Evaluating Performance of Severely Aphasic Patients on a Computer-aided Visual Communication System

Richard D. Steele, Michael Weinrich, Maria K. Kleczewska, and Gloria S. Carlson
Palo Alto Veterans Administration Medical Center, Palo Alto, California

Robert T. Wertz
Martinez Veterans Administration Medical Center

INTRODUCTION AND BACKGROUND

Novel approaches in the rehabilitation of severe aphasia require ingenuity and scrupulousness in the collection, analysis, and interpretation of data. The more novel the approach, the less one can rely on clinical intuitions or preceding work, and the greater the necessity to generate well designed, specially targeted, controlled studies to confirm or disprove specific hypotheses. Our work to develop a Computer-aided, Visual Communication (C-VIC) system provides an apt example.

Gardner and colleagues (1976) developed a manual, visually representative, alternative communication system (VIC) for severely aphasic patients. They did not use controlled single-subject designs and left few tracks for subsequent work to follow. Thus, our effort to computerize the VIC system (C-VIC) did not inherit well-developed, coherent methodologies for establishing training efficacy, selecting rules for visual lexical representation, or choosing between competing system designs. Much of the C-VIC work has sought to address these issues.

Initially, we modified the PICA scoring system to rate performance in our visually based medium. The result, described in the Appendix provides a sensitive measure of performance for our computer-aided communication system. The scoring adaptations reflect the fact that our computer interface requires patients to deal with some entirely unfamiliar entities, such as "windows" and "menu bars" (areas on the computer screen which appear, support manipulations of various kinds, and disappear). It also requires patients to perform novel operations, such as dealing with hierarchies of symbols, transferring images discontinuously from place to place, retaining in memory the images which have been selected for operations, and "stacking up" procedures for eventual serial performance. These tasks were not encountered in earlier work, much less scored.

The purpose of this paper is to report our use of a computer to enhance communication, while describing techniques to monitor performance during training, identify trends in performance, formulate hypotheses about trends, and conduct single-subject designs which enabled us to understand better the nature of the processes at work.

CASE REPORT

The data in this report reflect the performance of a single patient, MC. He is a 63-year-old right-handed man who was well until July, 1983, when he suffered a massive left intracerebral hemorrhage. At that time, an emergency craniotomy and clot evacuation were performed. Post-operatively, he has been left with a severe right hemiplegia, a moderate right visual field deficit, and global aphasia. Table 1 shows his recent BDAE and PICA performance

Table 1. MC's Boston Diagnostic Aphasia Examination and Porch Index of Communicative Ability performance.

	PERCENTILES:	0	10	20	30	40	50	60	70	80	90	100
SEVERITY RATING			(0)	1				2		3	4	5
FLUENCY	ARTICULATION RATING		(1)	2	4	5	6		7			
	PHRASE LENGTH			(1)	3	4	5	6	7			
	MELODIC LINE		(1)	2	4		6	7				
	VERBAL AGILITY		(0)	2	5	6	8	9	11	13	14	
AUDITORY COMPRE-HENSION	WORD DISCRIMINATION	0 (11)	15	25	37	46	53	60	64	67	70	72
	BODY-PART IDENTIFICATION	(0)	1	5	10	13	15	16	17	18		20
	COMMANDS	0 (1)	3	4	6	8	10	11	13	14	15	
	COMPLEX IDEATIONAL MATERIAL		0	2	(3)	4	5	6	8	9	11	12
NAMING	RESPONSIVE NAMING			(0)	1	5	10	15	20	24	27	30
	CONFRONTATION NAMING		(0)	9	28	43	60	72	84	94	105	114
	ANIMAL NAMING				(0)	1	2	3	4	6	9	23
ORAL READING	WORD READING			(0)	1	6	7	15	21	26	30	
	ORAL SENTENCE READING					(0)	1	2	4	7	9	10
REPETITION	REPETITION OF WORDS		(0)	2	5	7	8		9		10	
	HIGH-PROBABILITY			(0)	1		2	4	5	7	8	
	LOW-PROBABILITY					(0)	1		2	4	6	8
PARAPHASIA	NEOLOGISTIC	40	16	9	4	2	1		(0)			
	LITERAL	47	17	12	9	6	5	3	2	1	(0)	
	VERBAL	40	23	18	15	12	9	7	4	3	1	(0)
	OTHER	75	12	5	3	1	(0)					
AUTOMATIC SPEECH	AUTOMATIZED SEQUENCES		(0)	1	2	3	4	6	7		8	
	RECITING				(0)	1				2		
READING COMPRE-HENSION	SYMBOL DISCRIMINATION	0 (1)	2	5	7	8	9		10			
	WORD RECOGNITION	0	(1)	3	4	5	6	7		8		
	COMPREHENSION OF ORAL SPELLING				(0)	1		3	4	6	7	8
	WORD-PICTURE MATCHING		(0)	1	4	6	8	9		10		
	READING SENTENCES AND PARAGRAPHS		(0)	1	2	3	4	5	6	7	8	0
WRITING	MECHANICS	1		(2)		3		4			5	
	SERIAL WRITING		(0)	7	18	25	30	33	40	43	46	47
	PRIMER-LEVEL DICTATION		0	(1)	4	6	9	11	13	14	15	
	SPELLING TO DICTATION					(0)	1	2	3	5	7	10
	WRITTEN CONFRONTATION NAMING				(0)	1	2	3	6	7	9	10
	SENTENCES TO DICTATION						(0)	1	3	6	8	12
	NARRATIVE WRITING		(0)	1			2			3	4	5
MUSIC	SINGING		0	(1)		2						
	RHYTHM		0	(1)				2				
SPATIAL AND COMPUTA-TIONAL	DRAWING TO COMMAND	0	6	7	8	9	10	11	12		13	
	STICK MEMORY	0	3	4	6	7	8	9	10	11	13	14
	3-D BLOCKS		0	2	4	5	6	7	8	9	10	
	TOTAL FINGERS	0	54	70	81	93	100	108	120	130	141	152
	RIGHT-LEFT	0	1	3	4	6	8	9	11	14	16	
	MAP ORIENTATION	0	2	5	6	9	11	13		14		
	ARITHMETIC		0	2	4	8	11	14	17	21	27	32
	CLOCK SETTING	0	3	4	6		8	9	10	12		
		0	10	20	30	40	50	60	70	80	90	100

PICA SCORES

Overall: 9th Percentile
Gestural: 6th Percentile
Verbal: 2nd Percentile
Graphic: 24th Percentile

From June 1986 through December 1986, MC was an inpatient at the Palo Alto VA Medical Center, receiving training in the use of the C-VIC system two hours a day, five days a week.

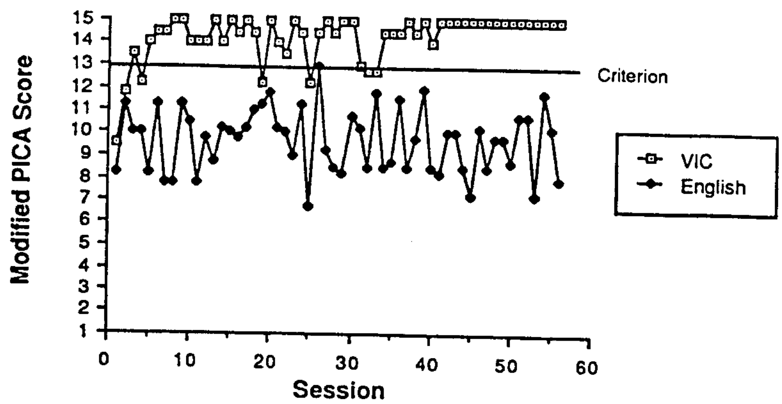


Figure 1. Receptive performance for Subject MC for first two weeks of training.

We monitored MC's performance from the outset. Figures 1 and 2 show the evolution of MC's receptive and expressive abilities in natural English and in C-VIC during early training. These data show performance when MC received equivalent training on functionally analogous tasks in English and in C-VIC. Figure 1 shows his ability to select an item from a field of objects in response to a spoken word or presentation of a C-VIC symbol. The criterion score of 13 represents functionally useful performance. MC's receptive performance in C-VIC stabilized above criterion, but receptive English remained nonfunctional throughout, with no discernible trend toward improvement. In Figure 2, the contrast in MC's expressive performance is even more dramatic. He remains unable to speak the name of any object, but his ability to retrieve the C-VIC symbol designating objects presented stabilized above criterion.

The limitation of the data presented in Figures 1 and 2 is that they do not establish what caused MC's receptive and expressive C-VIC performance to improve. The improvement was important, because it indicated that MC could handle the cognitive and motoric demands made by the system at this level. If performance had not improved, C-VIC might be contraindicated for MC, or modifications in the system might be necessary. Still, to understand the causality of phenomena that training-only studies may document, one must employ a different design.

EXPERIMENT I

FIELD SIZE STUDY

We had observed that MC's receptive performance, at least in response to spoken English, deteriorated as the number of stimuli increased. We surmised that field size was the controlling factor for competence and accuracy

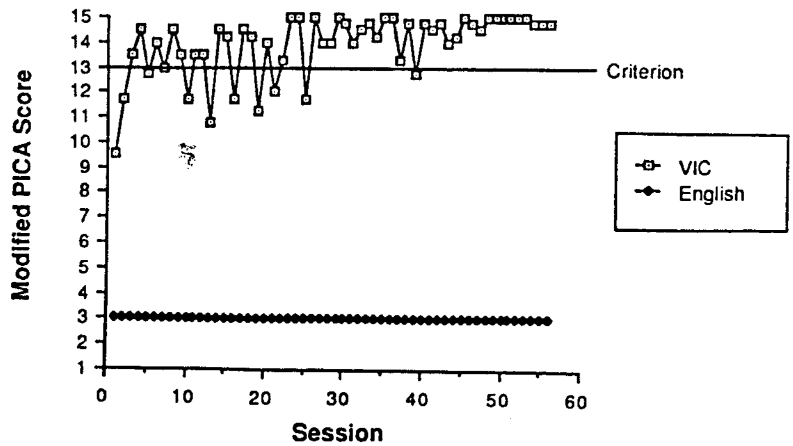


Figure 2. Expressive performance for Subject MC for first two weeks of training.

in response to verbal stimuli, and a study was designed to test the hypothesis that MC's receptive English performance deteriorates to chance levels as the number of items before him increases. We further hypothesized that performance in C-VIC would not be influenced by field size, so that increasing the number of objects would leave MC's performance unaffected. The results are shown in Figure 3.

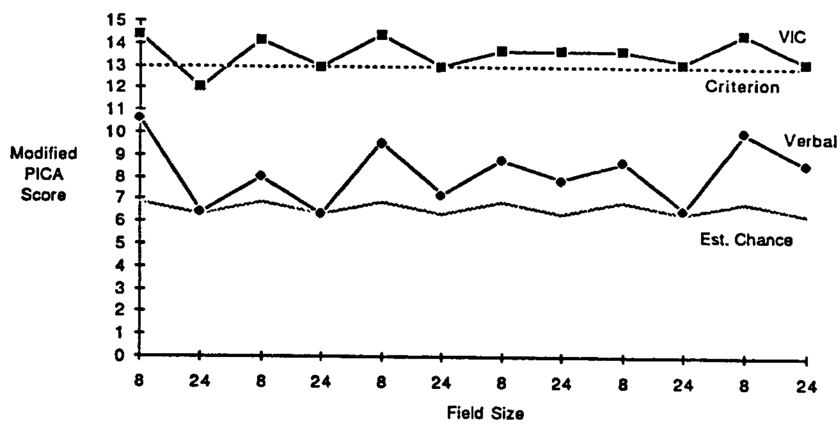


Figure 3. Subject MC's performance in field size study.

MC was required to select, one at a time in response to the spoken English name, 8 objects randomly selected from a previously trained set of 24. These 8 objects were: a) mixed in with the remaining 16 objects as foils (field size = 24); b) mixed in with 8 foils randomly selected from those 16 (field size = 16); or c) not combined with foils (field size = 8). In each condition, he was asked to select the 8 objects, and his accuracy was recorded.

Figure 3 shows that MC's performance was consistently better with the smallest field size (8) than the largest field size (24). Indeed, in half the trials with the largest field size, his performance in response to spoken English was no better than chance. The data also reveal no trend toward improvement over time. These results confirmed the hypothesis that increasing the field size was causing MC's performance in the English-only condition to decline. In comparison, his performance in response to C-VIC was, with a single early exception, functional at both the largest and smallest field sizes.

Clinically this approach was useful. It provided a practical and principled way to select between ongoing alternate therapies. The result justified discontinuing training in spoken English, because MC's already nonfunctional performance deteriorated when the number of stimuli was increased. Conversely, the C-VIC results in this study justified a decision to continue this type of therapy with MC, because (with a single exception) performance using the C-VIC system exceeded criterion performance regardless of the number of stimuli presented. While field size did influence C-VIC performance, MC could nonetheless use C-VIC at or above criterion with either 8 or 24 stimuli present.

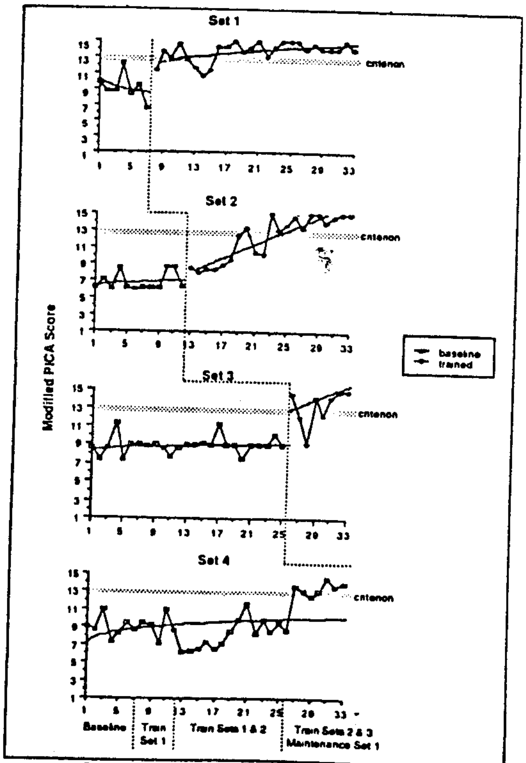
EXPERIMENT II

ABSTRACT "NAMING" STUDY

A second single-subject study looked at another question -- whether MC's C-VIC performance relied upon picture-to-object matching, or whether MC was capable of more abstract "naming" behavior. In this study, he was required to produce the C-VIC symbol for an object after the trainer pantomimed the use of that object. While the actions of the pantomimes were selected to be easily comprehensible (e.g., a peeling and eating motion for "banana," or a dialing and speaking motion for "telephone"), they were presented in the absence of the object. Thus, to perform correctly, MC had to interpret the pantomime to infer the object intended.

Twelve objects familiar to MC were selected, assigned randomly to 4 different categories, and the order of training and testing of the subgroups was randomized. First, baseline for all 4 groups was established. Then, while MC was trained on the first subgroup, performance in all subgroups was monitored periodically. When MC's performance with the first subgroup exceeded criterion in 3 consecutive sessions, training was begun in the second subgroup, and performance monitored in all subgroups until criterion was reached in subgroups 1 and 2 in 3 consecutive sessions. Next training was conducted in subgroups 2 and 3, with subgroups 1 and 4 untreated and performance monitored in all subgroups.

The results, shown in Figure 4, reveal several salient features about MC's learning. First, there is the predictable outcome that he does poorly on a task prior to being introduced to it. MC's pretraining baseline behavior indicates consistent performance below criterion level with no discernible trend either upwards or downwards. Second, subgroups 1, 2, and 3 show the effect of treatment. When MC was trained on each subgroup, his performance in that subgroup improved to exceed criterion. Third, during periods when new material is being integrated, the old material suffers somewhat, with items already at criterion showing a small but noticeable drop in performance when



Trained Learning with Retention and Generalization

Figure 4. Subject MC's performance in multiple-baseline pantomime study.

a new subgroup is introduced. Finally, MC's performance generalized from treated stimuli to untreated stimuli. Performance with the fourth subgroup reached criterion and stayed there for 3 consecutive sessions, even though MC was not trained on these stimuli.

DISCUSSION

The work described here has been necessary to develop and understand an alternative, visually-based communication system for severely impaired aphasic patients. It illustrates the need to combine flexibility and rigor in working within a new context. Modifications of existing tools, such as the adaptation of the PICA scoring system, and their use in controlled single-subject studies can help clarify the nature of the phenomena observed, identify the strengths and weaknesses of trainees, and establish the ways in which the system itself should be designed and operated.

ACKNOWLEDGMENT

This work was supported by the Rehabilitation Research and Development Service of the United States Veterans Administration with additional support from the Apple Corporation and Stanford University

REFERENCES

Gardner, H., Zurif, E., Berry, T., and Baker, E. Visual communication in aphasia. Neuropsychologia. 14, 275-292, 1976.

DISCUSSION

Q: If I understood you right, you were locked into the PICA screening system because the patient had a limb apraxia. My question is did you have to give any training to help him deal with the apraxia of mouse?

A: Actually, no. One of the things that we've noted with all of our trainees is that using a mouse gives them a fairly simple pathway to operating the interface. They appreciate it and they pick it up quite quickly. The mouse is designed to be operated with one hand, and there's only one button on it, so basically you can do two things with it: you can position a cursor on a screen somewhere, and you can press the button. Those are both motorically not overly demanding tasks. For the subjects with which we have worked, these tasks fall entirely within the range of things that they can handle with their left hands. I didn't happen to mention it, but MC--like all the rest of our trainees--was premorbidly right handed and, in this case, now has a severe right hemiplegia which forces him to do things with his left hand. But this falls entirely within the range of things that he can do easily with his left hand.

Q: Did you ever combine verbal responses with the pictograms?

A: Yes, but it wasn't reported on today, and we haven't defined studies that would make it reportable, although we will do that. I have some such studies in mind. Impressionistically, I can tell you what we've noted. At least with the subjects with whom we've worked, we've found that the performance using the C-VIC system in conjunction with spoken English provides them with the best conditions for performance. Their performance is both faster and more accurate.

Q: For those of us who work with patients and have strong feelings about communicative functionality--can you make a comment on that?

A: We've documented that in comparison with the original system--which was implemented on index cards with drawings--use of the C-VIC system allows for both faster performance in retrieving symbols and more consistent performance. This latter is useful because it means that the person has some idea of what level of demand is going to be made on them before they start a task. What we're aiming for eventually is a system which is transportable so it allows people to carry it with them to facilitate their communication in a variety of different settings. To do this, we need to solve a number of problems. The original study demonstrated that there were tasks that are normally mediated by language--like asking and answering questions, giving and receiving commands, describing events, and expressing simple wants. But it didn't transfer out of the clinic, and some of the reasons for it not transfering out of the clinic were: 1) that it was cumbersome to use, 2) it required the user to clear off a large space on the table, and 3) everyone had to be trained on the system. One of the things that we're aiming towards in the system that we're developing is getting around all of those practical kinds of problems by having a small system which doesn't require you to clear off the table, which can be moved around, and which also can be operated by people who haven't necessarily been trained on it. We currently have on the system--and I didn't show you this, because we were using foils with strings of "pqr" so that there would be no evidence that the person was using the printed words to support their performance in this system--not only the capability of putting glosses underneath the pictures themselves, but we have the capability of translating them into grammatical English sentences using a parser and a translator. The parser goes through and determines whether the construction--the string--is grammatical according to the rules of our grammar. If it is, then it hands it off to a translator which could be in any one of a variety of languages--we have English--and then translates it into a grammatical sentence. That can be driven in both ways. One of the things we want to do later is put a keyboard onto this thing so that somebody who doesn't know the system would be able to type in something and it would translate it back into C-VIC.

APPENDIX

Selected Examples of Adaptations of the PICA Scoring System for Use with the C-VIC Project

Illustrative Task: "As completely as possible, tell me what you do with this." (knife)

A. PICA score: 15
- -- "Complete": described as being accurate, responsive, complete, prompt, efficient.[a]
- -- Illustrative verbal response: "You cut." -- produced unassisted, without delay or distortion.[b]
- -- Illustrative C-VIC response: "[.] [JS] [cut] [.]" -- produced unassisted, without delay or symbol misplacement. This is analagous to the verbal response above, judged against: a) the rules of C-VIC grammar; and b) the cognitive and motor demands made by interface operation.

B. PICA score: 14
- -- "Distorted": described as being accurate, responsive, complete or complex, prompt, distorted.
- -- Illustrative verbal response: "Y-o-u c-u-t s-o-m-e m-e-a-t." -- the production might be slow without being delayed; or the speech might be clear but with the aberrant or unusual prosody.
- -- Illustrative C-VIC response: "Distorted" responses are those that meet all the requirements of "complete" responses in regard to meaning and use of C-VIC symbols, but which show difficulty in using the computer medium (e.g., the patient who knows exactly what he means to do, but due to apraxia or motor weakness moves the mouse slowly, or raises it up in the air rather than moving it along the table; or the patient who accidentally clicks the mouse an extra time and erases an image).

C: PICA score: 12
- -- "Incomplete": described as being accurate, responsive, incomplete, prompt.
- -- Illustrative verbal response: "Cut." -- produced unassisted, without significant delay or distortion.
- -- Illustrative C-VIC response: "[.][JS] [eat][.]." This is analogous to the verbal "related", but judged against the rules of the C-VIC grammar and the demands of the interface.

E. PICA score: 3

-- "Minimal": described as being incomprehensible and undifferentiated.

-- Illustrative verbal response: "do do do".

-- Illustrative C-VIC response: Random mouse-screen activity.

---

[a]These category labels and accompanying descriptions are taken directly from the PICA manual.

[b]Here and below, only a single illustrative example is given for each label, although many types of responses fit the category descriptions.