Evaluation of the Effectiveness of a Computer Based Communication System in Enhancing the Communicative Abilities of Individuals with Severe Aphasia

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Abstract

One of the most significant recent advances in improving the communicative abilities of individuals with chronic severe aphasia has been the development of augmentative and alternative communication (AAC) methods; that is techniques, strategies, and symbols for augmenting or replacing natural speech. The major aim of this proposal was to implement and evaluate the effectiveness of a computer-based AAC communication system in nonspeaking individuals with aphasia. Eight individuals with severe chronic aphasia received extensive training on a special software program that turns a microcomputer into an electronic communication device. This software program is designed to offer representational graphic/pictorial symbols in conjunction with synthetic voice output to nonspeaking individuals. During the first phase of the training, participants were trained in two primary tasks: first, accessing the software program and identifying and manipulating the symbols/vocabulary items from different grammatical categories; second, constructing sentences using simple subject-verb-object syntax. Phase II involved providing each participant with a communication book which contained symbols specific to each individual subject. The caregivers and the subjects were trained on the efficient and effective use of the book. Overall, the results of this study reveal that individuals with severe aphasia are capable of learning the mechanics of a computer to access, manipulate, and combine graphic symbols to produce simple sentences. The finding that individuals with aphasia can learn computer -based graphic symbols has significant clinical and public policy implications.

Individuals with little or no functional speech frequently rely on augmentative and alternative communication (AAC) symbols, strategies, and techniques to augment or replace natural speech. Computer based graphic symbol communication systems are one of the most recent additions to the current repertoire of AAC options. The primary purpose of the current study was to evaluate the ability of individuals with severe aphasia to acquire and produce selected graphic symbols using Talking Screen (TS). It is estimated that approximately 300 people acquire symptoms of aphasia every day in the United States (LaPointe, 1994). The foremost cause of aphasia is a cerebro-vascular accident (CVA). Every year approximately 180,000 individuals in the United States need nursing home care as a result of a stroke (National Stroke Association, 1991).

The TS is a software program which is designed to offer graphic symbols in conjunction with synthetic voice output to nonspeaking individuals (Words+, 1992). The TS is available both as a dedicated communication device and as stand alone software. It is compatible with IBM or IBM based computers and most of the currently available speech synthesizers (e.g., Dectalk, Real Voice, VocaLite).

The TS is a menu driven program which presents symbols in a dynamic display format. This format allows symbols to be presented across multiple screens in a logical sequence. For example, a participant may click on one of the superordinate categories (e.g., food) in the first screen which will result in explosion into several subordinate categories (e.g., hamburger, ice-cream, etc.) in the second screen and further click "ice-cream" in the second screen to chose the flavor (e.g., vanilla, chocolate, etc.) in the third screen. The screens are designed in a manner so that each symbol is presented in a separate grid. The grids are formed by a matrix of rows and columns. Figure 1 depicts the hierarchical organization of the vocabulary in the TS. The number of symbols to be displayed on each screen will essentially depend upon the size of the monitor and the participant's cognitive, linguistic, and visuo-perceptual skills.

Each symbol can be programmed to produce a spoken message. For example, a symbol for Coke may be programmed to produce the message “I'd like some Coke”. Further, some symbols which represent referents in categories such as pronouns, prepositions, and function words can be programmed to produce instant speech (i.e., name of the referent). Examples of some of those symbols are “yes”, “no”, “hello”, “and” “good-bye”. Additionally, symbols selected across several screens can be stored and combined to produce syntactically simple sentences and phrases. A participant may select “I” from one screen, “want” from the second screen, and “coffee” from the third screen to produce the message “I want coffee”. The TS can be accessed via a mouse or an adapted switch or through scanning. For a detailed discussion of TS, please refer to the Talking Screen User Manual (Words+, 1992).

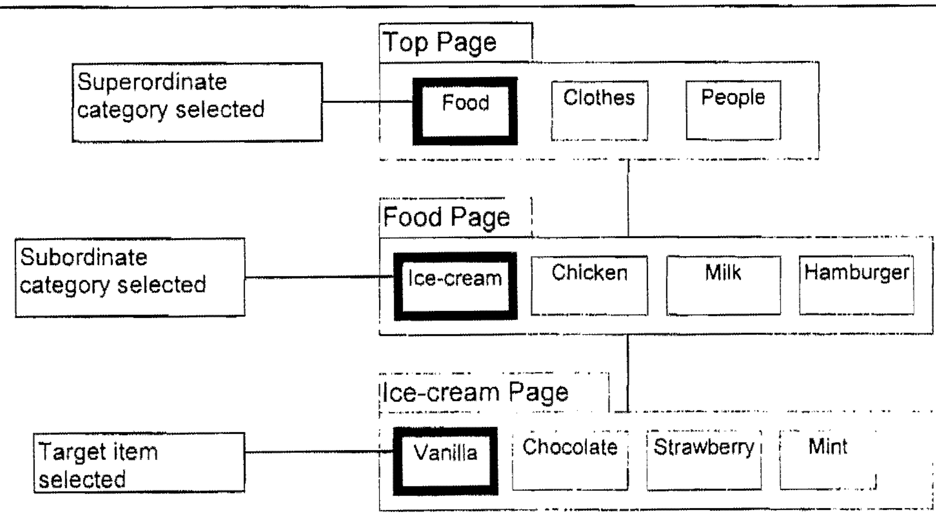

Figure 1. **Hierarchical organization of the Talking Screen vocabulary.**

Almost all of the recent studies conducted to determine the efficacy of alternative forms of communication for individuals with severe aphasia have used the computer-based visual input communication system (C-VIC) (Steele, Weinrich, Wertz, Kleczewska, & Carlson, 1989; Weinrich, Steele, Carlson, Kleczewska, Wertz, & Baker, 1989). The C-VIC is designed to offer representational graphic symbols in conjunction with synthetic voice output to nonspeaking individuals (Weinrich, 1992). Additionally, the development of C-VIC has enabled researchers to study the relationship between processes involved in an alternative form of communication and in natural language communication (Weinrich, McCall, Weber, Thomas, & Thornburg, 1994). In general, results with C-VIC indicate that individuals with chronic, severe, or global aphasia can access, manipulate, and combine graphic symbols following rules specific to the C-VIC system. Further, researchers have demonstrated that C-VIC training on simple subject-verb-object (S-V-O) sentences and prepositional phrases results in marked improvement of verbal production of those phrases and sentences by severe/global aphasics (Weinrich et.al, 1994).

A critical aspect of AAC intervention in this study was to provide efficacy data on an alternative form of communication. Specifically, eight individuals with severe aphasia received intensive training on the TS. During the first phase of the training, participants were trained in two primary tasks: first, accessing the software program; second, identifying and manipulating symbols/vocabulary items from different grammatical categories. After the participants had demonstrated the ability to successfully access the TS and to select the symbols without any cues, training consisted of expanding the symbol vocabulary. A set of symbols specific to each participants individual needs were introduced after consultation with the caregivers and other support personnel. Finally, participants were trained on simple subject-verb (S-V) constructions with training focusing on comprehension and production of those sentences. Additionally, the Boston Assessment of Severe Aphasia (BASA) (Helm-Estabrooks, Ramsberger, Morgan, & Nicholas, 1989) was administered before the beginning of the training to study the relationship between BASA scores and symbol learning.

Subjects

Eight severely aphasic individuals participated in this study after informed consent was obtained from either the subjects or their caregivers. All participants had suffered only left hemisphere strokes by history, medical records, and computerized tomography (CT) scan reports, and were at least 6 months post onset before the beginning of the TS training. All participants had right hemiplegia, and none of them had any college education. Minimal criteria for participating in the study included the ability to select symbols using trackball or mouse and adequate visual skills as determined by the ability to match identical symbols. Subjects were referred by speech-language pathologists working at long term care facilities and nursing homes

The Boston Assessment of Severe Aphasia (BASA) (Helm-Estabrooks, Ramsberger, Morgan, & Nicholas, 1989) was administered to all participants. Results of this assessment and demographic characteristics of subjects are presented in Tables 1 and 2.

Subject	Approximate Age	Gender	Approximate Time of CVA	Site of Lesion
1	69	F	1994	Left CVA
2	62	M	1994	Left CVA
3	57	M	1990	Left CVA
4	75	M	1989	Left CVA
5	69	M	1990	Left CVA
6	82	F	1994	Left CVA
7	73	M	1994	Left CVA
8	75	M	1994	Left CVA

Table 1. Demographic and clinical characteristics of the selected subjects.

Subject	Auditory Comprehension		Praxis (Bucco-Facial and Limb)		Oral-Gestural Expression		Reading Comprehension		Other Items		BASA Total	
	Total Correct	Percent	Total Correct	Percent	Total Correct	Percent	Total Correct	Percent	Total Correct	Percent	Total Correct	Percent
1	13	81.25	4	66.67	10	47.62	8	72.73	6	85.71	41	67.21
2	10	62.50	3	50.00	13	61.90	10	90.91	7	100.00	43	70.49
3	12	75.00	5	83.33	3	14.29	9	81.82	4	57.14	33	54.10
4	12	75.00	5	83.33	16	76.19	9	81.82	4	57.14	46	75.41
5	11	68.75	4	66.67	5	23.81	1	9.09	4	57.14	25	40.98
6	0	0	0	0	1	4.76	0	0	0	0	1	1.64
7	12	75.00	4	66.67	5	23.81	10	90.91	4	57.10	35	57.30
8	9	56.25	2	33.30	14	66.60	8	72.70	5	71.40	38	62.20

Other Items = The sum of gesture recognition, writing, and visuo-spatial tasks.

Table 2. Subjects' performances on the Boston Assessment of Severe Aphasia (BASA).

Training Material

The TS software was loaded onto an IBM compatible lap-top computer. A lap-top computer was used so that the investigator was able to collect data at long term care facilities. The graphic symbols used in this study were Picture Communication Symbols (PCS) (Mayer-Johnson Co., 1990). The PCS symbols were obtained from picture library files included in the TS software. The PCS are primarily comprised of simple line drawings that represent the referents most commonly used in daily communication (Johnson, 1985). In comparison to other symbol sets, the PCS are the most translucent across nouns, verbs, and modifiers (Bloomberg, Karlan, & Lloyd, 1990).

Initially, a total of 61 PCS symbols 1 (Appendix A) were developed and placed in separate grids across multiple screens in a logical sequence. For example, when a participant clicked on the symbol "need", a new screen emerged with the following symbols: "water", "pillow", "bathroom", "medicine", "blanket", and "nurse". The number of symbols on each screen varied depending on the number of logical sequences. Further symbols such as "he", "she", and "my" were added to screens representing noun and verb symbols so that participants could be trained to combine symbols to produce simple S-V (e.g., He walks) sentences. A separate TS file comprising of several symbol screens was created for each subject. Figure 2 displays the separate symbol screens developed for baseline evaluation and training.

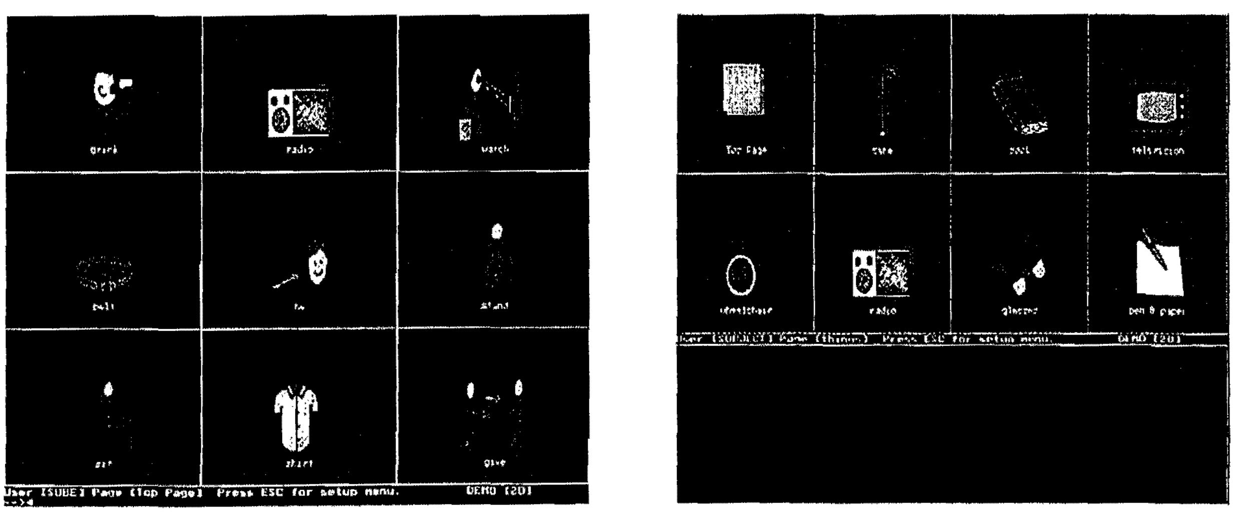

Figure 2 - Talking Screen symbol screens

The initial vocabulary was selected from various word lists (AAC Vocabulary Manager, 1993; Worthley, 1978) based on the criteria that the words had potential for frequent use by participants residing in long term care facilities. Those participants who successfully acquired symbols for all the initial vocabulary items, were subsequently trained on other referents. These additional vocabulary items were specific to the individual participant's needs and were selected after formal consultations with the immediate caregivers. The caregivers were asked to provide the investigator with a list of words that they thought were of immediate functional use to the individual participant. Appendix B presents the referents for additional symbols acquired by each participant. Some of the additional referents on which participants were trained varied from subject to subject. The DECtalk synthesizer (Model DTC01-AA), which is compatible with TS software, provided speech output representing symbol or symbols selected by the participant or the investigator.

Procedures

Each subject received individualized training at least twice per week for approximately 16 to 21 hours. All subjects were seen in their rooms at the nursing care facility. A structured treatment protocol was followed with successively more and more difficult tasks introduced in a hierarchical fashion. Participants were first taught the mechanics of the computer and the TS program. The subgoals for participants at this stage were to learn to turn on the computer by pushing the power button, to manipulate the cursor using mouse or trackball, to understand that symbols are hierarchically organized across several screens, and to learn to move between different symbol screens. Simultaneously, they were taught noun symbols through identical and nonidentical matching. The identical matching involved the following steps: first, participant's attention was drawn to the PCS mounted on the index card; next, the investigator moved the cursor and selected the PCS on the screen which matched the symbol on the index card. These two steps were repeated twice for each referent. After this, the investigator would request the participant to match the symbol on the index card to the symbol on the screen by moving the cursor and clicking on the symbol. If the participant correctly matched the symbols in two consecutive trials, the training proceeded on to the next noun referent. If the participant was unable to match the symbol on the index card with the one on the screen, the investigator repeated the task. The same process was repeated for non-identical matching excepting that participants were required to match the verbal production of the symbol by the investigator to the PCS on the screen. For a complete description of the training paradigm see Appendix C.

Those subjects who could match and retrieve noun symbols with greater than 90% accuracy were introduced to symbols for verb referents for subject-verb (S-V) constructions using verbs such as "wash" and "sleep", and for more complex sentence constructions such as, "He drinks water." The participants were trained to produce S-V-O constructions by instructing them to describe pictures using symbols on the computer screen. For example, the participants would be shown a picture of a boy washing a car. Subsequently, the investigator would select and click on the symbols that describe the picture. After this, the participants would be instructed to describe the same picture by selecting appropriate the symbols in correct order. The correct order for the construction "He drinks water" would be selecting first the symbol for "he", followed by the symbol for "drinks", and then the symbol for "water". If the participants chose the wrong order, they were provided with appropriate corrective feedback.

Scoring Procedure

Responses were scored for each probe administered during the evaluation phase . Each response was analyzed as either correct or incorrect using a binary scoring system (+/-). The following dependent variables were measured during the process of training: (1) rate of learning of symbols from different grammatical categories; (2) percent correct expressive use of symbols during picture description task; and (3) percent correct identification of symbols in different contexts. Some subjects did not require any training for a few of the core and specific vocabulary symbols as they obtained correct responses for those during baseline evaluation. Those symbols were not considered for analysis of the results.

Results

The purpose of this study was to implement and evaluate the effectiveness of a computer based graphic symbol communication system in a group of individuals with severe aphasia. The results of this study are provided under the following subheadings:

Accessing computer software program

One of the most distinctive aspects observed during computer training was the relative ease and speed with which the aphasic individuals learned the computer skills necessary to operate the graphic symbol program. With the exception of subject 6, all subjects acquired the basic skills necessary to access and manipulate the software program. Four of the eight subjects learned the skills to operate the computer and the TS program within few trials. These four subjects had absolutely no difficulty with the established hierarchical system used in TS. However, subject 6 was unable to acquire the skills necessary to move the cursor and access the graphic symbols independently. The investigator, through the use of physical cues, helped her to move the trackball for the selection of the symbols. Subject 6 was the oldest participant in the study. She learned fewer symbols than any other subject in this study.

Training contexts

Performance varied across the two training contexts. Overall percentage scores for all the subjects were higher in the Picture Communication Symbol Matching (PCSM) context than that for the Verbal Production Matching (VPM) context. The reason PCSM percentage scores were relatively superior for all subjects is because this context involves a simple identical matching task. Subjects in this task did not have to infer meaning from the picture. They simply matched a PCS symbol on the index card to the PCS on the computer screen. As aphasia involves disturbances in verbal comprehension and production, it was not surprising that the VPM context generally presented a greater challenge to all subjects.

Noun condition

Results from this study suggest that seven of the eight subjects were able to learn all noun symbols with performance patterns yielding high percentage scores for both training contexts (see figure 3). Across subjects, scores ranged from 80.21% to 100% in the PCSM context. However, scores noticeably decreased in the VPM context, with scores ranging from 24.67% to 95.83%. The most notable decrease was seen in subject 4's percentage scores. He scored an average of 92.54% in the PCSM context and an average of 62.65% in the VPM context. Subject 6's average percentage score for the noun condition was 80.21% in the PCSM context and 24.67% in the VPM context. Subject 6's responses during the training sessions were slow and labored. It often took an entire session to train one context. Subject 6's baseline scores for untrained symbols remained at 0% for all training sessions, indicating treatment was effective. Similar results have been observed in previous studies where aphasic individuals were trained with graphic symbols and manual signs. (Coelho & Duffy, 1987; Skelly, Schinsky, Smith & Fust, 1974; Weinrich, Steele, Kleczewska, Carlson, & Baker, 1987).

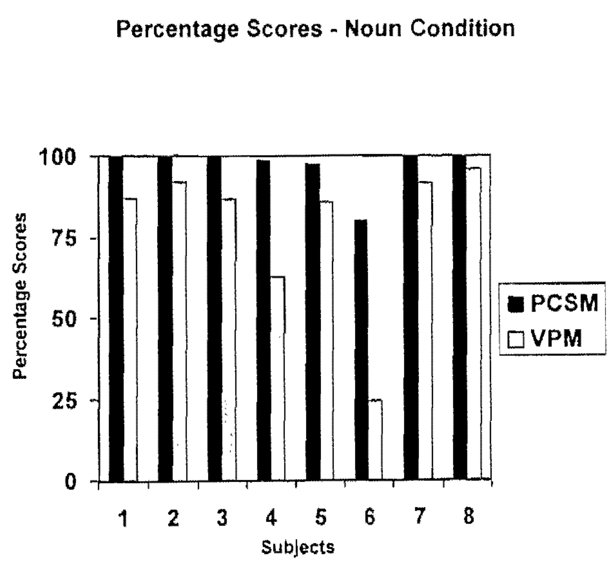

Figure 3. Average percentage scores obtained by each subject for the *noun condition* across two contexts: Picture Communication Symbol Matching (PCSM) and Verbal Production Matching (VPM).

In summary, results obtained for the noun condition indicate that since noun symbols tend to be iconic and concrete, these symbols are acquired easily. These results are supported by Funnell and Allport (1989), who found that words and graphic symbols with high iconicity and high concreteness were acquired more frequently than words and symbols with low iconicity and low concreteness by individuals with aphasia. The finding that translucency has a facilitative effect on learning also has clinical implications. If the goal of aphasia therapy is to provide an immediate means of communication to individuals with chronic severe aphasia, then it would be important to consider choosing initial lexical items which have a high degree of visual relationship between the symbol and the referent.

Verb condition

Percentage scores for all subjects decreased in the VPM context for the verb condition as compared to the PCSM context (see figure 4). The scores in the PCSM

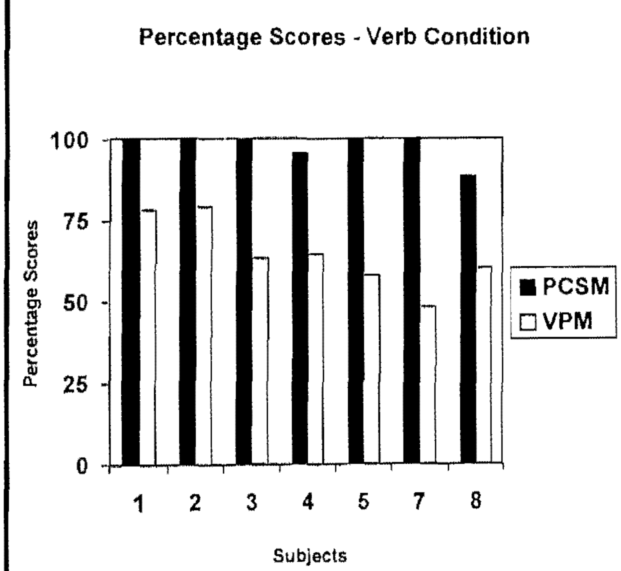

Figure 4. Average percentage scores obtained by each subject for the *verb condition* across two contexts: Picture Communication Symbol Matching (PCSM) and Verbal Production Matching (VPM).

Subject 6 did not proceed to this level.

context for verbs ranged from 88.88% to 100%. Additionally, percentage scores for the verbs in the VPM context were significantly low compared to the noun scores in VPM condition. Subject 5's average score was 85.56% in the VPM context for the noun condition and 57.94% in the VPM context for the verb condition which indicates a significant decrease in performance. Further, across subjects, no generalization to untrained verbs was observed. The results obtained are in essence with previous studies that have demonstrated that aphasic individuals have significant difficulty in retrieving verbs and applying verbs to novel contexts (Weinrich, 1992).

S-V Condition

Seven subjects in the present study demonstrated the ability to comprehend simple syntactic constructions (e.g., " she walks") with varying degrees of success (see figure 5). Although there was not a significant difference between percentage scores in

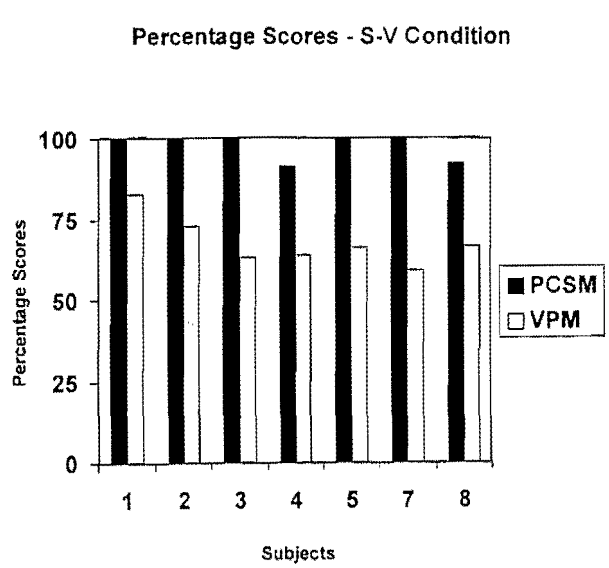

Figure 5. Average percentage scores obtained by each subject for the *S-V condition* across two contexts: Picture Communication Symbol Matching (PCSM) and Verbal Production Matching (VPM).

Subject 6 did not proceed to this level.

the S-V and the verb condition, performance across subjects for the S-V condition was significantly lower than that for the noun condition. The most notable response pattern observed during this training phase was the frequent usage of incorrect verbs (e.g.,"he needs money" instead of "he wants money").

Symbol production

A picture description task was used to evaluate the independent production of simple syntactic phrases (see figure 6). The average correct percentage scores on symbol production tasks across subjects ranged from 36.67% to 81.25%. During this phase of training, subjects presented a variety of errors. These errors included omission of the verb portion of the phrase (e.g., stimulus: "he gives ice-cream", subject's response: "he ice-cream"), selection of the wrong verb (e.g., stimulus: "she writes",

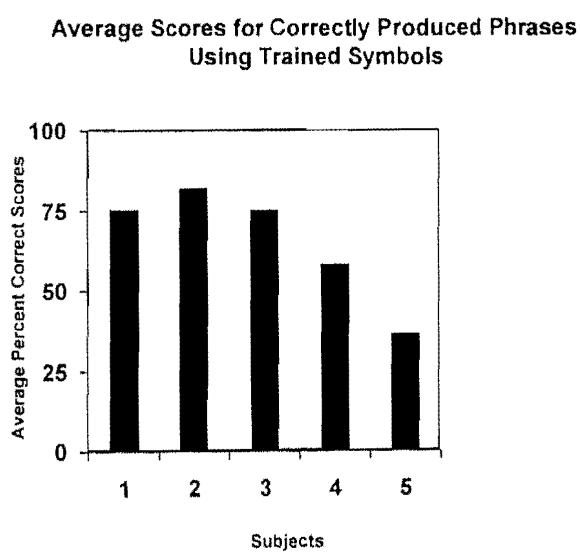

Figure 6. Average percentage correct phrases correctly produced by each subject.

Subject 6 did not proceed to this level and subjects 7 and 8 were not trained at this level.

subject's response: "she reads"), incorrect syntactical order (e.g., stimulus: "children eat hamburgers", subject's response: "children hamburger eat"), absence of subject and/or object (e.g., stimulus: "he reads book", subject's response: "he reads"). In summary, results indicate that individuals with severe aphasia performed better in receptive tasks as compared to expressive tasks.

Symbol learning and BASA Scores

In this study, subjects who obtained overall BASA scores greater than 26, learned more symbols with relative ease than compared to subjects whose BASA scores were below 26. Naeser, Palumbo, Baker, and Nicholas (1994) proposed that an overall score of 26 on the BASA test and a score of 7 on the auditory subtest of the BASA corresponds to an overall good performance on Computer - visual input communication. Any score below that may suggest a poor prognosis for computer based graphic symbols learning. However, future research needs to focus on the collection of data that can provide clinicians a prognostic indication vis-a-vis computer-based graphic symbol intervention.

Symbol training and development of communication books:

The rate of learning of symbols across different grammatical classes is shown in figure 7. After subjects demonstrated learning of both core and specific symbols, they were provided with a communication book. The communication book contained symbols specific to each individual subject. The caregivers and the subjects were trained on the efficient and effective use of the books.

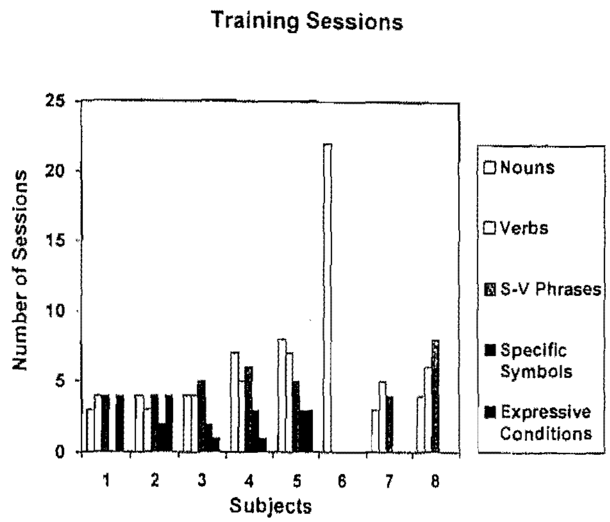

Figure 7. Number of sessions required for subjects to learn noun symbols, verb symbols, subject-verb (S-V) phrases, specific symbols, and expressive use of symbols.

Subjects 1,7, and 8 were not trained for specific symbols and Subject 6 required all 21 sessions for noun training.

Discussion

Overall, the results of this study reveal significant findings on graphic symbol learning in individuals with severe aphasia. This study indicated that: (1) individuals with severe aphasia are capable of learning the mechanics of a computer to access and manipulate graphic symbols; (2) subjects learned nouns with greater proficiency and ease than verbs; (3) the S-V and S-V-O phrase conditions were as difficult as the verb condition but more difficult than the noun condition; (4) the majority of the subjects' errors in the expressive condition were in the use of verbs in addition to one subject who demonstrated word order problems when constructing a simple S-V-O phrase.

The finding that individuals with aphasia can learn graphic symbols has significant clinical and theoretical implications for aphasia therapy. The ability of individuals with severe aphasia to acquire graphic symbols, and their inability to reacquire spoken language skills even after long and intensive therapy provides support for a theory of multiple symbolic capacities. Aphasiologists have debated frequently whether aphasia entails a central symbolic deficit in which there is a decrease in competence across a range of symbol systems (i.e., from non-verbal pictures to purely linguistic symbols), or if aphasia specifically impairs only the ability to process linguistic symbols. The theory that there are multiple profiles of symbolic capacities in aphasia is strongly supported by the data obtained in the current study on recognition and production of graphic symbols. If the main objective in aphasia treatment is to improve the ability of aphasic individuals in order for them to convey their thoughts and ideas, clinicians need to consider incorporating an alternative non-speech modality into the rehabilitation process. The results from this study are limited to receptive and expressive tasks involving matching of single graphic symbols and production of simple syntactic constructions. Future research should extend to designing studies in which (1) aphasic individuals use graphic symbols in explicitly communicative acts such as receiving and giving commands, answering and asking questions, and expressing events in reference to present, past, and future; (2) aphasic individuals use of graphic symbols in novel contexts to increase their communicative effectiveness; (3) studying the pattern of errors observed during the use graphic symbols and comparing them to errors observed during natural language evaluation.

Recommendations

The major aim of this demonstration project was to implement and evaluate the effectiveness of a computer-based graphic symbol communication system in a group of older individuals with severe aphasia. A critical aspect of AAC intervention in this study was to provide efficacy data on an alternative form of communication. Results of this study suggest that the use of computer technology in conjunction with graphic symbols can significantly enhance the communicative abilities of individuals with severe and/or global aphasia. In general, the observed improvement in communicative abilities as a result of high-technology AAC intervention also suggests that this intervention may significantly enhance the quality of long term resident care as nonspeaking individuals with aphasia will be able to explicitly convey their wants and needs and other relevant information to nursing care personnel. However, the successful outcome of technology-based approaches are dependent upon the extensive involvement of communication partners in the intervention program. The results of this study suggest that caregivers, as well as nursing care personnel, are willing to participate in the selection of symbol vocabulary and the use of communication books.

By sponsoring this demonstration research project, the Institute for Quality Improvement in Long Term Health Care (IQILTHC)has helped in providing data on an aphasia treatment based on an alternative form of communication. This data will help speech-language pathologists and other allied health professionals working in acute care settings, rehabilitation centers, and nursing homes make informed decisions in the selection of the appropriate treatment for individuals with severe aphasia.

At a public policy level, the option of high-technology AAC approaches needs to be available as individuals with severe aphasia make transitions from the acute rehabilitation setting to either the long term care facility or home. However, the inclusion of these high-technology approaches may involve the modification of service guidelines as well as funding by a variety of agencies. It is recommended here that IQILTHC play a crucial role in encouraging public policy changes in this area.

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Appendix A

1. apple
2. bathroom
3. belt
4. blanket
5. book
6. bread
7. brush
8. candy
9. cane
10. cheese
11. children
12. comb
13. cookie
14. deodorant
15. drink
16. eat
17. give
18. glasses
19. hamburger
20. he
21. help
22. ice-cream
23. light
24. lunch
25. man
26. medicine
27. money
28. my
29. need
30. nurse
31. pants
32. pen and paper
33. pillow
34. pajamas
35. radio
36. razor
37. shampoo
38. she
39. shirt
40. shoes
41. sit
42. sleep
43. smell
44. soap
45. socks
46. soup
47. stand
48. sweatshirt
49. television
50. toothbrush
51. toothpaste
52. walk
53. want
54. wash
55. washcloth
56. watch
57. water
58. wheelchair
59. woman
60. write
61. you

S-V Phrases

children eat

children sleep

he brushes

he drinks

he eats

he gives

he helps

he washes

she brushes

she drinks

she gives

she helps

she sleeps

she stands

she walks

she washes

she watches

she writes

you sit

Appendix B

airplane
bathe
bed
buy
candy
cap
car
cigarette
coat
coke
daughter
doctor
draw
egg
fast
food
game
happy
hungry
hurt
letter
lunch
mad
milk
money
pickup
pie
pizza
sad
shaving cream
shop
shower
sick
slippers
slow
smoke
soda
store
sweater
sweatshirt
thank you
thirsty
tired
towel
travel
truck
walkman
western

Appendix C

Computer Training

- Skill: to learn the mechanics of the computer and the "Talking Screen" program.

- Subject subgoals:
  1. To push the power button to turn on the computer.
  2. To manipulate the cursor by learning how to move the mouse.
  3. To click the mouse button.
  4. To learn selection of a graphic symbol by placing the cursor on the symbol and pushing the button.
  5. To understand that symbols are hierarchically organized based on semantic categories.
  6. To learn how to move between different symbol pages.

- Sample Script:

Investigator: " I am going to teach you how to use this computer. I am going to demonstrate to you certain steps and then I will allow you to try the same steps."
(Models how to turn on the computer by pushing the red power button.)
Subject: (Subject imitates investigator by pushing the red power button and the computer is turned on.)
Investigator: (Models how to move the trackball in order to move the cursor to a certain symbol on the screen.)
Subject: (Subject imitates investigator by moving the tracking ball to access a certain graphic symbol.)

Noun Training

- Skill: To learn nouns

- Subject Subgoals:

1. To select a target symbol accurately in two consecutive probes during both identical and non-identical matching contexts
Materials: PCS mounted on an index card.

- Sample Script:

Context 1 (PCS to symbol matching)
Subject: The subject's attention was drawn towards the PCS denoting the symbol on the screen.
Investigator: The investigator moved the cursor and selected the symbol which matched the PCS of a target noun. The same procedure was repeated twice.
Subject: Then the subject was asked to select the symbol which matched the PCS of a noun. The subject was asked to repeat this task twice. If the subject correctly selected the symbol in two consecutive probes, training proceeded to the next noun referent.

If the subject was unable to match the PCS and the symbol correctly, the investigator repeated the task.

Context 2 (VP to symbol matching)

- Sample Script:

Subject: The subject listened to the verbal production of a noun referent.

Investigator: Verbally produced the word for a noun referent. Then the investigator moved the cursor and selected the symbol which matched the VP of a target noun. The same procedure was repeated twice.
Investigator: The investigator verbally produced the word in order for the subject to match the VP to the symbol on the screen.
Subject: The subject was asked to select the symbol which matched the VP of a noun. The subject was asked to repeat this task twice. If the subject correctly selected the symbol in two consecutive probes, the training proceeded to the evaluation phase. If the subject was unable to match the VP and the symbol correctly, the investigator repeated the task.

- Evaluation

The investigator informed the subject that she would orally produce the word for a noun referent in random order. The investigator instructed the subject to select the symbol which matched the VP of the target noun. If the subject correctly selected the symbol, evaluation procedures proceeded to the next noun referent. If the subject was unable to match the VP to the symbol correctly, the investigator showed the subject where the correct match was and asked the subject to try selecting the target symbol again. If the subject correctly selected the symbol in two consecutive probes, the evaluation proceeded to the next noun referent.

Note: Identical procedures were applied for training verbs, specific vocabulary items, and S-V-O combinations.

S-V and Specific Vocabulary Training
Note: subgoals, scripts of procedures, and evaluation procedures will not be listed separately for these phases

- Skill: To describe a picture by using graphic symbols on the screen.

- Subject Subgoals:
  1) To choose the appropriate symbols to describe the picture.
  2) To place symbols in the correct order.
- Sample Script:

Investigator: Asked subject to look at a picture carefully. The picture was a boy washing a car. Then, the investigator instructed the subject to look at all the graphic symbols on the screen. The investigator then asked the subject to choose graphic symbols that could

describe the picture. The investigator told the subject to place the graphic symbols in the correct order as demonstrated earlier.
Subject: Looked at picture and chose the verb of the sentence that described what the boy was doing (i.e., washing).
Investigator: Told the subject he was right but when we produce a sentence we must begin the sentence with a certain word. The investigator only gave clues as to what the word was. Then the investigator told the subject to remember back when we worked on sentences. What was the first word?
Subject: The subject remembered and chose the noun "he". Then the subject chose "wash" and "car".
Investigator: Told the subject he was right and then asked the subject to put together the whole sentence one more time.
Subject: The subject chose "He wash car".
Investigator: Commented on how well the subject was doing and then proceeded to the next picture.