perceptions of the program for their child. All 11 parents' responded as positively as the teachers'. They supported the project and all wanted to see it continue during the next school year. When asked to cite specific benefits that they believed their child had received from the program, they mentioned most often improved communication skills and personal attitudes. Included in their comments were: "better eye-hand coordination, more expressiveness, making more complete sentences, organizing thoughts and writing them down, learning symbols well, using the overlay at home independently, and trying to vocalize words more." Parents mentioned further improvements in "self-confidence, attentiveness, enthusiasm about work and pride in their letters from the computer."

Case Studies

In order to give a more detailed description of the results from the study, three representative case studies will be given. In order to protect the identity of the students, their names have been changed in this article.

Case 1. Edward (in Group I) is mentally handicapped 13-year old boy with cerebral palsy primarily affecting his left side. In spite of his handicaps, he is able to run and play actively with the other children, although he rarely uses his left hand due to his motor disability. Edward is categorized as severely multiply handicapped, is basically nonvocal, but knows about 50 signs such as "mother, baby, toilet, yes and no." He writes very little, but uses a Rebus communication board made by the speech therapist who estimated that he knew at least 25 symbols before the study. Edward gestures, grunts,

[illegible] touche inappropriately according to his teacher report. He [illegible] over [illegible] to [illegible], but can be quite stubborn at times.

During the training sessions Albert could often touch the practice's shoulder or chair or if he tried the color or pattern in the [illegible], with two hands and not two hands. Sometimes he could run through on the computer [illegible], since his teacher petitioned him to leave the classroom. When asked to practice on the computer during his recess, Albert could drag from his swing or slide down the slide and [illegible] while the training. It was easy to feel his excitement when coming to the computer room.

Albert made rapid progress in his ability to use both communication boards. Figures 8 & 9 show how Albert, when using the Graphics Tablet, was able to produce the final sentences in

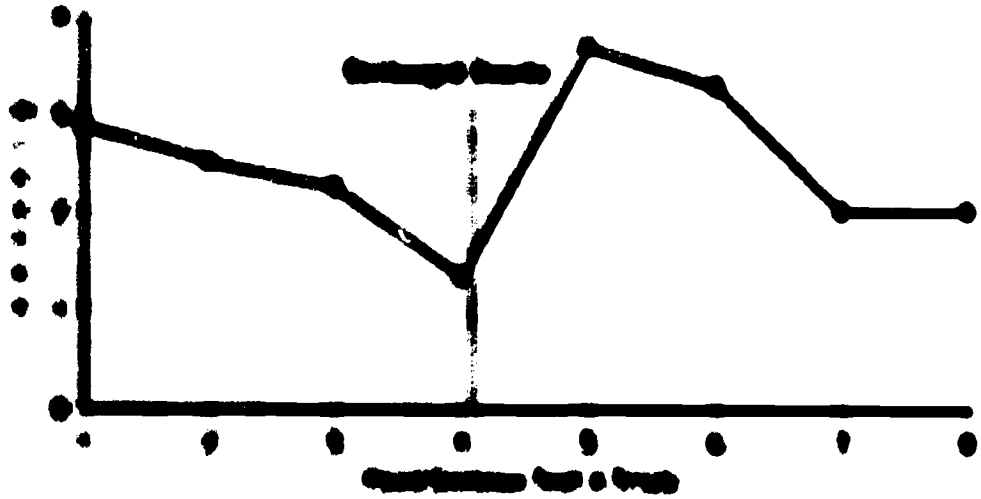

Figure 9. Albert's speed using both hands.

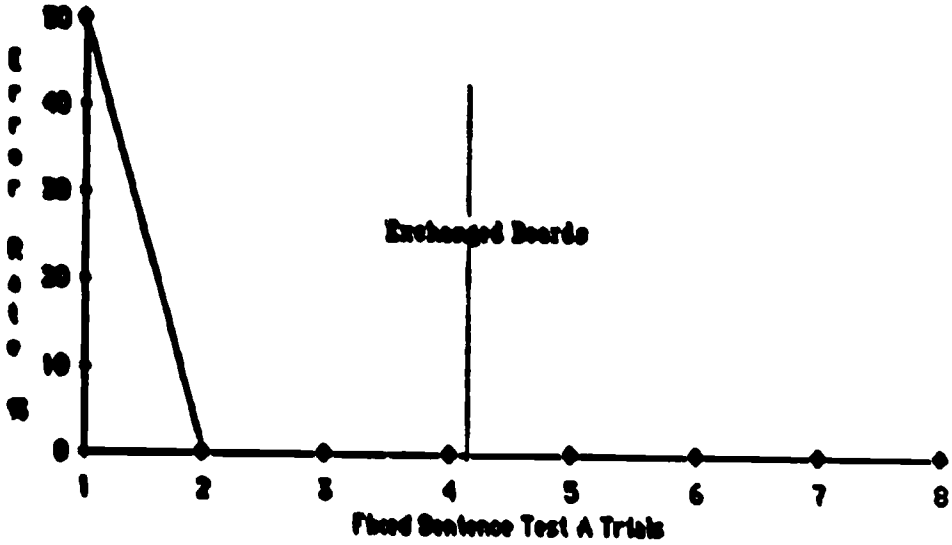

FIGURE 5 Edward's error rate using both boards.

less than half the time after only four trials. Later, when he used the Power Pad, he obtained similar results, reducing his initial speed from 3 minutes, 42 seconds, to 2 minutes on the fourth trial. He seemed to show slightly faster speed when using the Graphics Tablet than when using the Power Pad, but the differences were not large. His accuracy on both boards was excellent. Only on the first trial (with the Graphics Tablets) did he made substantive errors. When changing to the Power Pad, he immediately responded with the same degree of near perfect accuracy.

While working on the computer, Edward typically clapped his hands and laughed. At the beginning of each session, he would usually press the board randomly and would then become extremely excited about pressing numbers, and the words: "go," "up" and "bus." He soon was

fascinated by the function of the erase key. He would press any group of symbols and then use the back-arrow and erase them one by one. As he watched the symbols disappear from the screen from the screen after pressing the erase key, he would become extremely excited and begin clapping his hands crazily.

At times Edward was easily distracted from the symbol processing task. It was at these moments that it became difficult to understand what he meant by the symbols he pressed. For the first three weeks he just made random selections of symbols with segments of phrases such as "play ball" and "bus to ride in."

On one occasion, Edward was asked to write about his activities after school. He wrote the following in five minutes, "I go my house. I like bus to ride. My teacher hello with me. I see TV TV in my house." Riding a bus and swimming seemed to be the focus on his daily activities. During a later session, Edward spent over eight minutes composing a 32-word letter. He wrote about playing ball with an animal, swimming with boys and girls, music, his parents eating cookies and his enjoyment of books. During this session his ability to focus on the task seemed especially keen.

Observation of each student's performance indicated that each user of the Symbol Processor seemed to view the function or purpose of using the system differently. Some had greater needs to express themselves and were more serious about writing down their inner feelings; while others seemed to view the task more like a computer arcade game. Edward often portrayed the more playful, gaming attitude, while David, presented in the next case description, displayed an attitude that was

more intense and communicative.

Case 2. David is a moderately retarded eleven-year-old boy with good motor and fair fine motor control. His favorite sport is basketball. He was in Group II and, therefore, started with the Power Pad and then switched to the Graphics Tablet. David has little speech, but signs very well, and does at times speak in 4-word sentences. He is learning to write his name, but is unable to write other words or sentences. Prior to the study, his teacher reported that he did not know any Rebus symbols. One of David's strengths is his ability to interact socially. He enjoys teasing other students and teachers and making them laugh. His ability to follow directions is also more well developed than some of the other participants in the study.

When David first attempted to use the Power Pad, he quickly learned the meaning of the symbols and showed excitement when he was able to recognize them. He was especially happy each time the big smiling face appeared on the screen as the computer was loading a file. It was at these early moments that he became the most distractible and playful. When entering symbols, he could use either his left or right hands interchangeably. He intended to look at the screen very closely when his letter was printed, and touched the screen to point to each symbol.

Not only did David make tremendous progress in speed and accuracy (See Figures 6 & 7),

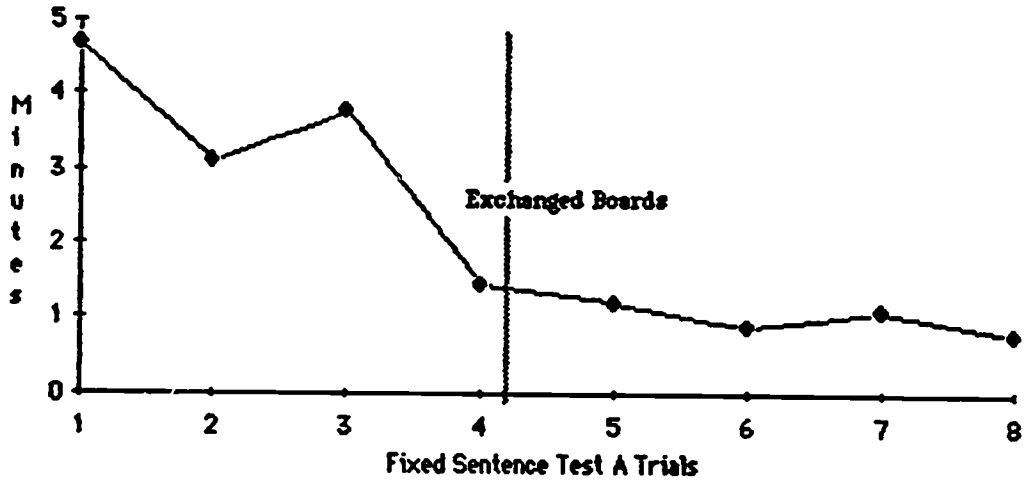

FIGURE 6 David's speed using both boards.

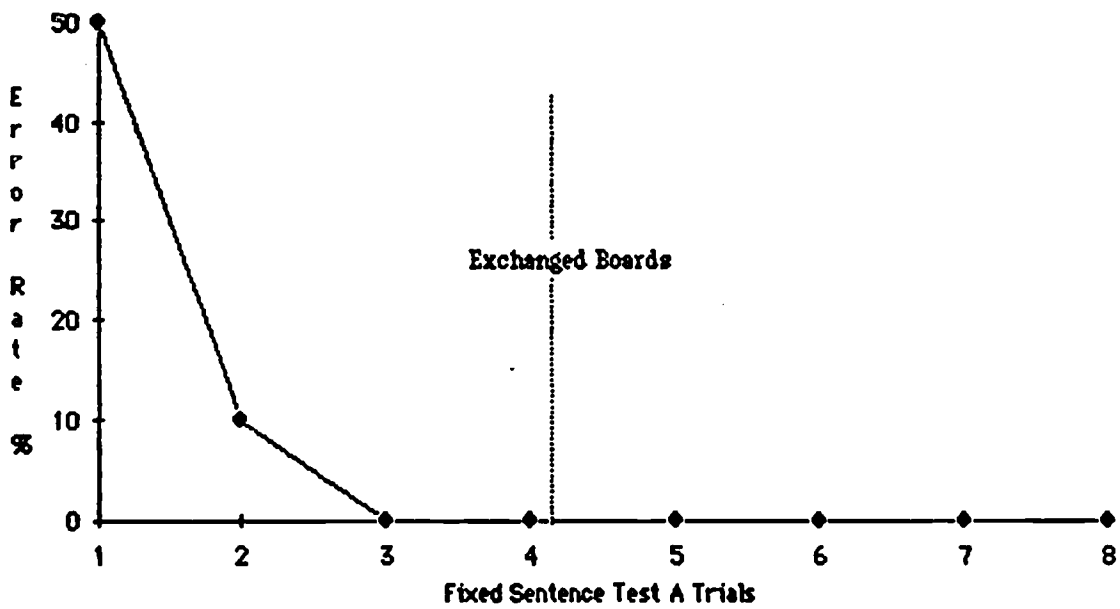

FIGURE 7 David's error rate using both boards.

he also composed 19 understandable entries out of 22 free-expression trials. On one occasion he wrote, "I watch TV with my family. I go toilet in my house. I ride bus bus." He was laughing all the time while writing this message. Like other users, David wrote often about his desires, one day writing a letter indicating his desire to read books; another time writing, "I want milk milk. I want to see TV. I want to ride bus bus."

Near the end of the study, for the first time, David wrote about his feelings toward his girl friend. He said, "I like my girl friend. I want to call girl. I want to kiss my girl friend." (See Figure 8) He wrote this 18-word letter in less than three minutes (2'58") using his left and right hands

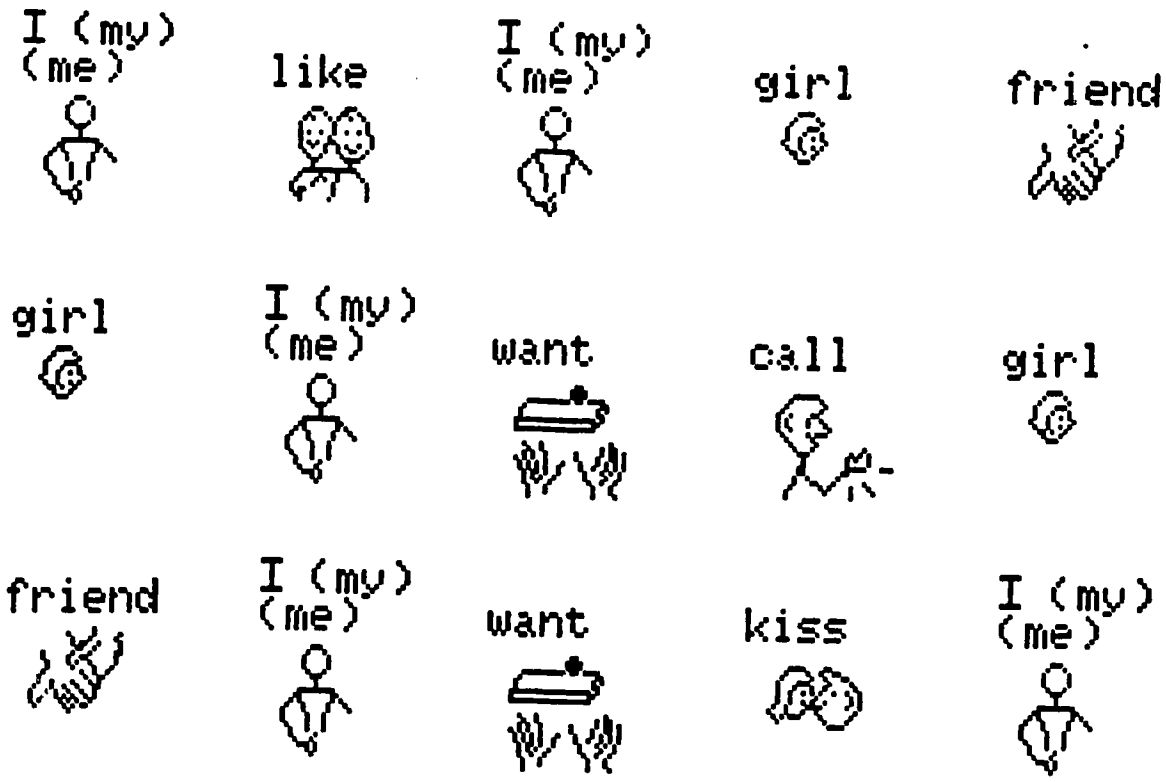

FIGURE 8 A sample of David's writing.

interchangeably. It was fascinating to observe his efficiency in using the system to express himself.

David's genuine interest in using the symbol processor was clear throughout the course of the study. During the last week of school, all the students were invited to a stocking dance party which was scheduled at David's computer time. While he was dancing with his creative stockings, a teacher asked him if he wanted to continue dancing, or go work on the computer. When he heard the word, computer, he said, "Yes." When the teacher asked a second time, "Are you sure you want to go?" David responded again even more loudly and with a big nod.

Furthermore, David carried his interest in computers into his home. In a telephone interview, David's mother expressed that he often reminded her that he wanted a computer for his birthday. His mother also said that he never failed to show his computer printouts to family members.

Case 3. Bryon is an energetic 15-year-old boy classified as severely multiply handicapped. He has very good gross motor ability, but his fine motor skills are not as well developed. His communication skills, include some signing, some verbalizing and a great deal of pointing and gesturing. The most complex vocal expressions he makes are two-word phrases. His homeroom teacher reported that Byron had the ability to recall information and follow directions in the classroom.

When Bryon began using the symbol processor, he soon became one of the fastest writers. He seemed to especially enjoy increasing his

speed on the system. Each time he came into the computer room with vigor and excitement, usually showing his emotions by laughing aloud, jumping up and down and clapping his hands. Bryon's accuracy was excellent in finding and understanding the symbols on both boards (See Figure 9). His speed progress was even more

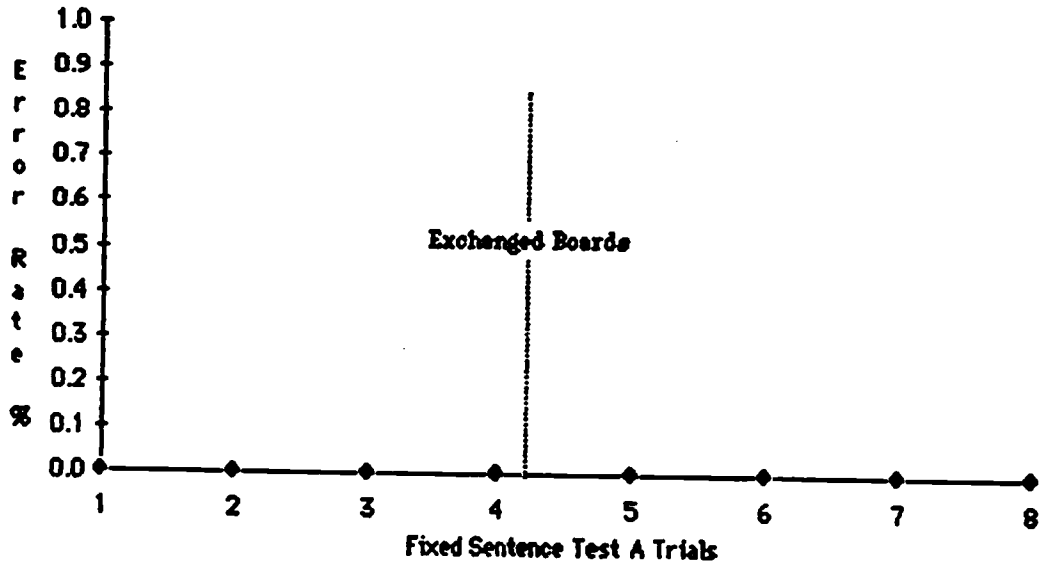

FIGURE 9 Byron's error rate using both boards.

impressive. He improved his speed on fixed sentences from 4 minutes 29 seconds to 46 seconds in only 4 trials (See Figure 10).

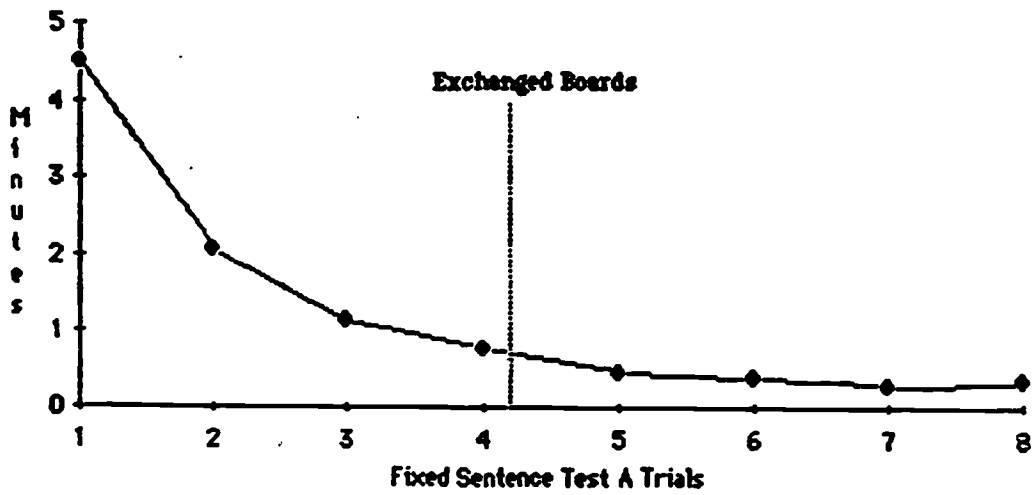

FIGURE 10 Byron's speed using both boards.

Numbers and colors were Bryon's favorite symbols. He often perseverated by going from one row to the next or pressing the same symbols again and again. However, Bryon was also capable of composing meaningful sentences even at the beginning of his free expression trials. For example, in one of his first attempts at free expression, he wrote to his teacher, "I like you. You good teacher."

During the first fur weeks of the study, Bryon spent most of each session selecting random strings of symbols, but would also usually compose at least one meaningful sentence. Included among his meaningful entries: "I have four brothers," "I want radio," and "I want ice cream."

As Bryon gained more experience with the system, he continued to improve in both the speed and the meaningfulness of his entries. During one session he wrote a 22-word letter in only 2 minutes and 20 seconds.

Bryon often wrote about his girl friend, watching television at

home, and eating cookies. During one of his typical sessions, Bryon became so excited at his ability to create communication on the computer, he screamed and clapped his hands. He wrote, "I like computer. Computer helps me write letter..... I [am] happy to work on [the] computer."

In spite of his ability to create meaningful sentences, Bryon seemed to enjoy his random selections and perseveration of symbols far more than writing down organized thoughts, unless he had a great need to write, such as writing letters to his teacher and girl friends (See Figure 11).

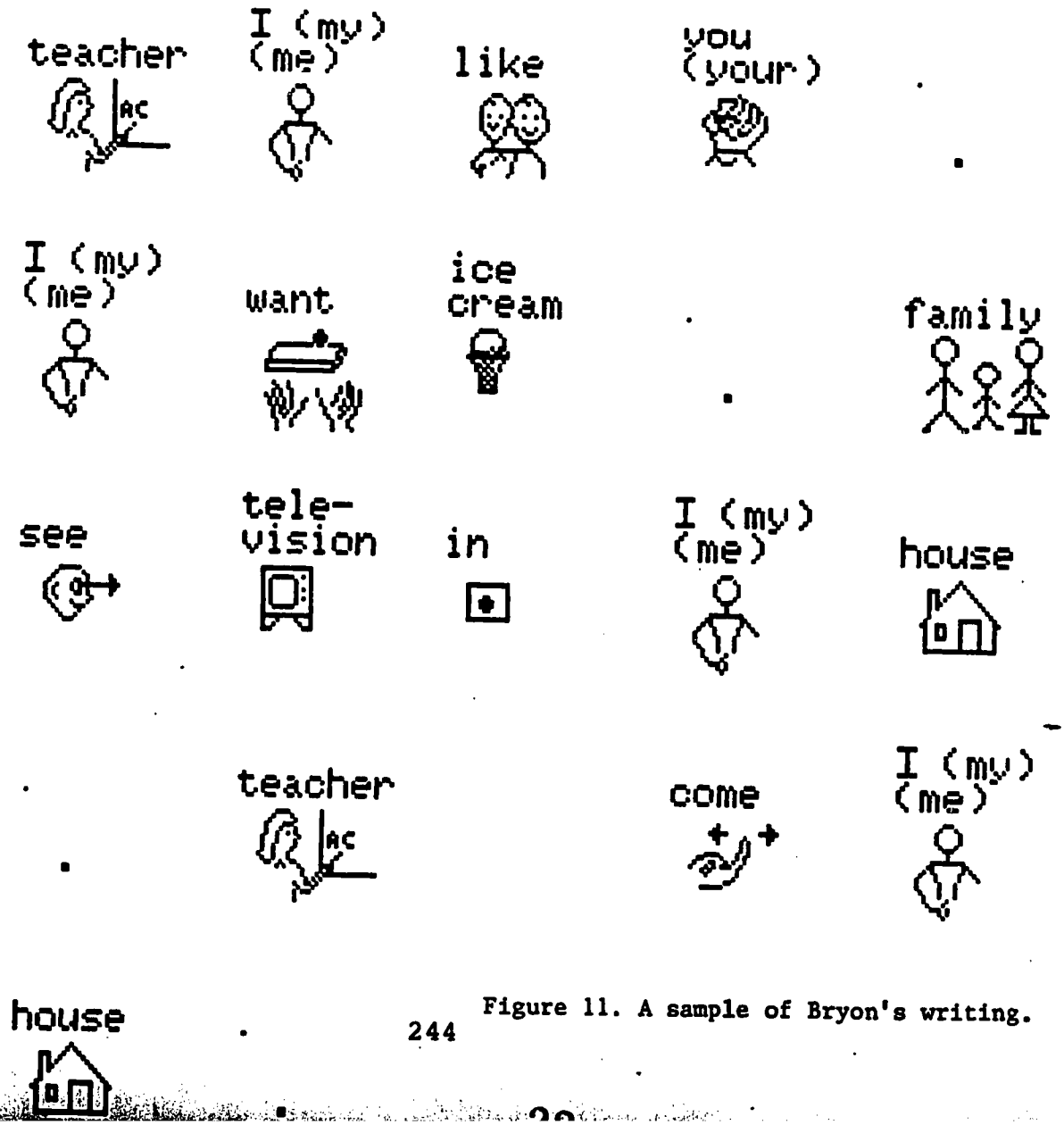

Figure 11. A sample of Bryon's writing.

This characteristic was in clear contrast to other students, like David who preferred to spend most of his free expression time creating meaningful communication.

One of the reasons for Bryon's success on the symbol processor was the support given by his teacher. Although most teachers were openly supportive of the project, Bryon's teacher seemed to take special interest in the progress her student was making on the system. On the last day of school his teacher came to the computer room and asked if she could write a letter to Bryon using the system to express her feelings as well as to remind Bryon of some summer events. After writing her letter to Bryon, she expressed her gratitude in being able to use the system, and then made a strong request that the project continue during the coming school year. Before she left, she described how Bryon's enthusiasm for symbol processing had become obvious to everyone in her class because Bryon always liked to show his letters to the class immediately after returning from the computer room. She also mentioned how Bryon would always remind her of his computer time and thought himself very special to take part in the project. It was this feeling of increased self-esteem that Bryon's teacher felt was the most important result of the symbol processing project.

Conclusions and Discussion

The results of the research reported in this article shows that students with severe communication impairments can be trained in a relatively short period of time to express themselves independently in writing. For students like Bryon and Edward, who have never before had the ability to express their thoughts in writing, symbol processing

systems offers an important new dimension to their communication skills. For the majority of students participating in the research, it was the first time that they had ever seen their own words in print. Observers clearly noticed that students were as excited to read and reread their own printouts, as they were to create the communications. This finding has important implications for communication training. For example, there has been increasing evidence of the importance of personalizing early reading experience so that when a child is asked to read a passage, each of words is meaningful to the child (Smith, 1983). This theory has already caused many teachers to introduce writing much earlier in a child's education, so that children can read their own, as well as other children's communications. Although the theory has been developed primarily through observing nonhandicapped children, the data collected in the symbol processing studies indicate that print fluency (including symbol fluency) may be enhanced by allowing students to read their own communications. Further research is needed, however, before firm conclusions can be drawn regarding the role of symbol processing in improving print fluency.

Regarding the relative merits of the two symbol boards employed in the research, it can be concluded that both can be effectively used by severely and multiply handicapped students, although the Power Pad has some unique advantages over the Graphics Tablet. One important finding from the second study was that students generally did much better when they exchanged boards, regardless of which board they used first. The pen on the Graphics Tablet was not a serious deterrent to student performance, once students were accustomed to using an electronic board. However, the Graphics Tablet was not as dependable as

the Power Pad, largely due to the sensitive connection between the pen and the computer. Students' sporadic hand movements sometimes broke the pen wires, requiring repairs. The Power Pad seemed to be more reliable, requires no interface card, and costs much less than the Graphics Tablet. These advantages, alone make the Power Pad a more attractive choice for symbol processing. However, it should be noted that other electronic boards currently exist (Greystone, P., 1984; Unicorn Engineering Company, 1984) and others will likely be developed, none of which were tested in these research studies. The desirability of alternate software and hardware configurations should be considered in continuing research on symbol processing.

In addition to testing other symbol processing systems, it is critical in future studies to broaden the population of users. In these initial studies students all possessed moderate to severe mental retardation in addition to a variety of motor impairments. However, since Rebus symbols are becoming more common as a tool for early reading instruction, symbol processing for learning disabled, and even nonhandicapped students should be researched. Anyone who is unable to write fluently using the traditional alphabet is a potential candidate for symbol processing. While the implementation of such programs and the intended benefits may vary, such research may provide valuable insights into early language development, as well as offer testable techniques for improving early reading instruction.

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