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ABSTRACT

The report describes a series of studies conducted to determine the extent to which severly handicapped students who were able to comprehend language and language structure but who were not able to write or type could communicate using various man-machine systems. Included among the systems tested were specialized electric typewriting machines, a portable telephone communications system for the deaf and/or speech handicapped, and a punctiform tactile communications system for the blind. Reported upon are pilot studies in the instruction of handicapped students at field centers, the development of screening procedures to determine latent reading ability, development of assessment procedures and forms, the use of phonemes of the Armenian language for punctographic codes used by the visually handicapped, a word and picture communications system, and other variations of man-machine communication systems. Numerous photographs illustrate the equipment described. Appendixes contain field center data, experimental studies, instructional procedures and programs, and handwriting and typing samples. (See EC 030 060, EC 050 267-050 270 for related reports.) (KW)

STUDY OF MAN-MACHINE COMMUNICATIONS SYSTEMS FOR THE HANDICAPPED

C/R/I
Vol. III
Final Report

Systems to Enhance Man's Communicative Abilities

C/R/I

C/R/I Final Report

Project No.18-2003 and No.7-0533
Grant No. OEG2-7-070533-4237

STUDY OF MAN-MACHINE COMMUNICATIONS SYSTEMS FOR THE HANDICAPPED

VOLUME III

HAIG KAFAFIAN

CYBERNETICS RESEARCH INSTITUTE

June 19, 1971

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION
BUREAU OF EDUCATION FOR THE HANDICAPPED

"...this is an important work that we do, not just for the handicapped children we serve and their parents, and not just for the teachers who will participate in it. But, it is important work for all of the United States because at least, in part, it helps promote this understanding of equality. Because it helps all American citizens to understand the intrinsic nature of man and that his worth is not dependent on whether his arms and legs work the same as a non-handicapped person's arms and legs work.

Or whether he's as able to quickly grasp arithmetic or reading, or whether his skin is black or white. What is important is that he is a human being and that under our system his humanity must be responded to. Your efforts to bring the right to learn to your children are the efforts which will strengthen the character of our nation. And so, do not hesitate to claim that right. Do not feel your purposes are selfish. They serve every man..."

—Martin. Excerpt from a paper "The Right to Learn" for the 8th Annual International Conference of the Association for Children with Learning Disabilities, Chicago, Illinois, March, 1971, by Dr. Edwin W. Martin, Associate Commissioner, Bureau of Education for the Handicapped, U.S. Office of Education, Department of Health, Education and Welfare.

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Washington, D. C.

The research reported herein was performed pursuant to a grant with the OFFICE OF EDUCATION, U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. Grantees undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official OFFICE OF EDUCATION position or policy.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION
BUREAU OF EDUCATION FOR THE HANDICAPPED

"Responsible and clear thinking national leaders have long recognized that a society has the moral duty to care for its handicapped individuals, be they physically or intellectually disabled. The recognition of this duty can be traced from antiquity as evidenced by the following account:[1] "During the pontificate of St. Nerses the Great, descendant of St. Gregory the Illuminator and Katholikos of Armenia from 353 to 373 A.D., a vast network of hospices, hospitals, and schools dotted the landscape of Armenia. Immediately on accession, Katholikos St. Nerses

'. . . directed that in every province, every canton, and every corner of the territory of Armenia the most suitable places be selected to construct hospices for the indigent and the orphans, and hospitals for the sick, the lepers, the paralytics, that is all those who suffered from any kind of malady. Hospitals for the lepers and for ordinary patients were established simultaneously and provisions made for their daily needs and for giving the poor what was necessary . . . . In every district of Armenia he founded schools . . . . In his home the widows, the orphans, the indigent always found shelter and food, and the poor found solace. His palace and his table were always prepared to receive the poor, the strangers, and the wayfarers. Although he had already built many hospices in every canton and had supplied them with the indispensable provisions so that they may not be obliged to leave their beds and go begging, he, inspired by his great love for the poor, permitted them free access to his palace and the lame, the blind, the paralytics, the deaf, the crippled, the wretched, the indigent, all set at his table and shared his meals.'

Faustus of Buzanda[2]
Circa Mid-5th Century, A.D."

The fulfillment, in our day, of similar responsibilities can be realized. As man approaches the 21st century, let historians record an era exemplified not only by technological achievements that allowed a handful of courageous men to travel to and from the moon. Let future scribes also extol the story of their 20th century forebears, who balanced the scales in the remaining three decades, by directing man's attention to even more fertile fields to be conquered. New vistas here on Earth, with humanitarian goals to be probed and explored, are in view. Let us emulate the work begun by the exemplary Katholicos Nerses with programs that will benefit man, enhance his environment, and allow his progeny to survive.

It is hoped that this study designed to help handicapped children, in a small way, stimulates others to rise to this challenge."*

[1] S. A. Essefian, PhD. "Socio-Political Aspects of Armenian History," Georgetown University lecture series, Washington, D.C., February 1970.

[2] Faustus of Buzanda, *History of Armenia*, ed. P'awstosi Buzandac'woy Patmut'iwn Hayoc' (Venice, 1933), Iv. 4.85. Cf. V. Langlois, *Collection des historiens anciens et modernes de l'Arménie* (2 vols.; Paris, 1866, I, 239–240).

*Haig Kafafian, *C/R/I Second Report, Volume I, 1970*

PREFACE

This third volume of the C/R/I Final Report is the fourth in the series of seven volumes and an interim report covering the C/R/I Study of Man-Machine Communications Systems for the Handicapped. The series includes the C/R/I Interim Report, 1968; Volume I and Volume II of the C/R/I Second Report, 1970; and Volumes III, IV, V, VI, and VII of the C/R/I Final Report, 1971, which present evaluative procedures, demonstration guides, and instructional and training materials developed and utilized in the study. The reports also disclose pilot tests conducted, including research data and analyses, and recommendations. Films of subjects and equipment, and 35mm slides of written and picture messages employed in the study are also part of this final report.

These B.E.H. projects, identified as Project No. 7-0533 and Project No. 18-2003, were supported from June 7, 1967 to June 19, 1971 by the Bureau of Education for the Handicapped, Office of Education, Department of Health, Education, and Welfare under Grant No. 7-070533-4237 and supported in part by Cybernetics Research Institute, (C/R/I), and Cyber Corp., of Washington, D.C.

"But we are 'all-the-way' people. We are committed to the handicapped. We do want to go all the way for the handicapped. We are moving in that direction.

You are pointing the way.

It is the American way, the moral way, the right way.

It is the way of total commitment by all. Yes, it is the way to a better world for the handicapped -- a better world for all the people, everywhere.

May you have the strength and the power to bring about this day soon."

-- Spiro T. Agnew. Excerpt from a speech delivered at the Annual Meeting of the President's Committee on Employment of the Handicapped, Washington, D.C., April 23, 1970.

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*Licensed to Cybernetics Research Institute, Inc., for Grant OEG2-7-070533-4237.

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Tables

ACKNOWLEDGMENTS

The major support by the Bureau of Education for the Handicapped, Office of Education, Department of Health, Education, and Welfare for this study is gratefully acknowledged, together with the hundreds of teachers, students, parents, and others who envisioned the potential benefits of combining special education technology and innovative man-machine systems, employed in this program, for handicapped children, youth, and adults in critical need of communications and life-support means.

To all of my colleagues who have helped me in this study and in the preparation of this report, and to those whom I may have unintentionally overlooked, I express my genuine appreciation.

Although it is not feasible to list the many persons whose participation, encouragement, and criticism have made this project worthy, the endeavor of the following people is reflected by those disabled individuals who served in the program and successfully demonstrated their ability to communicate effectively.

Special gratitude is extended to the following members of the Board of Trustees: the late Professor Warren S. McCulloch, M.D., Chairman Emeritus of Cybernetics Research Institute, and the late Professor William J. Fry, Chairman of the Cybernetics Research Institute Executive Committee; Professor Samuel C. Ashcroft, Department of Special Education, University of Maryland; Professor Julian H. Bigelow, Chairman Emeritus of the Cybernetics Research Institute Board of Trustees and Permanent Member of the Institute for Advanced Study at Princeton, New Jersey; Professor Joseph H. Engel, Systems Engineering Department, University of Illinois; Professor Emerson Foulke, Perceptual Alternatives Laboratory, Department of Psychology, University of Louisville; Professor James J. Gallagher, Department of Special Education, South Carolina University; Professor Rufus P. Isaacs, Operations Research and Industrial Engineering, Johns Hopkins University; Dr. George M. Mardikian, Chairman of the Board, George M. Mardikian Enterprises; Associate Professor N. Henry Moss, M.D., Director of Medical Education, Albert Einstein Medical Center and Temple University Health Services Center; Professor Azriel Rosenfeld, Computer Science Laboratory, University of Maryland; Professor John C. Townsend, Department of Psychology and Psychiatry, The Catholic University of America; Professor Heinz Von Foerster, Chairman Emeritus, Cybernetics Research Institute and Director of Biological Computer Laboratory, University of Illinois; and Rose G. Kafafian, Vice President of Cybernetics Research Institute.

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Members of Cybernetics Research Institute appreciate the cooperation of the various site-visit teams, and especially the following members and representatives of the National Academy of Sciences who visited and reported on C/R/I's research and C/R/I's Field Center in Leetsdale, Pennsylvania, The D. T. Watson Home for Crippled Children: Dr. Dudley S. Childress, Northwestern University; Dr. June Cornog, National Bureau of Standards; Dr. Randolph Hanes, Johns Hopkins Applied Physics Laboratory; Mr. Hector W. Kay, Assistant Executive Director, Committee on Prosthetics Research and Development; Mr. Maurice A. LeBlanc, Staff Engineer, Committee on Prosthetics Research and Development; Dr. Colin A. McLaurin, Chairman, Committee on Prosthetics Research and Development, Ontario Crippled Children's Center, Toronto; and, Miss Margaret Young, Ontario Crippled Children's Center, Toronto.

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To the following C/R/I Field Center affiliates, the principal investigator extends recognition for their pioneering efforts in collecting data for this study, and in demonstrating the usefulness of the "Cybertype" system in a classroom environment: Gene Moore and Jean Kidwell of Belle-Willard Elementary School, Fairfax, Virginia; Robert Duerr of Buffalo Public School No. 84, Buffalo, New York; Dr. Phillip Massey and Rosalyn Monet of the Coastal Center, Ladson, South Carolina; Max Millard, Catherine Fletcher, and Margaret McCurdy of the D. T. Watson Home for Crippled Children, Leetsdale, Pennsylvania; Marie Veenendall and Alice Donahue of Eastern Orthopedic School, Grand Rapids, Michigan; Paul Kavanaugh, Judy Schust, and Edith Wells of Illinois Children's Hospital School, Chicago, Illinois; Charles Hagen and Mary B. Chorewycz of Lindsay School, St. Paul, Minnesota; Sister Mary Georgeann and LaVerne Knabel of Louisville Cerebral Palsy Center, Louisville, Kentucky; James Bonner, Barbara Moessner, and Jay Sikkenga of Marquette School, Muskegon, Michigan; Dr. Douglas Daniels, Jane Stevens, and David Colley of Moody School, Galveston, Texas; Mary Harms and Ruth Bourne of Oakman School, Detroit, Michigan; Chester Phelps and Eleanor Rennie of Richmond Cerebral Palsy Center, Richmond, Virginia; and Abraham Albert and Rhona Gorsky of Widener Memorial School, Philadelphia, Pennsylvania.

INTRODUCTION

This report describes educational, instructional, and evaluative research studies conducted for the Bureau of Education for the Handicapped (B. E. H.), Office of Education, U. S. Department of Health, Education, and Welfare. The purpose of these studies was to determine to what extent severely disabled students who could not effectively write or type but who had language comprehension and a knowledge of language structure could communicate using man-machine systems. These systems include "Cybertype™*," an electric typewriting machine for students with physical and/or neurological impairments; "Cyberphone™*," a portable telecommunications system for the deaf and/or speech-impaired; HAIBRL, an unambiguous tactile system for the blind; as well as other such innovative aids, i. e. "Cyberlex™*," and "Cyberlamp™*.

The disabled individual's general inability to communicate effectively with his environment is a recognized problem, the seriousness of which is reflected in that there are more than 7 million handicapped persons in the United States, of whom approximately 4 million school-age children and youth are not receiving sufficient educational assistance. This situation is compounded by the fact that many of these children have health deficiencies, are emotionally disturbed, or have serious learning disabilities. Moreover, there is a large population of disabled veterans and other adults who do not benefit from most educational institutions and rehabilitation centers. This study was focused toward the advancement of the education and well-being of handicapped persons through an approach in which special education technology was combined with innovative man-machine communications and life-support systems.

Two broad groups of handicapped individuals in need of more efficacious means of communicating were considered as potential beneficiaries of this approach. The first group was composed mainly of physically and neurologically impaired students, and those persons diagnosed as deaf and/or speech-impaired, and blind and visually impaired. The second group included those students who did not have adequate language comprehension or who lacked knowledge of language structure and, thus, were in critical need of a medium of communication.

This study has shown that, for the first time, significant advances in the education of many handicapped individuals can be achieved by employing writing and communicating systems which can be matched to the user's remaining capabilities.

Pilot studies were conducted at numerous C/R/I Field Centers throughout the United States. Details of these pilot studies are found in Parts One A and One B of this report. Communicating by typing with the tongue was introduced to two severely paralyzed subjects; a review of this pilot experiment is presented in Part One C.

The study was concerned with the research, exploration, and development of screening procedures to determine latent reading ability and degrees of reading pro-

*Trademark, Cyber Corp., Washington, D. C.

ficiency in multiply handicapped, non-verbal, and learning-disabled children; these preliminary procedures are covered in Part Two. For those students who had limited reading and language comprehension, preliminary experiments were conducted with a "word and/or picture-message" communication system as described in Part Three. Since most of the severely disabled students participating in the pilot programs were representative of handicapped individuals attending special education classes throughout the nation's schools and institutions, efforts were directed toward matching the students' remaining motor capabilities to electric writing machines which were designed to meet classroom requirements; these writing machines are described and illustrated in Part Four of this report.

The aforementioned investigations led to collateral studies related to assessment procedures, and resulted in the development of the "C/R/I Inquiry Form" and the "C/R/I Capabilities Inventory Form," which appear in Part Five. One phase of the study, as disclosed in Part Six, revealed the rate and accuracy of message comprehension and perception by deaf and speech-impaired subjects using a "Cyberphone" portable communication system. This system was equipped with "Cyberlamp" or "Cyberlex" displays, which conveyed the message to the viewer. Part Seven introduces HAIBRL, a new punctiform communication system for the blind developed during the course of the study. Other innovative life-support and man-machine systems considered beneficial to the handicapped are discussed in Part Eight.

In another phase of the study program, Part Nine, use of phonemes of the Armenian language was proposed for use by the blind and visually impaired; this particular language was employed because of its universal characteristics.* Other unique approaches to introducing written language to a beginner were presented through "epsilontau," a system by which letters of an alphabet are arranged by frequency of usage. Codes for the Arabic, Armenian, English, French, German, Hebrew, Italian, Portuguese, Russian, and Spanish languages were studied.

Appendices A through H of the report contain test data, references, experimental studies, instructional procedures, tests, children's handwriting and typing samples, and an individual and group instruction program.

The principal investigator is responsible for errors which may appear in the seven volumes covering these projects. If requested, a master errata sheet will be compiled and sent to recipients of these reports.

Concepts, descriptions and data from the C/R/I Interim Report (1968) and the C/R/I Second Report, Volumes I and II (1970) are repeated intentionally in Volume III of the C/R/I Final Report when necessary for continuity, and also -- sometimes verbatim -- to minimize the reader's need for constant reference. Where space was available the principal investigator has inserted quotations related to the needs of the severely handicapped and the indigent.

For the individual who is unfamiliar with the man-machine systems employed herein or who has not reviewed the earlier reports, it is suggested that he first read Part IV of this report before proceeding to the Field Analyses and Data sections.

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*See Dr. Margaret Mead, "The New York Times," September 8, 1968.

PREFACE
FIELD CENTER DATA

The following section of the report is prefaced with an explanation that these data, as obtained from the C/R/I Field Centers, were gathered enroute to the completion of a traditional behavioral science design as initially planned and implemented for the project. However, certain basic assumptions for the application of statistical models could not be met by these interim data which were available at the time this work was discontinued. For instance, small numbers of subjects under a wide variety of conditions precluded application of the usual tests and the resulting establishment of statistical significance.

Hence, an operations research analysis of the interim data based upon an *ad hoc* analytic approach valid in its applicability to the data, was employed. The results provided revealing and meaningful information in the form of trends, often strong. If the reader accepts less than customary analysis of these interim data, then relevent but tentative conclusions can be drawn at this stage of the study and evaluation program.

> *"More than 7 million preschool and school-age children in the United States with physical, neurological, or learning disabilities necessitate formal teaching, training and special education programs. A recent report from the Bureau of Education for the Handicapped disclosed that more than 1.75 million handicapped children do not receive appropriate educational services. General and special educators, within their limited resources, are attempting to meet the critical need for establishing educational programs designed to service these children. Their efforts may prove futile, for the success of their programs depends on legislation yet unenacted to financially support implementation of their programs."*
>
> - Kafafian. Excerpt from a paper "Cybernetics Systems in the Education of the Handicapped ," for the American Society for Cybernetics, Fourth Annual International Symposium, Washington,D.C., October 8-9, 1970. (Other boxed quotations which follow, unless otherwise noted,are from the same paper.)

Part One ANALYSES

A C/R/I FIELD CENTER TEST DATA

Introduction

This analysis deals primarily with that portion of the program involving a pilot study with observations of 70 severely handicapped children in 15 schools throughout the United States who were introduced to CYBERCOM, a family of man-machine communication systems and in particular to the "Cybertype," an electric writing machine operable from various styles of portable interfaces or keyboards which can be coupled to and controlled by the remaining capabilities of the user. A basic training series of lessons and tests (Kafafian, C/R/I Instruction Manual, 1970) was administered by their own teachers in their own schools under the guidance of C/R/I's staff. These children entered the study program between October 1970 and May 1971. In most cases they did not complete the entire series of lessons and tests which comprise the initial "Cybertype" code acquisition sequence. However, a small number of students who completed the code acquisition phase have started work on the advanced practice and test exercises.

Data relating to students who were engaged in an earlier preliminary pilot study with these systems during late 1969 and early 1970 at the D. T. Watson Home for Crippled Children (Kafafian, C/R/I Interim Report, 1968; C/R/I Second Report, 1970) also have been reviewed for potential correlation with results obtained with the later group of students who provided the bulk of the data analyzed herein.

The selection of students and the interfaces for inclusion in the training and data collection program was accomplished by C/R/I's staff in cooperation with personnel at the schools participating in the C/R/I Field Center Program. Where possible, it was a key criterion that all of the students have no effective means of written communication prior to their introduction to this program. This prerequisite was met by all but a few of the students selected. Other criteria were that the students have some reading ability, although three of the 70 had only alphabet recognition capability, rather than a measurable grade reading level, and that they have sufficient sensory-motor capability required to operate and control at least one of the various configurations of the "Cybertype" portable keyboards provided. Criteria were in terms of practical, operational communications abilities and limitations, in an educational environment; they allowed for a wide range of differences in background, motivation, age, reading level, disabilities, and variations in the configurations of the interfaces used.

The pilot program of data collection was exploratory in character, rather than analytical, in the sense that there was an attempt to assist each individual child, rather than to compare the results of alternative methods and treatments on a population of disabled students. Consequently, this analysis attempts to examine the interaction of each student with the writing machine together with the training and instructional materials employed by the teacher.

Answers for the following five questions were sought:

1. How many students who could not previously write in any form have been given new, useful written communication capabilities to help them in their educational pursuits?

2. How many of these students show promise of acquiring a useful written communication capability through continuation of training with the "Cybertype" systems provided?

3. How many of the students involved in the study appear to need better matching or coupling of the "Cybertype" interfaces to their specific disabilities before they can achieve a useful written communication capability through continuation of training?

4. What criteria or other means are available, or can be developed, for early screening of physically and/or neurologically handicapped students involved in the training program who may or may not have serious learning disabilities?

5. What viable relationships can be identified between successful acquisition of the skills acquired and other characteristics such as reading level and clinical descriptions of the disabilities?

Tests and Data Collection

The chief source of data for the analysis was the sequence of tests developed by the C/R/I staff and administered to the students as part of the code acquisition program. Test data were tallied by members of the professional staff of the C/R/I Field Centers and sent to investigators at C/R/I for assembly and analysis.

For each such test, in addition to the student's name, code number, and date, the following were recorded:

1. Total number of functions performed in the test together with a breakdown of the number of functions performed during the first minute of the test.

2. Total time to complete the test.

3. Number of errors made in the test.

4. Number of days.

5. Number of training sessions.

6. Total number of minutes in training and practice since the previous test.

Representative average function rates and tallies of data obtained from the C/R/I Field Centers appears in Appendix A.

Auxiliary information on each subject relates to the date of entry into the program, and, if available, includes among others, reading level, age, clinical description of handicap, school grade.

Measures of Effectiveness

Two questions to which these analyses are directly related require definitions of the phrase "useful written communication capability" which in itself implies an ability to think, and the phrase "show promise of acquiring a useful written communication capability."

The first statement requires a measure of rate of production of correctly written text, and its intelligibility or accuracy in producing individual characters in a desired sequence. The second statement requires a measure of the rate of acquisition of necessary skills which are accessible from the collected data. This approach to measure effectiveness relies on calculations from the basic data with the following as underlying assumptions, or hypotheses, suggested by the data and comments on data forms.

1. Each child was matched to one of the system's interfaces through trial and close observation. This match was monitored throughout the test program. Exchanges of interfaces were made as to permit the student to attain the highest potential within constraints of the particular "Cybertype" used.

2. Although tests were designed to be administered at standard intervals, usually after the student had completed two one-hour sessions in the sequence, teachers allowed student progress or difficulty to govern the actual test interval. Teachers administered tests when the student had mastered the test material and had attained a function rate and error rate which could not be improved in a reasonably short additional practice period.

3. There appear to be no consistent upward or downward trends in function rates or error rates as students progressed through the code acquisition series of lessons and tests, although scores on individual tests in the sequence fluctuated widely. It has been assumed that there are no consistent trends over this phase, so that average function rates and error rates based on only a few of the early tests may be compared without adjustment with averages based upon most, or all of the seven tests in the code acquisition lesson sequence. Appendix A (Figures 1, 2, and 3) indicates test-by-test function rates for several students to illustrate this point.

Considering the above assumptions, the quantitative measures of:

a. Average function rate.
b. Average error rate.
c. Average learning time (measured in practice minutes between successive tests).

were tallied for each student for all of the tests completed to the last recorded point in the sequence.

Arbitrary points or "bench-marks" were then selected for each of these statistics, as the following:

a. Average function rate: 10 functions/minute.
b. Average error rate: 10%
c. Learning and practice time: 240 minutes (4 hours).

The rationale for these selections was not complete, but included the following considerations:

1. That a function rate of 10 per minute approximately corresponds to only two words per minute of communication.

2. That more than 10% errors may begin to inhibit dialogue and intelligibility of the communication or the teacher's ability to discern which errors were due to faulty communications and which to incomplete absorption of subject material by the students.

3. That the learning and practice time had been designed to be two hours with the cut-off established at twice the prescribed time.

With these points established, it was then considered feasible to sort the students into four classifications designated as H, P, D, and N where:

H= function rate above 10/min., error rate below 10%, practice time less than 4 hours.

P=one of the three criteria not met.

D=two of the three criteria not met.

N=function rate below 10/min., error rate above 10%, and practice time above 4 hours.

Results

The chronological development of the C/R/I Field Center program is shown graphically in Figure 1; results to June 1971 are tabulated in Table I. The numbers of students in each of the categories has been further subdivided into those who have completed Test No. 4 and those who have not. This separation was motivated by the observation that the syllabus material covered by the lessons leading to Test No. 4 is sufficient to permit the student who has mastered it to "cybertype" 99.9% of ordinary English into readable form.

If one is then willing to make tentative interpretations of the H, P, D, and N categories in terms of usable written communications capability, these results may provide at least tentative answers to the first questions asked in the Introduction to this section.

Hence, students in the H ("useful") group who have completed Test No. 4 can be interpreted as having acquired a "usable written communication ability," while those in the same category, but who have not yet completed Test No. 4, can be interpreted as belonging to the P ("probable") group (i.e., "showing promise of acquiring a useful written communication ability"). For students in the D ("possible or doubtful") classification and those in the N ("need") classification, the interpretation is that these students are "in need" of other configurations of interfaces; or new or improved training materials; or, possibly, an entirely different approach to written or other means of communications.

TABLE I

SUMMARY OF STUDENT PERFORMANCE IN C/R/I FIELD CENTER STUDY PROGRAM

Category	No. of Students	% of Students
H past Test No. 4	5	
before Test No. 4	15	
Total	20	28.6%
P past Test No. 4	9	
before Test No. 4	14	
Total	23	32.8%
D past Test No. 4	5	
before Test No. 4	12	
Total	17	24.3%
N past Test No. 4	1	
before Test No. 4	9	
Total	10	14.3%
Total Students	70	100%

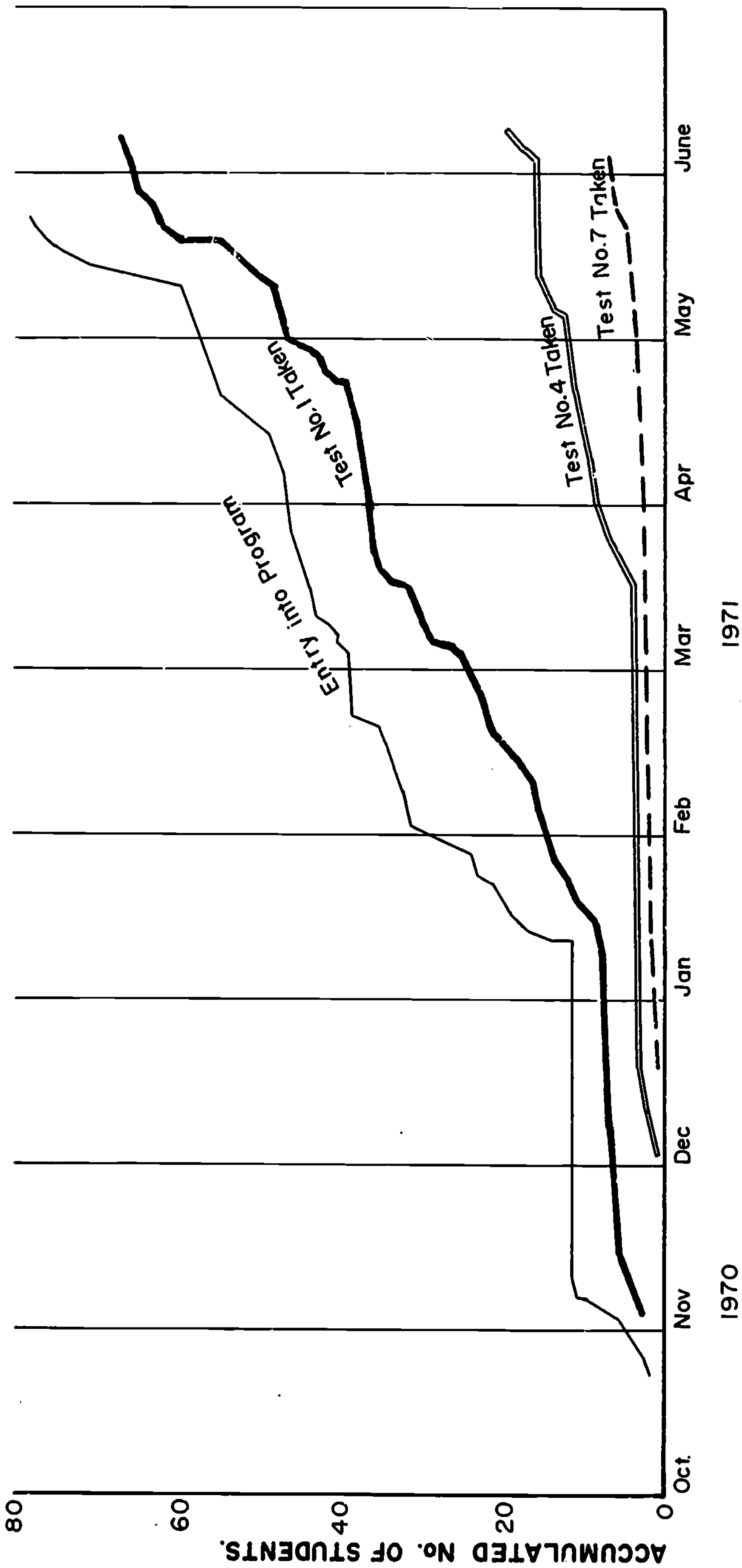

Figure 1. CHRONOLOGICAL DEVELOPMENT OF C/R/I FIELD CENTER PROGRAM

Thus, over 60% of the 70 severely disabled students who previously had no means of effectively communicating in written form participated in the C/R/I Field Center Study Program and are clearly proceeding favorably in learning to develop writing skills, and about 40% are in the "doubtful" and "in need" groups, or they may indeed require continued instruction or additional assistance in attaining a useful written communications ability.

These preliminary results provide clues to such answers as are now available to the first three questions addressed by this analysis.

The question of criteria for early screening may be considered by use of the categories of H, P, D, and N, suitably modified by further experience, provided that their use does not lead either to an early rejection of severely disabled students where teacher/student communications are lacking or to excessively long efforts to train a severely disabled child for which an inappropriate interface has been selected or for other reasons, and at the time is not adequate for development of a useful ability.

These comments suggest questioning the stability of the assignments to the four categories H, P, D, and N. Table II shows, for subjects who completed Test No. 4 or a subsequent test; the relationship of their category assignments after completing Tests No. 1 and 2, to their category assignment after their last completed test (No. 4 or above).

TABLE II

STABILITY OF CATEGORIES WITH PROGRESS IN TRAINING

Changes in Category Assignment from Completion of Test No. 2 to Assignment at Completion of Latest Test (No. 4 or above)	No. of Students
No Change in Category	13
Change from N to D	0
D to P	2
P to H	0
H to P	1
P to D	3
D to N	1

The results in Table II also suggest that the category assignment after students have taken Test No. 2 may be useful as a predictive guide to their further development of writing and other skills. These results are based upon too few cases, however, to be more than suggestive; further data, review and analysis are needed as more students are observed in an extended program.

With these categorizations of disabled students, it was also possible to test the results for possible relationships to other student characteristics, i. e., specifically, reading level, capability to control and operate specific interfaces, and clinical descriptions of the student's handicap. Tables III, IV, and V summarize the comparison of student categories of performance with reading level.

TABLE III

NUMBER OF SUBJECTS AT INDICATED PERFORMANCE LEVEL
(as a function of reading ability)

Reading Level	Performance Level				Reading Level Total
	N	D	P	H	
Alphabet	1	1	1	0	3
Primer	3	2	5	1	11
Grade 1	1	6	6	3	16
2	1	4	7	4	16
3	2	1	0	0	3
4	1	1	0	2	4
5	0	0	1	2	3
6	0	0	0	1	1
7	0	0	0	1	1
8	0	0	0	0	0
9	0	1	0	2	3
10	0	0	0	1	1
11	0	0	0	1	1
12	0	0	0	1	1
All Known Reading Levels	9	16	20	19	64
Unknown Reading Level	1	1	3	1	6
All Reading Levels	10	17	23	20	70

TABLE IV

NUMBER OF SUBJECTS IN INDICATED READING POPULATION AT INDICATED PERFORMANCE LEVEL

Reading Level	Performance Level: N or D	Performance Level: P or H	Reading Level Total
Grade 4 or below	24	29	53
Grade 5 or above	1	10	11
All Known Reading Levels	25	39	64
All Reading Levels	27	43	70

TABLE V

% OF SUBJECTS IN INDICATED READING POPULATION AT INDICATED PERFORMANCE LEVEL

Reading Level	N or D	P or H
Grade 4 or below	45%	55%
Grade 5 or above	9%	91%
All Known Reading Levels	39%	61%
All Reading Levels	38%	62%

For all statements derived from these data, the small number of cases suggests that the results are considered tentative. Yet, it appears that for students whose measured or estimated reading ability is at or below 4th grade level it may be equally likely that they may fall into any one of the categories of success in learning and using these new means of writing. For students who have attained at least a 5th grade reading capability, it appears that they are likely to have success in learning to communicate through the aid of "Cybertype" writing machines. Such a statement takes on added and significant meaning for these students when it is recalled that most of them represented by these data did not have any form whatsoever of usable written communication capability at the beginning of their participation in this study program.

Tables VI and VII summarize relationships between the student categories and the interface/limb combination which the student used. In the Tables, the designation DC means "dual concurrent" (i. e., to execute a function, the student may use two parts of the body to depress two buttons concurrently) and DS, "dual sequential" (i. e., to execute a function with one part of the user's body activating the dual input through one button and then another in sequence).

Should continued use of these man-machine systems offer means by which severely disabled students can reinforce their learning and advance at a faster rate in their classroom work than they normally would, a way may be found to reduce their lengthened stay in school. If this indeed is the case, then secondary to huge savings to the educational system, the schools could make room for other disabled children who are not receiving help.

TABLE VI

NUMBER OF SUBJECTS AT INDICATED PERFORMANCE LEVEL AS A FUNCTION OF MODE OF OPERATION

Mode of Operation		Performance Level N	D	P	H	Mode Total
DC	Finger	1	0	0	5	6
	Fist/Hand	1	4	6	9	20
	Foot	1	0	2	1	4
	Head/Fist	0	0	0	1	1
DC	All	3	4	8	16	31
DS	Finger	1	2	1	1	5
	Fist/Hand	6	10	11	3	30
	Foot	0	0	0	0	0
	Head	0	1	3	0	4
DS	All	7	13	15	4	39
All Modes		10	17	23	20	70

(DC = Dual Concurrent; DS = Dual Sequential)

TABLE VII

NUMBER OF SUBJECTS AT INDICATED PERFORMANCE LEVEL AS A FUNCTION OF MODE OF OPERATIONS

	Performance Level		Mode Total
	N or D	P or H	
Dual Concurrent (DC)	7	24	31
Dual Sequential (DS)	20	19	39
All Modes	27	43	70

Finally, Table VIII summarizes student performances as related to the clinical description of handicaps. No standard has been determined for sequential ordering of the degree of disability represented by the various clinical descriptions. It appears from Table VIII, which reflects an extremely small sample, that no matter what ordering might be proposed, it could not be supported by student performance, and clinical description may imply that there can be no screening on the basis of such descriptions. However, it might be more useful to approach the question of describing remaining sensory-motor capabilities of students in terms of their performance levels in these training programs. Table VIII can only be suggestive in this regard.

This overview of the analysis indicates the need for quantitative descriptions of remaining sensory and/or motor capabilities of handicapped individuals and suggests that the family of man-machine systems, under study, assist in making such determinations. Further exploration of these operational requirements may yield the appropriate questions to consider and possibly new approaches of dealing with these problems.

TABLE VIII

NUMBER OF SUBJECTS AT INDICATED PERFORMANCE LEVEL AS A

FUNCTION OF SUBJECT'S CLINICAL HANDICAP

Handicap	Performance Level N	D	P	H	Total
Cerebral Palsy	0	1	1	0	2
CP, Spastic	0	0	1	1	2
CP, Mixed	2	2	2	1	7
CP, Quadriplegic	2	1	1	2	6
CP, Spastic, Quad.	1	4	6	6	17
CP, Athetoid	5	0	7	0	12
CP, Quad., Athetoid	0	6	3	5	14
Total CP	10	14	21	15	60
Other (Not CP)	0	3	2	5	10
Total	10	17	23	20	70

The D. T. Watson Home for Crippled Children Student Performance

The foregoing section of the pilot program has concerned itself with the performance of new students introduced to the measurements program who are still in the training program. Those students who were trained earlier at the D. T. Watson Home for Crippled Children have been reported previously, (C/R/I Second Report, 1970). They have continued to use their systems which are now integrated into their regular school curriculum. Their improvements in facility and accuracy of use of the system are shown in Table IX.

The first set of results is drawn from student performance on the first two advanced test exercises taken by the students in the first two weeks following the code acquisition training period. The second set of results is drawn from student performance on the ninth and tenth advanced tests, taken in the ninth and tenth weeks after completion of the code acquisition training period which was in August, 1970. The third set of results is drawn from the last two advanced practice tests taken in May and June of 1971, about one year after initial introduction to the pilot program.

TABLE IX

STUDENT PERFORMANCE

School D. T. Watson Home for Crippled Children	Early Advanced Test Results		9th and 10th Week Advanced Test Results		1971 Advanced Test Results		
Student Number	Function Rate	Error Rate	Function Rate	Error Rate	Function Rate	Error Rate	Function Rate Improvement Factor
124	10.0	3.3	9.6	0.0	48.1	0.7	4.8
123	8.4	2.7	26.6	0.0	35.1	1.9	4.2
129	7.9	1.1	19.6	0.1	35.9	0.0	4.5
128	9.6	1.1	20.9	0.0	30.7	0.3	3.2
126	7.4	9.1	12.8	2.2	17.9	1.0	2.4
125	11.6	1.9	33.6	0.1	61.2	0.4	5.2
122	14.7	3.0	13.6	0.1	22.7	1.8	1.5
127	18.7	6.3	24.6	0.1	27.2	2.2	1.5

All students in the pilot program displayed considerable improvement in function rates, combined with an improvement in accuracy, ranging from a 50% increase to a 5-fold increase for individual students after about one year of practice. The fact that the early results at the D. T. Watson Home for Crippled Children are similar to those now being recorded by more recent trainees in H, P, and even D categories suggests that these longer term results may be expected for the group if they continue in the program.

Conclusions

1. The pilot studies at the C/R/I Field Centers indicate that about 60% of all handicapped students in the program probably have attained, or show good promise of attaining, a usable and effective written communication capability which they had not had before their introduction to the man-machine systems under study.

2. The remaining 40% of the severely disabled students give indication of the need for further investigations in the matching or coupling of the students' remaining motor capabilities to the interface of the system, and/or new training and instructional materials, or an alternative method of attaining written or other communications ability.

3. The category scheme used in this analysis may show further promise of providing a useful predictive guide for teachers for subsequent student performance capabilities with this family of man-machine systems.

4. Further practice and integration of the acquired writing skills into student learning and leisure activities may multiply student written communication rates by factors of 1.5 to 5 over their initial rates at the end of the code acquisition phase given about a one-year period of continued practice.

5. Severely disabled students' abilities in learning these new writing skills cannot be reliably predicted by reference to:

a. clinical descriptions of students' disabilities,
b. the interface/limb combination "best" adapted to the students' remaining capabilities,
c. (measured)reading ability which is at or below the 4th grade level, and
d. measured reading ability, in general.

6. For handicapped students shown to be capable of attaining 5th grade or higher reading skill level and some ability to operate one of the keyboards matched to their remaining motor capabilities, it is most probable that they can also develop a continuing usable and effective written communication ability with the system.

7. Data available are too sparse to permit detailed investigations of perhaps more significant relationships suggested by the results. For this reason, among others, and to provide for continuous reflection of the handicapped child's educational needs, it is essential to probe, search, expand, and further structure the field study and data collection programs which have been launched.

This has been the very first formal study and evaluation of "Cybertype" writing machine systems in an educational environment with students severely disabled physically and/or neurologically. In order to ensure objectivity in the analyses, C/R/I subjects were not employed in this portion of the research program. All candidates selected as subjects met the prerequisites of not having the ability to write or type but had some knowledge and comprehension of the English language. All were students attending schools and organizations nominally designated as "C/R/I Field Centers" and in no way were they or their students affiliated with C/R/I.

Once the teachers in the field had received guidance and training by C/R/I professional personnel, they were literally "left-on-their-own." Thereafter, the "C/R/I Field Centers" provided raw data to C/R/I researchers for analysis; these data were subsequently re-analyzed by independent consultants for confirmation of earlier findings by C/R/I investigators. In this manner, the goal towards maintaining objectivity was achieved.

"Education of handicapped children is not unlike other difficult tasks that are not well defined and understood. The problem is more than dealing with children who cannot communicate effectively and have no effective educational programs to help them. Many of them are required to spend their lives in a most undesirable environment, at an enormous cost to society. Moreover, inevitable increases in our Nation's handicapped adult population are bound to place an even more devastating economic and social burden on our society. Even with funds we cannot train without teachers and learning aids."

Part One B | PILOT STUDIES

INSTRUCTIONAL RESEARCH PROGRAMS AT THE D. T. WATSON HOME FOR CRIPPLED CHILDREN.

Introduction

Two pilot studies were initiated at the D. T. Watson Home for Crippled Children in Leetsdale, Pennsylvania. The first preliminary pilot study provided orientation, and the second was in process at the time this report was prepared. Subjects selected in both studies were tested and provided with experimental instructional materials and "Cybertype" writing machines.

The objectives of this phase of the program were (1) to determine the rates at which severely disabled children learn the keying codes, (2) to assess improvements in communications performance with extended practice, (3) to evaluate the extent to which the selected severely disabled children effectively write and communicate in classroom situations, (4) to determine what questions to consider for improving the contents of the instructional materials and procedures to be used in future work.

The first three objectives were determined to be of primary concern for determining the effectiveness of man-machine communications systems as aids for severely disabled students in an educational environment. The fourth objective was considered to be of significance since it provided critical feedback to the investigators.

Method

Eight severely disabled children of the D. T. Watson Home for Crippled Children were selected on the basis of observation and performance testing which indicated that the following criteria had been met:

(1) inability to produce handwriting or to effectively use writing machines with standard keyboards, (with or without "keyguards") due to physical and/or neurological disabilities;
(2) sufficient motor coordination and sensory capability to operate a "Cybertype" keyboard;
(3) ability to understand the basic concepts of written language; that is, to recognize letters of the English alphabet and to have a basic comprehension of how letters are involved in the formation of words, phrases and sentences for meaningful communication.

The first two criteria, relating to motor performance and sensory capability, were established by observing each child's coordination responses, and ability or lack thereof, to produce handwriting or operate a standard electric typewriter keyboard, and/or to operate one of a variety of "Cybertype" keyboards.

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The third criterion, concerning reading ability, was determined by consultation with teachers and others at the school and by use of a Flash-Card Reading Test (FRT) which contained single words for the child to identify. This test has since been developed as the "C/R/I Screening Test of Latent Reading Ability" (C/R/I Quarterly Report, August 19 - November 19, 1970; C/R/I Second Report, 1970; and Volume III, Part Two of this report).

Subjects were assigned the following styles of portable keyboards matched to their remaining motor capabilities:

(1) keyboards consisting of small keys (1/2 x 1/2 inch keytop area) with a center-to-center lateral separation of 1 inch, for operation with the fingers or knuckles of each hand; (See Plate 14, Part Four).

(2) intermediate size keyboards equipped with medium size keytops (1 inch in diameter) having a 2-1/4 inch lateral separation for operation with the fists, fingers, or heels of the hands by a child whose coordination and control is not adequate for the small finger-operated keyboard; (See Plate 12, Part Four), and;

(3) large keyboards equipped with 1-1/2 inch diameter keys spaced 3 inches apart, for operation by arms, feet, or other parts of the body by a child capable of providing only gross motor coordination. (See Plate 16, Part Four).

TABLE X

CHARACTERISTICS OF SUBJECTS AND INTERFACE ASSIGNMENTS

Subject No.	Sex	Age	Diagnosis	"Cybertype" Interface
122	M	12	CP, Spastic	Small (finger operation)
123	F	14	CP, Rigidity	Large (foot operation)
124	F	19	CP, Athetoid	Large (fist operation)
125	F	13	Arthrogryposis	Small (finger operation)
126	F	11	CP, Spastic	Small (finger operation)
127	M	12	CP, Athetoid	Intermediate (fist operation)
128	F	8	CP, Spastic	Small (finger operation)
129	F	7	Osteogenesis Imperfecta	Small (finger operation)

Subject characteristics are summarized in Table X, which reveals that five of the eight subjects were assigned 14-key, finger-operated interfaces, because they demonstrated adequate coordination to operate these smaller keytops with at least one finger on each hand. In each case, preliminary observation and testing revealed that these children had extreme difficulty in attempting to produce legible handwriting or to operate a standard typewriter keyboard. These five subjects consisted of: three children (Subject Nos. 122, 126, 128) having cerebral palsy with spasticity and tremor; one child (Subject No. 129) with osteogenesis imperfecta, a condition resulting in severely retarded body growth and fragile bone structure; and one child (Subject No. 125) with cerebral palsy and arthrogryposis with distortion of the hands and fingers.

A fist-operated interface (intermediate size) was assigned to a child (Subject No. 127) diagnosed as a cerebral-palsied athetoid-quadriplegic. This subject was unable to provide sufficient manual coordination for use of the small, finger-operated interfaces, but was capable of using his fists, fingers, or heels of his hands to operate with good control the intermediate size interface.

A large interface was also assigned to Subject No. 123 who is cerebral-palsied with extreme rigidity of the upper limbs, making it virtually impossible for her to provide functional movements of hands and arms. However, this child retained exceptionally good coordination in legs and feet, and was easily able to adapt her feet to operate pairs of keytops located on the large interface placed on the floor.

Subjects were given instruction individually and in groups by a senior special educator from January to June 1970. Four of the children were instructed as a group, i. e., three children (Subjects 122, 125, and 126) used the small finger-operated interface, and one child (Subject No. 127) used the intermediate, fist-operated interface, and the second (Subject No. 124) was given the large fist-operated interface.

Each subject received one hour of instruction each day, four days per week. The "Cyber-Circus Story" and other instructional materials (C/R/I Instruction Manual, 1970; C/R/I Interim Report, 1968) were used by the teacher as aids for the students in learning the keying positions of the letters, symbols, and functions available on the electric writing machines. Each lesson included the introduction of keying positions for new letters or symbols, together with practice exercises utilizing those typing functions previously learned. Following memorization of the entire code (98 functions, including upper and lower case), daily practice continued, with weekly tests of ability to assess changes in performance over time.

Secondary Consideration: Education and Performance Tests. An attempt was made to evaluate the psychological, educational and motor effects of the instructional procedures by administering a battery of tests to subjects prior to and during the commencement of the program. These tests were the Peabody Picture Vocabulary Test (PPVT), the Illinois Test of Psycholinguistic Abilities (ITPA), the Wide Range Achievement Test (WRAT), Spelling Subtest (Level One), and the C/R/I Tapping Test of Finger Dexterity" (C/R/I Second Report, 1970). The ITPA and WRAT were administered in slightly modified and abridged form, commensurate with the special requirements of these handicapped subjects and the objectives of this study program.

In order to distinguish between changes in test performance due to special instruction with interface systems and changes due to ordinary classroom experiences, maturation, and general learning, a "control" or "comparison" group of subjects was selected. Each control subject received the same battery of tests at the initiation and for the duration of the study, but did not receive special instruction with communications systems. Each subject in the experimental group was paired with a control subject enrolled in the same classroom. Furthermore, an attempt was made to match the two groups of subjects for chronological age, mental age, sex, and sensory-motor characteristics, but constraints posed by the limited subject population and student classroom assignments precluded the achievement of this goal of matched subject pairs. In general, control subjects were less severely impaired in motor coordination than were the experimental subjects, and this fact deserves consideration in evaluating pre-test and post-test results for the two groups.

Moreover, another consideration is that the pre-test and post-test sessions were separated by a period of only five months. It was recognized in advance of this phase of the study that this pre-test/post-test interval might be too brief to produce a significant degree of improvement in test performance for either experimental or control groups. However, it was decided to administer the test battery in spite of this fact, in order to observe any trends in test score improvement which might be in the process of emerging.

TABLE XI

MEDIAN LESSON NUMBERS FOR INTRODUCTION OF EACH LETTER, SYMBOL, AND TYPING FUNCTION D. T. WATSON PROGRAM (N=8)

Function	Space	Carr. Ret.	e	t	a	o	n	i	Period	Upper Shift	Lower Shift	
Median Lesson No.	1	1	1	1	1	1	1	1	2	3	3	
Function	r	s	c	1	h	Comma	y	2	7	9	0	
Median Lesson No.	4	5	5	6	6.5	6.5	8	8	8	8	8	
Function	m	u	j	d	b	3	4	5	6	8	f	p
Median Lesson No.	8.5	8.5	8.5	9	9	9	9	9	9	9	11	12.5
Function	g	Apostrophe	w	?	;	/	k	q	v	z		
Median Lesson No.	12.5	12.5	13	13	14.5	18.5	19	19	20.5	23		
Function	"	Back Space	x	:	(	)	_	*	–			
Median Lesson No.	23	25	26.5	27	28	28	29	30	31.5			

Results

Main Effect: Communications Performance. Interface keying positions for new letters, symbols, or typing functions were introduced from lesson to lesson as subjects demonstrated mastery of the material taught in preceding lessons. The average rate at which the letters, symbols, and typing functions were introduced is shown in Table XI. This table presents for each letter, symbol, and function, the median lesson number at which that character was introduced for the eight subjects.

It can be discerned from Table XI that, by the ninth lesson, subjects had learned 13 of the most frequently used letters in the English language (e, t, a, o, n, i, r, s, h, d, c, l, m) and the principal typewriter symbols and functions. All numerals, nearly all letters, and the most commonly used symbols and typing functions had been introduced and learned by the 20th lesson, representing about five weeks of training with one teaching and practice session each day, four days a week.

Following instruction and memorization of the letter-keying code, daily practice sessions were continued with exercise materials selected to consolidate the students' retention of the interface keying positions and to improve their communications performance. Timed tests of performance were administered to students individually at the weekly sessions. Each test consisted of three short sentences, presented to the subject in large type centered on a standard sheet of 8-1/2 x 11 inch white writing paper. The subjects were instructed to "cybertype" the sentences introduced to them, using the assigned interfaces and working as rapidly and accurately as possible. Total time to complete the exercise was recorded. Since the tests differed somewhat in length, the performance of each subject was scored in terms of the average number of letters, symbols and functions produced per minute, and in terms of error-rate expressed as a percentage of the total number produced.

Results for the group are shown in Figure 2, which indicates the median number of letters, symbols, and functions produced per minute by the eight subjects across 11 weekly tests. Test No. 11 was actually a repetition of Test No. 1. Median typing speed increased from about 9 characters and functions per minute on the first test, to about 25 characters and functions per minute on the last test. Improvements in the subjects' performance are statistically significant at the 0.0005 level (Wilcoxon Test). Error rates dropped rapidly from a median of about 3.7% on the first test to about 0.5% on the third test, and varied between 0.5% and 1.5% through the last test. This decrease in error rate is considered significant, not only statistically (p=0.025), but also in terms of the improved performance abilities and motivation of the subjects, as observed by their teachers.

These remarkable results reveal that the severely disabled children tested, who heretofore could neither write nor type, learned to communicate in written form in a relatively short period of weeks. Furthermore, the data indicates that extended practice over a ten-week period resulted in general improvement in communications performance to a level adequate for practical daily use in producing classroom and homework exercises, in spite of severe disabilities. The students in this study continued daily practice and exercise during the 1970-1971 school year, and their performance in an educational environment is documented in Volume III, Part One A of

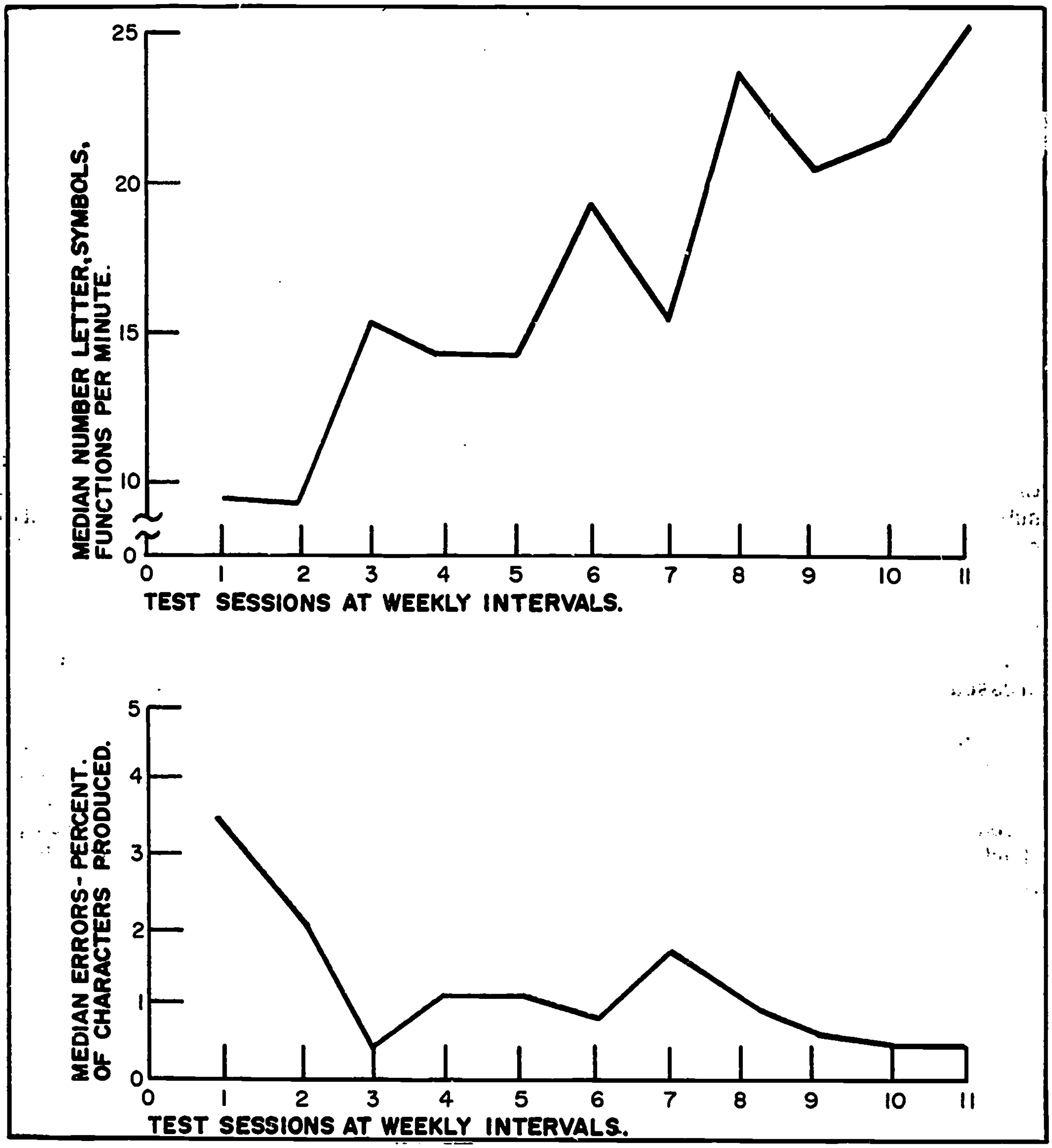

FIGURE 2

EFFECTS OF PRACTICE ON PERFORMANCE WITH 14-KEY, BILATERAL-INPUT SYSTEMS (N=8) this report.

It may be stated here that this portion of the study reveals that many of the severely disabled children who participated in this study and evaluation program were indeed thinking for themselves and were unquestionably motivated to continue their educational endeavors. They represent a significant population of the types of physical and neurological disabilities that are not uncommon in our schools.

Secondary Effects: Educational and Performance Tests. The battery of tests administered before and after training requires some explanation. The Peabody Picture Vocabulary Test (PPVT) was administered according to standard procedures, with Form "B" given at the initiation of the program and Form "A" at its conclusion. The Illinois Test of Psycholinguistic Abilities (ITPA) was reviewed and edited to omit those subtests which, in the opinion of the testers, were not compatible with the characteristics of the subjects being tested. The six ITPA subtests used were "Auditory Reception," "Visual Reception," "Auditory Association," "Auditory Sequential Memory," "Visual Association," and "Grammatic Closure." The Wide Range Achievement Test (WRAT), Spelling Subtest, Level 1, was selected for this program as being relevant to the verbal experiences acquired during instruction and practice in the experimental program, and consistent with the characteristics and capabilities of the subjects.

In the "C/R/I Tapping Test of Finger Dexterity," a pad containing water soluble paint was attached to each finger tip, and the subject was required to tap a spot of paint inside 1/2 inch diameter circles inscribed on the test page. For each finger, the subject was given 15 seconds to tap as many target circles as possible. Two forms of the test were given for each finger. Form 1 involved empty circles arranged in rows on the page, with the subject instructed to work across rows from left to right. Form 2 presented rows consisting of four circles, with two circles in each row containing an X and two circles being empty. The subject was instructed to tap only the empty circles in each row for a 15-second period.

The results of this testing series are presented in Tables XII, XIII, XIV, and XV. The group of subjects receiving instruction and training is referred to as the "experimental" group. Subjects receiving no special instruction compose the "control" group.

Table XII presents results for the PPVT and reveals that the control group produced a median pre-test IQ score lower than the median pre-test score for the experimental group. However, this difference in pre-test performance between experimental and control groups is not statistically significant (Mann-Whitney Test), which suggests that the two groups were at least comparable in IQ test performance at the start of this study.

Both the experimental and control groups showed statistically relevant improvement in post-test IQ scores at the end of the instructional program (Table XII). The magnitude of change from pre-test to post-test performance is also expressed as a percentage of the pre-test score, to reflect the fact that the importance of a given magnitude of change in an individual's IQ index is relative to the basal test score.

The test score improvement shown by the control group is somewhat larger than the improvement shown by the experimental group, but this difference is small and not statistically relevant (Mann-Whitney Test). Consequently, it may be inferred that the test score improvement occurring in both groups may have been due to such factors as pre-test experience with the PPVT itself, maturation, and general classroom development.

The experimental procedure and statistical methods used, as well as the small number of subjects available for this phase of the program, were insufficient to resolve the question of whether instruction with the man-machine communications systems significantly affects PPVT performance over a test interval as brief as five months.

Results with the ITPA are presented in Table XIII. The median test scores for the experimental group measure 193 at the beginning and 201 at the end of the training interval, whereas the control group showed a small decrease in median score from 202 initially to 200 at the end of the same time interval. The test score improvement shown by the experimental group was small, and there is little difference between pre-test and post-test scores for the control group (Wilcoxon Test). Furthermore, the pre-test scores for the experimental and control groups do not differ significantly, suggesting that the two groups were comparable in ITPA test performance at the commencement of this phase of the study. These findings suggest that the experimental group subjects involved in this phase of the study did not demonstrate gross improvement in ITPA performance over a five month interval as a result of the instruction. Moreover, a larger number of subjects and a longer pre-test-post-test interval would be required for a more definitive indication of any possible effects of instruction on ITPA test performance.

Results from the "C/R/I Tapping Test of Finger Dexterity" are presented in Table XIV. Subjects No. 123 and 124 are omitted from this table because their motor impairment was so severe that they were unable to produce tapping responses with any of their fingers. As already explained, this test involves tapping inside target circles with each finger for 15 seconds with Form 1 and for 15 seconds with Form 2. For purposes of this analysis, responses with Forms 1 and 2 of the test have been combined, yielding a total test duration of 30 seconds for each finger. Results for each subject are expressed as the average number of "accurate" tapping responses per finger per 30 seconds of testing time. Since some subjects were not able to use all five fingers on each hand, the information in parentheses refers to the number of fingers used on the right hand (e.g., R5) and the number of fingers used on the left hand (e.g., L3).

Table XV presents results from the WRAT Spelling Subtest. The experimental and control groups did not differ significantly in pre-test scores, indicating comparable performance at the start of the program. The experimental group showed an improvement from pre-test to post-test scores, although not significant at the 0.05 level (Wilcoxon Test), while the control group demonstrated a somewhat smaller degree of improvement. The difference between experimental and control groups, in terms of post-test score improvement, does not reach importance at the 0.05 level (Mann-Whitney Test). Thus, under the conditions of this phase of the study, the special instructional experience received by the experimental group did not produce a significant improvement in WRAT performance. Again, considerations of subject sample size and program duration cannot be neglected, as with results for the PPVT and ITPA. The findings of the pilot study indicate the need for further modification of the experimental design, including the involvement of larger populations.

TABLE XII

PEABODY PICTURE VOCABULARY TEST: PRE-TEST AND POST-TEST IQ SCORES FOR "EXPERIMENTAL" AND "CONTROL" SUBJECTS

	"Experimental" Group				"Control" Group			
S No.	Pre-Test	Post-Test	Difference Score	% Change	Pre-Test	Post-Test	Difference Score	% Change
122	82	93	+11	+13.4%	75	82	+ 7	+ 9.3%
123	104	96	- 8	- 7.7	82	90	+ 8	+ 9.8
124	105	122	+17	+16.2	(No Control Subject for No. 124)			
125	59	57	- 2	- 3.4	73	81	+ 8	+11.1
126	89	99	+10	+11.2	108	106	- 2	- 1.9
127	104	127	+23	+22.1	110	143	+33	+30.0
128	94	101	+ 7	+ 7.4	75	77	+ 2	+ 2.7
129	78	90	+12	+15.4	106	121	+15	+14.2
Median	92	98	+10.5*	+12.3%	82	90	+ 8*	+ 9.8%
	Difference Score: +6 = 6.5%				Difference Score: +8 = 9.8%			

*Significant at 0.05 level (Wilcoxon Test)

> *"It is a humane and moral society that endows its leaders with confidence to attend to the welfare of its handicapped citizens, be they physically or intellectually disabled. And the problem, even with the best intentions, is perplexing not only to administrators who do not have the resources and solutions to handle these dilemmas, but to parents and the teachers in whom handicapped children are compelled to place their trust."*

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TABLE XIII

ILLINOIS TEST OF PSYCHOLINGUISTIC ABILITIES: PRE-TEST AND POST-TEST "RAW SCORES" FOR "EXPERIMENTAL" AND "CONTROL" SUBJECTS

	"Experimental" Group				"Control" Group			
S No.	Pre-Test	Post-Test	Difference Score	% Change	Pre-Test	Post-Test	Difference Score	% Change
122	185	200	+15	+ 8.1%	179	190	+11	+ 6.1%
123	190	207	+17	+ 8.9	209	206	- 3	- 1.4
124	249	214	-35	-14.1	(No Control Subject for No. 124)			
125	188	188	0	0.0	202	200	- 2	- 1.0
126	199	184	-15	- 7.5	212	207	- 5	- 2.4
127	201	238	+37	+18.4	212	231	+19	+ 9.0
128	195	202	+ 7	+ 3.6	160	177	+17	+10.6
129	145	155	+10	+ 6.9	155	163	+ 8	+ 5.2
Median	193	201	+8.5	+ 5.2%	202	200	+ 8	+ 5.2%
Difference Score: +8 = 4.1%					Difference Score: -2 = 1.0%			

"What can be done to help these children? For even with the necessary resources, educational programs, materials, and legislation, there remains a need for appropriate surrogates which will supplement the shortcomings of the handicapped individual."

TABLE XIV

"C/R/I TAPPING TEST OF FINGER DEXTERITY":

AVERAGE NUMBER OF ACCURATE TAPPING RESPONSES PER FINGER PER 30 SECONDS

(Note: Information in parentheses refers to number of fingers used with right and left hands)

	"Experimental" Group				"Control" Group			
S No.	Pre-Test	Post-Test	Difference Score	% Change	Pre-Test	Post-Test	Difference Score	% Change
122	11.1 (R5, L5)	13.0 (R5, L5)	+1.9	+17.1%	27.3 (R5, L5)	38.9 (R5, L5)	+11.6	+42.5%
125	29.7 (R5, L1)	33.6 (R5, L2)	+3.9	+13.1	25.1 (R5, L5)	46.2 (R5, L5)	+21.1	+84.1
126	6.8 (R4, L5)	9.0 (R5, L5)	+2.2	+32.4	22.9 (R5, L5)	39.0 (R5, L5)	+16.1	+70.3
127	11.8 (R2, L2)	16.8 (R3, L2)	+5.0	+42.4	37.1 (R5, L5)	49.9 (R5, L5)	+12.8	+34.5
128	21.1 (R5, L5)	19.5 (R5, L5)	-1.6	- 7.6	10.2 (R5, L0)	17.6 (R5, L0)	+ 7.4	+72.5
129	10.7 (R5, L5)	14.5 (R5, L5)	+3.8	+35.5	20.5 (R5, L5)	23.1 (R5, L5)	+ 2.6	+12.7
Median	11.4	15.6	+3.0	+24.7%	24.0	39.0	+12.2*	+56.4%
	Difference Score: +4.2 = 36.8%				Difference Score: +15.0 = 62.5%			

*Significant at 0.65 level (Wilcoxon Test)

TABLE XV

WIDE RANGE ACHIEVEMENT TEST (SPELLING SUBTEST): PRE-TEST AND POST-TEST "GRADE SCORES" FOR "EXPERIMENTAL" AND "CONTROL" SUBJECTS

S No.	"Experimental" Group				"Control" Group			
	Pre-Test	Post-Test	Difference Score	% Change	Pre-Test	Post-Test	Difference Score	% Change
122	3.5	5.3	+1.8	+51.4%	2.9	3.5	+0.6	+20.7%
123	6.0	5.0	-1.0	-16.7	12.2	13.0	+0.8	+ 6.6
124	3.2	3.7	+0.5	+15.6	(No Control Subject for No. 124)			
125	4.5	5.5	+1.0	+22.2	3.2	3.9	+0.7	+21.9
126	5.5	6.0	+0.5	+ 9.1	13.0	9.7	-3.3	-25.4
127	4.7	5.3	+0.6	+12.8	5.7	5.5	-0.2	- 3.5
128	3.0	4.7	+1.7	+56.7	2.5	3.0	+0.5	+20.0
129	0.5	2.2	+1.7	+340.0	2.2	3.0	+0.8	+36.4
Median	4.0	5.2	+0.8	+18.9%	3.2	3.9	+0.6	+20.0%
Difference Score: +1.2 = 30.0%					Difference Score: +0.7=21.9%			

"Consideration of man-machine systems designed to efficiently utilize a person's remaining motor capabilities may provide solutions heretofore not available. Through use of these systems, many disabled persons will overcome their handicaps and become equal to and even exceed standards of performance usually established for nonhandicapped individuals. It is through an understanding of the handicapped person's human requirements, recognition of their remaining motor capabilities and application of the principles of cybernetics, that many of them can, when given the opportunity and appropriate feedback systems, supplement their living systems with surrogates. It is through these insights that researchers engaged in studying systems to enhance man's communicative abilities can offer new hope."

Part One C | TONGUE KEYBORDS

TYPEWRITERS OPERATED WITH PORTABLE TONGUE INTERFACE.

The effectiveness of typing with the tongue by severely disabled individuals was studied initially with two subjects. One subject, a female, was almost totally paralyzed from the neck down and in need of writing means. The etiology of this subject is allegedly traced to poliomyelitis at age 19 which resulted in quadriplegia and severe respiratory involvements.

The subject was selected as a candidate in the C/R/I training program since her disability is not uncommon; it is representative of the disabilities of many school-age children who have been in diving accidents, e.g., plunging into shallow water head first and striking a hard bottom, or attempting to dive through an inflated automobile-inner-tube which is afloat in a body of water. Objectives of the study were also to determine the capabilities and constraints involved in an experimental training program in the operation of "Cybertype" systems by severely paralyzed subjects and to ascertain their potential effectiveness for severely disabled school children and adults.

Prior to being instructed in the use of the "Cybertype," the subject had learned to operate a standard 49-key electric typewriter by activating the keys with a "type-stick" held in her mouth or by hitting each key independently with an eraser-tipped pencil attached to her right hand and controlled via an ingenious electro-mechanical surrogate arm developed and built by engineers at Rancho Los Amigos Hospital in Downey, California. The mouth-stick method of typing was slow; nevertheless, the subject's high motivation enabled her to type at a speed of approximately eight words per minute. It was also an objective of this phase of the study and evaluation program to determine if it might be easier and less tiresome for this subject to operate a tongue-finger interface.

The subject had extremely limited residual muscular function in the fifth digit of the right hand. It was decided that this limited muscle function could be utilized to operate the mode-selector switch of a dual-input "Cybertype" interface which has eight double-throw keys (two banks of four each) operable by the tongue and a three-position lever switch which is operated by pressure from a slight finger movement.

The "Cybertype" used (see Volume 3, Part Four, of this report) was mounted on a table positioned at a height which enabled the subject to drive a Rancho Los Amigos electrically powered wheelchair into the proper typing position. A tongue-finger interface, which was mounted on a table was made accessible to her. A three-position state-selector lever switch was mounted on the table in a manner which permitted her to activate it with very slight movement of a finger of the right hand. A double-mirror was arranged on the typewriter so that she could see, from her wheelchair, what was being typed.

Shortly after the installation, this subject was involved in an automobile accident in which she was injured and her control system and wheelchair were damaged. She was not able to work until she was fitted with another electrically powered prostheses and wheelchair. Subsequently, she was able to commence, but practice was extremely sporadic due to interruptions caused by illness and moving into a new home.

In June of 1970, the subject was introduced to an organized instructional program. A schedule of regular lessons was initiated. The goal for the instructional program was to have the subject master the total code of 92 functions. Once the program got underway, it proceeded without major interruptions, and the subject's progress was rapid and, in fact, remarkable. Her error rate decreased while her typing speed increased considerably, as did her confidence in herself and determination to use the writing machine as an everyday communications tool.

In August of 1970, the subject's typing speed was measured at a rate of 11 words per minute. This speed was greater than she had been able to attain on a standard typewriter keyboard when typing with the mouth stick or with a pencil controlled by her prosthesis. Perhaps a more significant finding pointed out by observers was the fact that her motivation improved considerably and that she did not suffer from fatigue.

The subject has "cybertyped" at speeds in excess of 22 words per minute with a low percentage of error and without rapid tiring. She is now using the system for regular correspondence and other communications. This severely disabled subject may serve as an example to parents, teachers and severely handicapped individuals with similar severe disabilities that it is possible to communicate effectively, given the prerequisites of faith, discipline, and determination.

As an outgrowth of the results obtained from this subject, efforts were made to investigate the utility of these man-machine communications systems with even more severely disabled individuals (i.e., those who have no residual controllable movement in any part of the body below the neck.)

One male subject was selected. His disability allegedly resulted from the surgical removal of a cervical tumor. This subject was taught to operate a tongue interface. He is an unusually creative and highly motivated young man who, prior to the introduction of the tongue-operated interface (see Volume 3, Part Four, of this report), had no effective means of communicating, other than his extremely laborious--- due to the use of a trachial respirator---speech capability.

This subject did not receive the rigorous training as did the female subject. Hence, little quantitative data was available. However, the subject has demonstrated some typewritten communication at a rate of about 7 words per minute with mimimal error. It is anticipated that if this subject were provided with equipment and a fair opportunity to learn, he too could achieve increased speed and utility with more extensive practive.

With an increase in diving, hunting, pedestrian, automobile, and other accidents, the handicapped community is being expanded to a new population of disabled school-age children and adults. Thus, it appears worthy to pursue these studies with greater vigor in order to arrive at solutions and recommendations to aid this unfortunate population.

Part Two | SCREENING PROCEDURES

C/R/I SCREENING TEST OF LATENT READING ABILITY

Introduction

The "C/R/I Screening Test of Latent Reading Ability" was developed at C/R/I for the purpose of measuring degrees of reading proficiency in multiply handicapped, non-verbal, and/or learning-disabled children. The test was designed after an investigation and a literature search revealed that no comprehensive or standard tests were available to teachers and psychologists in the special-educational community for the purpose of testing severely disabled children. Verbal materials used in this screening test are presented in the section following this introduction.

As one of the criteria of subject selection for the pilot study, the C/R/I test provides a means of identifying children who demonstrate an ability to make distinctions that are required for an understanding of the concepts of written language. Letter-word recognition and matching skills are assessed with the aid of audio-visual presentations developed for this study.

Part I of the test is used to determine a child's ability to associate verbalization of a letter with visual presentation of the same letter on a card. After orientation and practice, the child is first asked to discriminate between five multiple-choice letters spoken in random order by the experimenter, and then to select the one which matches its visual correlate printed on a card. Letters of the English alphabet may be tested in random order.

Part II of the test is designed to test the multiply impaired child's ability to identify the spoken word corresponding to the word printed on a display card. Forty words were selected at random from the Dolch Basic Word List (Johnson, 1971), and each word was printed on a separate card. As each word card is displayed to the subject, the experimenter speaks five multiple-choice words, selected from the same word list, including the word printed on the displayed card. The subject's task is to indicate which spoken word corresponds to the word printed on the displayed card.

Initial versions of the test were administered by C/R/I researchers, who presented the multiple-choice verbalization orally. Subsequent forms of the "C/R/I Screening Test of Latent Reading Ability" have been tape-recorded in order to avoid vocal inflections and other cues which might indicate the correct answer, since it was observed that many of the children are extremely sensitive to facial expressions, body movements, inflections and tones of speech, and other mannerisms involuntarily exhibited by the tester.

The tests are preceded by examples which ascertain whether or not the child is capable of performing tasks required. Failure to comprehend items in the practice session precludes administration and continuation of either part of the test.

Initial sample testing revealed that revision of the test was necessary to accommodate the short attention span of many subjects, and to reduce the disproportionate amount of testing time required. In the first revision, Part I of the test was shortened to include a random sampling of only 14 letters of the alphabet, rather than 26. Part II was also revised to present 20 rather than the original 40 words. The presentation of the shortened test to the subject remains as originally developed and there appears to be no observable difference in the quality of the method.

It is suggested for future researchers that investigators modify and improve these pilot versions of the tests with particular emphasis on:

1. verification of choice of words from the Dolch List by Johnson;

2. refinement of initial measurements of latent reading ability, and reading and vocabulary level;

3. development of several stages of the test according to appropriate and sequential age-grade and maturation level;

4. development of tests for both upper and lower-case letters, since schools and institutions vary in the choice of instructional method, some preferring to teach upper case letters first, others preferring lower case;

5. development of both printed and pictorial presentations in order that latent reading ability may be adequately identified; and

6. design of testing materials to be compatible with man-machine systems.

The modifications and improvements outlined could ultimately provide teachers with a valuable means of testing multiply handicapped, non-verbal, and/or learning-disabled children which would help to provide researchers with consistent data regarding the reading proficiency and the latent reading ability of the subject population. The tests, when so developed and adapted, could have utility even for children, not disabled, who do not necessarily require man-machine systems for communication.

Pre-Testing Procedures

The first task to be accomplished with the child to be tested is the establishment of a pleasant dialogue and a consistent mode of response. This mode of response must be one which the child can readily accomplish and which the examiner can perceive and understand. The verbal child can simply respond with "Yes" or "No". A non-verbal child may respond by a nod or shake of the head, by eye movements, by various pre-arranged body movements (e.g., shrugging of shoulders or other parts of the body, with one movement indicating "Yes" and two movements indicating "No"), or by whatever other effective means is available to him. Once the mode of response has been established, however, it is important that it be maintained -- i.e., that the child consistently answer in the established mode.

Prior to administering the "C/R/I Screening Test of Latent Reading Ability", it is also necessary to ascertain whether the child has hearing and/or visual problems, since these can hinder the child's performance on the reading test. To determine whether a child has problems of perception or auditory acuity, test him in the manner of the examples given below:

1. Hold up a ball. Ask the child: Is this a bat?
   Is this a bone?
   Is this a bird?
   Is this a ball?

2. Hold up a sock. Ask the child: Is this a block?
   Is this a rock?
   Is this a sock?
   (and if the child has not responded to "sock")
   Is this a clock?

To ascertain whether a child has problems of visual acuity, perception, or association, test him as shown below:

1. Present a geometric form, preferably a square to the child at various angles and from various distances to ascertain what positioning is most readily visible to him.

2. Hold up a circle. Ask the child: Is this a square?
   Is this a circle?
   (and if the child has not responded to "circle")
   Is this a star?

3. Hold up a picture of a house. Ask the child: Is this a car?
   Is this a chair?
   Is this a house?

If the child fails to perform well on these simple pre-tests, do not administer the "C/R/I Screening Test of Latent Reading Ability". A check of the child's records (if available) and a discussion with his instructors may reveal the source of the child's hearing and/or vision problem and whether there is any chance that he could perform on the reading test.

Directions for Administering the "C/R/I Screening Test of Latent Reading Ability"

Letter recognition is to be tested in the following manner. Each letter is printed on a separate card (either in upper or lower case), and is numbered on the back as to its position in the frequency order. Present the child with these cards one at a time and in order of letter frequency. As the child views a letter card, play the tape recording of the series of the letters which corresponds to the letter on the card. (The letter on the card, of course, will be one of the letters presented in the oral series.) The child is to make a verbal or physical indication when the letter printed on the card is pronounced.

Be sure to first provide the child with practice on the example exercises. To demonstrate, with the first example, say to the child: "Johnny, this is a card. (Hold up card printed with "e"). It has a letter on it. Do you see the letter? (Yes or No answer. Act accordingly.) I am going to play a tape on which you will hear the names of some letters. Tell me right away when you hear the letter that is on this card." (Play the tape which sounds out "b-k-n-q-e ".)

Have the child practice all three examples. Following the first one or two examples, this dialogue can be abbreviated. Naturally, the dialogue should be varied to suit the individual child, but it must remain explicit as to each phase of the recognition and response process.

While practicing the example exercises for letter recognition, take care to ascertain that (a) the child knows how you want him to answer; (b) the child does answer in this manner consistently; (c) the child listens well, (encourage him to listen by verbal statements, voice tone, facial expression, etc.); and (d) the child does understand the sound-symbol relationship of the printed and pronounced letter.

Having completed the example exercises, proceed to the test of letter recognition and discrimination and administer it as you did the example exercises. If necessary during the test, remind the child to answer in the established manner or to listen when it is appropriate.

The procedure for testing the child on word recognition is identical to that followed when testing letter recognition. Each of the twenty words being directly tested and each of the three examples is printed in upper or lower case on a separate numbered card. Present the child with each of the word cards one at a time and in the correct numerical order. As the child views the card, play the tape recording on which the appropriate series of five words appears. (The word printed on the card will be one of those in the taped series.) Again, the child is to indicate verbally or physically when the word printed on the card is pronounced.

As when testing with letters, allow the child to practice the example exercises before commencing with the actual test. When word recognition is being tested, the dialogue for the first example would be:

" Jane, this is a card. (Hold up the card printed with "she".)
It has a word on it.
Do you see the word? (Yes or No answer. Act accordingly.)
I am going to play a tape on which you will hear the word that is on this card."
(Play the tape which sounds out "-how-she-from-carry-does-".)

This dialogue can be varied to suit the individual child. At this point in the test, it may only be necessary to provide one or two examples. This, of course, depends on the child's comprehension of the task.

Again, when going through the example exercises, be careful to ascertain that (a) the child knows how you want him to answer; (b) the child does answer in this manner; (c) the child listens well; and (d) the child does understand the sound-symbol relationship of the printed and pronounced words.

Now, proceed to the test of word recognition and discrimination. Remember never to pronounce the letter or word printed on a card when showing it to the child. Also, take great care that no one gives the child cues as to his performance.

During the testing session, have before you the pages entitled, "Order of Verbal Presentation of Letters" and "Order of Verbal Presentation of Words." These provide you with necessary information for the test and also serve as scoring sheets.

Scoring the Test

On the sheets giving the "Order of Verbal Presentation of Letters" and the "Order of Verbal Presentation of Words," circle the letter or words to which the child responds. At the top of the first page of the scoring sheets for each section of the test, indicate the number of errors the child made.

If the child fails to do well on this test, the indication is that his reading skills are not adequate to enable him to take part in a "Cybertype" program. The exact percentage of error that would disqualify a child from a "Cybertype" program has yet to be determined; this decision is to be based on the results of continuing experimentation with the test.

Test Materials

Note: Letter and word cards which have been used in the process of testing and revising the "C/R/I Screening Test of Latent Reading Ability" are presented in the pages which follow: the initial version of the test (pages 35-38), the first revision (pages 38-40), and the second revision (pages 40-43). The introductory overview of the test and instructions for its administration (pages 31-35) remain the same for each set.

C/R/I SCREENING TEST OF LATENT READING ABILITY: INITIAL VERSION

Part I

LETTER CARD	ORDER OF VERBAL PRESENTATION
e	b k n q e
t	i t d y p
a	u a f k t
o	u v i o j
n	v l m z n
i	f i s y p
r	c h r o j

Part I

LETTER CARD	ORDER OF VERBAL PRESENTATION				
s	l	i	d	j	s
h	a	g	h	s	w
d	c	g	r	d	e
c	c	a	m	w	p
l	u	l	i	w	x
m	u	b	f	m	w
u	u	h	n	q	e
f	c	f	h	t	y
p	l	r	t	n	p
y	v	m	y	p	x
b	b	f	e	s	w
g	u	g	t	o	p

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
goes	goes	get	as	show	open
at	drink	sing	at	your	read
then	out	then	draw	before	hot
wish	wish	walk	ran	green	red
shall	an	shall	seven	ride	much
around	it	around	wash	every	play
never	better	never	small	say	or
their	me	full	their	of	hold

C/R/I Screening Test of Latent Reading Ability, Initial Version, continued

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
because	under	so	because	black	we
hurt	hurt	clean	fast	fly	soon
with	little	he	into	ask	with
use	don't	use	now	like	get
it's	carry	have	it's	can	let's
us	is	think	where	us	I
after	old	hot	can	an	after
light	very	please	light	red	gave
his	green	his	it	sleep	does
saw	too	who	some	cold	saw
could	said	new	must	seven	could
flour	long	cut	eat	they	flour
came	there	big	myself	buy	came
brown	brown	done	only	help	both
him	in	every	much	him	your
take	of	this	funny	about	take
six	many	we	fall	six	better
what	what	found	let	like	before
was	were	white	was	into	work
why	why	drink	our	two	would
right	see	may	how	right	draw
three	do	three	wash	don't	yellow

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
fast	going	come	fast	say	went
for	for	hold	her	ride	start
wash	had	laugh	two	wash	got
under	ten	read	call	sleep	under
like	did	much	or	like	walk
make	the	make	bring	blue	were
she	how	she	from	carry	does
stop	stop	own	your	myself	found
don't	big	find	it	over	don't
just	again	far	just	little	eat

C/R/I SCREENING TEST OF LATENT READING ABILITY: FIRST REVISION

ORDER OF VERBAL PRESENTATION OF LETTERS

LETTER CARD	ORDER OF VERBAL PRESENTATION				
Examples:					
E	B	K	N	Q	E
H	A	G	H	J	W
S	L	I	D	J	S
Test:					
T	I	T	D	Y	P
A	U	A	F	K	T
O	U	V	I	O	J
N	V	L	M	Z	N

C/R/I Screening Test of Latent Reading Ability: First Revision, continued

Order of Verbal Presentation of Letters

LETTER CARD	ORDER OF VERBAL PRESENTATION				
Test:					
I	F	I	S	Y	P
R	C	H	R	O	J
D	C	A	M	W	D
M	U	B	F	M	W
B	B	F	E	S	W
G	U	G	T	O	P
W	A	G	Z	D	W
Q	C	V	K	Q	Y
Z	U	F	I	Z	J

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
Examples:					
SHE	HOW	SHE	FROM	WERE	DOES
CAME	THERE	MADE	FAR	US	CAME
WHAT	WHAT	FOUND	DAY	LIKE	BEFORE
Test:					
DAY	DAY	GET	AS	LONG	ME
AT	THREE	NO	AT	YOUR	ALSO
THEN	OUT	THEN	SO	BEFORE	MOST
TOO	TOO	BACK	ONE	PLACE	OVER
ANY	AN	ANY	TWO	BACK	THEN

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
Test:					
AROUND	IT	AROUND	SAME	FOUND	BACK
NEVER	BETTER	NEVER	SHALL	SAY	OR
THEIR	ME	THEN	THEIR	OF	HIS
BECAUSE	UNDER	SO	BECAUSE	BLACK	WE
HOW	HOW	RIGHT	WENT	LOOK	SOON
WITH	LITTLE	HE	INTO	EVERY	WITH
USE	DON'T	USE	NOW	LIKE	GET
ITS	DO	HAVE	ITS	CAN	PART
US	A	THINK	WERE	US	I
AFTER	OLD	HAT	CAN	AN	AFTER
FAR	VERY	KNOW	FAR	ANY	GAVE
HIS	YET	HIS	IT	PEOPLE	DOES
PART	TOO	WHO	SOME	HOW	PART
COULD	SAID	NEW	MUST	WHAT	COULD
YOU	LONG	NUMBER	EAT	THEY	YOU

C/R/I SCREENING TEST OF LATENT READING ABILITY: SECOND REVISION

ORDER OF VERBAL PRESENTATION OF LETTERS

LETTER CARD	ORDER OF VERBAL PRESENTATION				
Examples:					
E	B	K	N	Q	E
H	A	G	H	J	W

C/R/I Screening Test of Latent Reading Ability; Second Revision, continued

Order of Verbal Presentation of Letters

LETTER CARD	ORDER OF VERBAL PRESENTATION				
Examples:					
S	L	I	D	J	S
Test:					
T	I	T	D	Y	P
A	U	A	F	K	T
O	U	V	I	O	J
N	V	L	M	Z	N
I	F	I	S	Y	P
R	C	H	R	O	J
D	C	A	M	W	D
M	U	B	F	M	W
B	B	F	E	S	W
G	U	G	T	O	P
W	A	G	Z	D	W
Q	C	V	K	Q	Y
Z	U	F	I	Z	J

C/R/I Screening Test of Latent Reading Ability, Second Revision, continued

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
Examples:					
SHE	HOW	SHE	FROM	CARRY	DOES
CAME	THERE	BIG	MYSELF	BUY	CAME

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION				
Examples:					
WHAT	WHAT	FOUND	DAY	LIKE	BEFORE
Test:					
GOES	GOES	GET	AS	SHOW	OPEN
AT	DRINK	SING	AT	YOUR	READ
THEN	OUT	THEN	DRAW	BEFORE	NOT
WISH	WISH	WALK	RAN	GREEN	RED
ANY	ANY	SHALL	SEVEN	RIDE	MUCH
AROUND	IT	AROUND	WASH	EVERY	PLAY
NEVER	BETTER	NEVER	SHALL	SAY	OR
THEIR	ME	FULL	THEIR	OF	HOLD
BECAUSE	UNDER	SO	BECAUSE	BLACK	WE
HURT	HURT	CLEAN	FAST	FLY	SOON
WITH	LITTLE	HE	INTO	ASK	WITH
USE	DON'T	USE	NOW	LIKE	GET
ITS	CARRY	HAVE	ITS	CAN	LET
US	A	THINK	WERE	US	I
AFTER	OLD	HOT	CAN	AN	AFTER
LIGHT	VERY	PLEASE	LIGHT	RED	GAVE
HIS	GREEN	HIS	IT	SLEEP	DOES
SAW	TOO	WHO	SOME	COLD	SAW
COULD	SAID	NEW	MUST	SEVEN	COULD

Part II

WORD CARD	ORDER OF VERBAL PRESENTATION
Test:	
FLOOR	LONG CUT EAT THEY FLOOR

"Utilization of cybernetic principles to aid handicapped individuals was disclosed more than three decades ago by the founding fathers of cybernetics. Offering directions towards better understanding of man, his automata, and environment, the Josiah Macy,Jr. Foundation, brought together pioneers Warren S. McCulloch, Julian Bigelow, Norbert Wiener, Margaret Mead, Heinz Von Foerster, W. Ross Ashby, Arturo Rosenblueth, Frank Freemont-Smith and a host of other participants dedicated to discovering means to enhance man's communicative abilities. The universal language has not yet been found, but certainly we are evolving into awareness of new relationships and interactions. The laws of energy were overtaken by systems analysis in terms of energy yielding to analytical terms of the laws of information, purposive behavior, feedback, control, goals and domains. Thanks to the work and questions raised by Warren S. McCulloch, cybernetic epistemology is being broadened the world over in many fields of endeavor. Our attention is more clearly directed to limitations and capabilities of not only ourselves,but to nature's ecological systems: that environment in which we live, procreate and die."

Part Three | CYBER-GO-ROUND

WORD AND PICTURE COMMUNICATIONS SYSTEM

Introduction

"Cyber-Go-Round," under study as part of C/R/I's evaluation of automated and programmed visual man-machine systems for the very severely disabled student, consists essentially of an interface or keyboard, a control system, and a slide projector. It includes slides which provide a vocabulary of from 80 to 140 message units, depending on the type of slide projector used. The contents of the slides are designed to convey the basic needs to and from a child who has no other means of written or verbal communication. The contents are in picture or cartoon form for users who cannot express themselves through other means, or who do not have the language capability necessary for communication. "Cyber-Go-Round" may also be used as a basic communications system for other individuals who temporarily cannot read or speak.

In one control configuration of the "Cyber-Go-Round," the printed or pictorial message slides are sequentially accessed in either direction by means of three control buttons or switches suitably positioned for operation by various parts of the user's body. To facilitate appropriate selection and rapid access, the messages are organized into convenient and related categories, e.g., pain, discomfort, hunger, thirst, hygiene, clothing, social interaction, well-being, etc. Experimental printed and pictorial messages presently being developed may be found in Part 4 of Volume IV of this report.

In another configuration, a Kalavox™* carousel "talking-slide projector" is employed. Each visual message on the slide is accompanied by an audio message for the slide, which is derived from a magnetic tape reel located in the slide cassette. This cassette tape-slide mechanism, which fits on a standard carousel projector, permits the teacher to change the picture or printed message and the taped audio message at any time.

Three principal applications of the "Cyber-Go-Round" are presently being explored:

*Trademark, Kalart Victor Corporation, Plainville, Connecticut.

1. for use by severely disabled students as an educational aid for introducing and teaching letters, symbols, numeral recognition (prior to their learning how to operate a writing machine), and concepts essential in reading and understanding training instructions;

2. the utility of a basic communications system as a therapeutic and/or diagnostic means for severely disabled individuals; and,

3. the utility of self-operated printed slide and picture messages concerned with other than classroom needs, e.g., rehabilitation, vocational and avocational needs, as well as personal expressions, opinions, and other feelings, desires, etc.

The printed and pictorial message contents are being developed in cooperation with personnel at the following C/R/I Field Centers:

1. Cerebral Palsy School
   Louisville, Kentucky

2. D. T. Watson Home for Crippled Children
   Leetsdale, Pennsylvania

3. Buffalo Public School #84
   Buffalo, New York

4. The Widener Memorial School
   Philadelphia, Pennsylvania

5. Richmond Cerebral Palsy Center
   Richmond, Virginia

6. The Moody School
   Galveston, Texas

7. Coastal Center, South Carolina Department of Mental Retardation
   Ladson, South Carolina

8. Illinois Children's Hospital School
   Chicago, Illinois

9. Institute of Rehabilitation Medicine, New York University Medical Center
   New York, New York

10. Montgomery County Cerebral Palsy Center
    Silver Spring, Maryland

11. Belle-Willard School
    Fairfax, Virginia

Some of the contents of the experimental pictorial messages are cartoon-like characters which attempt to exemplify the desired meaning through pictures of "body language" and/or facial expressions. Brief statements, with "key words" emphasized by color and/or by size, are included on the pictorial slides for the purpose of aiding the English non-reading user in associating the printed word with the desired message needed for communication.

The potential application of the "Cyber-Go-Round" in an educational environment is to provide severely disabled students dialogue with their teachers and classmates via an automated control of messages in audio, picture, and/or written form by means of a simple interface and control system connected to an electrically powered carousel-type 35mm slide projector. The system appears to offer a possible means of more effectively communicating and enhancing the curriculum content for severely disabled children. If this is the case, then it may also have a potential for enabling them to enjoy greater independence and flexibility in their individual pursuits later in life as adults.

Several avenues are being followed by teachers at the C/R/I Field Centers in cooperation with C/R/I researchers in an attempt to increase the utility and effectiveness of the system, principally to determine its worthiness in an educational environment. The experimental instructional manuals presently being used in the "Cybertype" program can be expanded to include the "Cyber-Go-Round" presentation. Appropriate curriculum content already available can be adapted to the system in order to aid teachers, parents and students confronted with communication problems. Personal message units are being planned so that they can be grouped according to age/grade and maturation levels, thereby providing a more comprehensive catalogue of messages from which either teacher or student can choose sets (e.g., multiples of 80 or 140 slides) which are appropriate for a particular class or specific individual.

Materials are under development for specific age/grade and maturation levels. With these new materials it may be possible to achieve more independence in the learning situation together with greater teacher opportunities for individual and group instruction, especially in classrooms attended by severely disabled and multiple-impaired children.

> *"Today, we are applying the principles of feedback-control in order to better understand and hopefully reveal new insights and features of learning which are at times missed or overlooked by reinforcement theory. For example, the spatial organization of purposeful behavior is an aspect that is basic to the theory of feedback-control, but is frequently not clearly conceptualized by reinforcement learning models."*

"CYBER-GO-ROUND" PRINTED MESSAGE OUTLINE

PAIN

1. MY | HEAD | EYES | EARS | TEETH | HURT(S).
2. I HAVE A SORE THROAT.
3. I HAVE PAINS IN MY CHEST.
4. I ACHE ALL OVER.
5. MY | HANDS | ARMS | FEET | LEGS | HURT.
6. MY | NECK | BACK | HURTS.
7. MY STOMACH HURTS.

DISCOMFORT

8. MY

HEAD	EYE	EAR	NOSE
NECK	BACK	CHEST	ARM
HAND	LEG	FOOT	STOMACH

ITCHES.

9. I AM | COLD | HOT |
10. I FEEL SICK TO MY STOMACH.
11. MY HEAD FEELS CONGESTED.
12. I HAVE A COLD.
13. SOMETHING IS IN MY EYE.
14. I HAVE TO BLOW MY NOSE.
15. PLEASE MOVE MY FEET.
16. I AM UNCOMFORTABLE, PLEASE HELP ME.
17. IS IT TIME TO TAKE MY MEDICINE?
18. MY MEDICINE MAKES ME FEEL ILL.

EVACUATION

19. I HAVE TO GO TO THE BATHROOM.

20. I HAVE DIARRHEA.

21. I AM CONSTIPATED.

HYGIENE

22. PLEASE WASH MY

FACE	NECK	CHEST
LEGS	ARMS	HANDS.

23. PLEASE BRUSH MY | TEETH | HAIR |.

24. PLEASE CUT MY | HAIR | FINGERNAILS | TOENAILS. |

25. I WOULD LIKE MY DEODORANT.

CLOTHING

26. I WOULD LIKE TO WEAR

SLACKS	SWEATERS	STOCKINGS
SKIRT	SHORTS	SOCKS.

27. PLEASE | PULL UP | PULL DOWN | MY ZIPPER.

28. PLEASE | BUTTON | UNBUTTON | MY SHIRT.

29. I WOULD LIKE TO CHANGE MY CLOTHES.

30. I WOULD LIKE TO BUY SOME NEW CLOTHING.

COMMUNICATION

31. PLEASE TURN | ON | OFF | THE | TV | RADIO | RECORD PLAYER |.

32. PLEASE TURN OVER THE RECORDS.

33. WOULD YOU PLEASE CHANGE THE TV TO CHANNEL

2	3	4	5
6	7	8	9
10	11	12	13.

34. I WOULD LIKE TO READ A BOOK.

35. I WOULD LIKE TO READ A [NEWSPAPER | MAGAZINE].

36. WOULD YOU PLEASE TURN THE PAGE?

37. I WANT TO TYPE.

38. I WOULD LIKE TO USE THE TELEPHONE.

39. WHAT IS YOUR NAME?

40. I FEEL GOOD.

41. TODAY I AM [HAPPY | SAD].

42. WHAT DO YOU WANT?

43. I WOULD LIKE TO HELP PLAN THE [MEAL | PARTY].

44. WHEN ARE THEY COMING?

45. I WOULD LIKE TO GO VISITING.

46. I WOULD LIKE TO GO SHOPPING.

47. I LIKE [HIM | HER | YOU].

48. [SHE | HE] LIKES ME.

49. I LIKE WHAT YOU ARE WEARING.

50. THANK YOU FOR COMING TO SEE ME.

51. [HOW IS | WHERE IS] MY [MOTHER | FATHER | SISTER | BROTHER] ?

52. HAS MY [MOTHER | FATHER] CALLED?

53. I WOULD LIKE TO GO TO [CHURCH | TEMPLE].

54. I WOULD LIKE TO GO TO THE MOVIES.

55. I WOULD LIKE TO GO TO THE CONCERT.

56. I WANT TO BE WITH MY FRIENDS.

57. I WOULD LIKE TO GO TO THE LIBRARY.

58. I WOULD LIKE TO GO TO A MUSEUM.

HUNGER

59. I [AM | AM NOT] HUNGRY.

60. WHAT IS FOR [BREAKFAST | LUNCH | DINNER] PLEASE?

61. I WOULD LIKE A [DESSERT | SNACK]

62. I WOULD LIKE SOME SEASONING ON MY FOOD, PLEASE.

63. I WOULD LIKE MY DESSERT [NOW | LATER]

THIRST

64. I WOULD LIKE SOMETHING TO DRINK.

SLEEP

65. I AM TIRED.

66. I WOULD LIKE TO LIE DOWN.

67. PLEASE WAKE ME AT

1	2	3	4
5	6	7	8
9	10	11	12

O'CLOCK.

MISCELLANEOUS

68. WILL YOU PLEASE HELP ME?

69. PLEASE [OPEN | CLOSE] THE DOOR.

70. PLEASE [TURN ON | TURN OFF] THE LIGHT.

71. PLEASE [OPEN | CLOSE] THE WINDOW.

72. PLEASE MOVE ME [INTO | OUT OF] THE SUNLIGHT.

73. I WOULD LIKE TO GET [INTO | OUT OF] THE CHAIR BED.

74. WHAT CAN I DO NOW?

75. WHAT TIME IS IT?

76. WHEN WILL THE | MOVIE | CONCERT | TRIP | BE?

77. I SMELL SOMETHING BURNING.

78. | SOMEONE | SOMETHING | FRIGHTENED ME.

79. I AM AFRAID.

80. THERE IS SOMETHING I WANT, BUT IT IS NOT ON THIS LIST.

> "According to the theory of feedback-control, organized purposeful behavior involves responses to the spatial and temporal relationships and patterns in the environment. The use of the principle of feedback can be meaningfully applied to man-machine systems for use especially by handicapped individuals who have limited feed-forward capabilities."

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Part Four | CYBERCOM

FAMILY OF MAN-MACHINE COMMUNICATIONS SYSTEMS

Introduction

The complete family of interface configurations of the "Cybertype" writing machines are innumerable, but basically may be identified as dual-concurrent (DC), dual-sequential (DS), and dual-sequential-temporal (DST). Further identification within these categories is based on the intended means of operation: viz. "unicorn" or head stylus, finger, fist, elbow, toe, foot, tongue, other parts of the body, E. M. G. signals controlled by the muscles or E. E. G. signals controlled by the central nervous system. (See plates 1 through 39.)

Interfaces studied in the program in terms of their usefulness to the multi-handicapped student who knows the structure of the language (that is, how to form words and phrases), were evaluated in terms of the following requirements: (1) simplification of the task of providing the user convenient key, switch or control access; (2) reduction, to an acceptable minimum, of the accidental actuation of keys or controls; and (3) prevention of injury to the user.

The principal parameters which affect the degree to which these requirements are met are: key layout, key "guards," key-top size and shape, key actuation force, weight and portability of the controls, and reduction of sharp edges on the keys.

The interface key layouts shown in Plates 1 through 39 were available in this portion of the study program. One of the key-top shapes used for fist or foot operation is of a form having a slightly convex key-top with a well-rounded edge. For certain subjects, it was noted that use of a key-top of this type in conjunction with a gently contoured protective ring (Plate 6), reduces the incidence of inadvertent key actuation as the subject traverses from one area of the interface to another. Other key tops are convex in shape, and are more desirable for certain subjects. The use of an overlay or protective key guard with holes matching the key locations (Plate 3) appears to be an effective means of reducing the "false-alarm," or error rates, caused by the users who are, in most cases, severely disabled with tonic spasticity and little muscular control.

It was also observed that the key-actuation force is a critical parameter of all finger-operated keyboards; this importance diminishes for fist and foot operated interfaces. An actuation force of two to three ounces has been used with success with children in this program who used fist and foot interfaces.

Two types of "tongue-keyboards" have been employed. The first, which is operated exclusively by the tongue dual sequentially, has eight switch-levers consisting of seven function keys and one reset or error correction key. The second type consists of eight, double-pole mouth switches operated by the tongue dual-concurrently, that is together with a 3-position "state-selector" switch which is controlled from another position of the user's body, in this particular case one of the operator's fingers of her right hand.

Use of glove interfaces, with a conductive plate for contact, glove interfaces equipped with built-in contacts, joystick and single-control interfaces are available. In the process of being studied, are myoelectric (E. M. G.) and central nervous system (E. E. G.) controlled interfaces.

> "Human-engineered interfaces have been designed to couple the remaining motor control of handicapped individuals so that there is a quantitative compensation for specific physical disabilities and/or neurological dysfunctions. Persons who heretofore were unable to produce cursive writing or use typewriter keyboards, computers, and telephones are now dramatically demonstrating their ability to communicate. Deaf, deaf-blind, and language impaired individuals may now learn to communicate with each other and control automata, via appropriately coupled interfaces and programming methods."

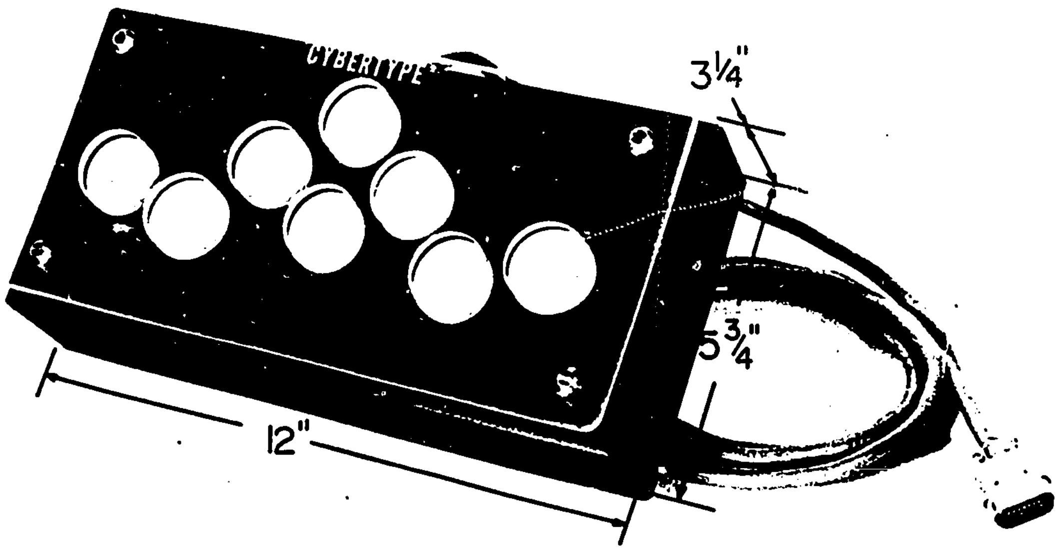

Plate 1
"Unicorn" "Cybertype" Keyboard

Interface with transparent protective key-guard and reset key. By having a reduced key-area, this interface permits operation controlled by minimum head movements with the aid of a "unicorn" or head-stylus.

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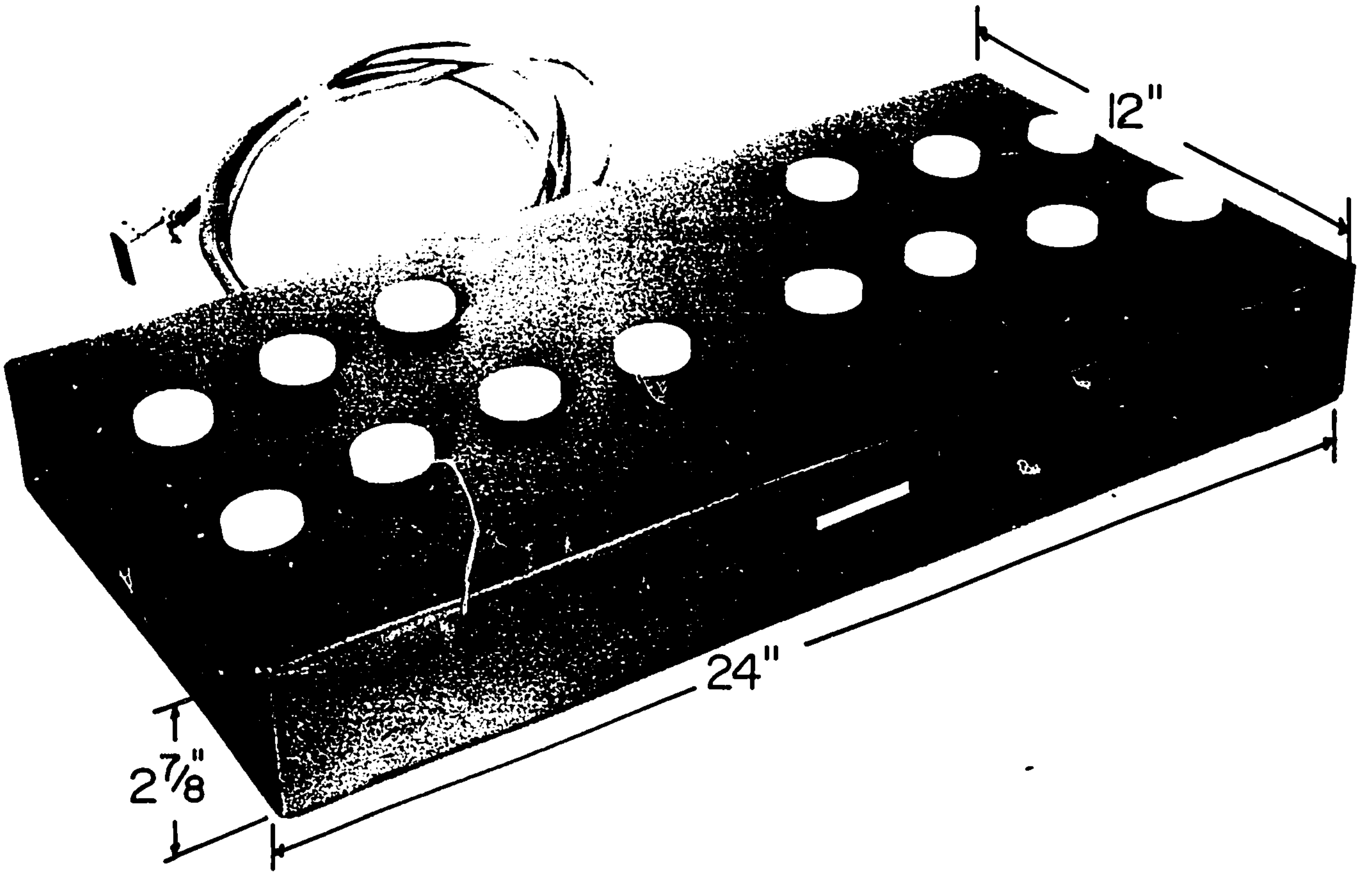


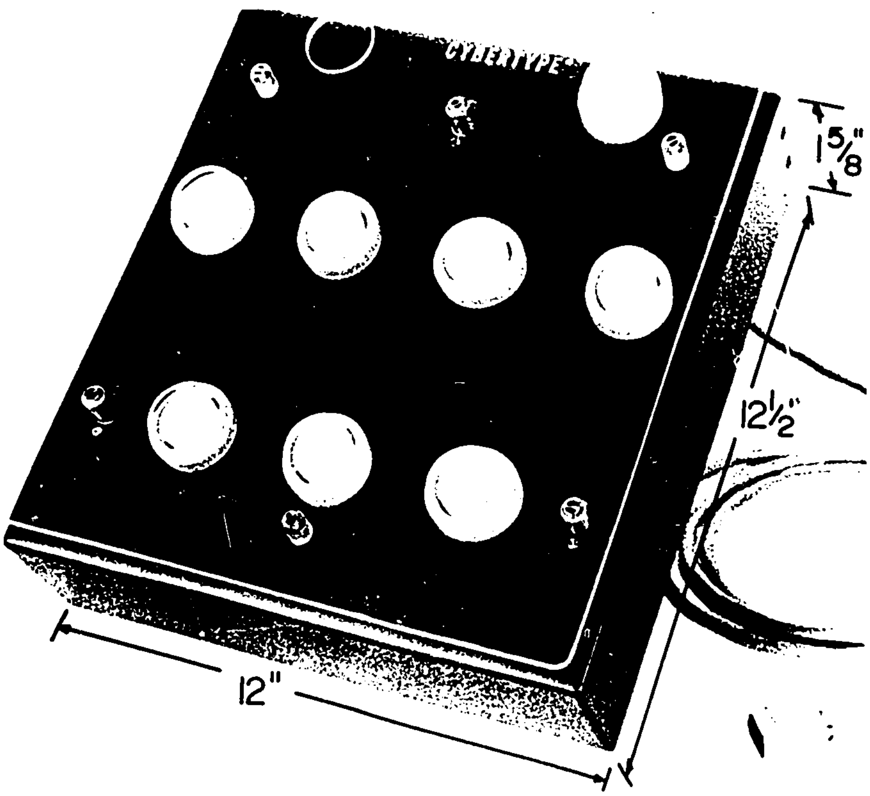


Plate 2
"Cybertype" Foot or Toe-Operated Keyboard
Interface with keytops which may be removed and exchanged for other types of varying sizes and design.

Plate 3
Rectangular "Cybertype" Keyboard
Interface with reset-key, and transparent key-guard magnetically secured to the keyboard chassis.

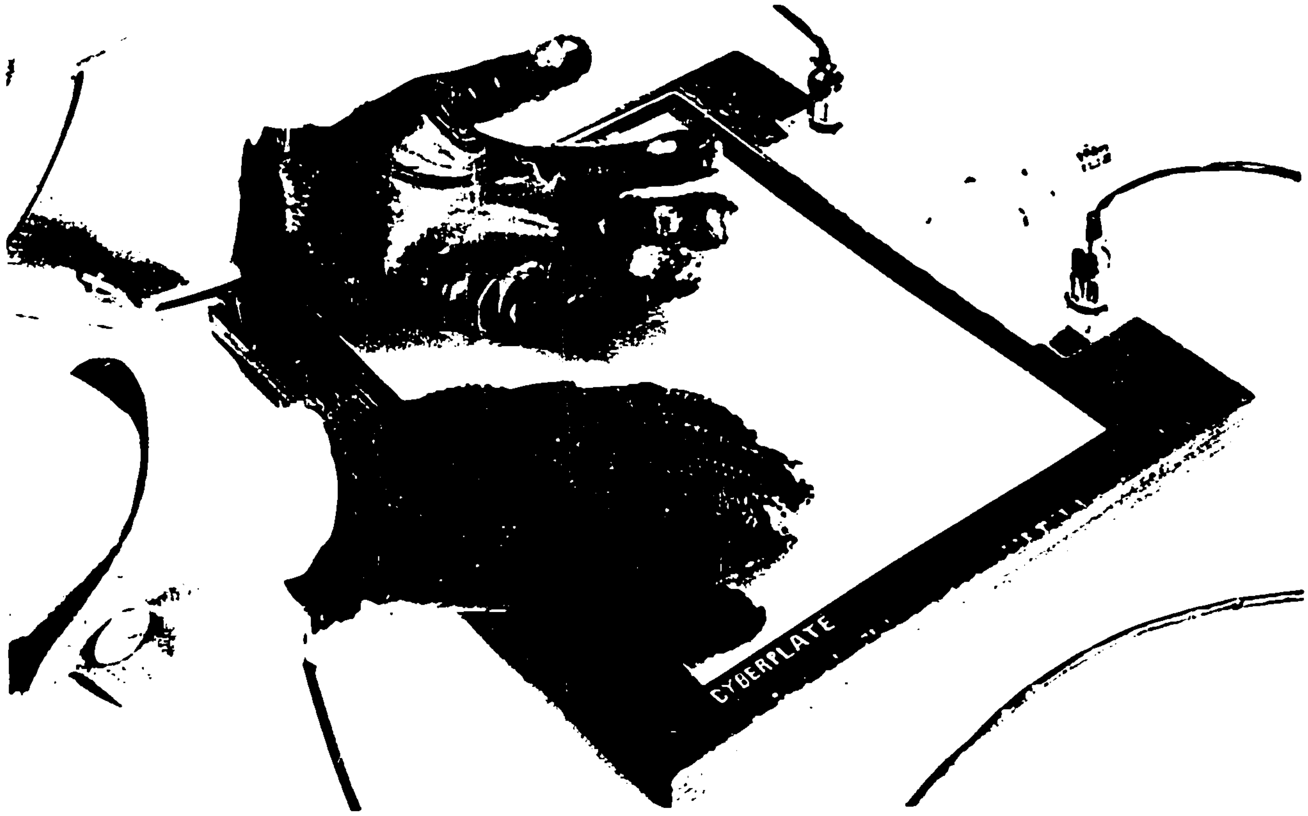


Plate 4

"Cyber-Plate" Keyless Typewriter Keyboard

The "Cyberglove" with its contacts and the "Cyberplate" with its metal contact plate are shown here. The metal plate serves as one contact element of a keying switch, and contacts on the gloves serve as the other element. The large cable in the center connects to a "Cybertype" using an IBM™ * Model "C" electric typewriter; it may also be connected to other devices or appliances to be controlled.

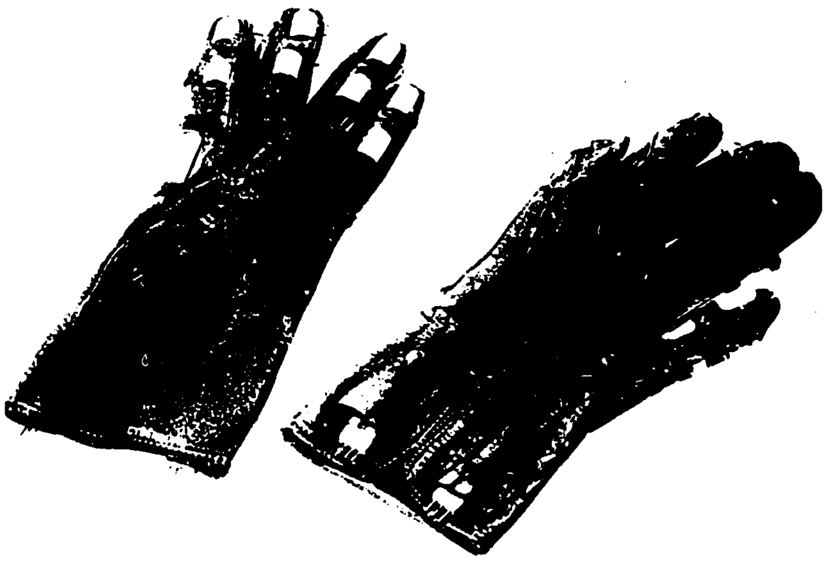
---

* Trademark, International Business Machines Corporation, Armonk, New York.

Plate 5

"Cyberglove" Keyboard

Gloves with finger contacts which have miniature connector plugs are shown attached by a cable to the device to be controlled. By moving the appropriate fingers, contacts can be made which correspond to a predetermined code.



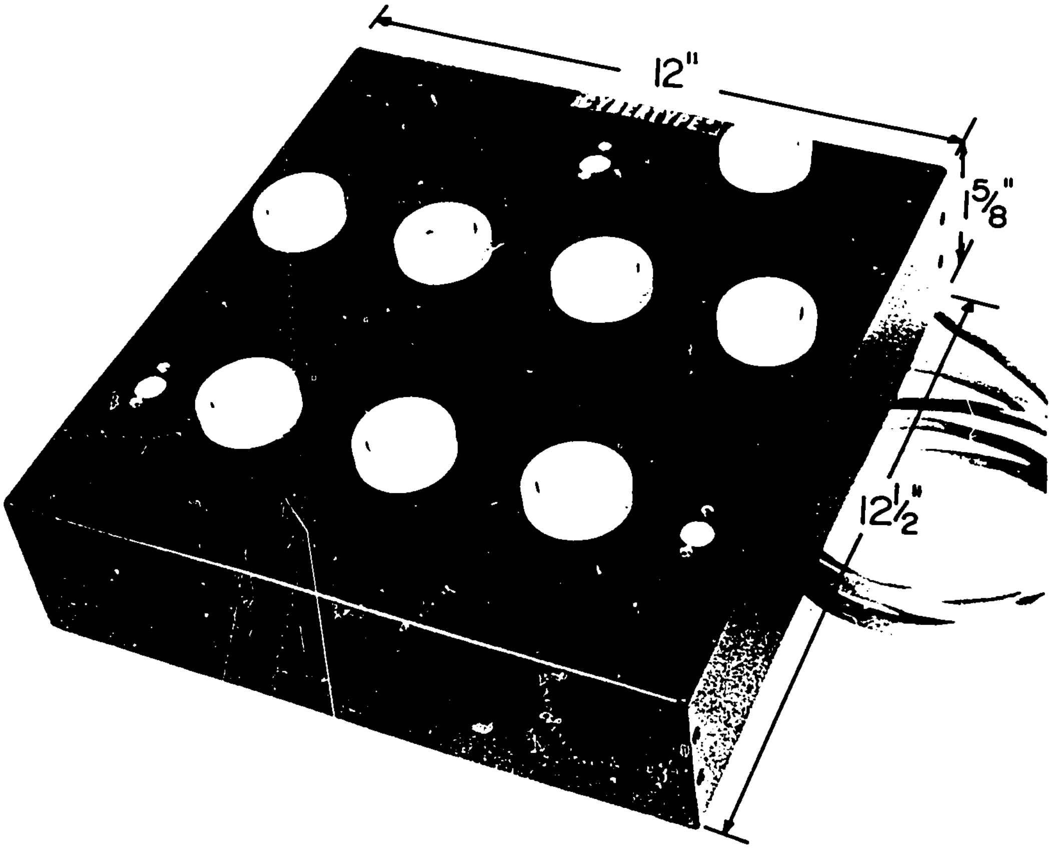


Plate 6
<u>Rectangular "Cybertype" Keyboard</u>
Interface, as shown in Plate 3; with magnetically attached key-guard removed.

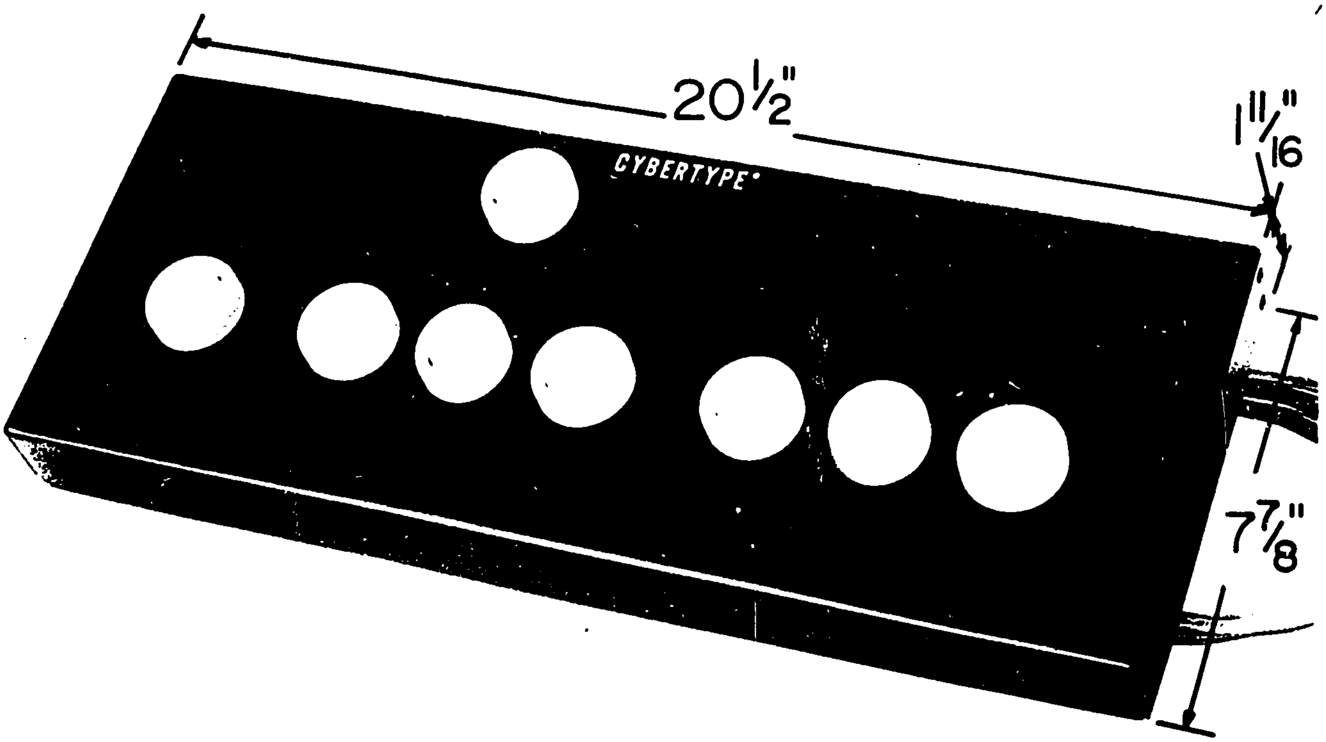


Plate 7
<u>In-Line "Cybertype" Keyboard</u>
Interface with reset-key, for use by fist, foot, elbow, or other single portion of the body which has "in-line" motion capabilities.

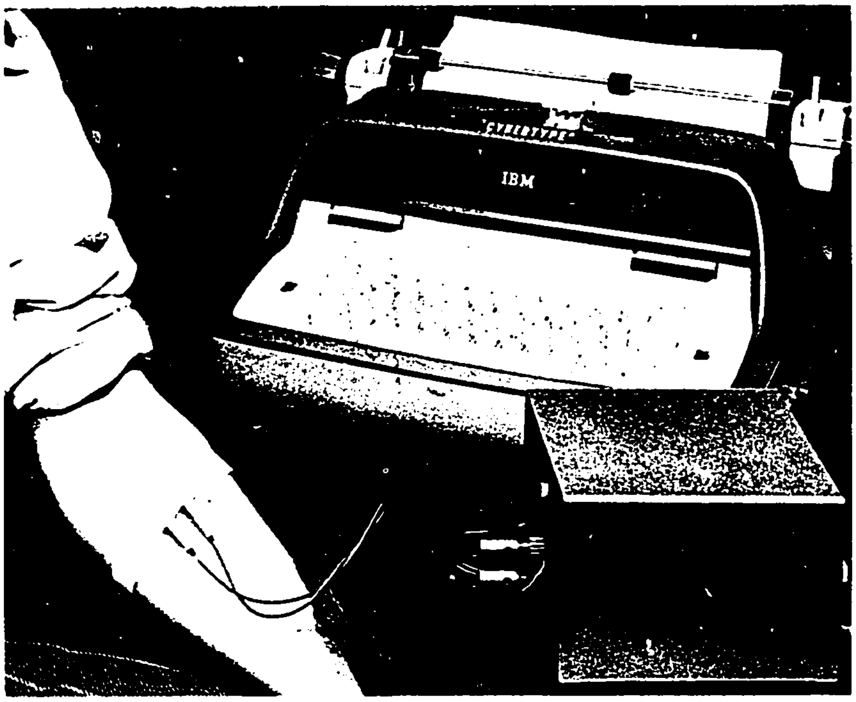


Plate 8

Experimental CYBERCOM™ * Myoelectric Interface Controller

This photograph shows a subject in an experiment to determine transducer position for operation of "Cybertype" electric typewriter via muscle control.

*Trademark, Cyber Corp., Washington, D. C.

> "In addition to systems which are applicable to children with cerebral palsy or other debilitating afflictions, a large portion of the disabled population have other handicaps such as severe hearing and/or language impairments. They are generally unable to use ordinary household and office telephones and, in most cases, they cannot use standard public telephones. In an effort to restore some measure of communications capability to these individuals, various devices and methods have been employed by private communications organizations with limited success. Telephone amplifiers, signaling lights, vibrators, meters, and a host of gadgets have been designed to respond to predetermined coded signals. The major shortcomings of these partial devices and methods have been the lack of feedback, limited message capability, the difficulty of learning the coded instructional program, and the inability to couple these systems to others."
>
> "Cyberphone$_{TM}$ and Cyber-Tone$_{TM}$, two members of the CYBERCOM family, may be used by persons with hearing and/or learning impairments. Both mechanisms are transportable and may even be used by individuals with visual and motor dysfunctions."

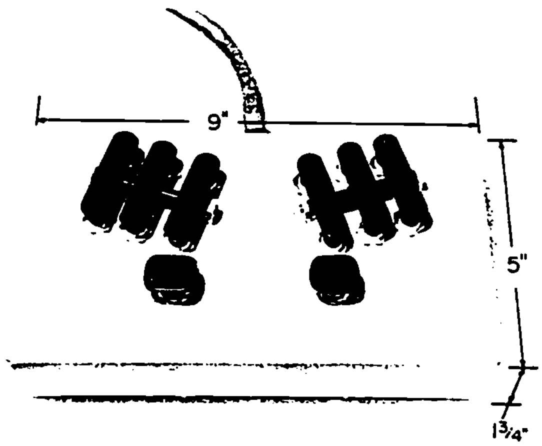


Plate 9
Finger-Rocker "Cybertype" Interface
A rocker-key keyboard for use by persons who have limited finger, wrist, or arm movements.

Plate 11
"Cybertype"
This photograph shows an IBM™ Model "C" electric typewriter, modified for use as a "Cybertype". The "Cybertype" is mounted on a trolley equipped with a lamp.

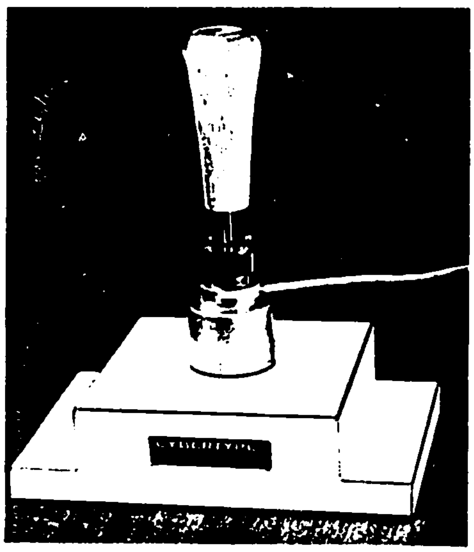


Plate 10
Single-Key "Cybertype" Interface
Keyboard for operation by a single portion of the body.

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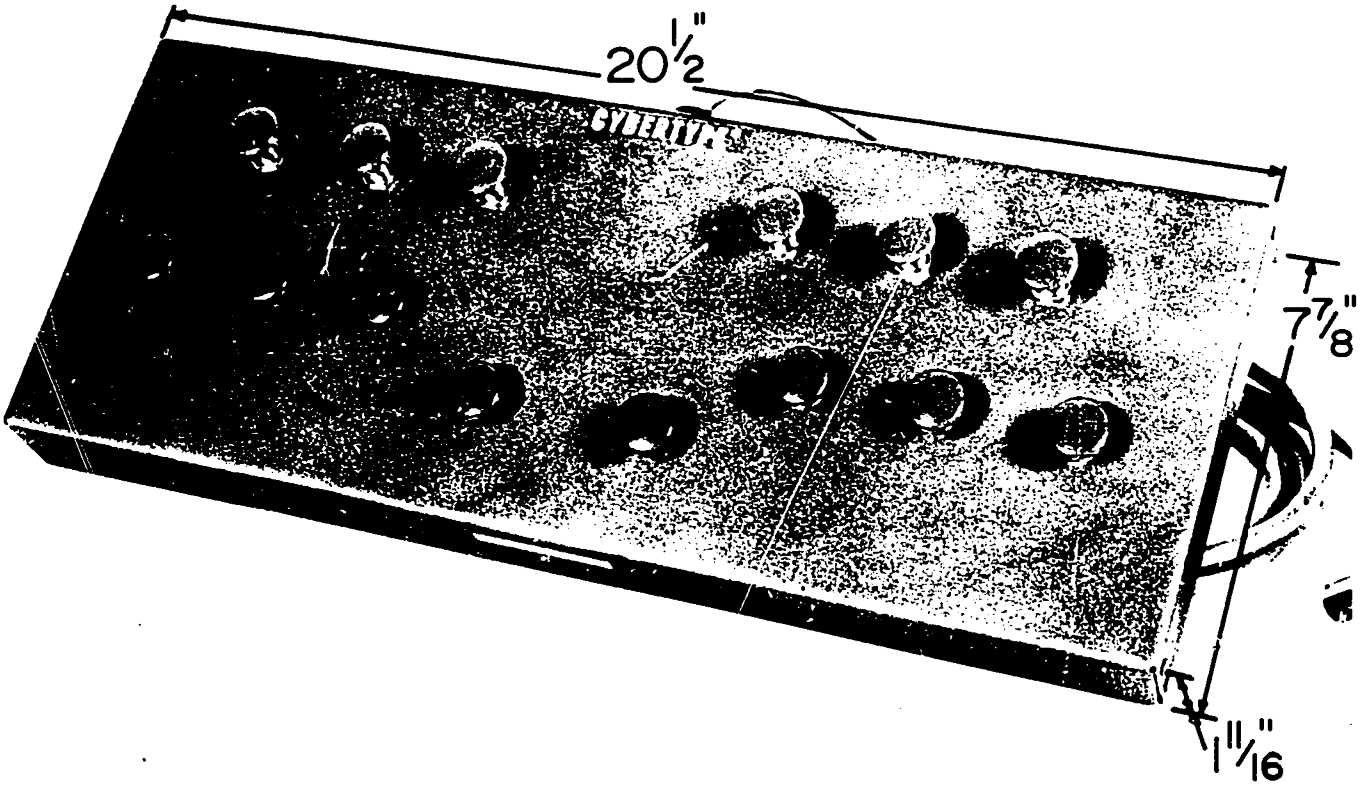


Plate 12
"Cybertype" Fist-Toe Interface

The fist keyboard is for use by fists and/or fingers. It may also be operated by the toes.

"The 'Cybertype' consists of essentially three components: (1) the input consisting of an interface or man-machine coupler available in different configurations, adjustable to match the capabilities of the user; (2) the throughput or electro-mechanical means for converting simultaneous or sequential dual inputs into single sequential outputs; and, (3) the output, a message in a typewritten, visual (alphanumeric display), tactual, audible, punched and magnetic card or tape form."

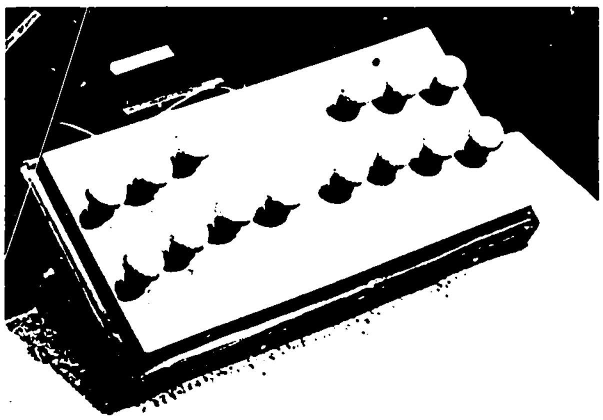


Plate 13
Padded-Key "Cybertype" Keyboard

An adjustable interface with padded keys which are operable from a prone or sitting position.

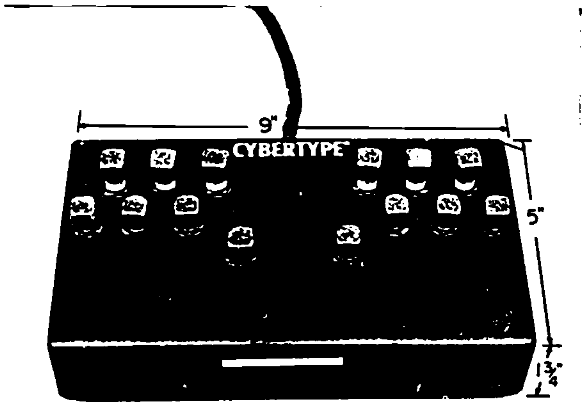


Plate 14

"Cybertype" Staggered-Key Finger Interface

This interface provides large spacing between keys within a prescribed keyboard boundary. It minimizes the striking of an incorrect key by the user who has poor control.

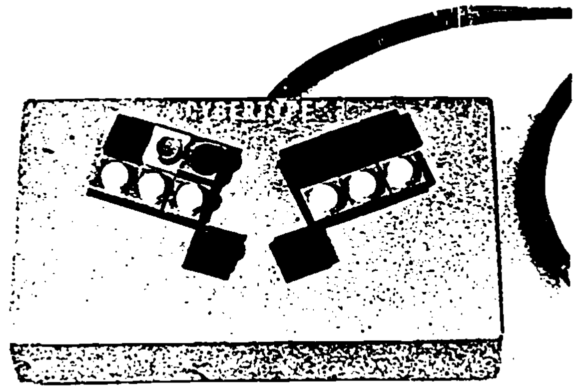


Plate 15

"Cybertype" Colored-Key Interface

Keyboard for use with fingers; the keytops are color-coded.

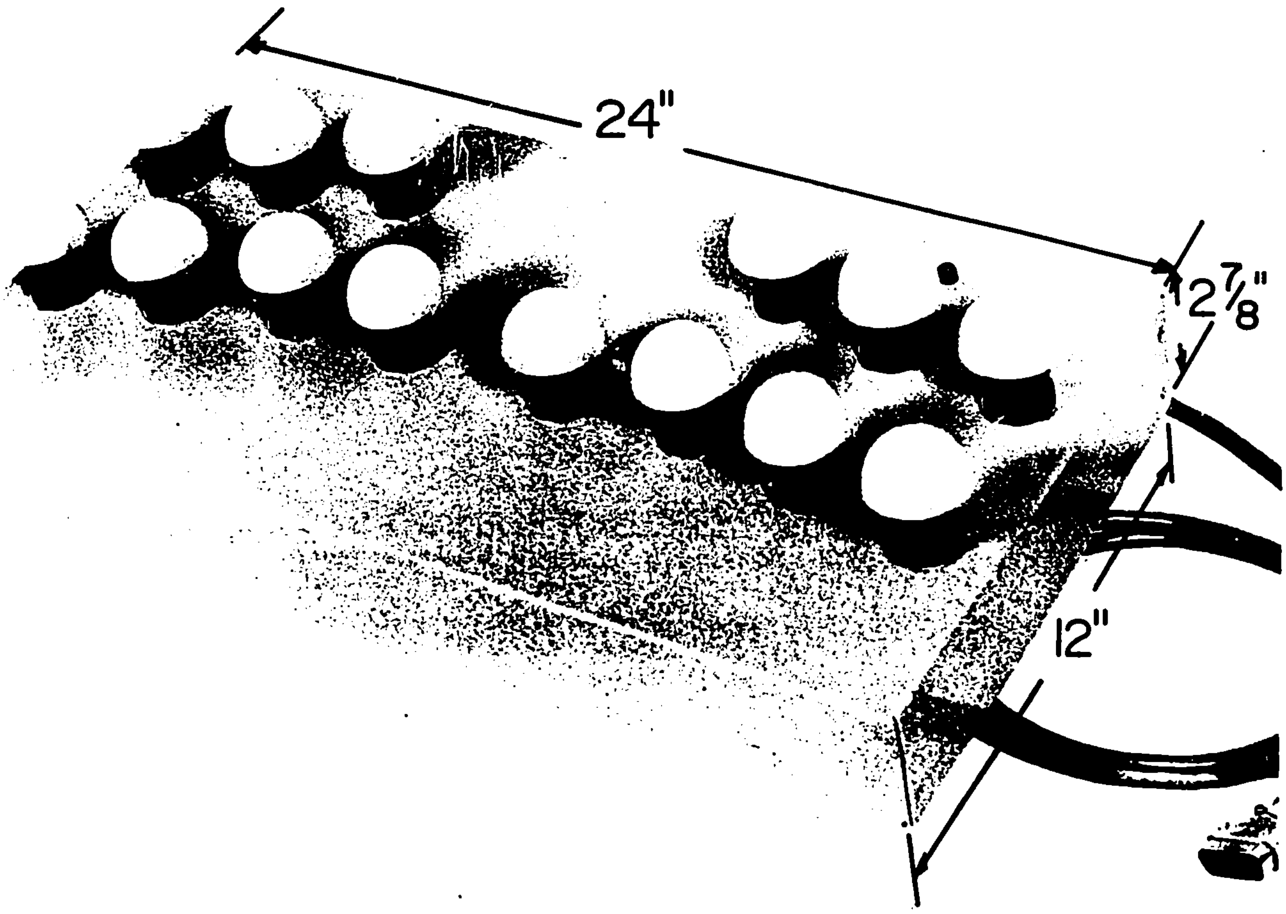


Plate 16

"Cybertype" Toe, Foot, Fist Keyboard

A 14-key, bi-lateral interface with padded key-tops for fist, foot, or toe operation.

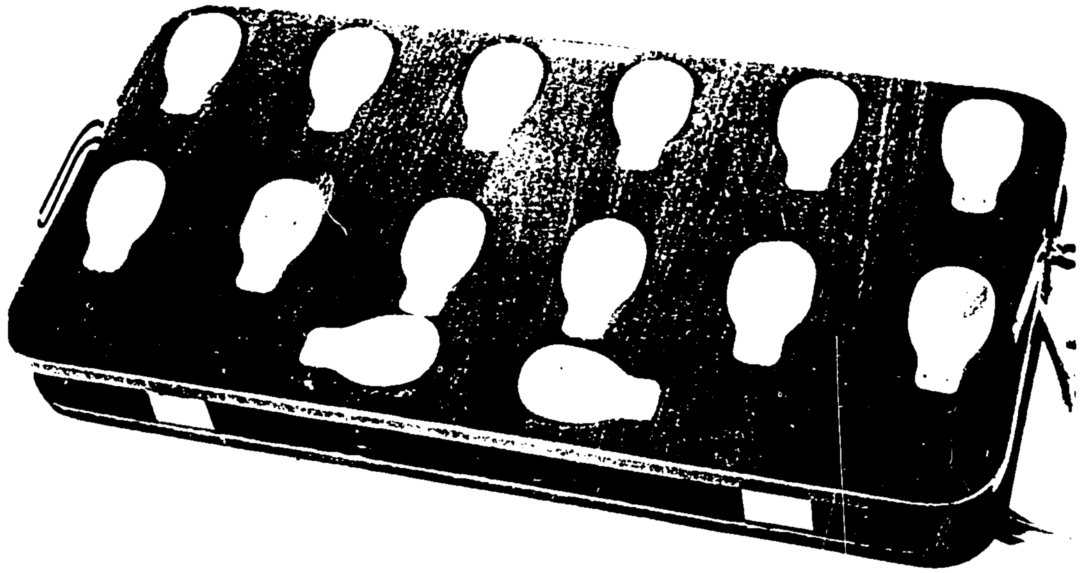


Plate 17

Adjustable "Cybertype" Prostheses Interface

A prostheses, foot, or fist operated interface; this type of keyboard may be adjusted over a 45° angle.

> *"The physically disabled individual who lacks fine motor coordination in arms, hands, fingers, and other parts of his body, and who may be unable to write or type effectively, may be aided by use of human-engineered interfaces which, when coupled to those portions of his body, will allow his remaining motor capabilities to be utilized."*

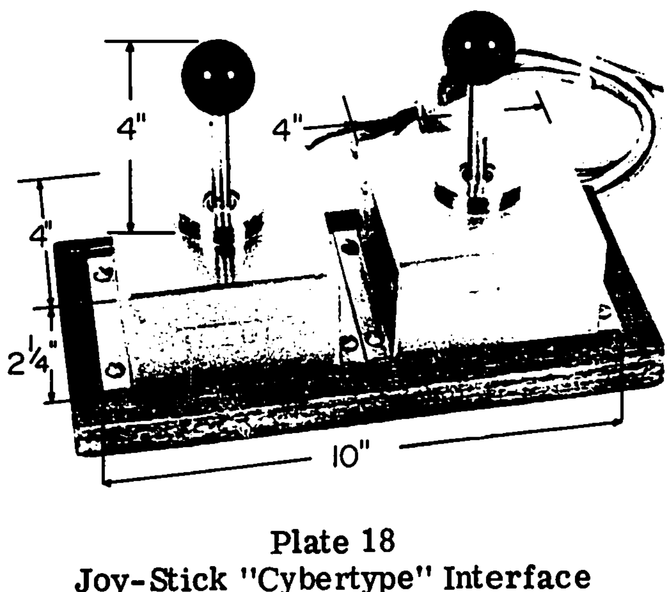


Plate 18

Joy-Stick "Cybertype" Interface

Interface for operation by blind, visually impaired, or severely physically disabled persons.

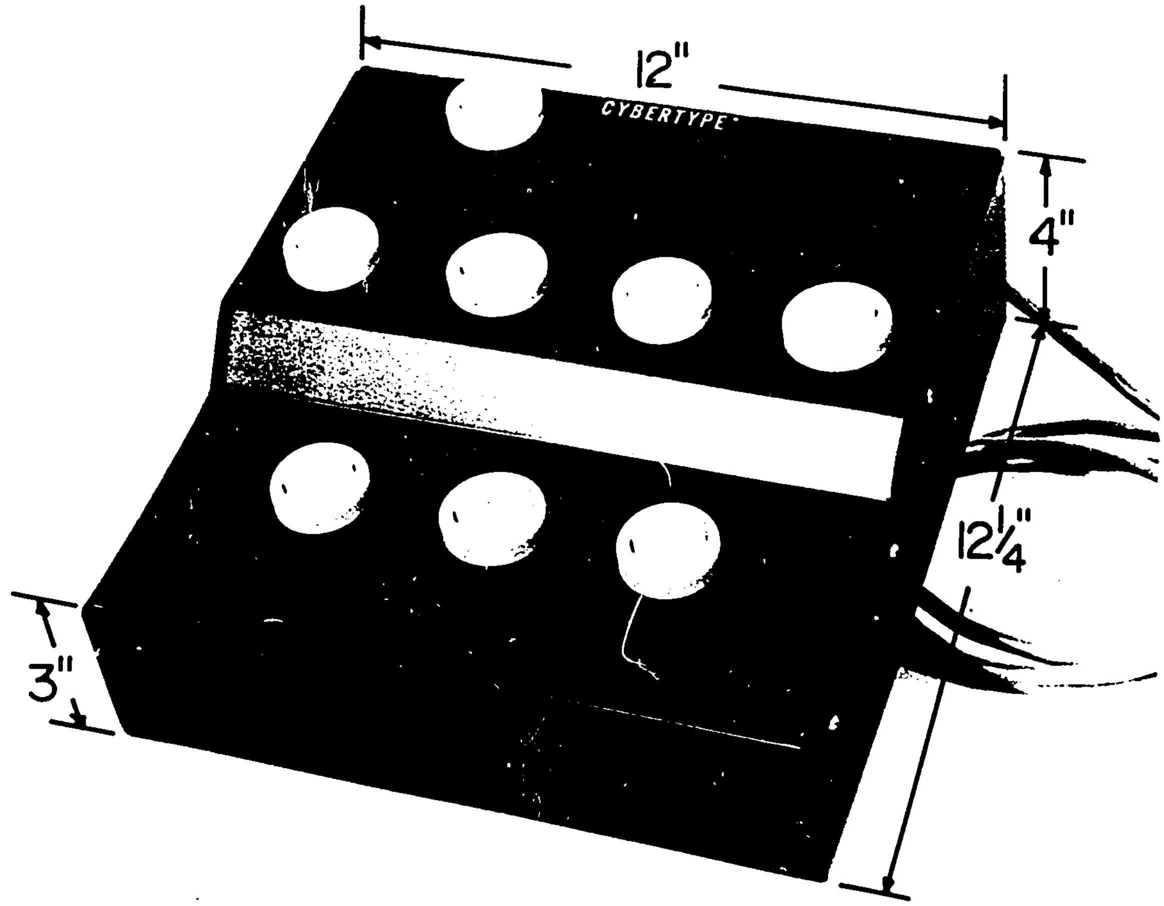


Plate 19

Bi-Level "Cybertype" Keyboard

Rectangular keyboard with reset key where the back row keys are raised to minimize the possibility of striking a key on the bottom row.

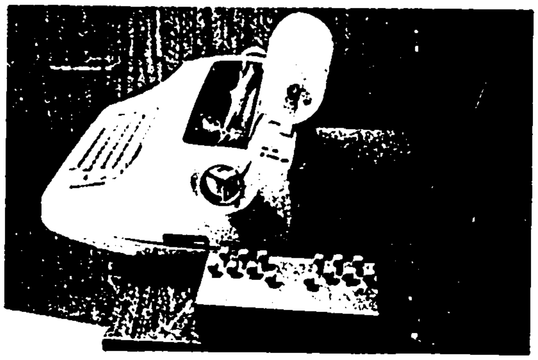


Plate 20

"Cybertype" with IBM Automatic Paper-Feed System

"Cybertype" using an IBM Selectric™ typewriter equipped with a roll of typing paper which is automatically fed to the typewriter platen as "cybertyping" takes place.

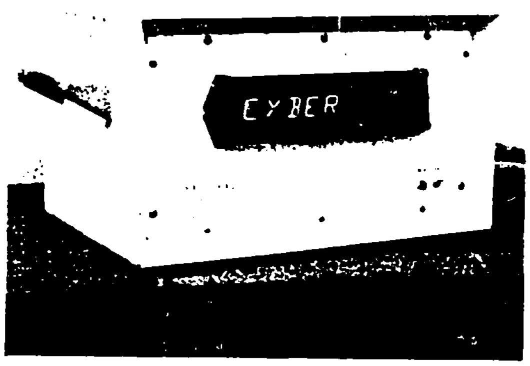


Plate 21

"Cyberlex"

A whole-word visual display, capable of displaying words of up to 8 letters.

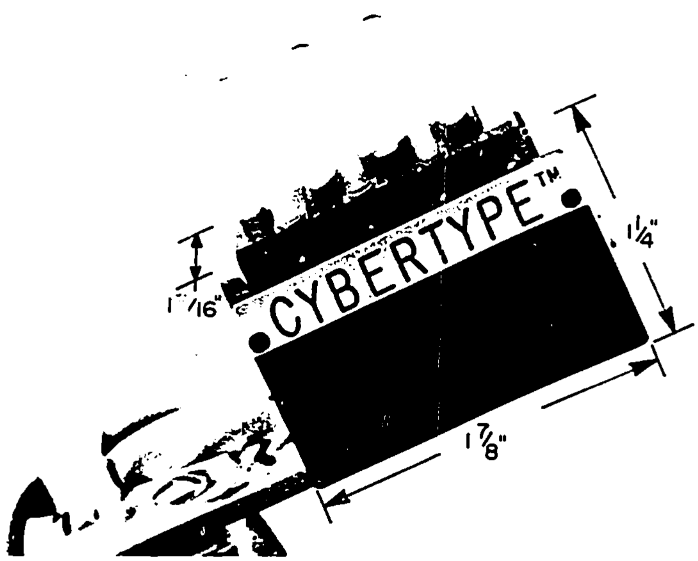
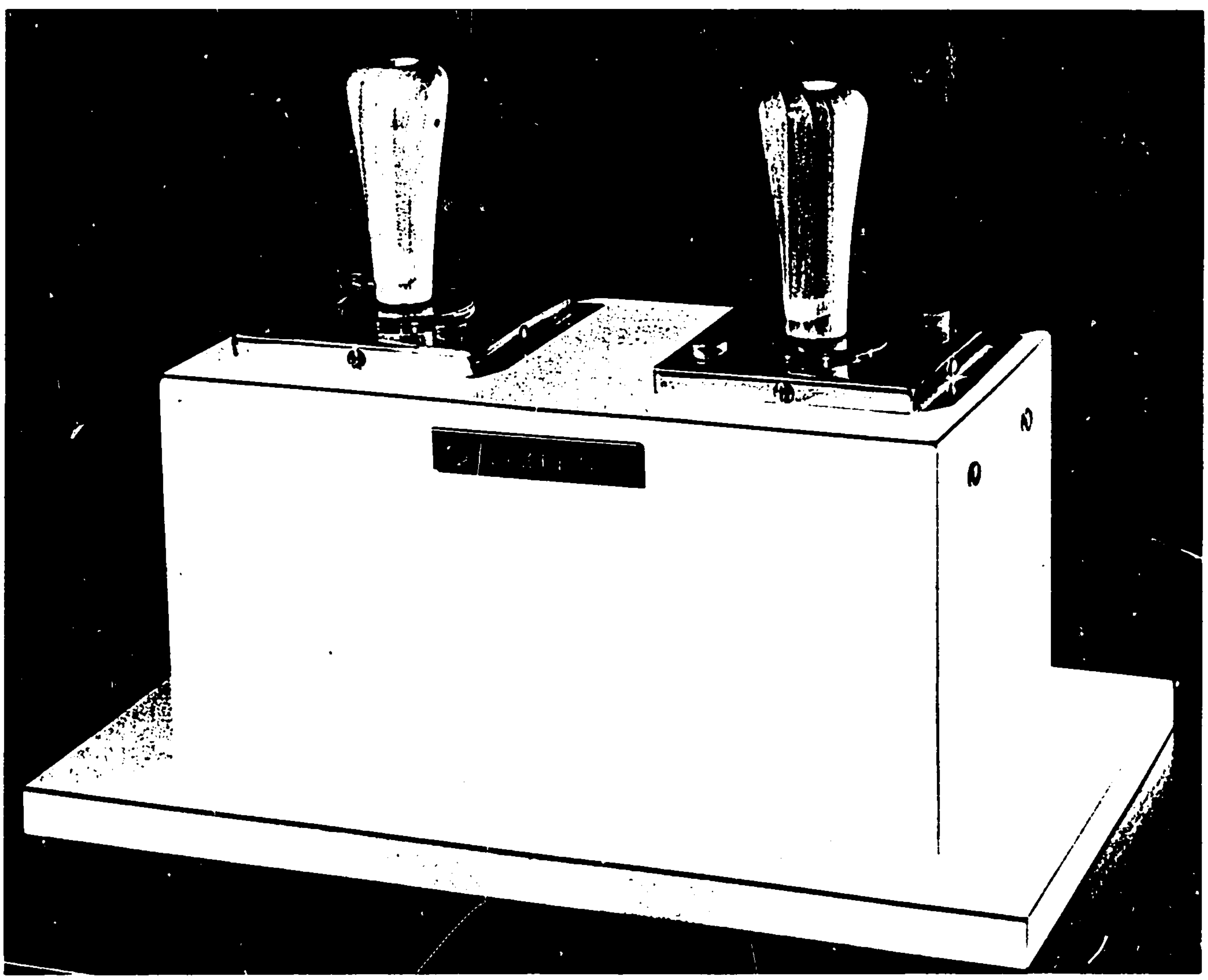


Plate 22

<u>"Cybertype" Tongue Keyboard</u>

This interface is equipped with a reset key. It may be used by severely paralyzed persons who have control over the tongue. The interface is shown here approximately of actual size.



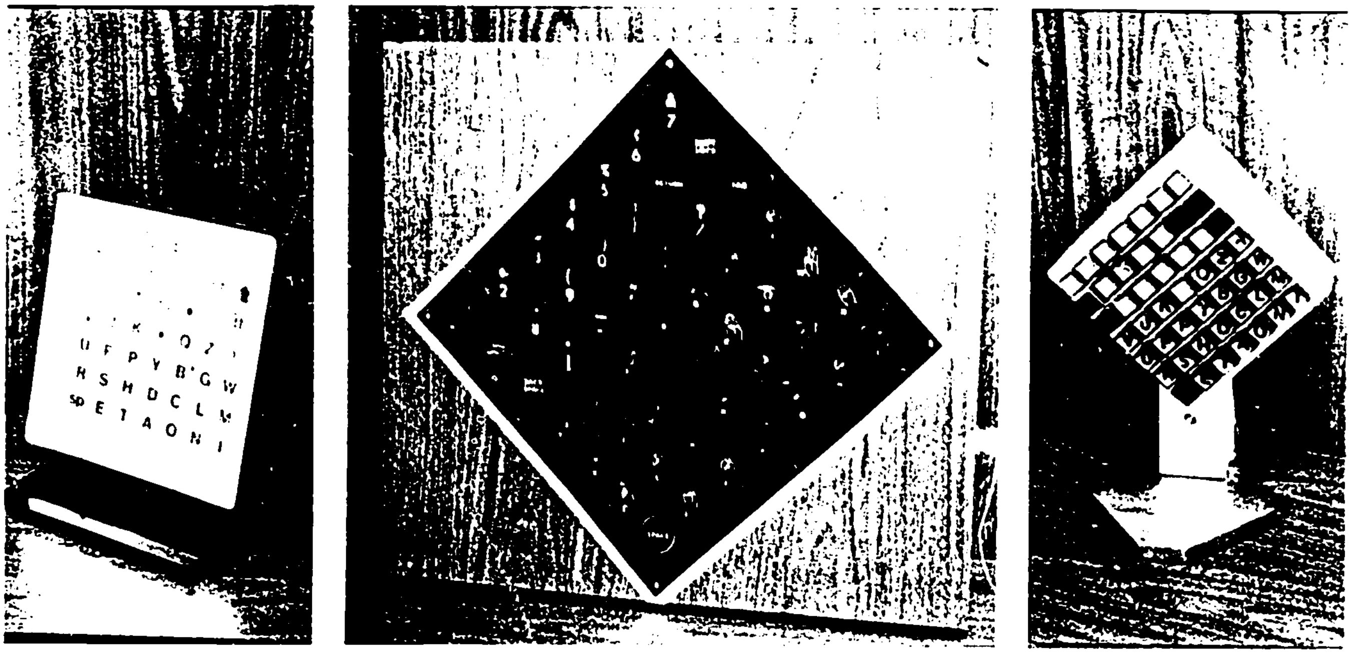


Plate 24
"Cyberlamps"
Individual letters, numerals and symbols are illuminated as they are being typed. Visual feedback is provided to the user who cannot see the typewritten page. The center "Cyberlamp" displays the sign-language symbols used in the one hand, manual alphabet.

Plate 25
Split "Cybertype" Interface
A finger-operated keyboard mounted on the arms of a wheelchair. It is used by individuals who are severely debilitated, but who have some finger control capability.

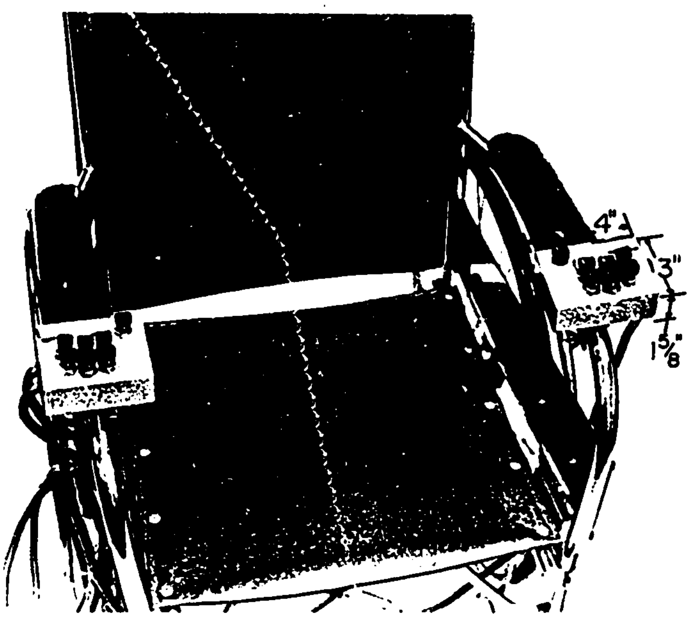
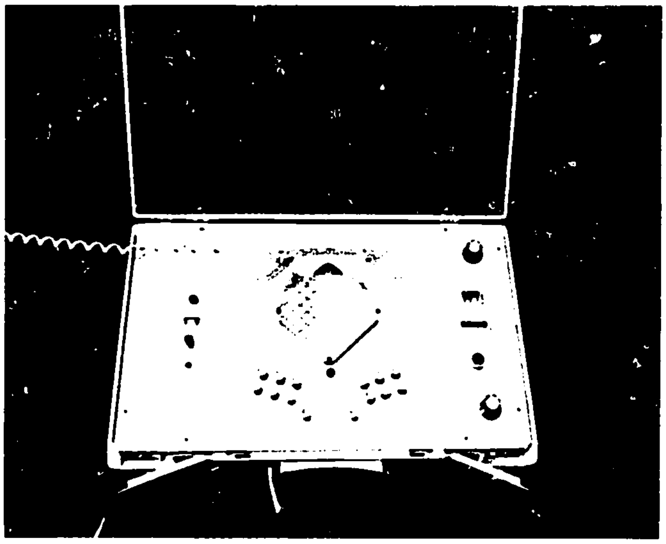


Plate 26

Universal Keyboard "Cyberphone"

A portable, self-contained "Cyberphone" telecommunication terminal with keyboard and visual read-out display which has connectors for 1, 2, 7, and 14-key keyboards, electric typewriters, and "Cyberlex" whole-word visual displays.



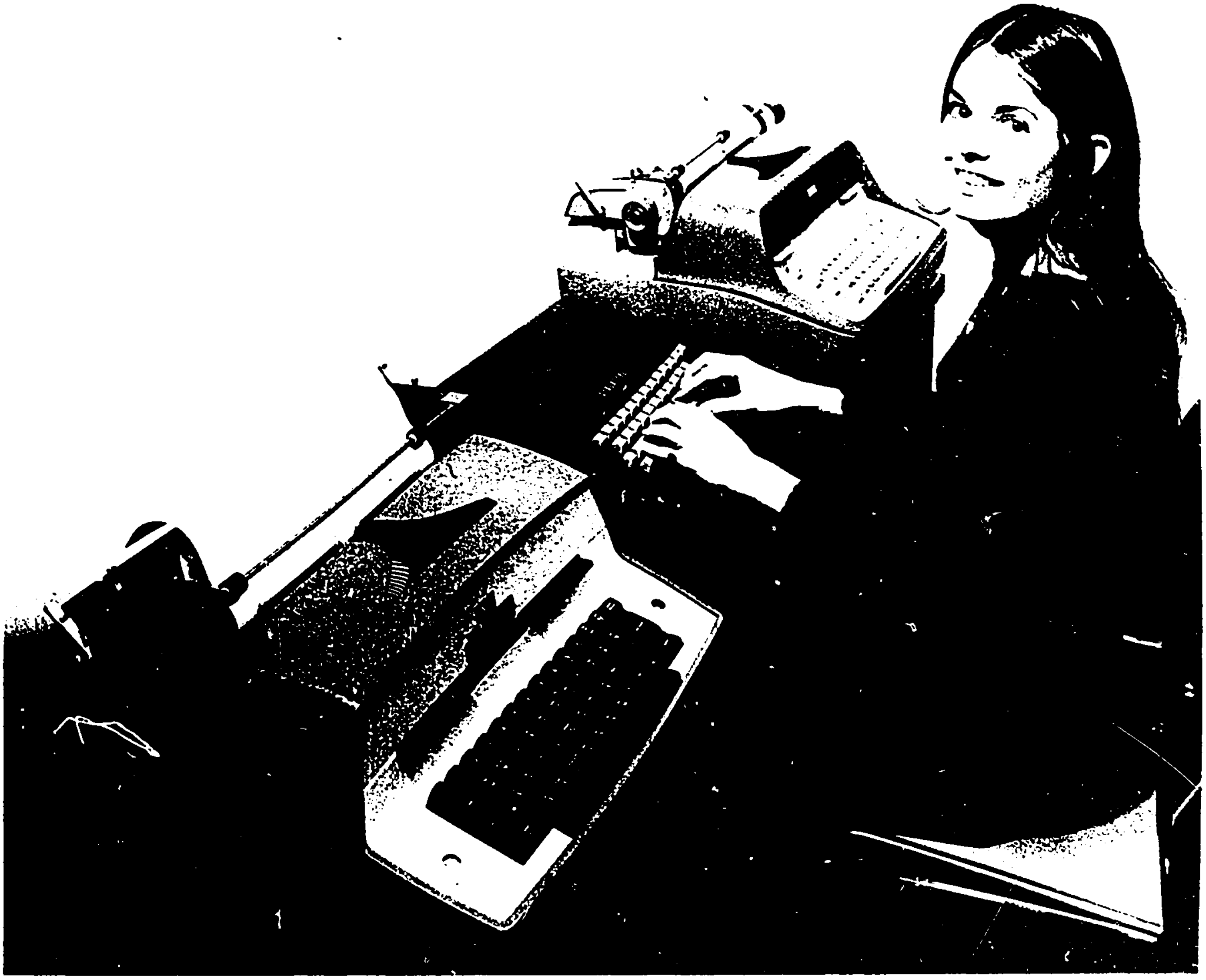


Plate 27

"Cyber-Brailler"

An IBM™ electric braille writer, and a "Cybertype" equipped with an IBM™ Model "C" typewriter operable from a common keyboard.

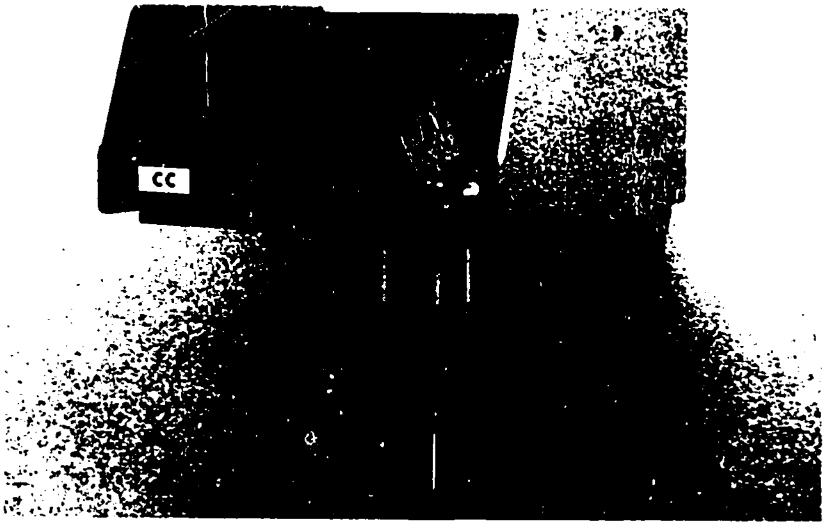


Plate 28
"Cyberlex"
An alphanumeric display capable of displaying words or phrases of up to 16 letters, symbols, or numerals.

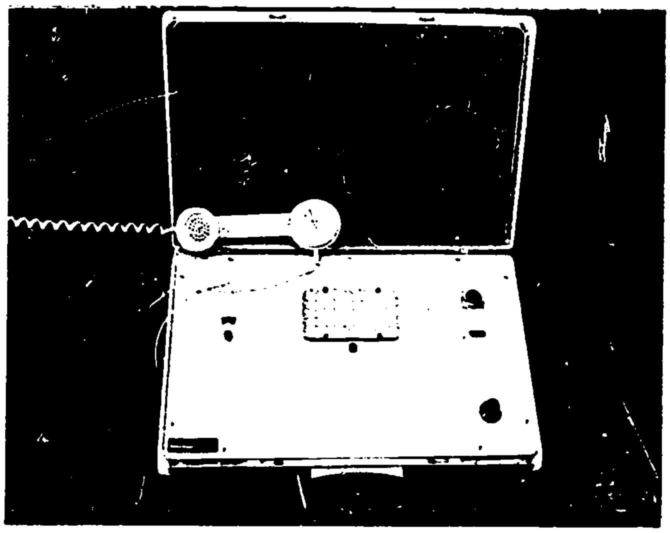


Plate 29
"Cyber-Tone"
A portable telecommunication system required only at the "receiving" end, shown with a "Cyberlamp" visual display. The "Cyber-Tone" operates from a tone-type telephone and does not require special equipment at the "sending" end.

Plate 30
"Cybertype" Tongue-Body
"3 x 16" Keyboard
The 8-key, 16 positions keyboard shown being controlled by the operator's tongue.

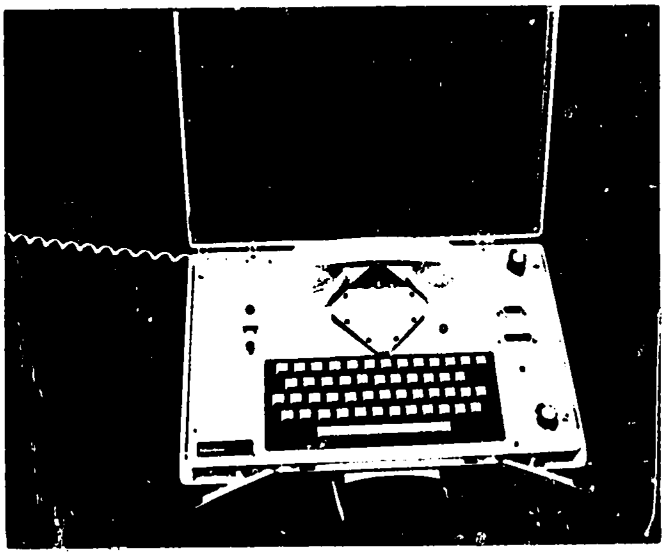


Plate 31
"Cyberphone" with Standard Typewriter Keyboard

A portable, self-contained telecommunications system, for use by deaf and/or speech impaired individuals, equipped with a "Cyberlamp" visual display, and connectors for the "Cybertype" writing machine and "Cyberlex" alphanumeric whole-word visual displays.

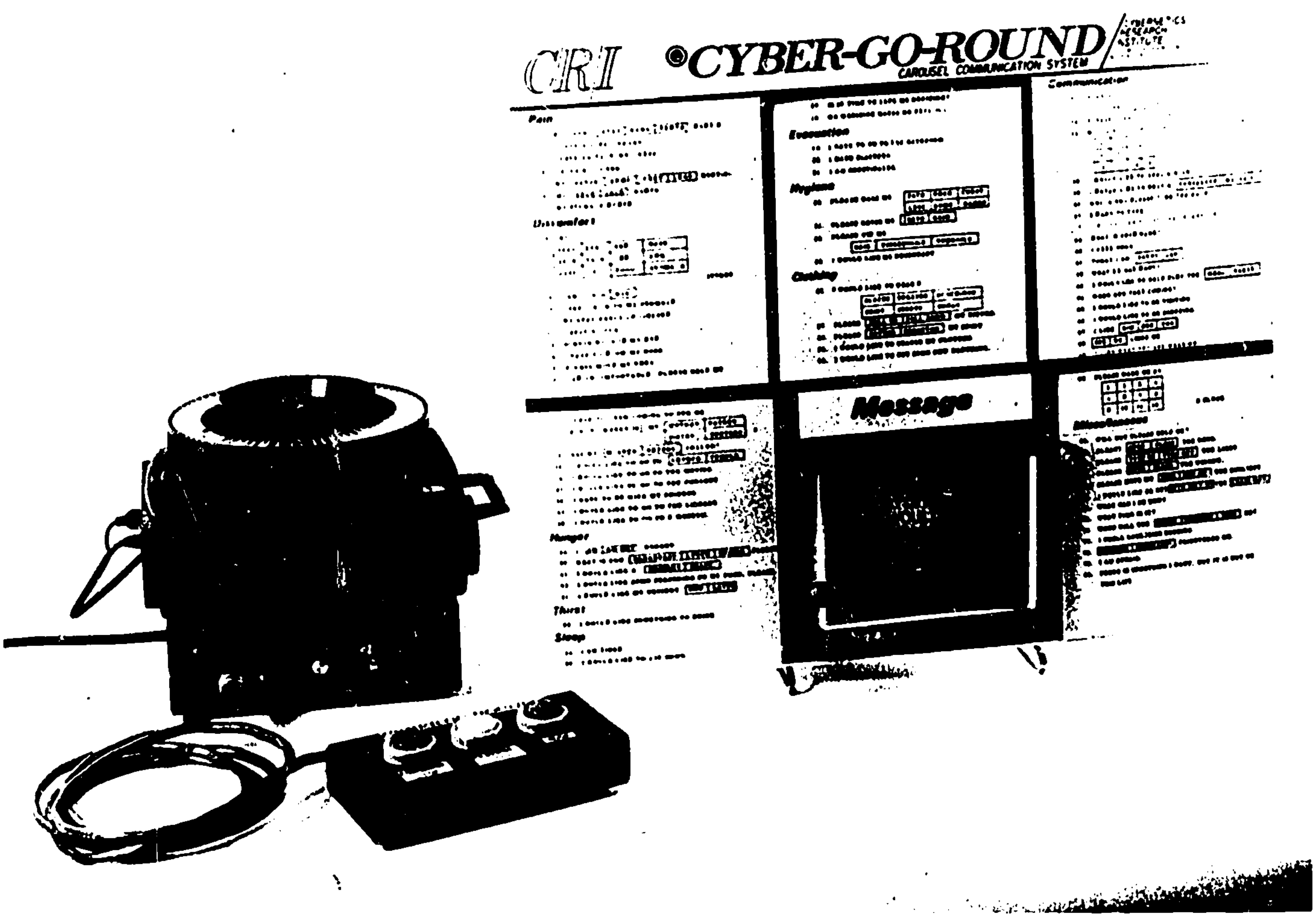


Plate 32
"Cyber-Go-Round"

A visual-message display system which utilizes a carousel slide projector, operable from a 3-key CYBERCOM interface.

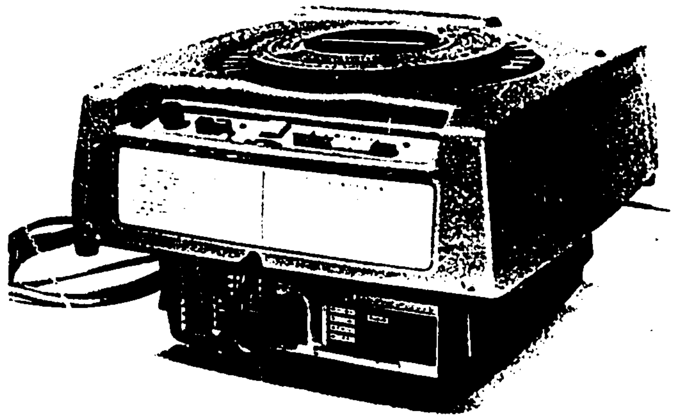


Plate 33
Kalavox™*

A visual-sound communication system, employing a standard Kalart Victor Kalavox™ used with a standard carousel slide projector. The flexibilities of this system allow changing the audio message contents in accordance with the specific needs.

* Trademark, Kalart Victor Corporation, Plainville, Connecticut.

Plate 34
"Cybertype" with Unilateral Keyboards

View showing five 7-key interfaces connected to a "Cybertype" with unilaterally operated dual-input keyboards.

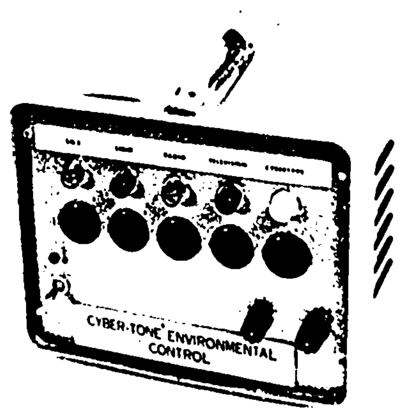
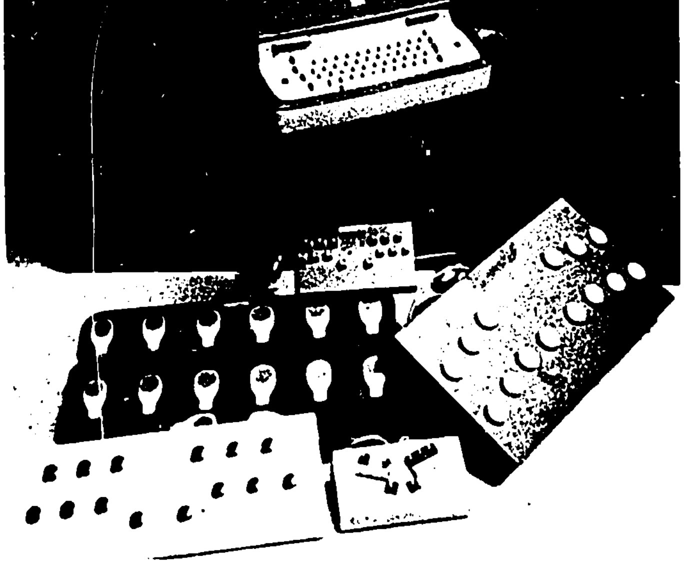


Plate 35
"Cyber-Tone" Environmental Control

A CYBERCOM life-support telecommunication control system for use from remote points by deaf and/or speech impaired individuals who have access to tone-type telephones. The unit shown is equipped with five A. C. outlets which allow for connection to emergency signalling, lighting, radio, TV, typewriter, or other controls via the telephone.



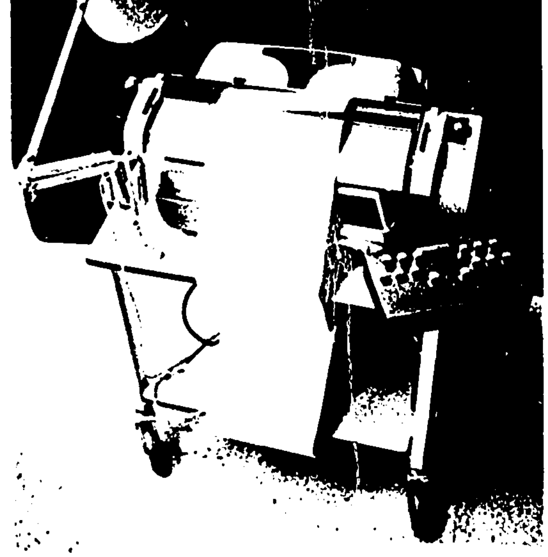


Plate 36

"Cybertype" with Bilateral Keyboards

View showing five 14-key interfaces connected to a "Cybertype" with bilaterally operated dual-input keyboards.

Plate 37

"Cybertype" with Paper-Tray

A view showing the storage of pre-folded paper in a tray beneath the typewriter. The paper is automatically fed into the typewriter.

"The characteristics of these systems provide the user with a complete typewritten language, including upper and lower case functions. They are equipped with meters and light indicators which signal presence or absence of a telephone dial tone, busy signal, ringing, and the presence of audio and other communications signals. These systems can also be used to operate numerous other devices either locally or remotely, such as a Telephone Environmental Control System (Cybertecs) which permits the user to have access to computers and to control various industrial or commercial appliances or perform unattended services from a remote point via a subscriber's standard telephone or a public telephone."

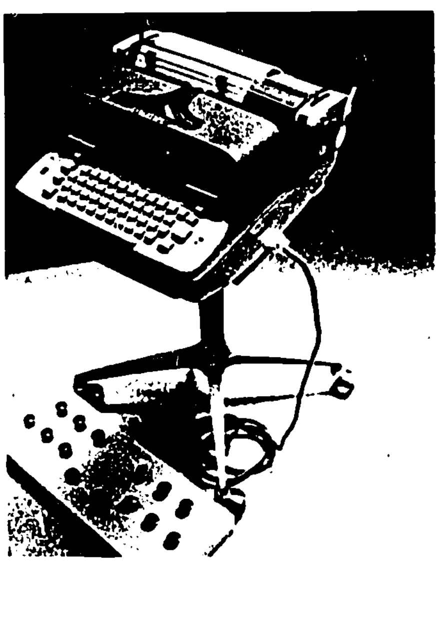


Plate 38

"Cybertype"

This photograph shows an IBM™ Model "C" electric typewriter, used as a "Cybertype", mounted on a portable stand. It may be connected to various members of the CYBERCOM family of man-machine communication and life-support systems.

Plate 39

Exhibit of Various Members of the CYBERCOM™ Family

The "Cybertype" electric writing machines with their various interfaces are shown together with the "Cyberphone" and "Cyber-Tone" telephone systems for the deaf and speech-impaired. Also shown are the "Cyberlamp" and "Cyberlex" letter and word displays.

"The design flexibility of these interfaces permits them to be scaled in size to match the performance capabilities of individuals whose dysfunctions preclude development of sufficient manual coordination and dexterity necessary for operation of controls with fingers or other parts of their body. The interface structure and the logic employed allow for the differential strengths and dexterities of the operator, and the frequency usage of graphic symbols in the language which is being programmed. The degree of motor coordination remaining in a handicapped person may be objectively and quantitatively evaluated in a number of ways, such as measuring the dispersion of aiming responses with part of the body via visually, tactually, or audibly perceived target areas. On the basis of this information, control interfaces are coupled to performance capabilities of the human controller."

Part Five | PROPOSED PROCEDURES

PROPOSED PROCEDURES

PLANS FOR ASSESSMENT OF REMAINING SENSORY AND MOTOR CAPABILITIES IN THE HANDICAPPED

Introduction

This section of the report covers activities in the project related to experimental assessment procedures. The "C/R/I Inquiry Form" and the "C/R/I Capabilities Inventory Form" both were prepared as aids to investigators in an effort to initiate a reference classification system and straight-forward procedural process for determining an individual's sensory-motor assets in forms of remaining afferent and efferent capabilities. One goal is to derive a symbolic notation and vocabulary together with a master classification assessment chart, which may be constructed, in one form as a two-dimensional array or matrix with transparent overlays. Thus, the degree of afferent freedom or control remaining, versus the efferent degree of freedom or control remaining, may quickly be discerned for a particular handicapped person.

It is hoped that this approach may serve as an introduction to provide diagnosticians with standard notational means and procedures for quantitatively determining an individual's capabilities and aptitudes via "stratification" tables with overlays where the degree of an individual's afferent capabilities, i. e., visual, auditory, tactile, kinesthetic, and other sensory modes are delineated. Efferent degrees of freedom may include such parameters as the degree of control of the digits, hands, arms, legs, tongue, mouth, and other parts of the body.

Subsequent to the development of procedures for quantitative measurement of an individual's motor assets, procedures for measuring sensory assets can be undertaken; together they may be used for referral by physicians, psychologists, teachers, and parents, and perhaps serve as a guide in mapping a particular individual's sensory and motor capabilities as related to his cognitive abilities.

As essentially disclosed in the Second C/R/I Report, Vol. I, (Kafafian, 1970), distribution of those segments of the handicapped population and interrelationship of handicaps suggested by the C/R/I assessment and mapping procedures may be valuable for better understanding of specific or multiple handicaps, especially how they may be among others, educationally treated with human-factor standards.

Procedures

The population of the classification would be comprised of subjects previously participating in the program and subjects who are to participate in future programs. This is essential for control feedback, and assessment. Results from evaluative programs with the population selected, using man-machine communications and life-support systems, may then be correlated to the "stratification" or classification tables and/or charts.

It may be too early to predict the extent to which learning and performance curves may be developed as a function of the prevailing characteristics of the individual's handicap. Having the capability for comparison of earlier and other related data will provide a source of information for use in predicting behavior and performance, all of which may be valuable in assigning an appropriate program to aid the student, and in determining whether or not there are improvements or retrogressions. Moreover, rates of degree of change in motor, sensory, and cognitive assessments can be observed.

Recommendations

Man-machine system flow diagrams and graphs can be developed from data to assist investigators in operations research analyses. Through studies and experiments of several elements comprising these systems and their subsystems over a period of time, it should be possible to determine the relationships of afferent and efferent characteristics of the human controller's learning and communication processes, independent of or with automata.

A universal notation must be created in order for the psychometrics developed by engineers and psychologists to have unequivocal meaning. Thus, a better understanding of the human controller and machine interface requirements can be achieved. Roebuck (1968) has directed to the attention of kinesiologists concerned with astronauts in aerospace programs, notations which deserve broader applications. In addition, consideration of the style of notation, as expounded by Eshkol and Wachman in their book Movement Notations (1958), and others, should be examined for style in the identification of parameters which may be helpful to the development of notation needed for identifying a disabled person's capabilities.

Several German investigators, cited by Dempster (1955), illustrate other approaches to quantify movements. A preliminary bibliography has been prepared and appears in Appendix B of the present report (see Reference).

A cybernetic approach of helping disabled persons, through the handling and processing of information with means of predicting and measuring feedback and/or feedforward parameters of the human controller with his automata in an educational environment, offers a new challenge to researchers in their quest to gain new insights into human behavior.

> *"It is our hope that these cybernetic approaches in education may enhance learning, improve cognitive development, and increase the communications capabilities of handicapped individuals so that they too can develop into independent and productive citizens."*

C/R/I INQUIRY FORM

Return to:

Cybernetics Research Institute
2233 Wisconsin Avenue, N.W.
Washington, D. C. 20007

Identification Number ___ ___ ___ ___
1 2 3 4

DATE: ____________________

Name of person for whom this inquiry is made: (Please print or have typed, if possible.)

Name ____
First Middle Initial Last

Address ____

County or City__________ State __________ Zip Code ______

Telephone Number__________ ____________________
Area Code Local Number

Congressional district in which you live:____________________

Please check (√) the appropriate responses:

5. Sex: Male ______ (0) Female ______ (1)

6. Marital Status: Single ______ (0) Married ______ (1)
Divorced ______ (2) Widowed ______ (3)

7. Employment Status: Employed ______ (0) Unemployed ______ (1)

Age Years ______
8 9

Your main occupation, training, or work experience (if any): (Write "none" if not applicable. (A) ____

____

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C/R/I INQUIRY FORM

10. Education: Elementary School ____ (0) Less than 6th grade ____ (1)
High School ____ (2) College ____ (3)
Vocational School or Special Training ____ (4)
Other ____ (5)

If you are currently enrolled in an educational, vocational, or rehabilitation program, or other institution, please provide name and address below: (B)

____
Name of Organization

____
Address County or City State Zip Code

Languages Which you Know:

11. English: Read ____ (0) Write ____ (1) Understand ____ (2) Speak ____ (3)
Others*: Read ____ (0) Write ____ (1) Understand ____ (2) Speak ____ (3)

*List other Languages: ______________________________

13. Source of your financial income or support:

Private source ____ (0) Social Security ____ (1) Veterans Adm. ____ (2)
Medicaid ____ (3) Medicare ____ (4) Other ____ (5)

14. Do you own or rent your own home? Own ____ (0) Rent ____ (1) Other ____ (2)

15. If not your own home, would your landlord permit structural changes on the property? (Support, rails, etc.?)
Yes ____ (0) No ____ (1) Don't Know ____ (2)

Name and address of hospitals, clinics, institutions, other organizations where you have been or presently are being treated. If at a private residence, please indicate: (Use additional paper, if necessary, and attach to this form.) (C) ______________________________

____

____

C/R/I INQUIRY FORM

Names and addresses of physicians, nurses, therapists, vocational and/or rehabilitation counselors, social workers or other friends working with or helping you. If additional space is required for this and/or other questions, please use another sheet and attach to this form. (D)____

General description of your disabilities. (E) ______________________________

16. Origin of your disability: ______________________________________

    From Birth (Congenital) ____ 0   After Birth (Adventitious) ____ 1

    Result of military service ____ 2   Result of accident ____ 3

    Other (please specify below) ____ 4

Nature of your disabilities - Specific information in detail. (F)________________

17. Were you born -   Right-handed ____ 0   Left-handed ____ 1

18. If you use a different hand now, is it the

    Result of an accident ____ 0   Result of illness ____ 1

19. Were your parents

	Father	Mother
Right-handed	___ 0	___ 1
Left-handed	___ 2	___ 3

20. Are your brother(s) and sister(s)

	Brother	Sister
Right-handed	___ 0	___ 1
Left-handed	___ 2	___ 3

21. Were your grandparents

	Father's Side	Mother's Side
Right-handed	___ 0	___ 1
Left-handed	___ 2	___ 3

22. If you are deaf or have a hearing loss, is it
    From Birth (congenital) deafness ___ 0
    Due to accident or illness (adventitious) ___ 1

23. Total ___ 0
    Partial ___ 1

24. Describe whether accident or illness:
    Accident ___ 0
    How it happened?
    Illness ___ 1
    What kind of illness?

25. Is there a history of hearing loss in your family? Yes ___ 0 No ___ 1
    Don't know ___ 2

26. Check if any of the following were hearing impaired or deaf:
    Mother ___ 0 Father ___ 1

C/R/I INQUIRY FORM

Grandparents	Grandmother	Grandfather
Mother's Side	____ 2	____ 3
Father's Side	____ 4	____ 5

Brother(s) ____ 6   Sister(s) ____ 7

27. If you are afflicted with Muscular Dystrophy, is there a history of it anywhere in your family? Yes ____ 0   No ____ 1

If yes, Mother ____ 2   Father ____ 3
Brother(s) ____ 4   Sister(s) ____ 5

THE FOLLOWING INFORMATION IS REQUIRED IN ORDER TO LEARN OF THE REMAINING CONTROLLED MOVEMENTS OF YOUR BODY. INDICATE WHETHER THEY ARE SLIGHT OR LARGE MOVEMENTS AND THE EXTENT (BY HOW MUCH) TO WHICH YOU CAN CONTROL THEM.

THESE REMAINING MOVEMENTS ARE:
(NOTE: If you are helping someone fill this questionnaire, please review each question carefully and check the appropriate space as provided. If more space is needed, use a separate sheet of paper.)

	NONE	WEAK	FAIR	GOOD	VERY GOOD
28. Head	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
29. Mouth	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
30. Tongue	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
31. Jaw	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
32. Chin	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
33. Eyes - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
34. Eyes - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
35. Arms - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
36. Arms - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐

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		NONE	WEAK	FAIR	GOOD	VERY GOOD
37.	Shoulder - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
38.	Shoulder - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
39.	Elbows - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
40.	Elbows - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
41.	Legs - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
42.	Legs - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
43.	Knees - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
44.	Knees - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
45.	Ankles - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
46.	Ankles - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
47.	Feet - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
48.	Feet - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
49.	Hips - Right	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
50.	Hips - Left	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
51.	Trunk	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
Fingers						
52.	Right thumb	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
53.	Right forefinger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
54.	Right middle finger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
55.	Right fourth finger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
56.	Right little finger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
57.	Left thumb	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
58.	Left forefinger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐

59. Left middle finger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
60. Left fourth finger	0	1	2	3	4
61. Left little finger	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
Toes					
62. Right big toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
63. Right second toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
64. Right third toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
65. Right fourth toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
66. Right little toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
67. Left big toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
68. Left second toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
69. Left third toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
70. Left fourth toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
71. Left little toe	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐

Other parts of the body you can control (not listed above.) (G) ______________________

____

Other muscles in the face you can control. Describe. (H) ______________________

____

72. Are any parts of your body missing? Yes ______ (0) No ______ (1)

73. If yes, please identify and describe:

Fingers ______ (0) ______________________________

Hands ______ (1) ______________________________

Arms ______ (2) ______________________________

Legs ______ (3) ______________________________

Toes ____ ________________________________
4
Other ____ ________________________________
5

Please comment briefly on the following:

Respiration (I) ________________________________

Approximate intelligence (average, bright, etc.) (J) ____________

Attitude (determined, apathetic, etc.) (K) ____________

Do you use any of the following aids?

				Comments
74.	Prostheses	Yes ____ 0	No ____ 1	____________
75.	Hearing Aid	Yes ____ 0	No ____ 1	____________
76.	Respiratory Aid	Yes ____ 0	No ____ 1	____________
77.	Special Glasses	Yes ____ 0	No ____ 1	____________
78.	Braces	Yes ____ 0	No ____ 1	____________
79.	Catheter	Yes ____ 0	No ____ 1	____________
80.	Wheelchair	Yes ____ 0	No ____ 1	____________
81.	Special Bed	Yes ____ 0	No ____ 1	____________
82.	Other	Yes ____ 0	No ____ 1	____________

83. If you use a wheelchair, is it operated by:
Battery and/or house current ____ 0
Hand-propelled by yourself ____ 1
Propelled by someone else for you ____ 2

If electronic, please indicate type of steering controls and whether or not they are satisfactory. (L)________________________________

____

84. If you use a wheelchair, please indicate which of the following facilities have ramps for your wheelchair (for going up and down ramps.)

Home ____ (0) Institution ____ (1) Place of Employment ____ (2)

Streets in your community ____ (3) Other ____ (4)

Do you use the following with or without help? Indicate "Yes" if with help, and "No" if without help.

85. Shower Yes ____ (0) No ____ (1)

86. Bathtub Yes ____ (0) No ____ (1)

87. Toilet Yes ____ (0) No ____ (1)

88. In toileting, do you require special assistance to aid you? Yes ____ (0) No ____ (1)

89. If yes, indicate below the person or means helpful to you:

Member of the family or companion ____ (0)

Practical nurse ____ (1)

Registered nurse ____ (2)

Automatic toilet devices ____ (3)

Other ____ (4)

100. Can you flush the toilet without aid? Yes ____ (0) No ____ (1)

101. If yes, which type:

"Pull Chain" ____ (0)

Commode Latch ____ (1)

Other ____ (2)

102. Does the toilet or bathroom you normally use have mechanical aids (rails, etc.) to support you? Yes ____ (0) No ____ (1)

103. Can you presently write? Yes ____ (0) No ____ (1)

104. If yes, do you write with great difficulty? Yes ____ (0) No ____ (1)

105. If yes, is your writing now legible and clear? Yes ____ (0) No ____ (1)

106. Can you type using the standard keyboard of a typewriter? Yes ____ (0) No ____ (1)

107. If yes, please indicate which kind: Electric ____ Mechanical ____
0 1

108. If you type, please indicate which of the following parts of the body you use in your typing:

Fingers of both hands ____ (0) Fingers of one hand ____ (1)
Right foot ____ (2) Left foot ____ (3)
Headstick (stylus, unicorn) ____ (4) Mouthstick ____ (5)
Other ____ (6)

109. If fingers, please indicate which fingers of which hand:

Right thumb ____ (0) Left thumb ____ (1)
Right forefinger ____ (2) Left forefinger ____ (3)
Right middle finger ____ (4) Left middle finger ____ (5)
Right fourth finger ____ (6) Left fourth finger ____ (7)
Right little finger ____ (8) Left little finger ____ (9)

110. If you type, about how many words per minute (w. p. m.) can you ordinarily type?

5 w. p. m. ____ (0) 5 to 15 w. p. m. ____ (1) 15 to 30 w. p. m. ____ (2)
30 to 45 w. p. m. ____ (3) 45 to 75 w. p. m. ____ (4) 75 w. p. m. or more ____ (5)

111. If you type, how long can you type before getting tired?
5 minutes ____ (0) 1/2 hour ____ (1) 1 hour ____ (2) more than 1 hour ____ (3)

112. Can you operate any kind of office, factory and/or other machines?
Yes ____ (0) No ____ (1)

If yes, please list and describe how well you can operate them. (M) ____________

113. Can you operate the controls of a TV, radio, or other home appliance, such as a washing machine, without assistance? Yes ____ (0) No ____ (1)

114. Can you operate a tape recorder that has not been modified?
Yes ____ (0) No ____ (1)

If yes, what type, make or model? (N) ____________

C/R/I INQUIRY FORM

115. Can you operate a record player that has not been modified?

Yes _____ (0) No _____ (1)

If yes, what type, make or model? (O)

116. Can you play any kind of musical instrument (i.e., mouth organ, clarinet, piano, etc.)? Yes _____ (0) No _____ (1)

If yes, please identify. (P)____

117. Can you use a telephone without assistance? Yes _____ (0) No _____ (1)

If yes, which of the following types:

Standard circular dial telephone _____ (0)

Push button "Touch-Tone®" telephone _____ (1)

Standard telephone (without dials or pushbuttons) _____ (2)

Party line telephone _____ (3)

118. Do you drive an automobile? Yes _____ (0) No _____ (1)

119. If yes, does it have special or modified controls? Yes _____ (0) No _____ (1)

If so, please describe. (Q)____

120. If not employed because of your disabilities, do you feel that, if electronic or other man-machine systems or other aids were available to you, you could become gainfully employed? Yes _____ (0) No _____ (1)

If any other electronic aids or man-machine systems would be valuable to you and/or make your life more comfortable, please identify them and explain why they might be helpful to you, your family, or others. (R) ____________________

121. Have you ever received aid, guidance or other help from any governmental or other organizations? If so, please give name. (S)____________________

Other comments: (T)

C/R/I INQUIRY FORM

If this INQUIRY FORM is filled in for you by someone else, please provide the following information so that, if needed, he or she can be contacted:

NAME: (of person filling out this form)

____

First Name   Middle Initial   Last

ADDRESS ____

Street and Number

____

County or City   State   Zip Code

TELEPHONE __________ ____________________________________

Area Code   Number

In order for this Form to be processed, please sign below to indicate that you have read and understood the following statement.

I, the undersigned, am voluntarily submitting the above information. I understand that it is only to be used to help in determining what should or can be done to benefit my disability and the condition of others who have handicaps and may be in need of electronic aids.

SIGNED BY ____

SIGNED FOR (IF APPLICABLE) ____________________________________

DATE ____________________

Mail To: Cybernetics Research Institute
2233 Wisconsin Avenue, N.W.
Washington, D. C. 20007

C/R/I CAPABILITIES INVENTORY FORM

Date ____________________

Age _____
Sex _____

Name ____
Address ______________________________________

Height: Standing _____ Length: Prone _____
Sitting _____ Supine _____

Telephone (__) - ____________

Missing Body Parts: ____

Paralysis: ____
Body Movements Apparently Controlled: ____________________
Prostheses: ____
Disability Diagnosis: ____
____

Preference of: Hands: L ____ R ____
Feet: L ____ R ____
Eyes: L ____ R ____

Speech Intelligibility:

Behavioral State: /__________ Awake /__________ Alert /__________ Excited /__________ Crying
______ Anxious
(Note changes during testing)

Social Responsiveness: /__________ Interested /__________ Disinterested /__________ Reluctant /__________ Refusal Resistance

Comments: ____
____
____
____
____
____
____

1.0

C/R/I CAPABILITIES INVENTORY FORM

SENSORY

Vision:
Blind? Yes ____ Partially ____ No ____
Glasses or Lenses? Yes ____ Corrected to ____________________

Position of Eyes:

Strabismus (concomitant)?				Heterophoria?			
____	L	Esotropia	R ____	____	L	Exophoria	R ____
____	L	Exotropia	R ____	____	L	Esophoria	R ____
____	L	Hypetropia	R ____	____	L	Hyperphoria	R ____
____	L	Hypotropia	R ____	____	L	Hypophoria	R ____

Non-concomitant strabismus? (describe) ____________________

Pursuit Movements
Range: ____________________
Control: ____________________

Convergence
Left eye ____________
Right eye ____________

Nystagmus
Horizontal ____________
Vertical ____________
Rotary ____________

Optokinetic Nystagmus
Symmetrical ________ Vertical ________
Assymetrical ________ Horizontal ________

Visual Acuity
Normal ____________
Abnormal (specify) ____________________

Visual Field
Normal ____________
Abnormal (specify) ____________________

Color
Normal ____________
Abnormal (specify) ____________________

Hemianopsia
Left Field ____________
Right Field ____________

C/R/I CAPABILITIES INVENTORY FORM

Audition

Degree of Impairment:
L: None___Mild___Moderate___Severe___Profound_____
R: None___Mild___Moderate___Severe___Profound_____

Hearing Aid?__________ Corrected to __________________

(Audiometer test)

____

____

____

____

Taction

Two Point Threshold

Fingers? _____

L		R
________	1	________
________	2	________
________	3	________
________	4	________
________	5	________

Cheeks

L ___ R ___

Lips? _____

L________
R________
C________
RC________
LC________

Forehead
L________
R________
C________

Motor

C/R/I CAPABILITIES INVENTORY FORM

Tongue: (5 switches in 3 positions with 3 force requirements)

Force Minimal (Switch time to activate)		position 1	position 2	position 3
	1	____	____	____
	2	____	____	____
	3	____	____	____
	4	____	____	____
	5	____	____	____

Force 2 Switch	position 1	position 2	position 3
1	____	____	____
2	____	____	____
3	____	____	____
4	____	____	____
5	____	____	____

Force 3	position 1	position 2	position 3
1	____	____	____
2	____	____	____
3	____	____	____
4	____	____	____
5	____	____	____

Length of tongue fully extended (lip to tip) ____________

Bite?

Control/Endurance

Bites per 1/2 minute ____________

Bites per minute ____________

Force

Bite (single) ____________

10 second sustained ____________

Breath?

Control: Suck - f/20 seconds ____________

Puffs - f/20 seconds ____________

Force: Blow - lb./sq. inch ____________

Eyelids	L	R	Both
Control f/30 sec.	____	____	____
Endurance f/min.	____	____	____

Facial

Controlled Movements: (eyebrows, nostrils, lips)
(describe) ____________

Head ____________

Apparent control of neck muscles:

None ____ Partial ____ Complete ____

Cybernetics Research Institute

C/R/I CAPABILITIES INVENTORY FORM

Standing and Sitting

Vection from Origin: F FL L BL B BR R FR
(Circle impossible movements)

Check Angular Rotation:
Clockwise ____
Counterclockwise ____

Prone and Supine
Rotation: L Center R
L Center R

Phalanges

Left			Right	
		Finger Spread/Close (Transverse, Forward, Pronated) Multiple Coord? ____ No Spread/Close? ____		
____	331-32		231-32	____
____	332-33		232-33	____
____	333-34		233-34	____
____	334-35		234-35	____
____	331-35	Dual Multiple Coord? ____	231-35	____
		Finger Hook/Open (Transverse, Forward, Pronated) Multiple Coord? ____ No Hook/Open? ____		
____	3313		2313	____
____	3322		2322	____
____	3332		2332	____
____	3342		2342	____
____	3352	Dual Multiple Coord? ____	2352	____

C/R/I CAPABILITIES INVENTORY FORM

Left		Right
	Fist/Open (Transverse, Forward, Pronated) Multiple Coord? ______ No Fist/Open? ______	
____ 3312		2312 ____
____ 3321		2321 ____
____ 3331		2331 ____
____ 3341		2341 ____
____ 3351	Dual Multiple Coord? ______	2351 ____

Wrist

Left		Right
	Swing Rotation	
____ c	(Transverse, Forward, Fist)	c ____
____ cc	Dual Coord? c ______	cc ____
	cc ______	
	contra ______	
	No Rotation? ______	
	Vection	
____ c	(Transverse, Forward, Pronated)	c ____
____ cc	Sag, Dual Coord? c ______	cc ____
____ c	cc ______	c ____
____ cc	contra ______	cc ____
	Trans, Dual Coord? ______	
	c ______	
	cc ______	
	contra ______	

Shoulder

Left		Right
	Vection	
____ (30)	(Standard/Pronated)	(20) x ____
	Sag, Dual Coord? c ______	x ____
	cc ______	
	contra ______	
	No Vection? ______	

C/R/I CAPABILITIES INVENTORY FORM

Left			Right
_____ (30)	Dual Coord? c _____	(20)	x _____
	cc _____		x _____
	contra _____		
	No Vection? _____		
_____ (30)	Front Dual Coord? c _____	(20)	x _____
	cc _____		x _____
	contra _____		
	No Vection? _____		

Rotation

c _____ 30	Sag? _____	c _____	20
cc _____	No Rotation _____	cc _____	
c _____ 30	Front (slightly forward)? _____	c _____	20
cc _____	No Rotation _____	cc _____	
c _____ 30	Trans (overhead)? _____	c _____	20
cc _____	No Rotation? _____	cc _____	

Elbow

Left			Right
	Rotation		
	(S:O, F:O, T:)		
	Dual Coord: _____		
	Sag; up _____	(22)	x _____
	down _____		x _____
	contra _____	(22)	x _____
	Trans; out _____		x _____
	in _____		
	contra _____		

Foot

Left			Right
	Toe Grasp _____		
	(Sitting or Supine)		
_____ 741	Multiple Coord? _____	641	_____
	No Grasp? _____		
_____ 742		642	_____
_____ 743		643	_____

C/R/I CAPABILITIES INVENTORY FORM

Toe Grasp (continued)

Left		Right
____ 744		644 ____
____ 745	Dual Multiple Coord? ____	645 ____

Ankle

Left		Right
	Rotation (Standing)	
____ c	No Rotation? ____	c ____
____ cc	Transverse ____	cc ____
	Vection (Standing, Supine)	
____ c	Sagittal ____	c ____
____ cc		cc ____

Knee

Left		Right
	Vection (Standing)	
____ 71-72	Backward	61-62

C/R/I CAPABILITIES INVENTORY FORM

Hip

Left			Vection (Standing)		Right
0 to ____	c			c	0 to ____
0 to ____	cc	70	Sagittal	60 cc	0 to ____
0 to ____	c			c	0 to ____
0 to ____	cc	70	Frontal	60 cc	0 to ____
0 to ____	c		Sagittal	c	0 to ____
0 to ____	cc	71		61 cc	0 to ____
0 to ____	c		Frontal	c	0 to ____
0 to ____	cc	71		61 cc	0 to ____

1?8

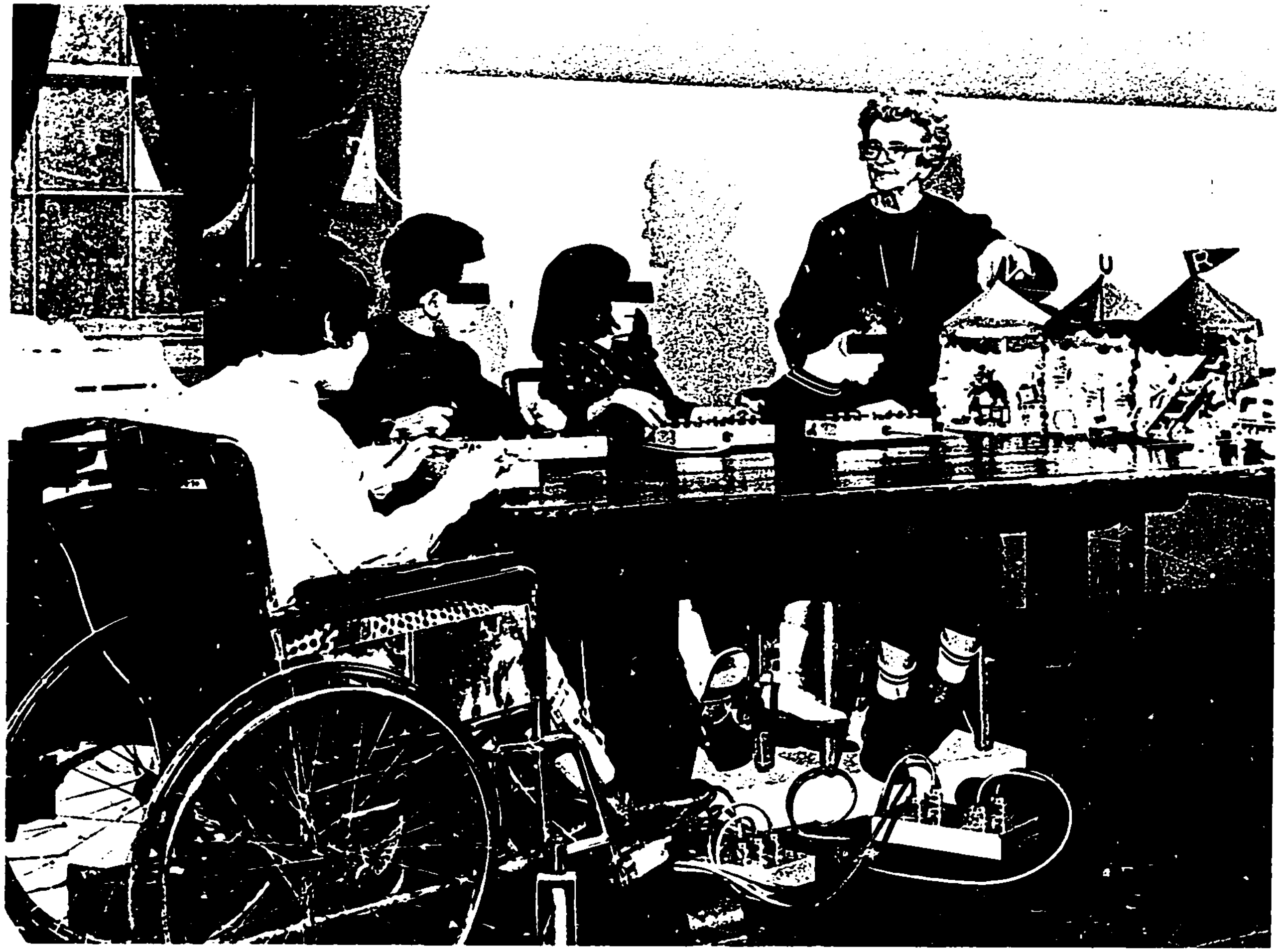

Plate 40

Anna Mae Gallagher, Creator of the Cyber-Circus "Cybertype" Instructional Materials, Shown with Students

Part Six | CYBERTYPE & CYBERLAMP

PORTABLE TELEPHONE COMMUNICATIONS SYSTEMS

Introduction

About 2 million persons in the United States, or 1% of the total population, have "severe" hearing impairments, defined as "frequent difficulty with loud speech," (Zakia and Haber, 1971) or worse. These persons with hearing disabilities, together with individuals who have speech impairments, and those who have no speech or hearing problems desire to communicate with one another, but cannot do so effectively by means of the telephone.

Some communications organizations provide special telephone amplifiers for handicapped subscribers who have a moderate degree of hearing loss. In addition, converted teleprinter systems (C/R/I Interim Report, 1968), where available, are used on a limited basis by persons with severe hearing impairments to type messages which may be printed at a remote receiving station equipped with a companion teleprinter. Unfortunately, these teleprinter systems are not self-powered, and cannot be carried about. They are bulky, heavy, and require permanent installations. Other telephonic systems for this population have been proposed, e.g., communications systems which use coded visual and palpable means. Severe constraints are prevalent with all of the systems.

Researchers at Cybernetics Research Institute are evaluating new man-machine communications systems (C/R/I Second Report, 1970) which may help overcome deficiencies of the systems already in existence.

The "Cyberphone" and "Cyber-Tone" are two members of the CYBERCOM family of man-machine communications systems which deserve consideration for use by the hearing and speech-impaired population, expecially in their educational and vocational environments. (C/R/I Interim Report, 1968 and Second Report, 1970)

The "Cyberphone" is a self-powered, light-weight,portable telecommunications system. It is a hand-carried, battery-operated, solid-state instrument contained in a slender briefcase with a control-display interface equipped with either a standard 50-key keyboard, or a variety of "Cybertype" control interfaces consisting of 1, 2, 7, or 14 keys, or other key combinations. The latter key configurations may be employed by persons with speech and/or hearing disabilities who have severe physical handicaps which preclude use of ordinary keyboards.

"Cyberlamp," a visual readout display for the presentation of letters and other graphic symbols, is contained on the control panel of the "Cyberphone," along with a telephone cradle, selector switches, a battery-test switch and meter, a power-input connector, and message display "read" and "print-out" terminals. Visual indicators, for signifying the presence of dial tones, rings, busy signals and other useful information present in the telephone circuit, are also contained on the panel.

When the desired letter, function or symbol is typed on the keyboard or interface by the sender, signals are transmitted via telephone lines or other means to a companion unit at the receiving end where the signals are decoded and converted for visual display, printed or other types of presentations.

The individual at the receiving end may "read" the message from the built-in visual readout display by composing words from individual, sequentially-presented letters, or the message may be read from a typed copy. The message contents may also be shown on the whole-word, "Cyberlex" display, which presents 1, 8, 16, or more letters at a time; other CYBERCOM devices may also be utilized for this purpose.

Experiment - Message Comprehension for Three Alphanumeric Displays

Of the many questions asked in this experiment, one was related specifically to the relative effectiveness of three types of alphanumeric displays. These displays were studied in a pilot experiment in order to compare the effects of message transmission rates on the intelligibility and comprehensibility of messages to the user. The messages were displayed, in the form of sequentially presented letters, in the following manner:

1. Display A had independently back-lighted letters and symbols arranged in a square, its diagonal perpendicular to the horizontal, to correspond with the letter frequency in English Text (Figure 3) and the C/R/I "E-T-A" Alphabet Chart.

2. Display B consisted of eight electronic alphanumeric lamps of the NIXIE™* tube type (Figure 4); and

3. A single "NIXIE" alphanumeric lamp was used for Display C (Figure 5). It had the capability to present any one of the 26 letters of the alphabet and ten numerals from "0" to "9", one at a time in temporal sequence. This condition was accomplished by using only one alphanumeric lamp of Display B.

Six message transmission speeds were used: 12, 24, 36, 48, and 72 words per minute, all within manual typing range. Procedural details of the pilot experiment are contained in Appendices C and D. Results are summarized in Figures 6 and 7, which show subject comprehension of the messages and ability to accurately reproduce the messages presented on the three types of displays. Questions were used to estimate subject comprehension of presented test messages. Whole-word accumulation, as presented in Display B, led to the highest percentage of correct answers to the questions. These results were generally independent of the message transmission speeds within the range of speeds in the experiment. Single letters, in Displays A and C, when presented at higher message transmission speeds became incomprehensible to subjects tested.

*Trademark, Burroughs Corporation, Los Angeles, California.

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The reader may question the fact that subjects tested answered 25% to 35% of the questions on comprehension correctly even when message readout errors were above 80% to 90%. This may be due to the employment of multiple-choice questions, each having four alternative answers, since random guessing would be expected to produce about 25% correct answers. It is important to note, however, that even the single-letter displays "A" and "C" provided reasonably good message reception and co. prehension for transmission speeds up to 24 words per minute (see Figures 6 and 7).

Since the pilot experiment indicates that use of the "Cyberlex" whole-word display is far superior to the single-letter display, it appears that consideration should be given to the employment of light-weight, whole-word, solid-state displays for use in portable telecommunications systems.

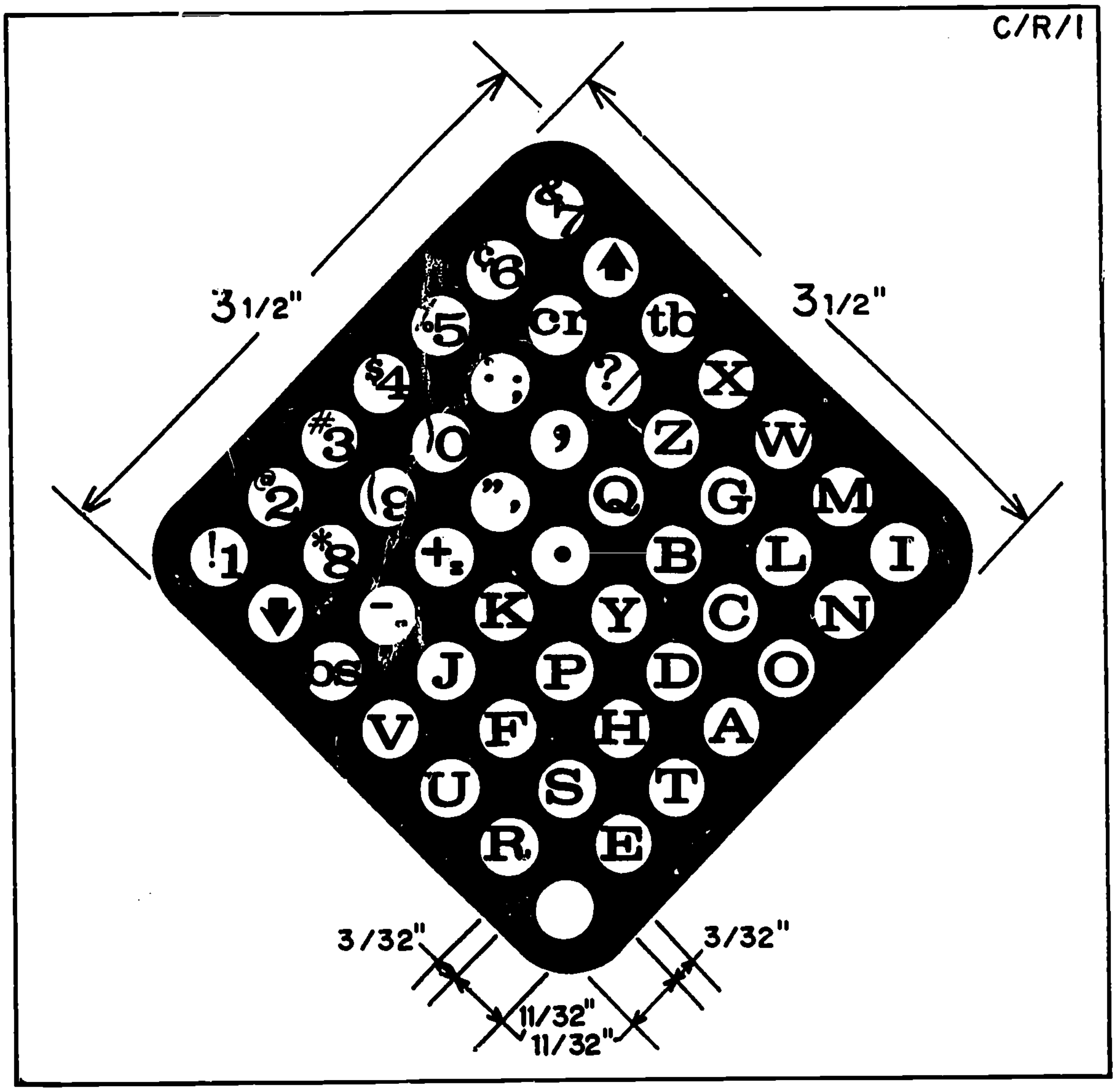


FIGURE 3 - DISPLAY A

"CYBERLAMP" USED IN "CYBERPHONE"

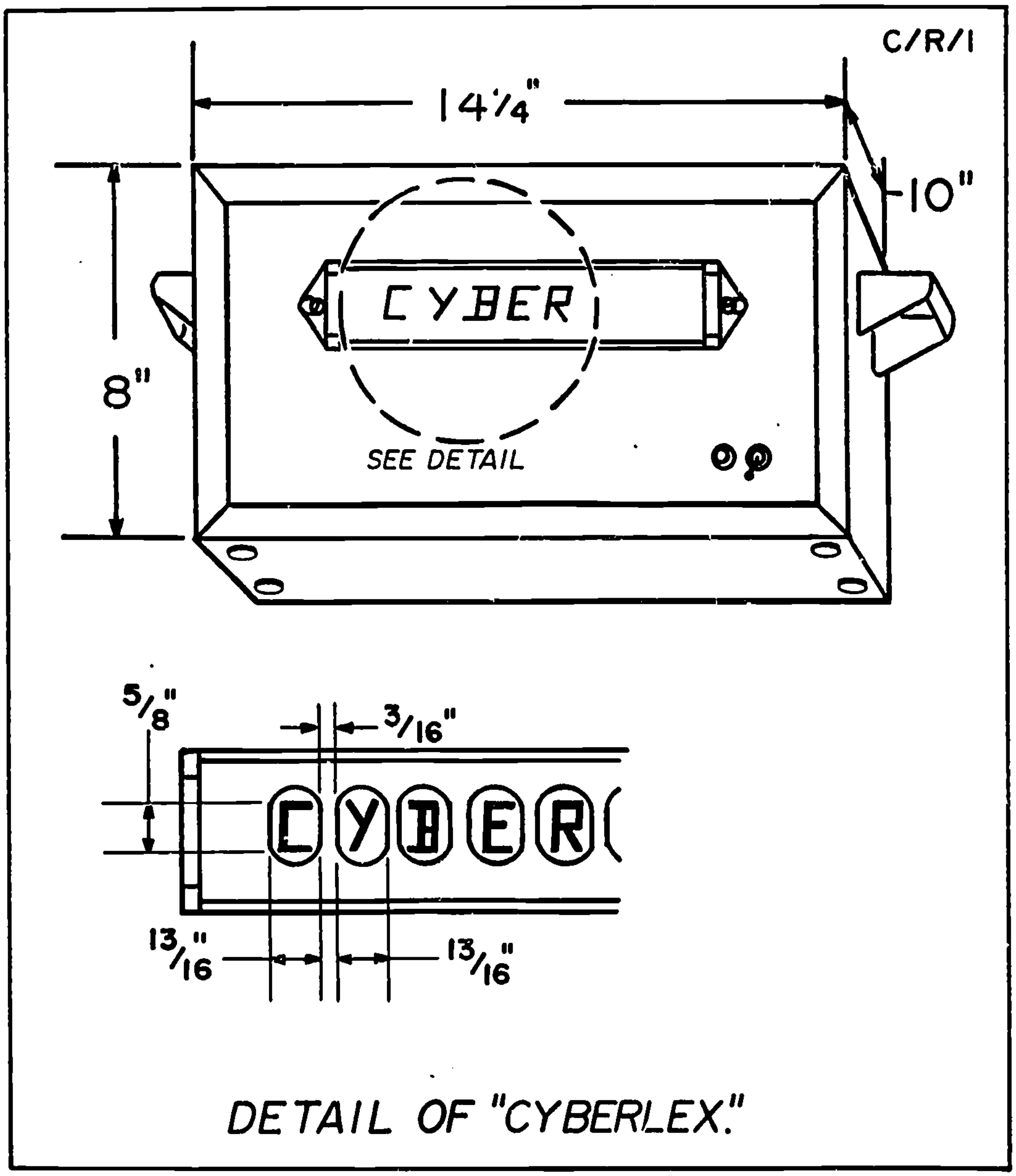


FIGURE 4

DISPLAY B - "CYBERLEX"

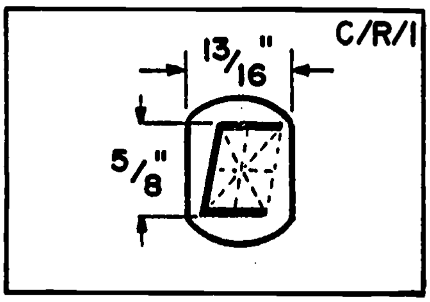


FIGURE 5

DISPLAY C - SINGLE "NIXIE" ALPHANUMERIC LAMP

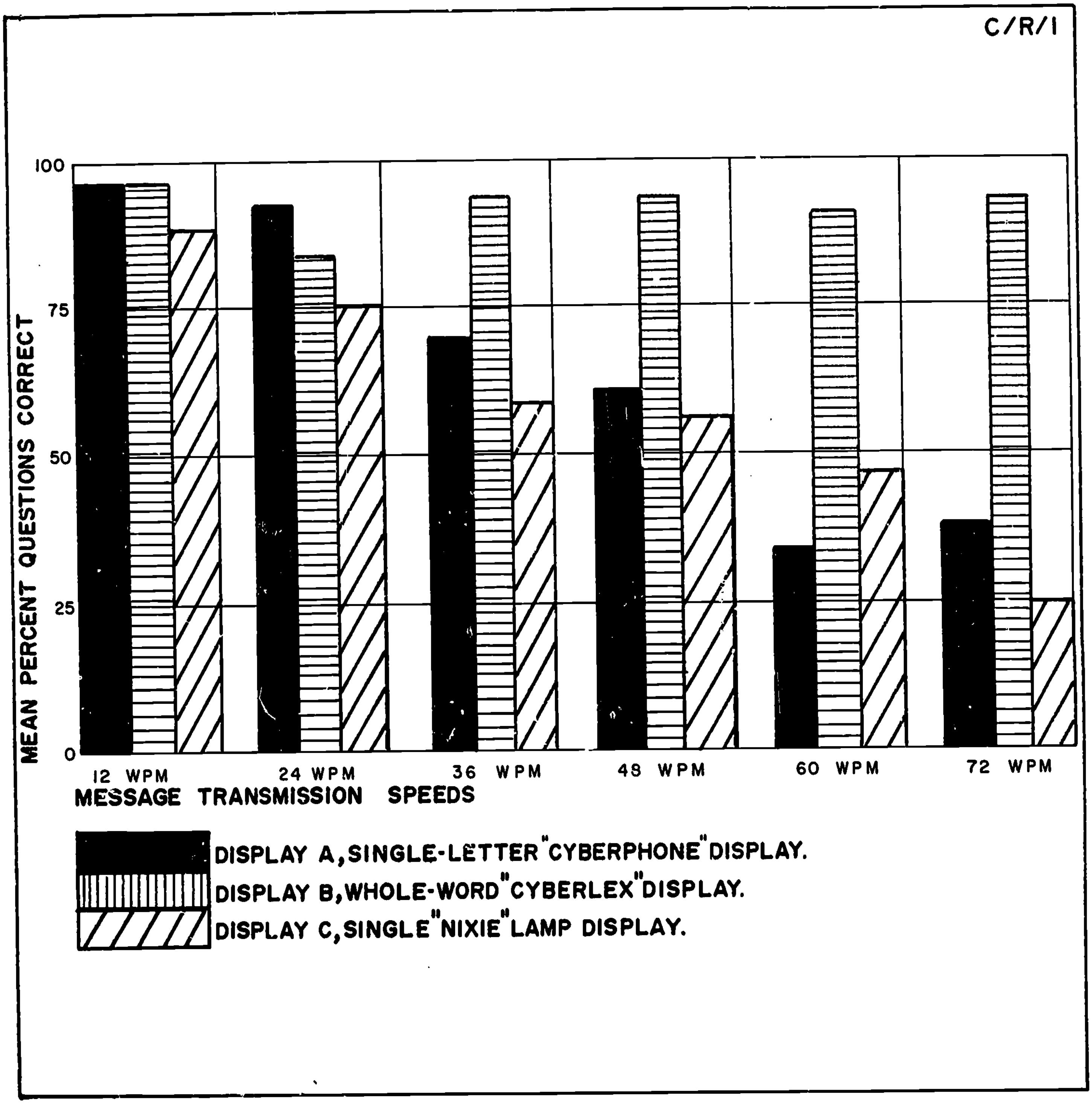


FIGURE 6

SUBJECT COMPREHENSION OF MESSAGES PRESENTED ON THREE TYPES OF DISPLAYS

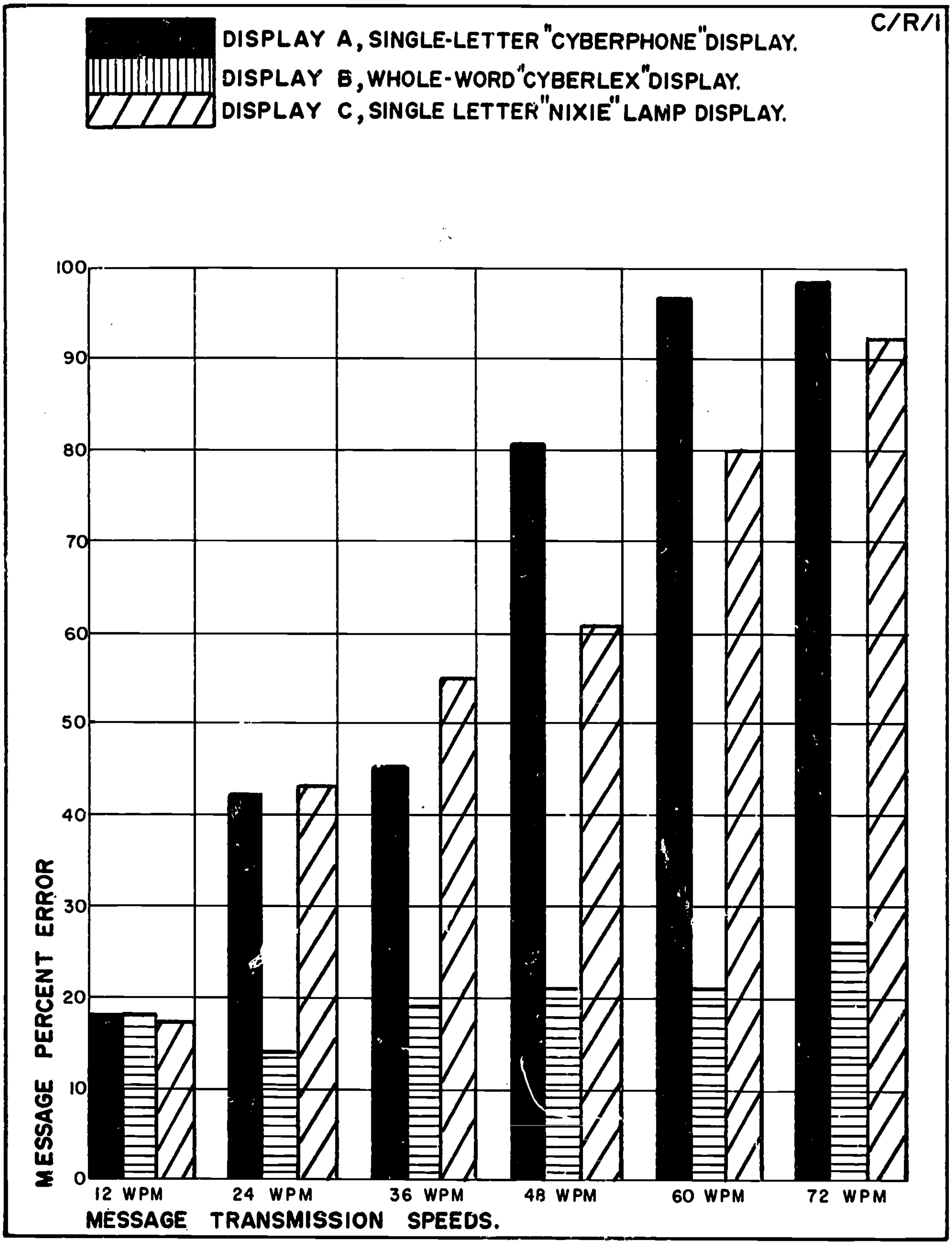


FIGURE 7

SUBJECT PERCEPTION OF MESSAGES PRESENTED ON THREE TYPES OF DISPLAYS

Part Seven | HAIBRL

A NEW EXPERIMENTAL PUNCTIFORM COMMUNICATIONS SYSTEM FOR THE BLIND

Introduction

There are more than 500,000 blind or visually impaired people in the United States. Many sources reveal that there are as many as 1 million people in the U.S. who cannot read newspaper print with or without eyeglasses. It has been estimated that about 33,000 of the 500,000, or less than 7%, use the braille punctographic tactile system. These estimates also reveal that only about 12,000, or less than 2.5%, of the blind or visually impaired population read braille with accuracy and proficiency. In technical and scientific fields, such as music and mathematics, the number of users falls drastically lower, i.e., fewer than 1000 people use braille music regularly. Hence, there is a large field and justification for the development of alternative punctographic tactile systems which might serve the enormous number of blind people who cannot learn braille or who lack any read/write capability.

Examination of the characteristics of braille reveals that several features appear to pose potential difficulty for any person attempting to learn to use the system. First, there is simply the problem of discerning the close similarities which are prevalent among many of the patterns. Secondly, out of the 63 possible braille patterns, 31 are ambiguous or closely similar to, and may easily be mistaken for, other braille patterns (C/R/I Second Report, 1970). Thirdly, in the effort to increase reading speed, and to allow for greater versatility, one popular version of the braille code has been assigned about 263 separate individual meanings. Most of the braille patterns have four possible meanings which must be differentiated principally by context, after the dot pattern of the cell has been correctly identified.

For more technical activities, such as music and mathematics, additional special braille codes based on the very same 63 patterns lend to new complexities and more multiple meanings. Except in isolated cases, most contemporary researchers of punctiform writing are preoccupied with attempts to improve the braille system primarily through additional or other assignments of meaning to its 63 available patterns. It may be noted that 31 of the potential ambiguities of the braille cell may be reduced to 4 by changing the shape of only two dots in the cell (see C/R/I Second Report, 1970, Volume I, Page 32, Figure 10, Part E).

In contrast, HAIBRL (C/R/I Interim Report, 1968) is a new experimental punctographic tactile communications system which differs from braille in that it provides for improved differentiation among all patterns available through use of a referent in each cell. HAIBRL may provide a potential for richer vocabularies and greater adaptability to technical subjects than is presently being offered by braille and other punctiform systems.

The unique and chief characteristic of the HAIBRL cell is the presence of its referent, which provides feedback and unequivocal pattern identification to the reader.

Hence, an individual may be able to determine with greater ease the specific location and orientation of the presented dot patterns without having to resort to context. One version of the experimental HAIBRL cell has 16 positions within the matrix which encompass the referent (see Figure 8).

Work with experimental HAIBRL has progressed, firstly, in the designs of the dot patterns, secondly, through pilot experiments of tactile discriminations and, thirdly, in the design of the codes to be considered for use with assigned dot patterns.

Two pilot experiments were conducted for comparing HAIBRL X1 and X2 configurations (see Figure 8; C/R/I Interim Report 1968 and Second Report, 1970). The first of these was conducted by Dr. Emerson Foulke, Head of the Perceptual Alternatives Laboratory (PAL), University of Louisville. Twelve sighted subjects were tested. They were presented with eight different single-dot characters of X1 and X2 configurations, and subsequently with 64 two-dot characters. The results of the test show mean errors of approximately 67% for each of the two HAIBRL cells. The conclusion from the first experiment, which seems to be supported by the second experiment described herein, is that there is little difference between X1 and X2 cells. This data obtained in the second experiment was based upon X2 cells.

The second experiment was conducted at C/R/I using 20 visually handicapped subjects. The same patterns were presented to subjects as were provided to the subjects in the first experiment. Again, the results seem to indicate little basis for choice between cells X1 and X2. However, no conclusion should be derived until more data is obtained.

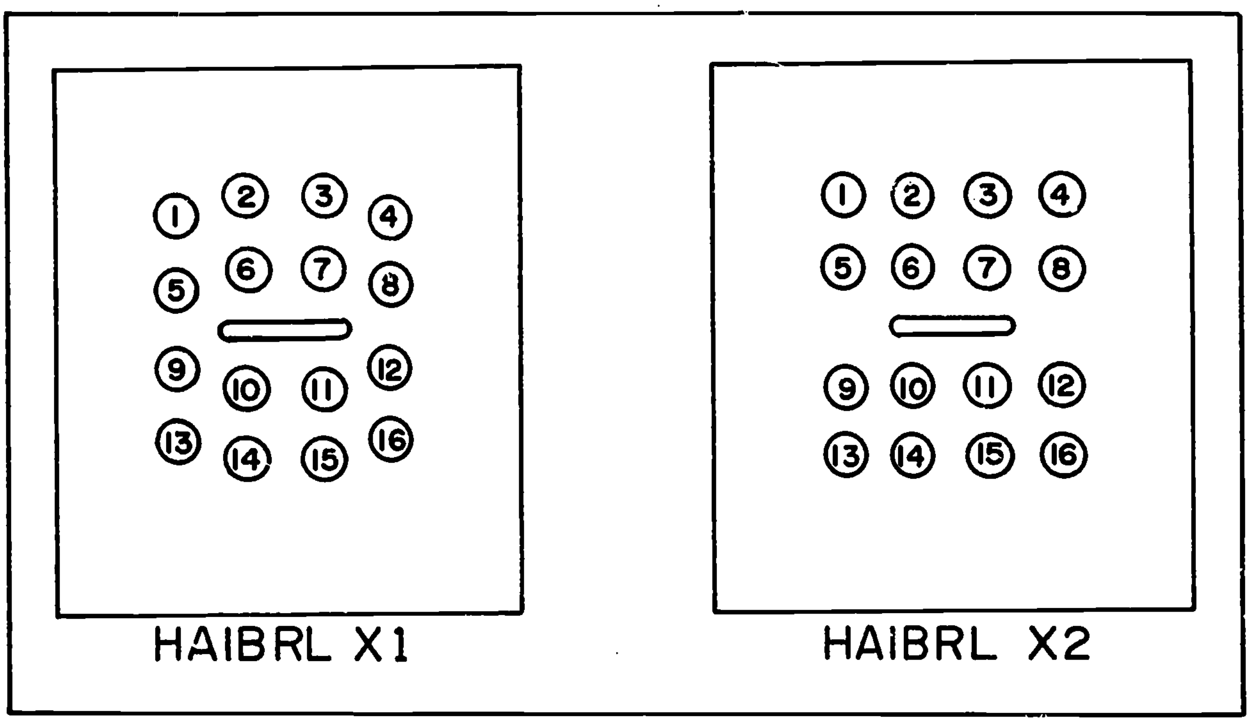


FIGURE 8

ENLARGED DIAGRAM OF TWO HAIBRL CELL CONFIGURATIONS

The experiments conducted at the Perceptual Alternatives Laboratory (PAL) of the University of Louisville and at Cybernetics Research Institute (C/R/I) in Washington, D. C. were primarily designed for comparison of X1 and X2 cell configurations. Even though they present only a fraction of the total possible set of single dots and pairs of dots, some valuable information can be derived from careful examination of the data. A preliminary analysis of some of these data has been conducted in order to gain insights applicable to the designing of a tactile code for use with the HAIBRL X2 cell.

It may first be observed that some of the data presented in the PAL experiments, as shown in Table XVI (C/R/I Quarterly Report, May 19 - August 19, 1970) can be combined to increase the statistical significance of the data obtained in the experiments. A similar approach was used for both analyses. Thus, characters 1, 4, 13, and 16 are each corner dots, while characters 5, 8, 9, and 12 may be termed interior dots. By reason of symmetry, the four corner dots may be combined, as may also the four interior dots, for there seems to be no prior reason in these instances for assuming biases of left over right or up over down within the cell. In similar fashion, appropriate pairs of dots may be considered as homologous to one another. For example, the pair of characters 1-2 may be considered equivalent in recognizability to 3-4, 13-14, and 15-16, as sensed in relation to the reference bar.

The most striking result of comparing the PAL and C/R/I HAIBRL data is the contrast of the overall error rates (See Table XVII). In PAL, it was approximately 67%, whereas the error rate for the C/R/I experiment ranges (depending on particular characters presented) from about 3% to about 13% or 14%. For example, concerning the corner dots, the twelve subjects in the PAL experiment had eight opportunities to identify interior dots. The error rate for these single characters were 45% and 50% respectively. In contrast, the C/R/I experiment provided 240 opportunities each for the corner and interior dots. For these, the error rates were 3.8% and 4.2% respectively. There is a magnitude of difference between the results of these two experiments. And if one considers the characters consisting of pairs of dots, either individually or collectively, there is a radical difference between the results of the two experiments.

The overall results obtained in the PAL experiment show that with 768 opportunities to identify pairs of dots there was a 68.7% error rate. For the corresponding C/R/I test, there were 1,920 opportunities and an error rate of only 7.9%.

It would appear that the most significant difference between the two experiments was in the backgrounds and abilities of the subjects. At the Perceptual Alternatives Laboratory, sighted subjects were used in the experiment; their degree of training and motivation was not known. In contrast, subjects for the C/R/I experiment were visually handicapped and were familiar with braille. Consequently, it may be assumed that the C/R/I group consisted of highly motivated subjects with significant experience in tactile perception and proficiency in reading punctiform textual materials.

From these data the following tentative position may be inferred: Even at this early stage of development, subjects who are unfamiliar with punctiform perception may require motivation and training before they can develop a capability to distinguish one pattern from another.

The data for the C/R/I experiment were obtained from a set of twenty subjects. Each subject was presented with each of 72 characters three different times. The 72 characters consisted of 8 single dots and 64 pairs of dots, each of which included at least one dot which was distinctively different from the X1 and X2 cell. The C/R/I HAIBRL experiment was specifically designed for a comparison of X1 and X2, and not for the determination of pattern distinctiveness. As a result, these conclusions can be considered tentative and subject to verification.

Upon examining the experimental data for single dot characters, the following may be observed:

(a) for the upper left corner dot, character 1, there were 60 opportunities for correct recognition. Of these, the subjects correctly recognized that this was indeed character 1 fifty-seven times; twice the character 5 was identified, and once the character 2 was cited instead of the character 1. For the other three corner positions, i. e., characters 4, 13, and 16, the scores for correct identification of the dot were, respectively, 56, 59, and 59. For the four corners taken together, with 240 opportunities for identification, success was achieved 231 times, yielding an error rate of 3.75%;

(b) it may be noted that for all four corners, the nine errors in identification of the dot occurred by naming of a character in an adjacent row or column or diagonally removed by only one square. This strongly suggests that if a single dot is to be used in a quadrant, it should always be the same dot, for example, the corner dot;

(c) comparable statistics for the inner dot positions, (i. e., characters 5, 8, 9, and 12) indicate identification 57 times out of 60 for each of three of these positions and, 59 out of 60 for character 9. Once again, each error was located within a radius of one of the dots to be recognized with a single exception. In one instance, as a matter of fact, the only error occurred when character 9 was presented and cell 11 was cited;

(d) for all single dot characters combined, there were thus 480 opportunities, of which 461 were correctly identified, giving an overall error rate of 4%. (This is contrasted to the 45% error rate for the 96 trial opportunities in the PAL experiment.) To reiterate, of the 480 single dot trials in the C/R/I experiment, all but one were within a radius of one of the presented dots.

TABLE XVI

PERCENTAGE ERROR RATE FOR IDENTIFICATION OF HAIBRL X1 AND X2 CHARACTERS

(Experiments conducted at Perceptual Alternatives Laboratory*)

Character	% Error X1	% Error X2	Character	% Error X1	% Error X2	Character	% Error X1	% Error X2
1	42	33	3-4	50	50	8-11	100	92
4	42	42	3-5	67	58	8-12	58	83
5	50	42	3-8	58	42	8-13	58	67
8	75	58	4-5	50	75	8-16	67	58
9	75	42	4-6	75	67	9-10	58	83
12	58	58	4-7	92	33	9-11	75	42
13	25	42	4-8	67	50	9-12	50	83
16	50	67	4-9	58	50	9-13	83	50
1-2	50	75	4-12	67	42	9-14	75	75
1-3	83	92	5-6	83	92	9-15	58	67
1-4	50	67	5-7	67	75	9-16	58	50
1-5	75	50	5-8	67	92	10-12	75	67
1-6	67	67	5-9	58	67	10-13	100	75
1-7	75	75	5-10	92	83	10-16	100	50
1-8	67	58	5-11	83	100	11-12	83	100
1-9	92	42	5-12	67	92	11-13	92	67
1-12	67	58	5-13	100	67	11-16	92	92
2-4	75	100	5-16	67	75	12-13	50	42
2-5	92	83	6-8	58	75	12-14	50	67
2-8	42	58	6-9	92	100	12-15	92	75
			6-12	58	50	12-16	50	50
			7-8	75	83	13-14	50	50
			7-9	75	42	13-15	92	75
			7-12	42	58	13-16	58	83
			8-9	67	58	14-16	83	92
			8-10	58	92	15-16	67	75

Mean Error: X1=68.3%; X2=66.5%
Median Error: X1=67.0%; X2=66.9%

(*Reproduced from C/R/I Quarterly Report, May 19, 1970 - August 19, 1970; page 38.)

TABLE XVII

COMPARISON OF ERROR RATES*

Preliminary Character Patterns	PAL EXPERIMENTS Error Rates of Sighted Subjects		C/R/I EXPERIMENTS Blind Subjects		Number of Double Errors
	Es	Ns	Eb	Nb	
Corner Dots (1, 4, 13, 16)	.460	48	.038	240	-
Inner Dots (5, 8, 9, 12)	.500	48	.042	240	-
1-2 3-4 13-14 15-16	.625	48	.050	120	6
1-3 2-4 13-15 14-16	.898	48	.133	120	10
1-4 13-16	.750	24	.050	60	0
1-5 4-8 9-13 12-16	.500	48	.042	120	2
1-6 4-7 10-13 11-16	.668	48	.066	120	2
1-7 4-6 10-16 11-13	.648	48	.066	120	2
1-8 4-5 9-16 12-13	.562	48	.058	120	0
1-9 4-12 5-13 8-16	.502	48	.092	120	1
1-12 4-9 5-16 8-13	.625	48	.058	120	0
2-5 3-8 9-14 12-15	.688	48	.108	120	6
2-8 3-5 9-15 12-14	.625	48	.116	120	3
5-6 7-8 9-10 11-12	.895	48	.132	120	14
5-7 6-8 9-11 10-12	.648	48	.050	120	2
5-8 9-12	.875	24	.083	60	2
5-9 8-12	.750	24	.117	60	2
5-10 6-9 7-12 8-11	.832	48	.092	120	3
5-11 6-12 7-9 8-10	.710	48	.050	120	0
5-12 8-9	.750	24	.050	60	0
All Pairs	.687	768	.079	1920	54

E_s - Error Rates as Decimals

N_s - Number of opportunities for correct recognition of characters in PAL experiment.

E_b - Error rates at decimals

N_b - Number of opportunities

*See text above for definition of symbols.

The preliminary analysis performed on the paired dot trials was done only for ten subjects. By number, these subjects were 21, 16, 17, 18, 22, 14, 6, 13, 5, and 3. Each of these subjects was presented 64 pairs of dots three times each for a total of 1,920 opportunities. The data were examined for each paired dot presentation to determine the number of times the pair was correctly identified with regard to both elements presented. A tally was made of the number of times both elements were wrong and what pair of dots was called by the subject. This tally was done only for the individual pairs in the experimental design, but a compilation was made combining data in accordance with analogous positions in other quadrants. For example, the 1-2 dot combination was considered equivalent (from symmetry considerations) with the paired dots 3-4, 13-14, and 15-16.

The accompanying table, Table XVII, summarizes the preliminary comparison of error rates for the two sets of experiments which have now been examined. The columns headed "Sighted Subjects" give the error rates (as decimal E_s) and number of opportunities (N_s) for correct recognition of characters in the PAL experiment. The columns under "Blind Subjects" give the error rates (E_b) as decimals and the number of opportunities (N_b). As noted above, there were twice as many opportunities analyzed for the single dot characters as compared to the two-dot pairs. Table XVII aggregates homologous pair patterns, as shown in the first column. The bottom row of the table shows that, for all pairs, the error rate was .687 in the 768 trial opportunities with sighted subjects, and .079 for the 1,920 trial opportunities with visually handicapped subjects.

The last column in Table XVII shows the number of double errors for each two-dot, paired configuration; i.e., the number of times a given paired configuration was misidentified with respect to both elements. It is noteworthy that of the 54 times that such double errors occurred, 13 were attributable to a lateral displacement, such as the pair 1-3 being identified as the pair 5-7. More striking, perhaps, is the fact that 16 of these double errors occurred from a diametrically opposed confusion factor; for example, the pair 1-2 being called 15-16 or vice-versa. Even more startling is the fact that 34 of the 54 double errors occurred with both dots in the same horizontal row (but not in the two corners). This strongly suggests that future codes of the cell configuration tested avoid, if possible, the placing of a pair of dots in the same horizontal row. This consideration may be reinforced by an examination of the paired dots which were singly in error, i.e., one of the two dots called correctly and the other one incorrectly. Two dots in the same horizontal row gave rise to either a single or a double error in 49 of the 151 occurrences of one or more errors.

It may be suggested that subjects who rely on their tactile senses for information have greater motivation; hence, with suitable training they may fairly accurately discriminate various tactile stimuli. One point of the analysis of the pilot study was to determine whether it was possible to extract from the results of these particular experiments sufficient viable information and direction which could assist the investigators and guide them towards devising a conceptual code to achieve desired and much needed standards. Such a code may assist to eliminate or considerably minimize prevalent stumbling blocks, many of which are insurmountable, found in braille and provide for a new tactile communications system using only mutually discriminable unambiguous symbols. Moreover, the patterns of the new system should be sufficiently simple to enable a larger population of visually handicapped individuals (especially blind children who cannot learn braille) to perceive them readily and rapidly, and also to allow the user a means of tactile reading and writing in a straight-forward, simple and rapid fashion with little, if any, dependence on context.

Another observation from this initial examination of the data is the fact that there were only 5 occurrences of a "missed dot" with HAIBRL when a pair of dots was presented to the subject and only one dot was discriminated. This may be a revealing contrast to observations reported by Nolan and Kederis to the effect that some of their trials with braille showed 86% "missed dots."

It may be emphasized that the experiments under which data were collected were designed to distinguish only the preference to be assigned to HAIBRL cells X1 and X2. They were not devised to determine the most easily identified HAIBRL cell characters.

New knowledge gained in this study may be helpful in the design of future unequivocal coded alphabets of symbols and patterns, which must subsequently be submitted to appropriate testing procedures prior to assignments of meanings, be they in the form of phonemes or other language symbology.

Application of the Experimental Results on Tactile Discrimination to Construction of HAIBRL Code Configurations

The "referent bar" of the HAIBRL cell basically permits the user to locate and identify the spatial location of a dot or dots, (that is, whether they are above and/or below in positions relative to the referent) and, by virtue of the limited width of the bar, the spatial left-right positions as related to the referent. Examination of the data taken in the pilot study indicates that subjects are generally highly capable in distinguishing one quadrant from another. Thus, for example, upper left is easily distinguished from upper right and lower left. Therefore, the construction of HAIBRL code configurations might commence with discrete elements within a quadrant, then proceed to combinations of quadrants containing particular elements. This approach is an extension of the development of the legend disclosed in C/R/I's Second Report, 1970.

The guiding principles to be considered in the further orderly design of one HAIBRL code might include the following requisites:

(a) The pattern coding itself should have no ambiguities; it should be simple, easy to learn, to read, and to write.

(b) The individual characters, character patterns or clusters of dots and their meanings, should be clearly discriminable and mutually distinctive to eliminate or minimize errors.

(c) The capacity of the code should be adequate to accommodate rich expression of all languages, be they letter by letter, by phoneme, or other structure.

(d) One writing tool common to all perforations should be used.

Coding should consist of basic or signifiable elements which are understandable, and can be grasped by that large segment of the population of visually handicapped who presently cannot use braille.

It may be that these factors of simplicity, discriminability and adequacy of language, are not fully compatible. Attempts to develop a suitable code may lead to constraints, inconsistencies or conflicts among these factors.

But if pattern ambiguities and multiple meanings to one pattern are eliminated, gains are assured. The employment of a tactile code would seem to proceed according to the following sequence:

(a) Sensing of all dot patterns or other elements present.

(b) Recognition of the specific configuration of tactile elements present, including a decision as to location of certain combinations which may assume several forms within the coded language.

(c) Association of the configuration, as identified, with its meaning (for example, in English), including identification of meaning in instances where several connotations may be implied from context or in association with other characters.

Figure 9, Section (e) also illustrates the "Edge" which consists of four consecutive aligned dots on one of the outside edges of the HAIBRL cell, either horizontal or vertical. The remaining two basic elements proposed for identification are the "Corner" and the "Angle" configurations. As shown in sections (f) and (g) of Figure 9, these are each three-dot patterns within a single quadrant of the HAIBRL cell. This pattern, identified as "Corner" consists of the corner dot of a quadrant, and the dot located along each of the two adjacent edges; the fourth position in the quadrant, the one closest to the reference bar, is not used. The "Angle" configuration uses the dot in the quadrant closest tothe reference bar and the two nearest edge positions.

Tables XVIII – XXII list a set of proposed HAIBRL X2, Mod 1 coding patterns based on the legend and illustrations of Figure 9. In Table XVIII, seven basic elements or configurations are listed in order of increasing use of cell position in the pattern, starting with the single dot (the corner "Dot" configuration)and leading up to the use of four positions for an "Edge" configuration. There is also a column in the table to show the number of orientations of the same basic pattern which are available by virtue of the presence of the reference bar for quadrant identification. Each of the basic elements can assume four different positions, yielding 28 possibilities for these particular seven basic elements in their various possible orientations.

Table XIX lists combinations of like elements. This is based on two assumptions: first, that the individual basic elements are easily recognizable in themselves, and second, that their location by quadrant is easily determined. If these two criteria are met, it may be possible for a reader to identify the same element structure used in two different quadrants, as well as to recognize the quadrants being used. Again, it is the referent bar, an inherent feature of HAIBRL, which makes such discriminations possible.

These combinations of like elements, utilizing anywhere from two to twelve dot positions in their patterns, give rise to a range of possible orientations from 1 through 6, as shown in Table XIX. It may be noted here that the number of cell positions in the pattern may affect the ease with which the code can be "written," although the ease in "reading" may not be completely correlateable with the number of dot positions used. For example, the "Corner" or "Edge" quad, which uses 12 dots along the periphery of the HAIBRL cell, may be one of the more easily identified configurations. These combinations of like elements are illustrated in Figure 10.

"Dots," "Edges," "Corners," and "Angles" are as examples illustrated in pairs, triples, and quads since, from a theoretical point of view, these would seem to be easily recognizable. Comparable trios or quadruples of "Spokes," "Catercorners," and "Verticals" have not been illustrated. There is, of course, the opportunity to introduce such configurations if they prove to be useful and if there arises a need for further combinations in order to extend the adequacy of the coded language.

Table XX lists combinations of unlike elements taken two at a time -- for example, a "Spoke" with a "Dot," an "Edge" with a "Catercorner," etc., where the two unlike elements appear in separate quadrants of the HAIBRL cell. As shown in the table, depending on choice of elements, the number of possible orientations is either eight or twelve. Figure 11 illustrates some of the possible combinations of unlike elements taken two at a time and using two separate quadrants.

Tables XXI and XXII have been included for illustrative purposes to show the use of two "Dots" in two separate quadrants and an additional element in the remaining portion of the HAIBRL cell. These combinations use from 4 to 6 positions and give rise to 12 possible orientations (except for the two "Dot" and "Edge," which permit only four possibilities). A "Dot" and two elements in a pair are shown in the last section of the table. Once again, three quadrants are used. Figure 12 presents samples of quadrant combinations using a "Dot" pair with an additional basic element. Figure 13 presents samples of three quadrant combinations using a single "Dot" with a pair of basic elements.

TABLE XVIII

PROPOSED HAIBRL X2 MOD 1 CODING PATTERNS

BASIC ELEMENTS

Identifier	Description	No. of Cell Positions in Pattern	No. of Orientations Possible	Group Total
D	Single Dot (in corner)	1	4	
S	(Radial) Spoke	2	4	
K	Catercorner	2	4	
V	Vertical (⊥ to Cybar*)	2	4	
E	Edge	4	4	
C	Corner	3	4	
A	Angle	3	4	28

TABLE XIX

PROPOSED HAIBRL X2 MOD 1 CODING PATTERNS

COMBINATIONS OF LIKE ELEMENTS

Identifier	Description	No. of Cell Positions in Pattern	No. of Orientations Possible	Group Total
D-D	Dot Pairs	2	6	
D-D-D	Dot Triple	3	4	
D^4	Dot Quad	4	1	
S-S	Double Spoke	4	6	
K-K	Double Catercorner	4	6	
V-V	Double Verticals	4	6	
C-C	Double Corners	6	6	
A-A	Double Angle	6	6	
E-E	Double Edges	8	6	
C-C-C	Triple Corner	9	4	
A-A-A	Angle Triple	9	4	
E-E-E	Triple Edge	10	4	
A^4	Angle Quad	12	1	
C^4 or E^4	Corner or Edge Quad	12	1	61

*The referent in each HAIBRL cell

TABLE XX

PROPOSED HAIBRL X2 MOD 1 CODING PATTERNS

COMBINATIONS OF UNLIKE ELEMENTS

Identifier	Description	No. of Cell Positions in Pattern	No. of Orientations Possible	Group Total
S-D	Spoke-and-Dot	3	12	
K-D	Catercorner-and-Dot	3	12	
V-D	Vertical-and-Dot	3	12	
C-D	Corner-and-Dot	4	12	
A-D	Angle-and-Dot	4	12	
E-D	Edge-and-Dot	5	8	
S-K	Spoke-and-Catercorner	4	12	
S-V	Spoke-and-Vertical	4	12	
S-C	Spoke-and-Corner	5	12	
S-A	Spoke-and-Angle	5	12	
S-E	Spoke-and-Edge	6	8	
K-V	Catercorner-and-Vertical	4	12	
K-C	Catercorner-and-Corner	5	12	
K-A	Catercorner-and-Angle	5	12	
K-E	Catercorner-and-Edge	6	8	
E-C	Edge-and-Corner	7	8	
E-A	Edge-and-Angle	7	8	184

TABLE XXI

PROPOSED HAIBRL X2 MOD 1 CODING PATTERNS

COMBINATIONS INCLUDING DOT PAIRS

Identifier	Description	No. of Cell Positions in Patterns	No. of Orientations Possible	Group Total
D-D-S	Dot Pair-and-Spoke	4	12	
D-D-K	Dot Pair-and-Catercorner	4	12	
D-D-V	Dot Pair-and-Vertical	4	12	
D-D-C	Dot Pair-and-Corner	5	12	
D-D-A	Dot Pair-and-Angle	5	12	
D-D-E	Dot Pair-and-Edge	6	4	64

Language Assignments to HAIBRL - Alternative Approaches

C/R/I is investigating assignment of meanings to HAIBRL patterns. To date, six alternative approaches to the assignment of meanings have been formulated for consideration. These briefly are:

1. A partially phonetic alphabet with less than or equal development to the ITA.* The narrower outlook would be to modify only consonant irregularities, since English vowel spelling involves interlocking and complex relationships within words. The broader scheme would entail vowel modification except for common words.

2. A self-contained phonetic alphabet consisting of separate coding areas (HAIBRL A and B) for English and International phonemes. This system would spell ITA's common words phonetically, and would allot one character per phoneme without regard to syllable frequency.

3. A coding strictly by syllable, more extensive than one by word, which would achieve (although failing to account for <u>all</u> syllables) a tremendous increase in speed.

4. A code utilizing phonetic spelling of word roots and characters for bound morphemes (prefixes and suffixes). Such a code may enable symbolization and quick identification of syntactic relators in sentences, and may tend to reinforce the memory structure during reading and perhaps improve comprehension.

5. Coding by the most frequent syllables (learnable and memorable by virtue of their frequency), with the remainder of syllables spelled in phonetics.

6. A mixture of the most frequent syllables as well as bound morpheme symbolization with the remainder of English text spelled phonetically. This may achieve an increase in speed and memory reinforcement over present orthography or strictly phonetic representation.

There is a further abbreviation mechanism which may be considered for use with any of these models, i.e., attribution of word values to phonetic characters in isolation. If syllables and morphemes are included in a code, the words represented should be chosen after these encodings so as to achieve a wider degree of abbreviation in words of lower frequencies while maintaining the words symbolized by phonetic characters within a relatively small frequency range.

A number of analyses of English words and reading texts are being reviewed for applicability to the selection among alternatives, and for ranking of importance for language elements for coding into HAIBRL. In addition to previously published analyses, C/R/I analysts are participating in the development of a computer program that will, within constraints, convert normal spelling into phonetic representation of words with manual transformation of the portion of the words not converted by the computer program. The program, when completed, should provide determinations, separately and together, of the frequencies of English phonemes, syllables and morphemes, and determine the percents of each item individually and by type, and also list the percents

*Pitman (Downing, 1964)

of two-phoneme patterns in the event that consonantal clusters should be preferred or incorporated to syllable and/or morphemic symbolization.

In addition, a limited code, based upon the second alternative approach cited previously, has been formulated. This code is capable of being used in further experimentation on the combined discrimination/reading characteristics of HAIBRL.

Conclusions

Extensive studies and experimentation are needed in development of usable HAIBRL patterns, linguistic analyses, and matching of HAIBRL patterns and meanings. The following appears to be an appropriate course for future experimentation in pattern recognition:

A. The concepts underlying the HAIBRL cell presented here must be subjected to experimental verification. Preliminary tests should be concerned with individual basic elements which have been proposed. Subsequently, efforts will be directed toward discovering whether they are easily perceived and correctly locatable with regard to referent and quadrant. The earliest tests should be dedicated to basic elements taken one at a time. Sighted and visually handicapped subjects will first be exposed and trained in practice sessions to the individual elements (starting with the corner "Dot") in the four corners of the HAIBRL cell. After practicing with individual "Dots" and "Dot" pairs(and, perhaps, triplet and quadruplet "Dots"), the subjects may be tested with regard to their ability to discriminate quadrants of the HAIBRL cell. Other elements, after they have been introduced singly, and in sequence, may then be tested with regard to quadrant localization, and tested in pairs and other combinations which seem most suitable (depending on earlier test results).

B. After an initial set of trials involving basic elements, a test should be conducted of mixtures of elements. Once again, simple "mixtures" should be introduced. (Here the term "mixture" is used in the sense of alternating patterns as presented to the subject, rather than mixed symbols within a single HAIBRL cell.) As the program proceeds, more and more elements may be introduced into the "mixtures" to determine discriminability as random patterns are presented. Subsequently, like pairs, then unlike pairs, then more "complicated" combinations should be introduced and tested. However, it may be unreasonable to expect subjects to discriminate complex configurations until they have had appropriate training, practice and understanding of the key to the codes with regard to the basic nature of patterns which are being offered.

C. Ultimately, tests should be conducted to determine which of the various combinations are most easily discriminated one from another, as well as relative recognizability of the collection of patterns employed. The results of such testing of recognizability and discriminability will permit an ordering of configurations for subsequent translation into (English) language, including letters, numerals, phonemes, syllables, words, etc. At this stage, it may be desirable to eliminate those particular configurations which may offer difficulties in production (i.e., the number of cell positions used) or which may present other difficulties with regard to use in reading.

Subsequently, tests may be conducted to determine how easily subjects can be instructed in a HAIBRL coding scheme to the point where they can use it in both writing and reading with facility and without substantial error.

D. Simultaneously with the above research on patterns, linguistic research directed towards the goal of providing greater assurance of effectiveness in assignment of meanings to patterns at latter stages of the experimentation described above should be pursued.

TABLE XXII
PROPOSED HAIBRL X2 MOD 1 CODING PATTERNS
DOTS WITH PAIRS

Identifier	Description	No. of Cell Positions in Pattern	No. of Orientations Possible	Group Total
S-S-D	Spoke Pair-and-Dot	5	12	
U-U-D	Overcorner Pair-and-Dot	5	12	
V-V-D	Vertical Pair-and-Dot	5	12	
C-C-D	Corner Pair-and-Dot	7	12	
A-A-D	Angle Pair-and-Dot	7	12	
E-E-D	Adjacent Edge	8	4	64

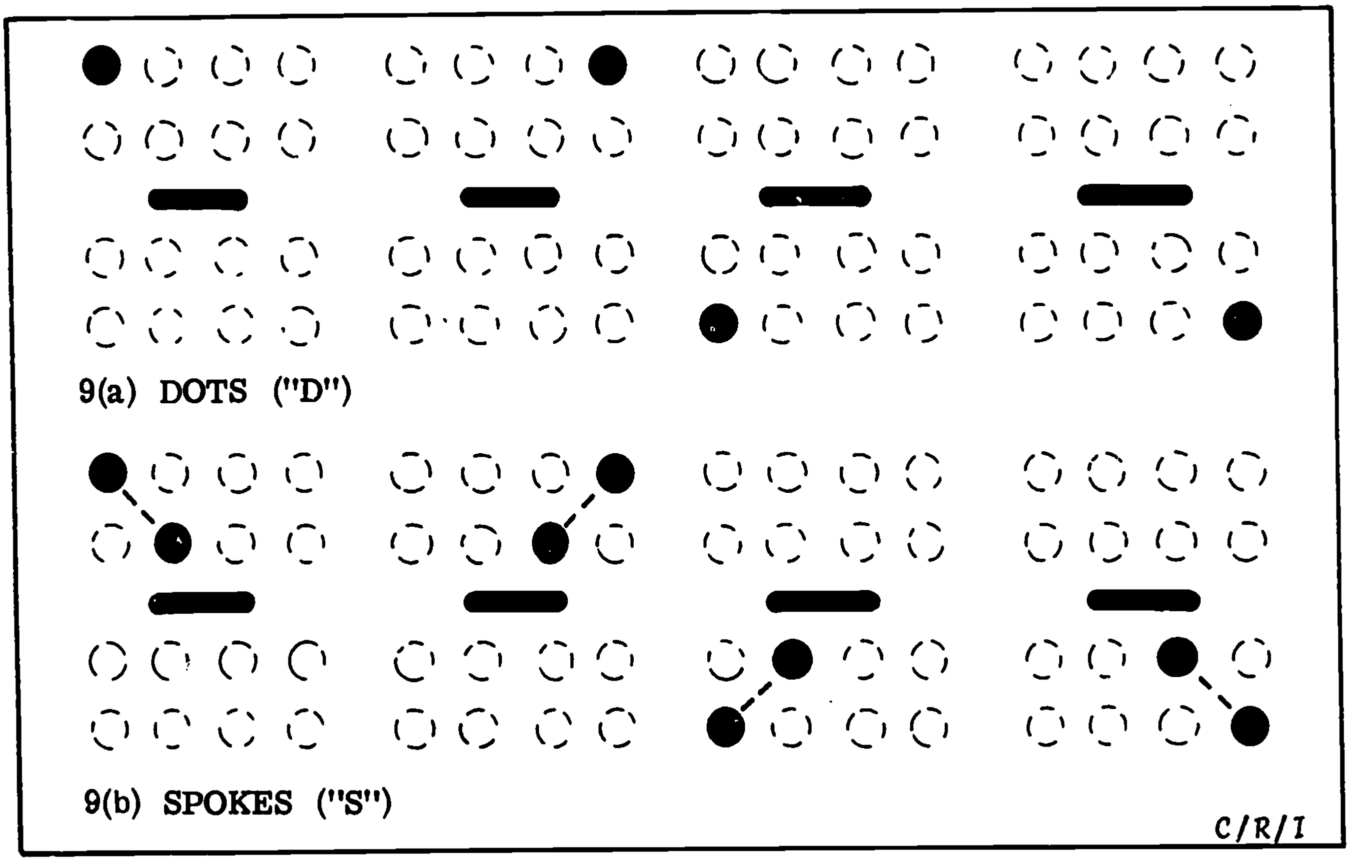
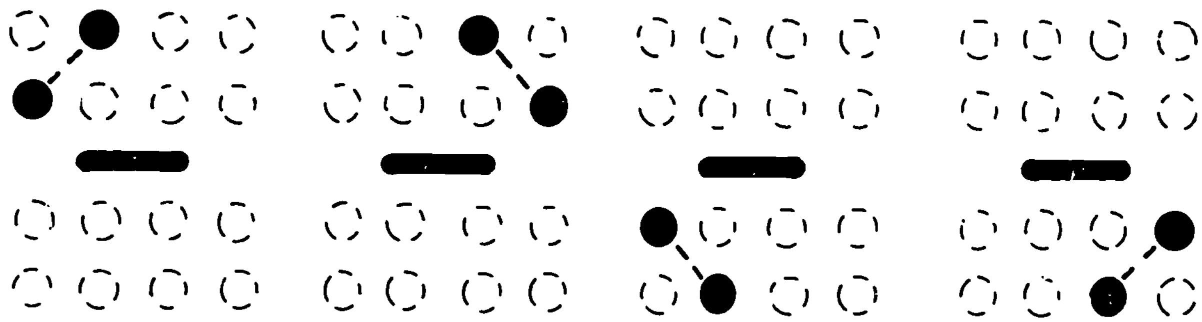
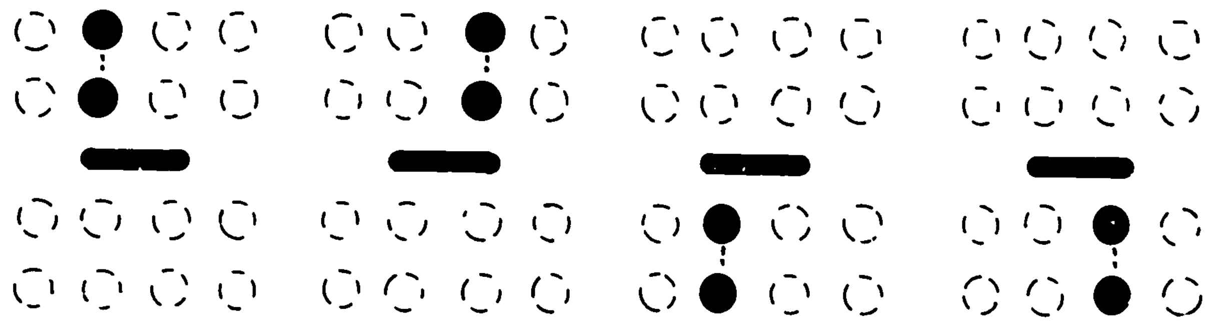


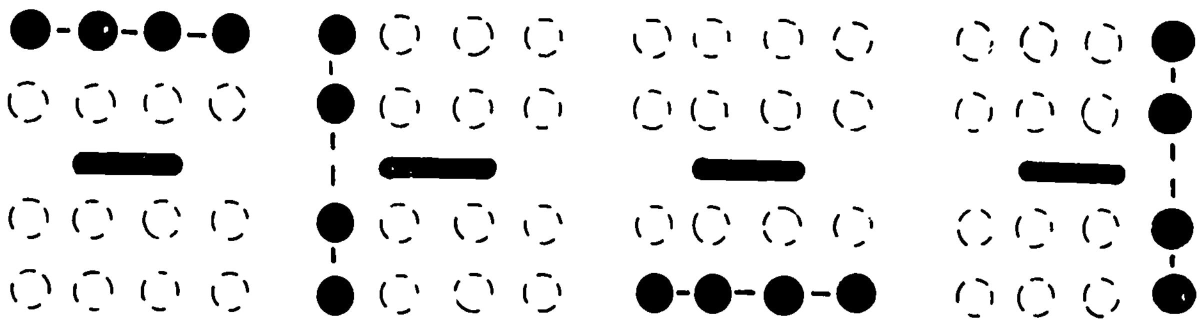
FIGURE 9
BASIC ELEMENTS FOR HAIBRL X2 MOD 1.



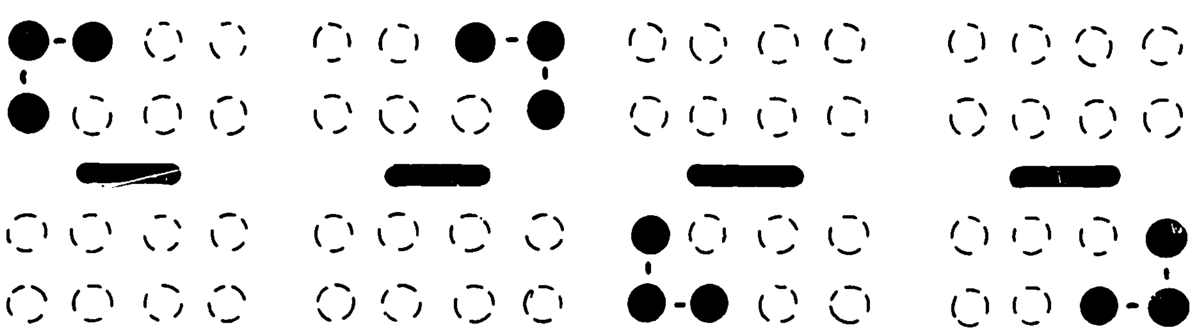
9(c) CATER CORNERS ("K")



9(d) VERTICALS ("V")



9(e) EDGES ("E")



9(f) CORNERS ("C")

C/R/I

FIGURE 9 (Continued)

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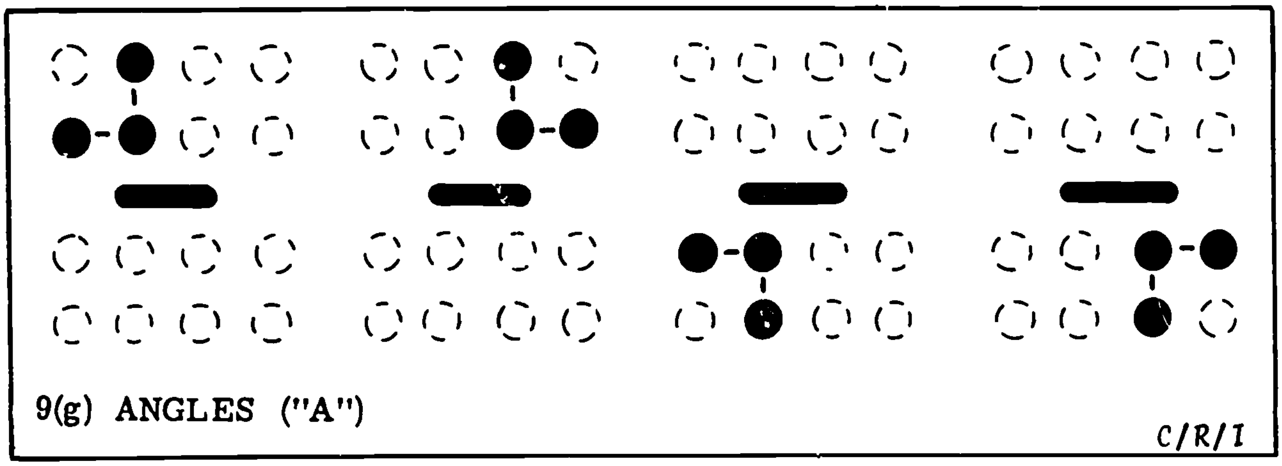

FIGURE 9 (Continued)

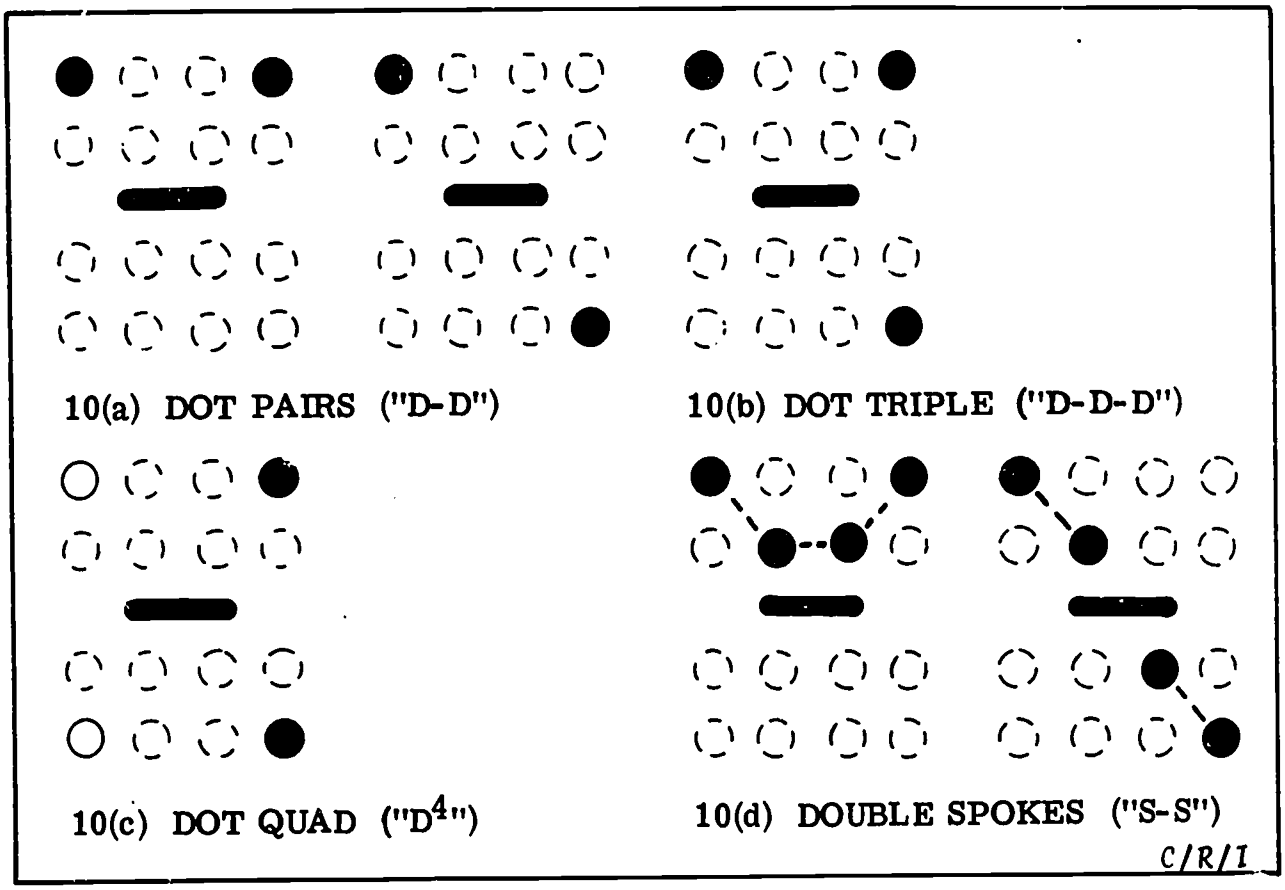

FIGURE 10

SAMPLE COMBINATIONS OF LIKE ELEMENTS

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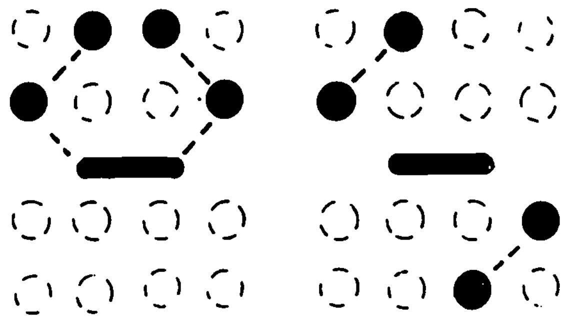
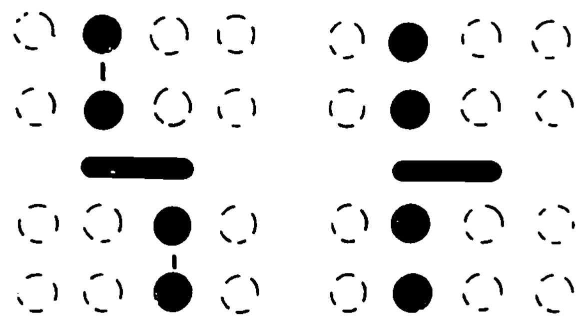
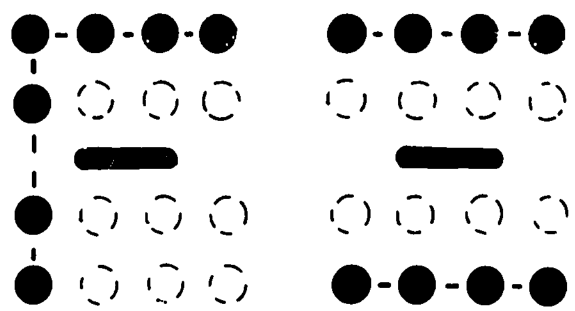


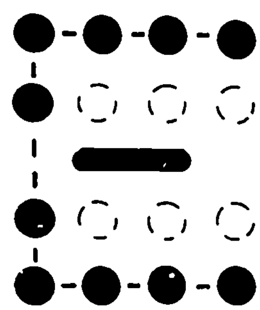
10(e) DOUBLE CATER CORNERS ("K-K")



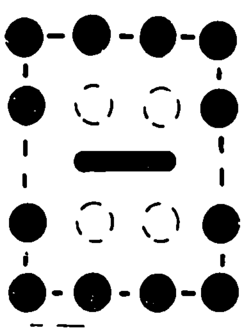
10(f) DOUBLE VERTICAL ("V-V")



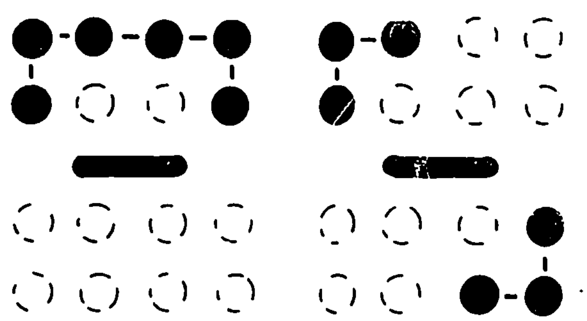
10(g) DOUBLE EDGES ("E-E")



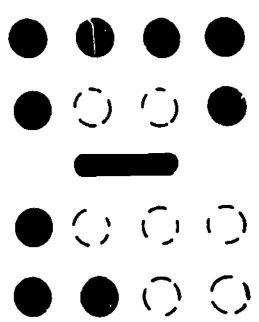
10(h) EDGE TRIPLE ("E-E-E")



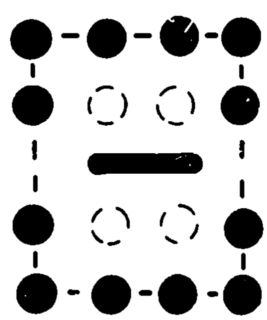
10(i) EDGE QUAD (E^4)



10(j) DOUBLE CORNERS ("C-C")



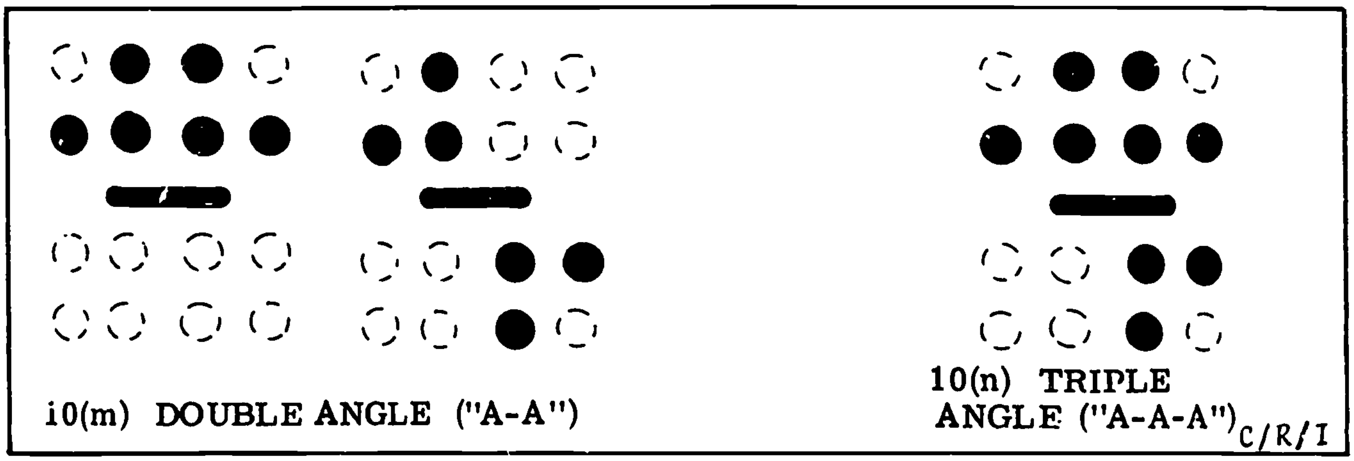
10(k) TRIPLE CORNER ("C-C-C")



10(l) CORNER QUAD ("C4-E4") (SAME AS EDGE QUAD)

C/R/I

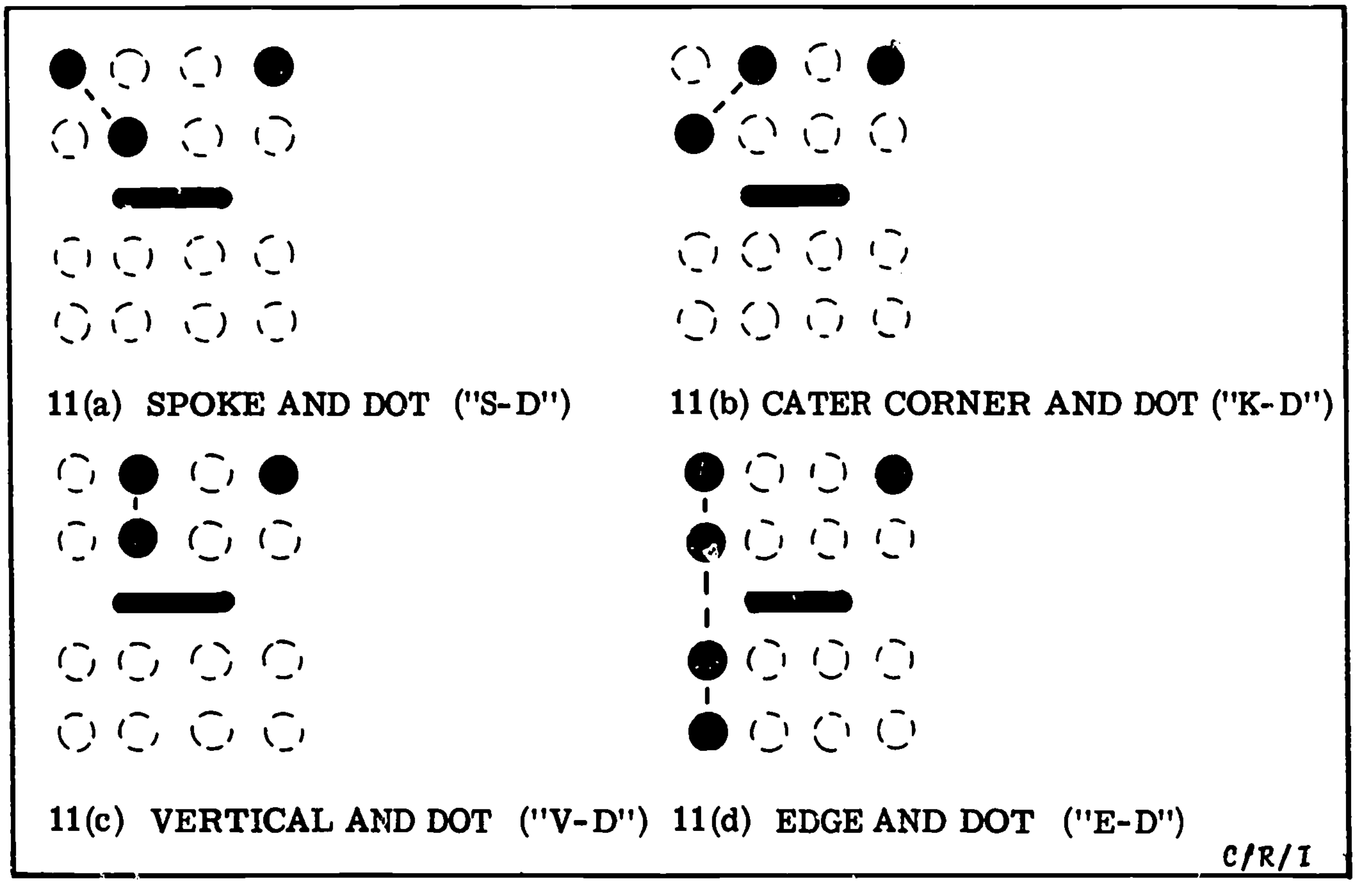
FIGURE 10 (Continued)



10(m) DOUBLE ANGLE ("A-A")

10(n) TRIPLE ANGLE ("A-A-A")

FIGURE 10 (Continued)



11(a) SPOKE AND DOT ("S-D")

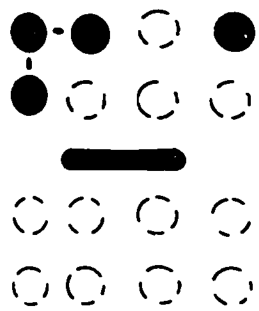
11(b) CATER CORNER AND DOT ("K-D")

11(c) VERTICAL AND DOT ("V-D")

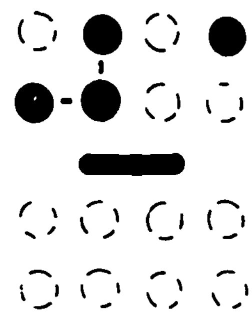
11(d) EDGE AND DOT ("E-D")

FIGURE 11

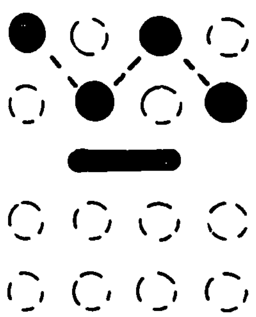
SAMPLE COMBINATIONS OF UNLIKE ELEMENTS



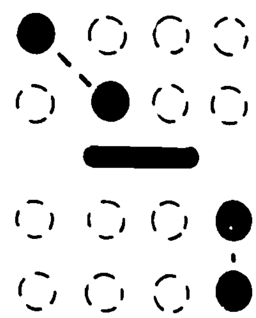
11(e) CORNER AND DOT ("C-D")



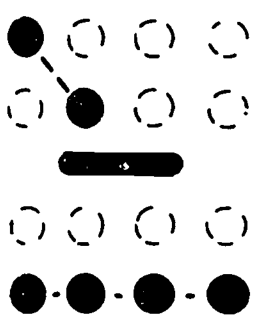
11(f) ANGLE AND DOT ("A-D")



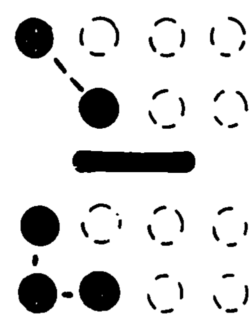
11(g) SPOKE AND CATER CORNER ("S-K")



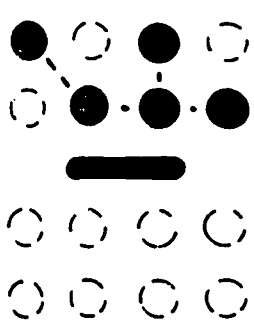
11(h) SPOKE AND VERTICAL ("S-V")



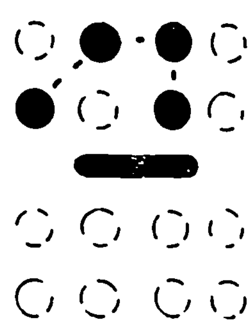
11(i) SPOKE AND EDGE ("S-E")



11(j) SPOKE AND CORNER ("S-C")



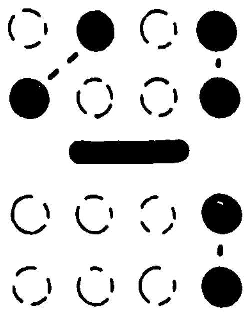
11(k) SPOKE AND ANGLE ("S-A")



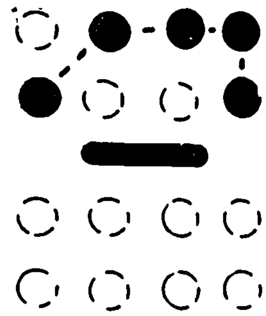
11(l) CATER CORNER AND VERTICAL ("K-V")

C/R/I

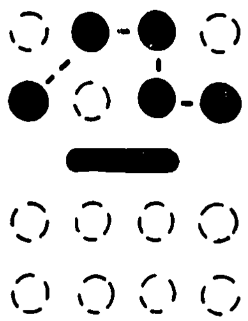
FIGURE 11 (Continued)



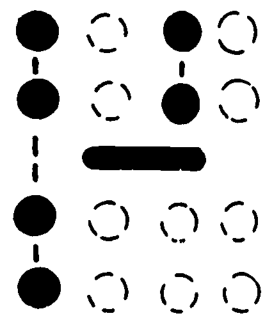
11(m) CATER CORNER AND EDGE ("K-E")



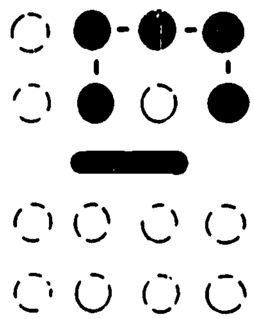
11(n) CATER CORNER AND CORNER ("K-C")



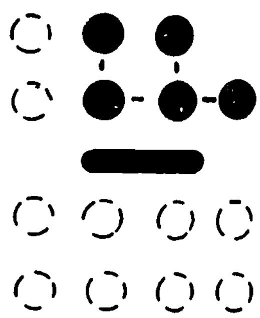
11(o) CATER CORNER AND ANGLE ("K-A")



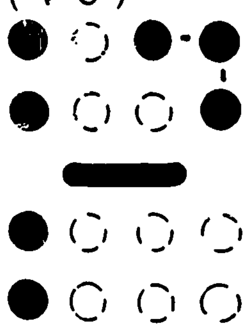
11(p) VERTICAL AND EDGE ("V-E")



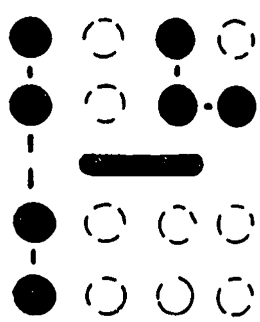
11(q) VERTICAL AND CORNER ("V-C")



11(r) VERTICAL AND ANGLE ("V-A")



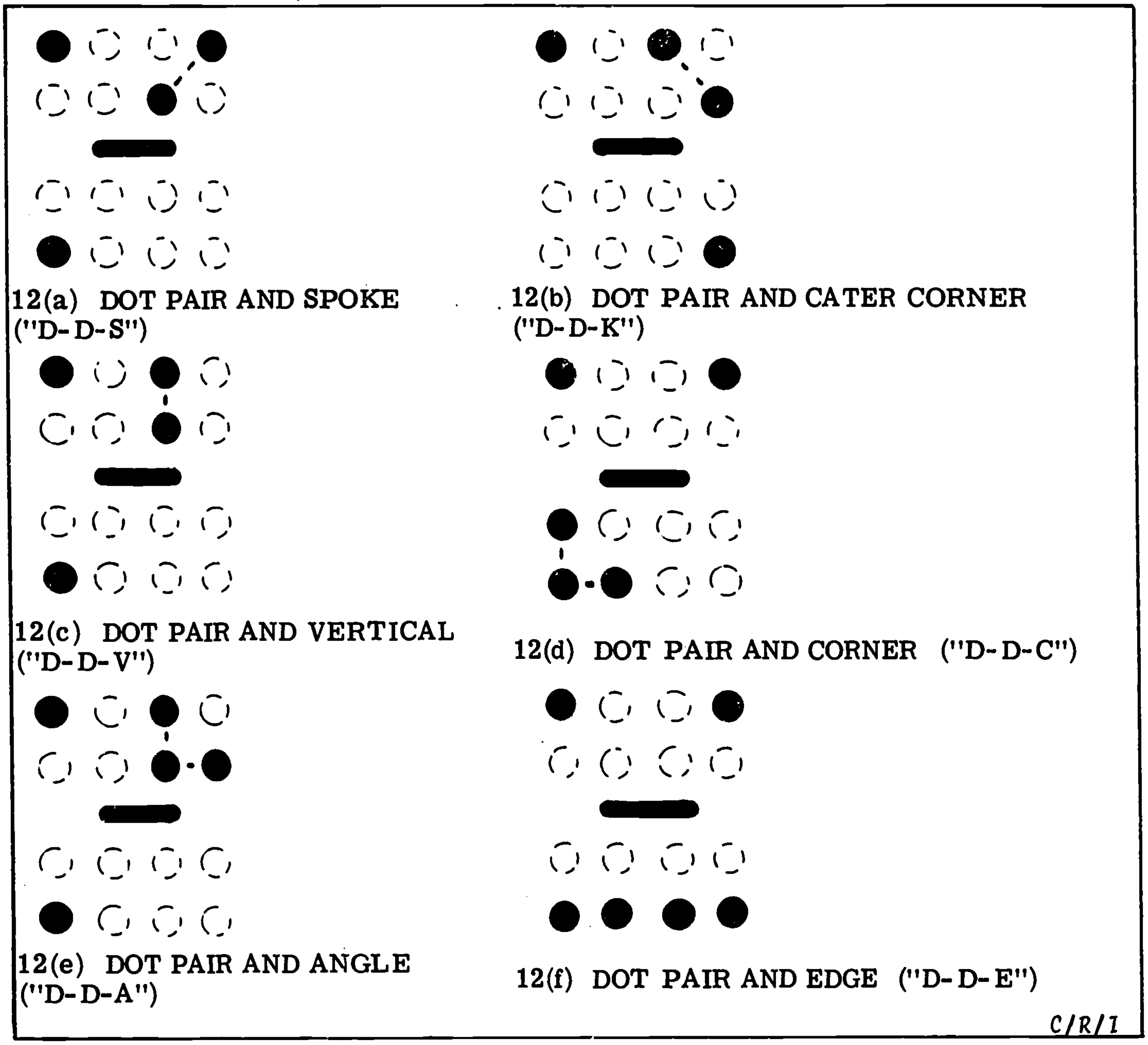
11(s) EDGE AND CORNER ("E-C")



11(t) EDGE AND ANGLE ("E-A")

C/R/I

FIGURE 11 (Continued)



12(a) DOT PAIR AND SPOKE ("D-D-S")

12(b) DOT PAIR AND CATER CORNER ("D-D-K")

12(c) DOT PAIR AND VERTICAL ("D-D-V")

12(d) DOT PAIR AND CORNER ("D-D-C")

12(e) DOT PAIR AND ANGLE ("D-D-A")

12(f) DOT PAIR AND EDGE ("D-D-E")

FIGURE 12

SAMPLES OF "THREE QUADRANT" COMBINATIONS WITH A DOT PAIR

> "The ambiguity in braille patterns, of which there are 31 out of 63 patterns, combined with the high multiplicity of dots per character, causes confusion to beginners, and requires highly concentrated reading for many users. The braille reader who lacks tactile discrimination, or the beginner, errs frequently because of the complexity of the configurations presented. Since whole-word recognition is an important element in successful reading, and since multiplicity of dots in a whole word impedes easy recognition, standard 6-dot braille has serious shortcomings."

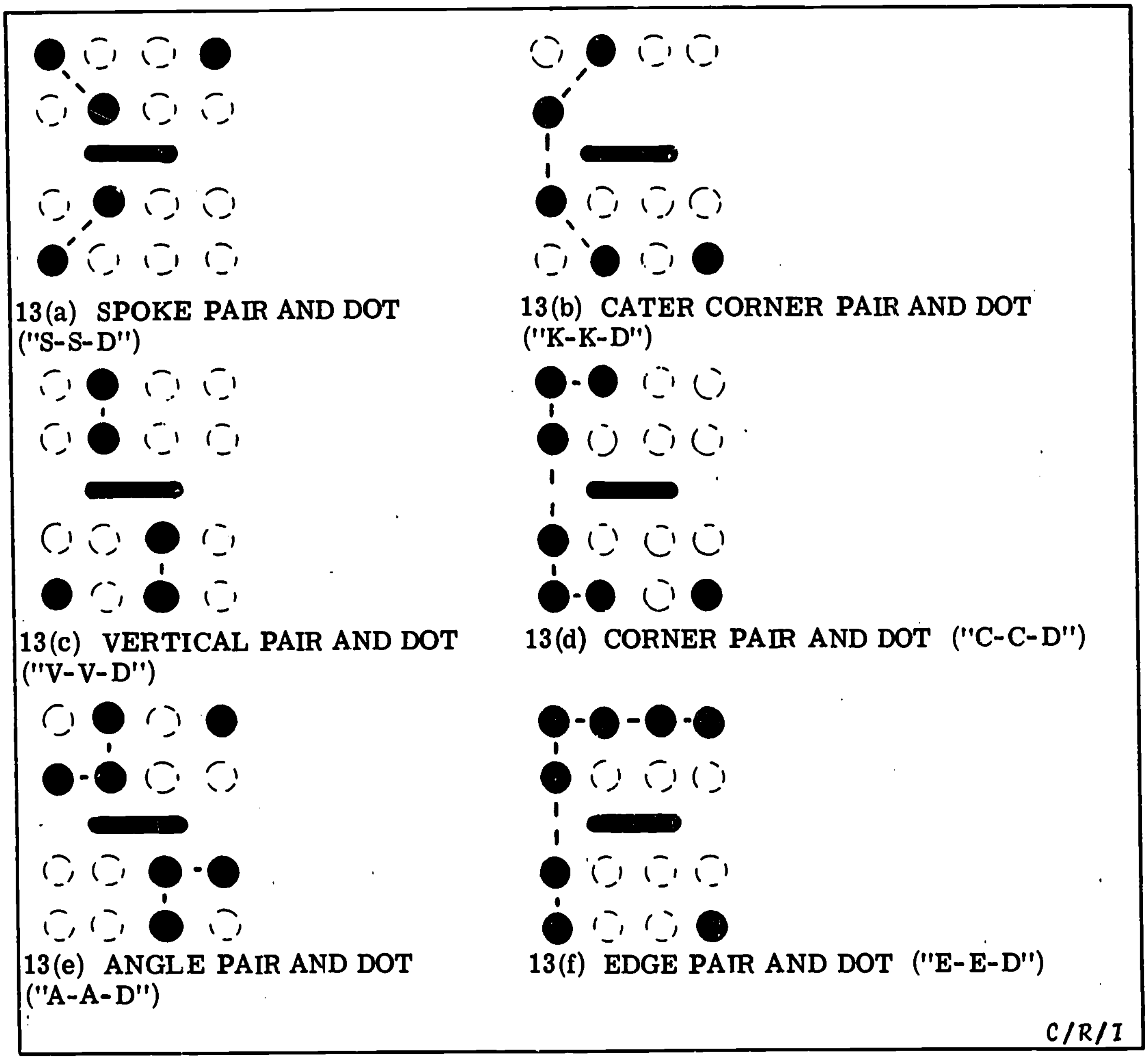


FIGURE 13

SAMPLES OF "THREE QUADRANT" COMBINATIONS WITH ONE DOT PLUS A PAIR

> "HAIBRL with its built-in feedback features, on the other hand, offers an opportunity to overcome the deficiencies of the braille method. Firstly, along with its reference bar or referent which provides a tactile feedback signal, it could use only 1 or 2 dots for "normal" language, reserving 3 or more dots for special applications. Secondly, its patterns are all unequivocal. Finally, the number of available patterns far exceeds present demands on a puntiform language system. Thus, this system's constraints might be only the memory capability of the user."

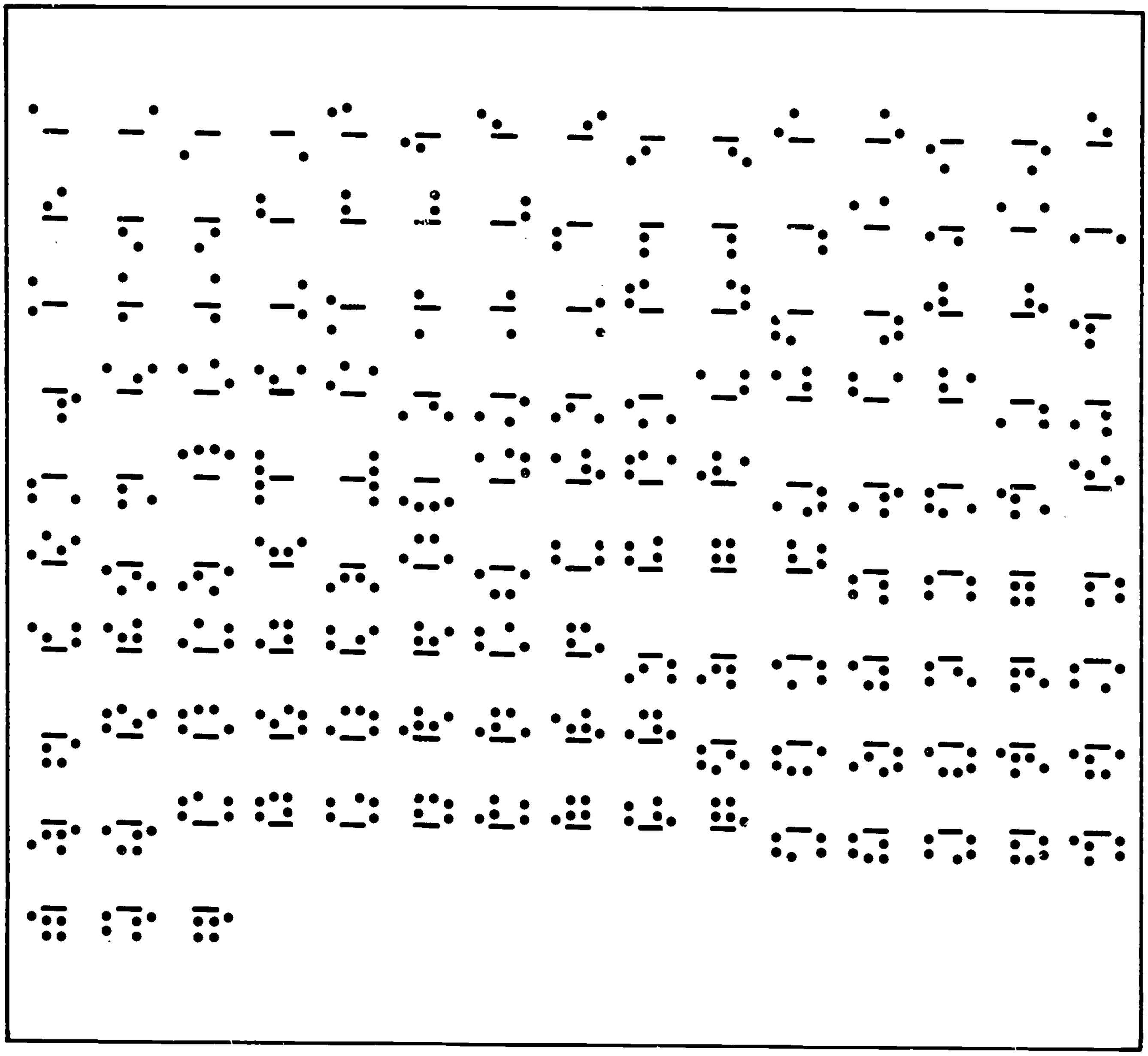
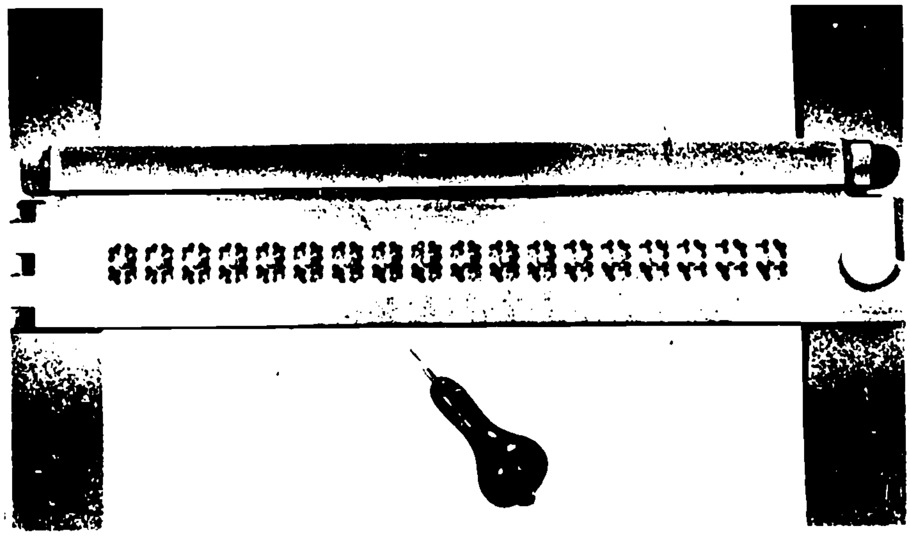
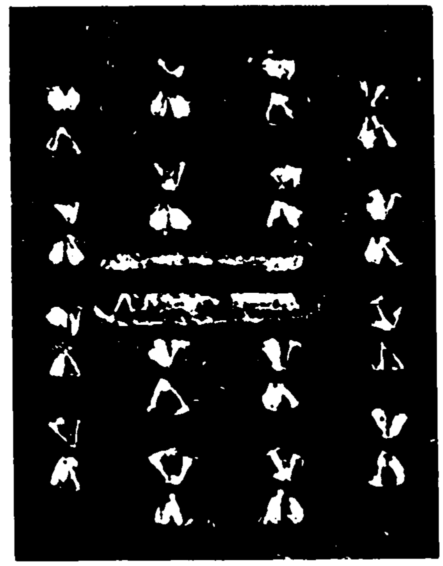


FIGURE 14

EXAMPLE OF HAIBRL X-1 CODING. FROM SINGLE-DOT TO FIVE-DOT PATTERNS WITH NO AMBIGUITIES.

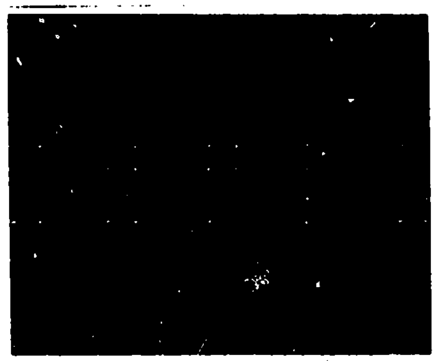


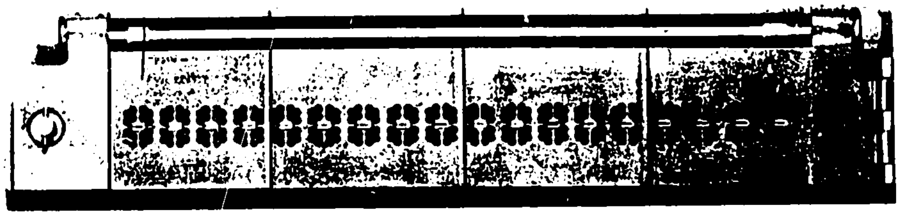
HAIBRL Slate, Upward Writing, and Stylus



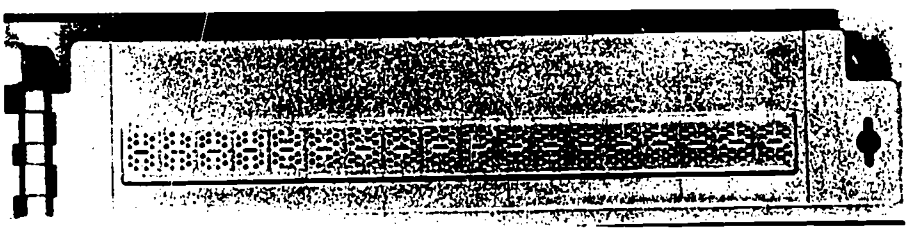
Scale 7:1

Scale 3.5:1





Cover Plate, Inside View



HAIBRL Slate and Stylus

Plate 41

Various Views of the HAIBRL Slate

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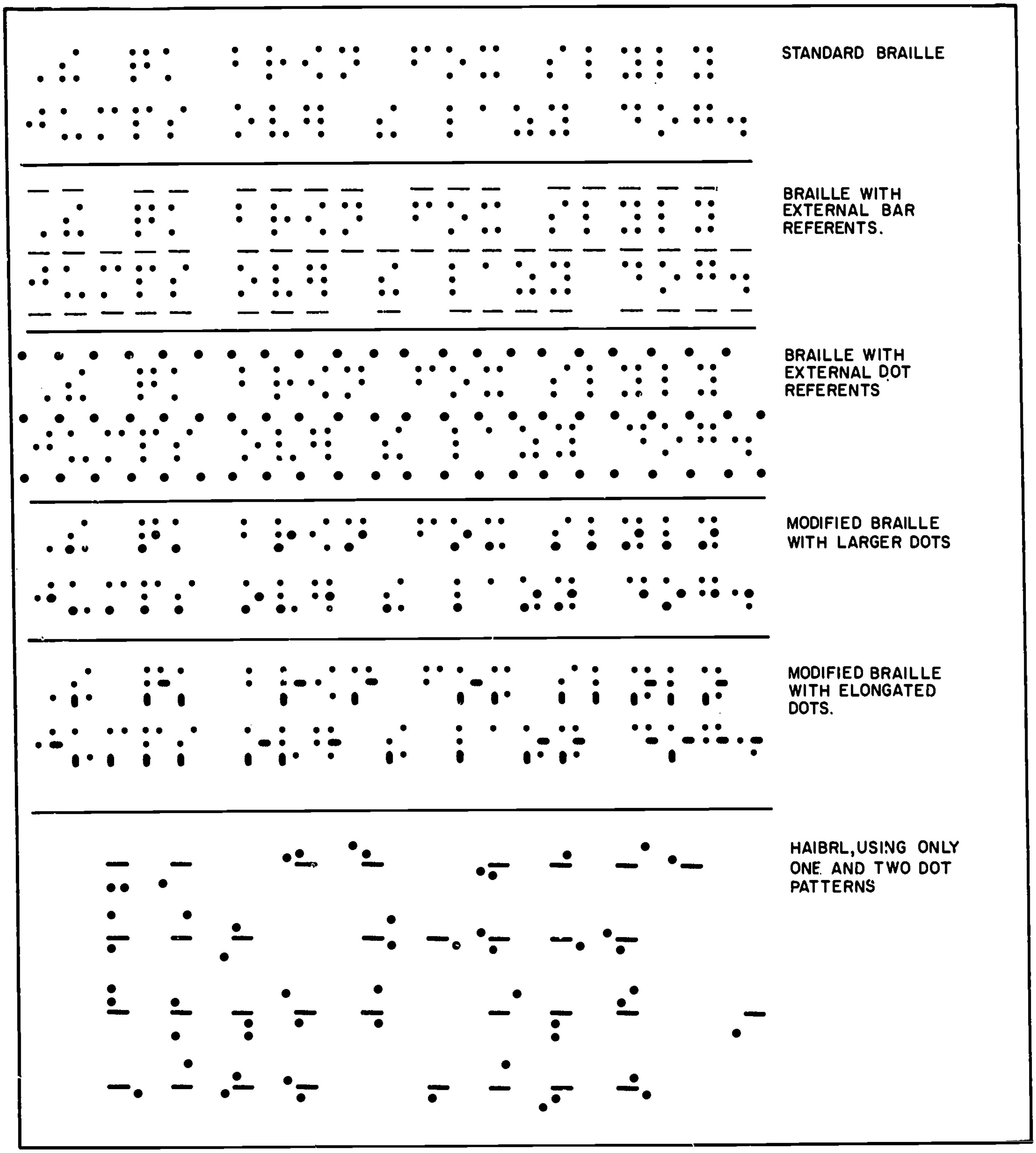

FIGURE 15

EXAMPLE OF PUNCTOGRAPH TEXT; BRAILLE WITH VARIANTS, AND HAIBRL

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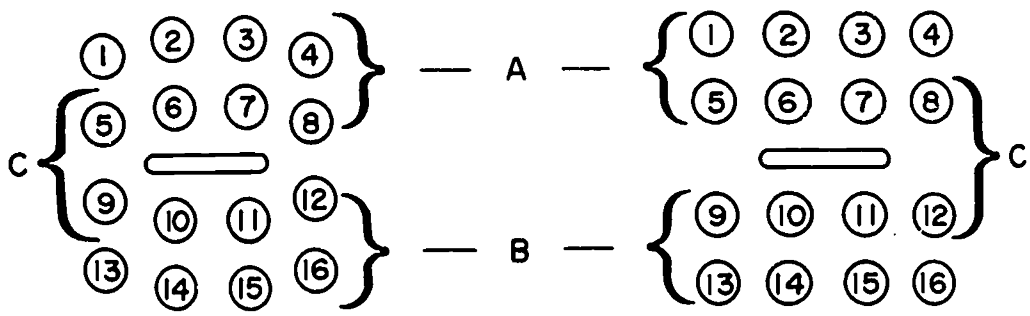

Experimental Cell X1 (Not to scale) Experimental Cell X2

[E: Extended (not shown), with less than or equal to three dots but more than the three-dot height of a standard braille cell.]

Class		"No-Dot"	1-Dot	2-Dot	Sub-total	3-Dot	Total
Less than 3-Dot Height	A	–	8	28	36	56	92
	B	–	8	28	36	56	92
	*C	1	–	16	17	48	65
3-Dot Height	D	–	–	8†	8	24‡	32
Sub-total		1	16	80	97	184	281
More than 3-Dot Height	E	–	–	40	40	376	416
Total		1	16	120	137	560	697

*Number in class C do not include configurations already counted in A and B.
†1-9, 1-12, 4-9, 4-12, 5-13, 5-16, 8-13, 8-16
‡1-5-9, 1-5-12, 1-8-12, 1-8-9, etc. . . .
Data are for style X1. For X2 combine figures in line D with line E.
Combination 1-5-10, and some others in class E are .030" higher than 3 Dots.

FIGURE 16

SUMMARY OF HAIBRL CELL COMBINATIONS

Part Eight | CYBERCOM LIFE-SUPPORT SYSTEMS

MAN-MACHINE SYSTEMS FOR THE HANDICAPPED.

Introduction

The disabled person's need for man-machine communication and life-support systems is recognized by not only the disabled and their families, but also by many state superintendents, local school boards, teachers' organizations, rehabilitation and vocational counsellors. This portion of the study deals specifically with the demonstration of two innovative life-support systems for the handicapped; other related systems are discussed with reference to future utilization.

Automated Bidet-Commode

One basic life-support system which is critically needed by a large segment of the disabled population, and one which may be used both in schools and in homes, is the automated bidet-commode (see Plate 42). In an experiment directed to meet this need, body cleansing is performed automatically without aid of attendents. Essentially, the process involves three stages: cleansing, drying, and flushing. In cleansing, a jet of clean, preheated water is directed from a nozzle toward the body for 30 seconds; this is followed by drying, which is accomplished by a stream of heated air from a blower-fan for 60 seconds. Flushing occurs automatically as the last phase of a 2-minute cycle. The pilot tests indicate that the systems tested are reliable and beneficial; the disabled person is maintained, and those persons formerly assigned to these essential hygienic duties are relieved of this responsibility. The success of the pilot tests for this life-support system strongly suggests that, in addition to use in schools, automated bidet-commode systems may be adapted and made portable for wheelchairs, chairs, and beds, and may be installed in public and private transport systems.

Cyber-Lift™*

Another significant and basic life-support system considered in this study relates to the question of how a disabled person may be moved in a classroom without a wheelchair or cart, whether for a few inches or feet, and without great physical effort by the attendant, teacher, or person being moved. In attempting to answer this question, an experiment was conducted with the "Cyber-Lift," an air-bearing platform (see Plate 42). The model used measures 27" x 29" x 1"; it has one connection for the blower hose attachment of a small home vacuum cleaner. Lift is maintained through the employment of the air-bearing characteristic of the platform, which acts as a friction-free cushion. Movement of the disabled person with only slight physical effort is accomplished because of the minimum low-friction characteristics of the system.

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*Trademark, Cyber Corp., Washington, D. C.

The constraint which limits its utility over large distances is the necessity for a long air hose; however, for restricted areas it appears that the "Cyber-Lift" system may be of value.

In the case where movement for short distances without the aid of hoists or wheelchairs is desirable, i.e., turning the person around or moving him toward or away from a wall, entrance, screen, or another person, and where the use of other mechanical means are prohibited or are not feasible, the merits of self-propelled air-platforms for use in confined areas should be investigated. On counts of maneuverability and low cost, air-bearing platforms which serve as supports and lifts deserve further consideration and study.

Future Life-Support Systems

In another area related to life-support systems for the handicapped, attention was directed to the need for "custom-built" chairs, seats, and beds, which could be matched to fit the contour of the person's body. Today's plastic molding techniques suggest solutions which would permit personnel at schools and institutions to fabricate these forms conveniently and efficiently. It is clear that this is an area that warrants support and development.

The use of automated, environmentally and cybernetically designed classrooms is another area which offers solutions to the problems of properly educating handicapped children. These classrooms would be of value especially to those students with "specific learning disabilities" and to individuals who have perceptual and/or neurological dysfunctions.

The study supports the possibility of using portable man-machine telecommunication systems in classrooms, workshops, and in the home. For example, the potential utility of a telecommunication information access and delivery system for use by the deaf and speech-impaired, as experimentally demonstrated in this study by the portable "Cyberphone," is indicative of the extension of educational systems to a rehabilitative and/or vocational atmosphere. Software factories which handle data processing and other information, can be located in the homes or institutions of the severely disabled. Moreover, educational man-machine communications systems for the disabled may also be applied to enhance the well-being of non-handicapped persons. As one example, the storage of information concerning a healthy individual can be made readily available with recommended strategy and action to be taken in case of a heart attack or other emergency. Based on detailed medical records derived from the individual's educational data bank, which contains information going back to pre-school periods, an individual who has maintained and supplemented his educational data bank with up-to-date health information can be assured that the physician will retrieve viable data. Hence, the educational man-machine communication and life-support systems offer many valuable spin-offs.

Another instance in which man-machine systems may be used to enhance living is in the modification of present usage of press, radio, telephone, and television media.

These media exemplify, at times, how ephemeral and polluted information can drain one of our valuable resources. Resource planners should be prepared to utilize and reserve the precious radio frequency spectrum for essential life-support systems. Information, disseminated via satellite, TV, radio, the press, video and audio tape, film and other means can be selected for distribution to local receiving networks in zones of reception equipped with direct-wire redistribution, as well as to schools, homes, and workshops; all this may occur without the use of another precious resource, paper, the future availability of which demands efforts at conservation. Through the use of the man-machine systems employed in this study, deaf and deaf/blind persons gain the benefits of TV, audio and video programs; the spoken portion of the programs is converted into, and communicated by, visual and tactile modes. The non-handicapped population may find other applications of these aids in commerce.

More importantly, the distribution of economical man-machine educational telecommunications systems to developing nations not yet equipped with adequate educational know-how or the facilities to enhance the quality of learning will help solve the growing problem of mass education for all citizens whether they are or are not disabled.

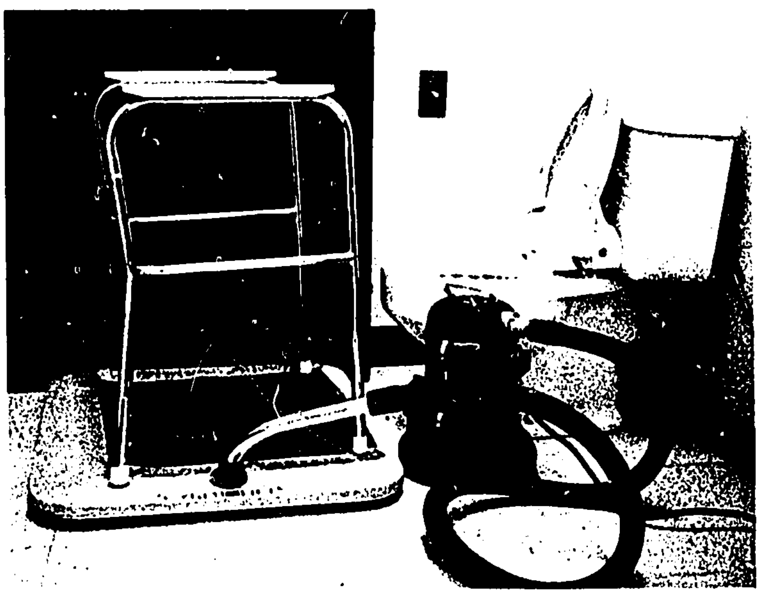

Plate 42
Automated Bidet-Commode and "Cyber-Lift"
Shown on the right is the bidet-commode, a hygienic life-support system. The "Cyber-Lift" platform, shown on the floor to the left, is utilized for moving an individual in a confined area.

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Part Nine PHONEME STUDY FOR PUNCTOGRAPHIC CODES

It has been estimated that there are about 3,000 languages spoken on our planet, many of which do not have a writing system; therefore, communication through numerous languages in a written form is not possible.* However, for those languages which do have established writing systems, sets of signs or symbols known as "graphemes" are employed and have assigned usages. These graphemes represent either a morphemic or phonemic reference. For example, the English word "tax" represents a set of three Latin graphemes of various subtypes of phonemic reference, all within the English written system. The phonemic reference of "t" is /t/ and may have slight variations, but these are essentially of no consequence. However, the reference of "a" in this instance is /æ/; it is really misrepresented by the grapheme "a". Similarly, the reference of "x" is /ks/, in reality a sequence of two phonemes. This and similar examples demonstrate intricacies which prevail between English writing systems and English phonology.

The English symbol "&" (ampersand), on the other hand, represents a reference to the morpheme "and", or when translated into the phonemic reference, /ænd/. Note that the symbol "&" does not graphically represent a sequence of phonemes, since only one graphic symbol is discerned. If the symbology did represent the three phonemes /æ/,/n/, and /d/, then spellings such as "h&" for "hand", "s&" for "sand", "&rew" for "Andrew" might be appropriate. Hence, this particular grapheme clearly has only a morphemic reference.

Graphemes with morphemic reference which represent an idea are called ideograms. There are writing systems which use ideograms, one of which is Chinese, where most of the graphemes have morphemic references. However, in most of the normal writing systems, graphemes have references within the phonologic system of the given spoken language.

Individual phonemes have individual graphemes, or individual graphemes may represent a sequence of phonemes. The first system is referred to as "alphabetic writing" such as in English, and the latter as "syllabic writing," of which Japanese is a good example.

English has a phonemic system in which subsystems are distinguished. The phonological analysis of the vowels presents difficulties in English. Most Americans and Britishers have the very same total of vowel phonemes in their phonology, although their description varies from dialect to dialect.

In studying the characteristics of any spoken language, linguists initially determine its phonemes. To do this, they compare and examine samples of the spoken language in question to ascertain words which are distinct in expression and in content without reference to context. Two minimally different samples which denote differences of content and expression are commonly called a minimal pair. By establishing the differences of minimal pairs, it is determined whether given phonemes in the given pair contrast in meaning and expression, e.g., bill – pill; chill – jill; till – dill; pet – bet; wet – yet; met – net.

In English, there are 9 simple vowels and the following 24 consonant phonemes.†

/b/ as in bill	/t/ as in till
/d/ as in dill	/v/ as in ville
/f/ as in fill	/w/ as in will
/g/ as in gill	/y/ as in yet
/h/ as in hill	/z/ as in zeal
/k/ as in kill	/θ/ as in thigh
/l/ as in lill	/ð/ as in thy
/m/ as in mill	/š/ as in shall
/n/ as in nil	/ž/ as in rouge
/p/ as in pill	/č/ as in chill
/r/ as in rill	/ǰ/ as in jill
/s/ as in sill	/ŋ/ as in sing

In order to demonstrate the distinction between each of the aforementioned phonemes, numerous minimal pairs are available with the exception of a few consonant phonemes, such as

*Joshua Whatmough, Language: A Modern Synthesis, (New York, Mentor Books, 1960).

†George L. Trager and Henry Lee Smith, Jr., An Outline of English Structures, 3d Printing – American Council of Learned Societies, Washington, D.C., 1957.

/θ/ and /ð/, or /š/ and /ž/. In the case of /θ/ and /ð/, only five minimal pairs are commonly known: thigh – thy: ether – either; mouth (noun) – mouth (verb); wreath – wreathe; thistle - this'll. The phoneme /ž/ in English occurs rarely e.g., dilution – delusion; glacier – glazier. Similar difficulties arise in the study of other languages. Hence, it is sometimes necessary to use other methods than simply the finding of minimal pairs.

One of these methods is articulatory phonetics. It is based on the assumption that characteristics of speech sounds are the result of the manner by which the very speech sounds themselves are formed. These characteristics are commonly described and classified in accordance with the position and action of human speech organs. In acoustic phonetics, investigators analyze speech sound through the study of linguistically significant features of speech from an acoustic viewpoint. Thus, the consonants may be grouped as follows:

Resonants:
- nasal - /m, n, ŋ/,
- lateral - /l/, and
- median* - /r, y, w/,

Fricatives:
- voiceless - f, θ, s, š/,
- voiced - /v, ð, z, ž/.

Stops:
- voiceless - /p, t, k/,
- voiced - /b, d, g/.

Affricates:
- voiceless - /č/ and
- voiced - /ǰ/.

*All English vowels are median resonants.

TABLE XXIII
LANGUAGES EXAMINED AND APPROXIMATE NUMBER OF USERS

A.	Indo-European		
	1.	Germanic	
		(a) English	400,000,000
		(b) Dutch	15,000,000
		(c) German	90,000,000
		(d) Danish	5,000,000
		(e) Norwegian	3,500,000
		(f) Swedish	7,500,000
		(g) Yiddish	5,000,000
	1.1	Greek	11,000,000
	2.	Romance	
		(a) Classical Latin	---
		(b) Italian	55,000,000
		(c) Spanish	120,000,000
		(d) Portugese (incl. Brazil)	80,000,000
		(e) Rumanian	20,000,000
		(f) French	60,000,000
	3.	Slavonic	
		(a) Serbo-Croatian	20,000,000
		(b) Polish	35,000,000
		(c) Russian	200,000,000
		(d) Other	10,000,000
	4.	Indo-Iranian (Persian, Pachtu Afghan)	45,000,000
	5.	Armenian	5,000,000
B.	Finno-Ugrian		
	1.	Hungarian	10,000,000
	2.	Finnish	4,500,000
C.	Turkic		
	1.	Osmanli	30,000,000
	2.	Azeri	5,500,000
D.	Semitic		
	1.	Egyptian/Arabic	30,000,000
	2.	Amharic	20,000,000
	3.	Hebrew	3,000,000
E.	Sino-Tibetan		
	1.	Mandarin (Chinese)	500,000,000
	2.	Japanese	100,000,000
F.	Indonesian		90,000,000
G.	Swahili		10,000,000
		TOTAL	1,990,000,000

TABLE XXIV

CHART OF AGGREGATED CONSONANT PHONEMES

POINT OF ARTICULATION	MANNER OF ARTICULATION									
	STOPS		AFFRICATES		FRICATIVES (SPIRANTS)		TRILLS	LATERALS	NASALS	SEMI-VOWELS
	VL	VD	VL	VD	VL	VD				
BI-LABIAL	p p'	b b'			ɸ	ʋ			m	w
LABIO-DENTAL					f	v				
INTER-DENTAL					θ	ð				
DENTAL	t t'	d d'								
PRE-ALVEOLAR			c ȼ'	ʒ			r̃	l	n	
ALVEOLAR					s	z	r			ɹ
POST ALVEOLAR (PRE-PALATAL)			č' č	ǯ	š	ž		ʎ	ñ	y
PALATAL	k^y	g^y								
VELAR	k k'	g g'			x	ɣ		ɫ	ŋ	
UVULAR	Q					ʁ				
PHARYNGEAL						ʕ				
LARYNGEAL	ʔ				h	ɦ				

VL = VOICELESS
VD = VOICED

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All the consonants are characterized by closure or narrowing at some point in the mouth and are classified by this point of articulation. In each case there are two parts which are called articulators, and they are brought together when we speak or utter words.

In the English language, stress and intonation are phonemic. However, a detailed discussion of their value is inappropriate here since that would be beyond the scope of this phase of the study or its application to the communication problems for the handicapped to which this part of the study is directed. In ascertaining the phonemic content most suitable for a simplified punctiform system for the blind, stress and intonation should not be considered at this time.

Using the same methods, in addition to English, the investigators have examined 30 other languages spoken by approximately two billion people (see Table XXIII).

TABLE XXV

CHART OF AGGREGATED VOWEL PHONEMES

	POINT OF ARTICULATION			
	FRONT		CENTRAL	BACK
	UR	R	UR	R
HIGH	i	ü	ɨ	u
MID-CLOSED	e	ö	ə	o
MID-OPEN	ɛ	ɔ̈		ɔ
LOW	æ		ɑ	a

R = ROUNDED
UR = UNROUNDED

MODIFIERS
: = LENGTHENED
•• = LABIALIZED
~ = NASALIZED

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TABLE XXVI

EPSILONTAU - LETTERS PRESENTED IN APPROXIMATE ORDER OF USAGE

ARABIC	ا ل ى ن ت د ه ب ر م و ح ف س ق ك ص ع ض ط ج ز ث خ ذ ش ظ غ
ARMENIAN	Ա Ն Ո Ր Ե Ի Մ Ի Ս Կ Յ Դ Տ Հ Ց Թ Վ Ը Լ Գ Ծ Պ Ք Բ Ղ Զ Է Խ Շ Ու Փ Ջ Ժ Ձ Ջ Օ Ճ Ֆ
ENGLISH	E T A O N I R S H D C L M U F P Y B G W V J K Q Z X
FRENCH	E A S I N T R U L O D C M P V Q G F B H J Y Z K W
GERMAN	E N I T S R A D H U G M L C B O F K W V Z P J Q Y X
HEBREW	י ה ו ר א מ ל ת ש ע ב ם* ד ח כ נ ק ן* פ ס צ ז ט ך* ג ץ* ף* *terminal
ITALIAN	E A I O N L R T S C D P U M V G H F B Q Z J K W X Y
PORTUGUESE	A E O R S I N D M T U L C P V Q F G H B J Z X K W Y
RUSSIAN	О Т И А Е С Ь Д Н В Л Р М К Г Ы Ч П Б З Я У Ж Ш Х Ц Ю Щ Э
SPANISH	E A O S R N I D L C T U M B P G V Y Q H F Z J X K W

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TABLE XXVII
ARMENIAN AND ENGLISH PHONEMES

ARMENIAN PHONEMES IN ORDER OF DECREASING FREQUENCY		ENGLISH PHONEMES IN ORDER OF DECREASING FREQUENCY	
ա	լ	ə	ɔ
ն	գ	n	b
ր	ծ	t	f
է	պ	r	k
ը	ք	I	ai
մ	բ	æ	a
ի	ղ	ɚ	e
ու	չ	d	p
ս	խ	i	θ
օ	շ	s	y
կ	ռ	ɛ	ao
վ	փ	w	U
թ	զ	v	g
տ	իւ	z	ŋ
հ	ժ	l	č
ց	ձ	m	š
դ	ջ	u	ǰ
ե	ճ	h	ɔi
յ	ֆ	o	ž

TABLE XXVIII

ARMENIAN PHONOLOGY *

UPPER	LOWER	WESTERN PHONOLOGY		EASTERN PHONOLOGY	
Ա	ա	a	arm	a	arm
Բ	բ	p	pill	b	bill
Գ	գ	k	kill	g	gill
Դ	դ	t	till	d	dill
Ե	ե	ye	yet	ye	yet
Զ	զ	z	zeal	z	zeal
Է	է	e	bed	e	bed
Ը	ը	ə	earn	ə	earn
Թ	թ	t	till	t	till
Ժ	ժ	zh	measure	zh	measure
Ի	ի	ee	meet	ee	meet
Լ	լ	l	life	l	life
Խ	խ	kh	(1)	kh	(1)
Ծ	ծ	dz	bids	ts	(2)
Կ	կ	g	gill	k	skate
Հ	հ	h	hill	h	hill
Ձ	ձ	tz	hats	dz	aids
Ղ	ղ	gh	(3)	gh	(3)
Ճ	ճ	j	Jill	j̇	(4)

UPPER	LOWER	WESTERN PHONOLOGY		EASTERN PHONOLOGY	
Մ	մ	m	mill	m	mill
Յ	յ	h, y	hill, yet (5)	h, y	hill, yet (5)
Ն	ն	n	nil	n	nil
Շ	շ	sh	shoe	sh	shoe
Ո	ո	vo, o	votes, oboe	vo, o	votes, oboe
Չ	չ	ch	chill	ch	chill
Պ	պ	b	bill	p	spill
Ջ	ջ	ch	chill	j	Jill
Ռ	ռ	rr	(6)	rr	(6)
Ս	ս	s	sill	s	sill
Վ	վ	v	villa	v	villa
Տ	տ	d	dill	t	steel
Ր	ր	r	rill	r	rill
Ց	ց	tz	bits	tz	bits
Ւ	ւ	v	villa	v	villa
Փ	փ	p	pill	p	pill
Ք	ք	k	kill	k	kill
Օ	օ	o	oboe	o	oboe
Ֆ	ֆ	f	fill	f	fill

*By courtesy of G. H. Assaturian

No English Equivalents:

(1) As in German Bach
(2) As in Italian zinco
(3) As in French Paris
(4) As in Italian ligio
(5) Depending on whether it occurs initially, medially, or finally.
(6) As in Scotch r

Those concerned for the handicapped have for decades recognized the deficiencies of braille. But braille is, in fact, the single successful punctographic system in common usage today, and is only used by about 33,000 persons, who have the cognitive ability to learn it. A tactile means of communication for the remainder of this population does not exist. In the past few years researchers have sought more easily learned punctographic media, not for the purpose of replacing braille, but to fulfill critical needs of those who cannot learn the ambiguous braille code. Since most blind persons cannot use braille or any other form of tactile writing (i.e., at least 95% of the one million persons in the U.S. cannot read newsprint with or without glasses) new tactile schemata must be researched.

Because of the fewer perceptual parameters in any punctographic system, and because learning and speed facility may be increased by practices other than those employed by the print community, consideration need be given firstly, to pattern legibility, secondly, to coding based on phonemes, and thirdly, to coding of syllables. These considerations can be met by systems, not meant to replace braille, which are unambiguous, yet rich in pattern structure. Such a proposed system is HAIBRL, which contains a referent in each cell to eliminate tactual ambiguity, and pattern variety to negate contextual confusion. Thus, now that a schema is available, it is possible to consider a phoneme methodology for all languages (see tables in this section).

Some educators have successfully demonstrated utility of phonemes through use of ITA (Initial Teaching Alphabet) to enable sighted children to acquire reading skills more rapidly. However, this approach has been limited to printed English and does not account for language diversity; neither is it applicable in teaching braille. But once HAIBRL has been developed, a universal phoneme coding will be applicable, especially where many language notations are involved. Hence, use of phonemic coding would extend the phoneme concept of communication, as employed in many languages, to tactile systems where common codes would facilitate processes of language learning. Moreover, development of natural language phonemic coding would yield a rich punctographic system, valuable even to users of braille.

An example of such a practical, universal phonetic alphabet or "uniphonabet" is the Armenian language; its phonemes encompass most Indo-European, many Afro-Asiatic, and other major language phoneme distributions, e.g. Japanese, and with expansions, Chinese. Armenian, because of its varied phonology, has a long history of successful usage by linguists who, since its development and introduction by Mesrop Mashtotz (circa 403 A.D.), have recorded in Armenian many vocal linguistic sounds occurring in the world's approximately 3,000 spoken languages. With a uniphonabet, syllable codings could then be determined by frequency in each language, whether used in print for the sighted or in punctographic notation for the blind or visually impaired.. Thus, the Armenian alphabet has been proposed for use in HAIBRL.

Through categorization of linguistic data into unique hierarchies, an unequivocal referent tactile communication system is enhanced by utilizing a language's indigenous letter or ideograph, phoneme, and syllable frequency.

Appendix A | FIELD CENTER DATA

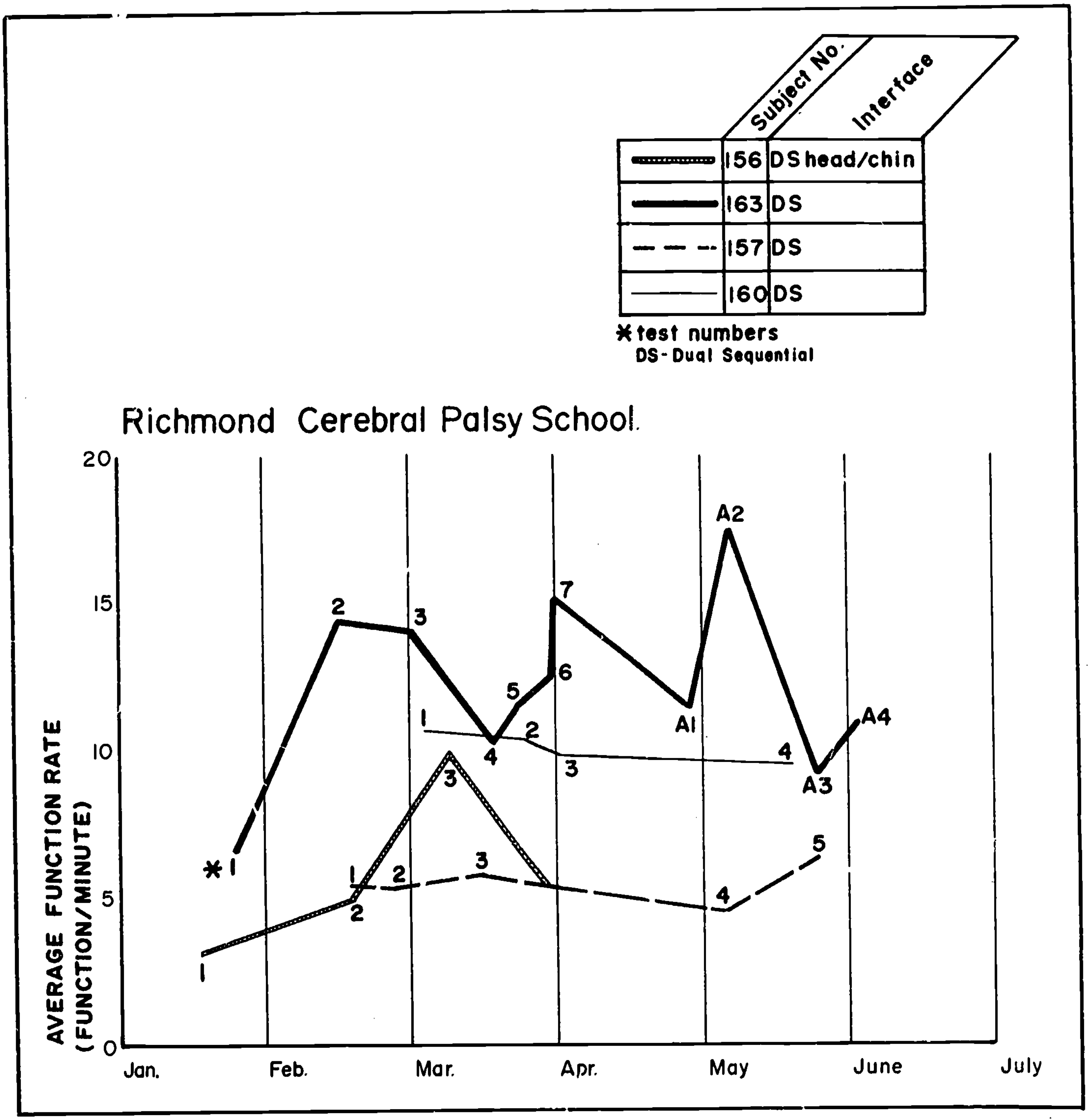

Figure 1

REPRESENTATIVE AVERAGE FUNCTION RATES OF STUDENTS ON SUCCESSIVE TESTS

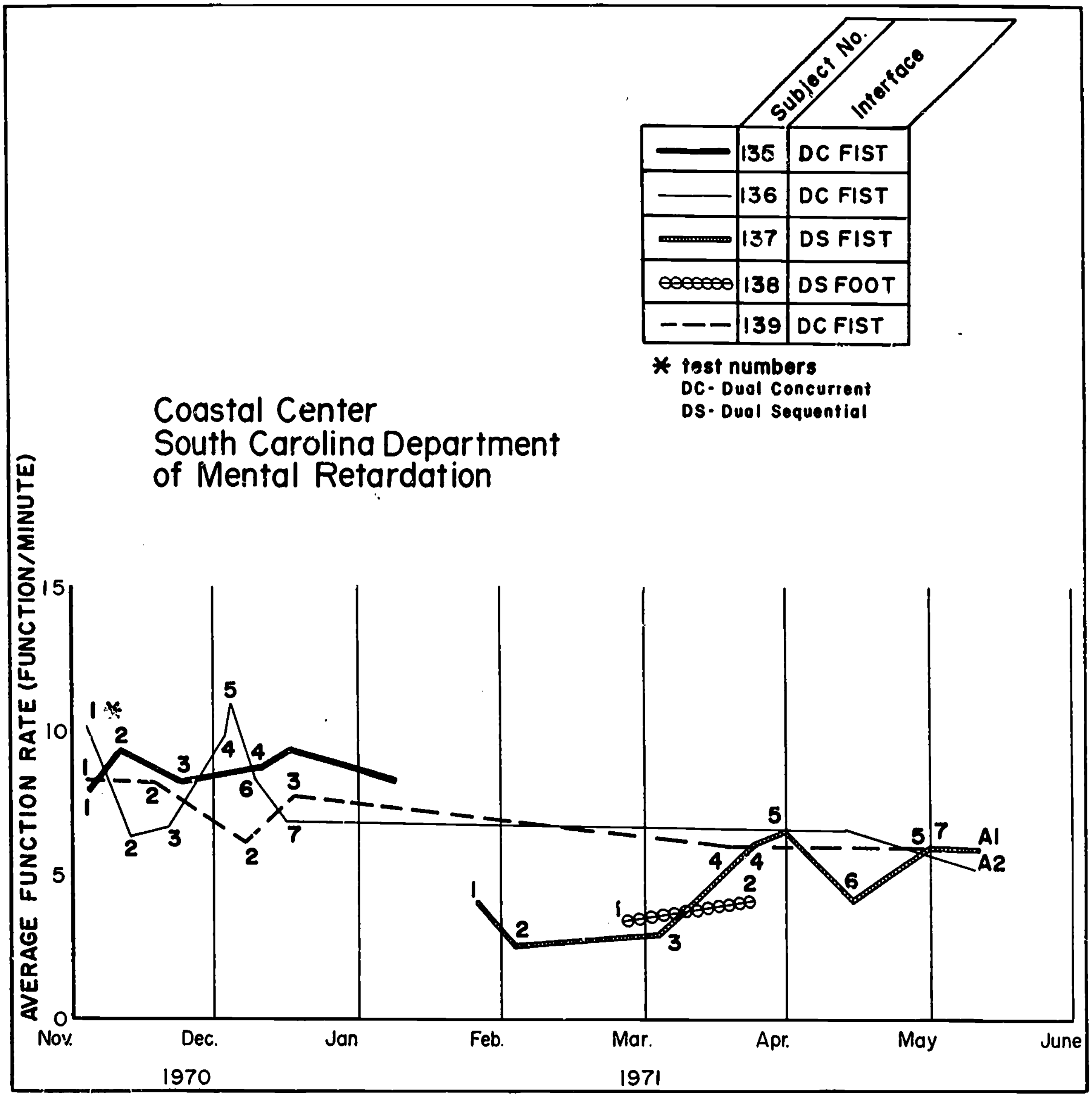

Figure 2

REPRESENTATIVE AVERAGE FUNCTION RATES OF STUDENTS ON SUCCESSIVE TESTS

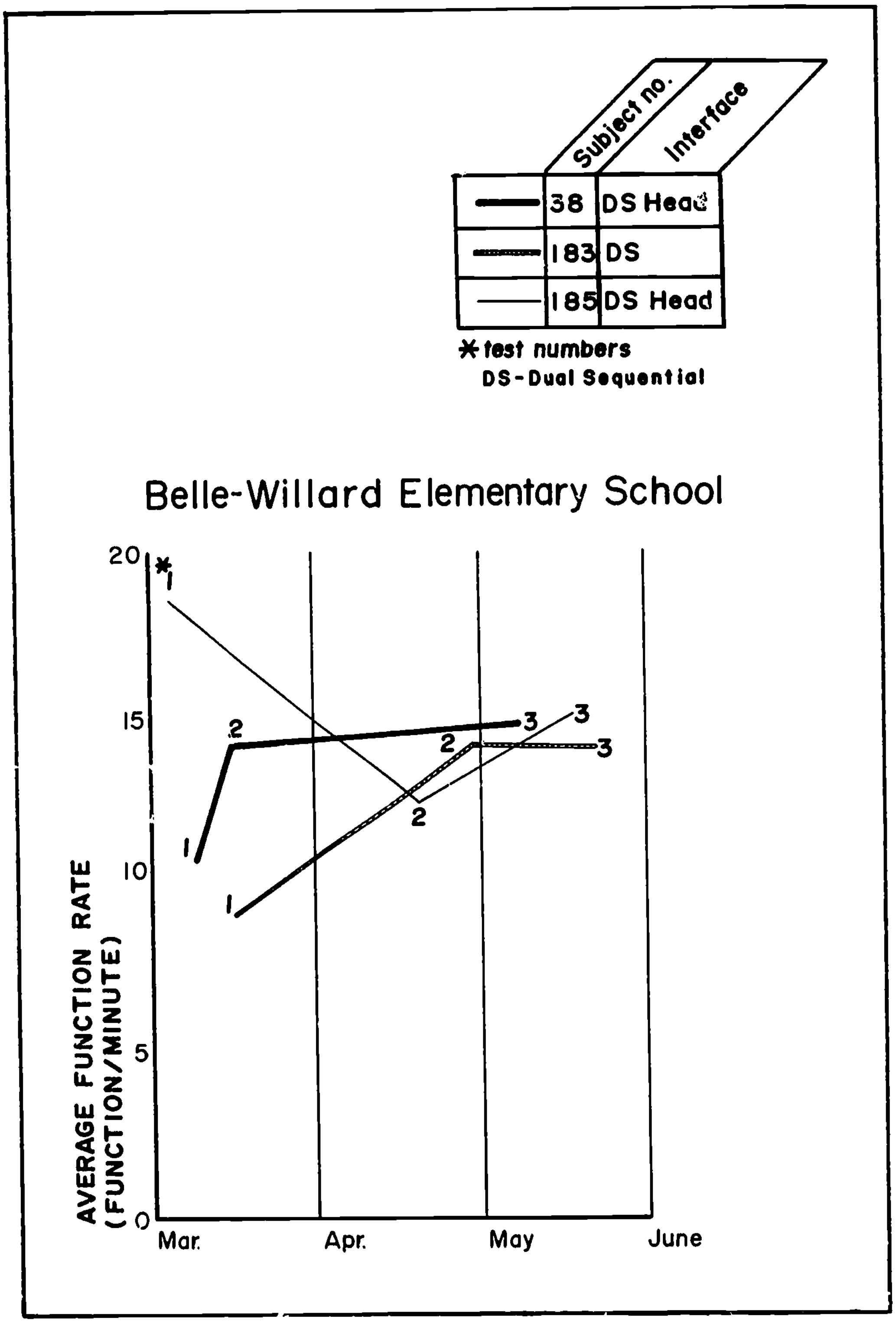

Figure 3

REPRESENTATIVE AVERAGE FUNCTION RATES OF STUDENTS ON SUCCESSIVE TESTS

TABLE I

RICHMOND CEREBRAL PALSY CENTER, RICHMOND, VIRGINIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Catagory
156	1	11-10-70	21	2	45	37	12:00	1	3.1	3.9				
	1	01-18-71	3	1	30	37	16:00	5	2.3	13.5	3.3	13.5	30	D
	2	02-19-71	31	7	155	43	8:34	0	5.0	0.0	3.3	6.2	79	P
	3	03-08-71	16	6	199	62	7:12	2	8.3	3.2	4.5	4.9	128	P
	4	03-31-71	22	6	132	76	14:17	1	5.3	1.4	4.7	4.5	129	P
161	1	02-15-71	35	8	103	42	4:00	6	10.5	14.3	10.5	14.3	103	P
158	1	11-12-70	20	2	23	38	2:00	1	19.0	3.6	19.0	2.6	23	H
	2	01-18-71	67	3	58	46	5:00	2	9.2	4.4	12.0	3.6	41	H
	3	02-15-71	26	5	121	60	11:00	5	5.4	8.3	8.0	5.5	67	P
165	1	02-18-71	35	7	192	56	5:30	17	10.1	39.7	10.1	30.3	192	P
	2	03-16-71	26	7	192	57	7:18	17	7.8	31.6	8.8	30.0	192	D
	3	05-18-71	62	9	147	72	10:50	21	8.6	39.1	7.8	29.7	177	D
157	1	11-13-70	20	1	20	48	4:00	10	12.0	20.8				
	1	02-19-71	37	2	43	36	6:30	1	5.5	2.77	5.5	2.8	43	P
	2	02-26-71	6	1	43	43	8:00	1	5.4	2.3	5.4	2.5	43	P
	3	03-17-71	18	4	105	59	10:00	1	5.9	1.7	5.6	2.1	63	P
	4	05-05-71	48	5	116	74	16:00	0	4.6	0.0				
	5	05-16-71	21	1	20	76	12:10	1	6.06	1.3	5.5	1.4	65	P
159	1	11-12-70	23	2	17	36	1:00	0	3.6	0.0	36.0	0.0	17	H

TABLE II

RICHMOND CEREBRAL PALSY CENTER, RICHMOND, VIRGINIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
159	2	02-22-71	71	4	55	51	4:00	8	12.8	15.6	17.4	9.1	36	H
	3	03-17-71	32	3	72	63	5:00	10	12.7	15.9	15.0	12.0	48	P
	4	04-09-71	51	7	111	79	6:00	8	13.2	10.1	14.3	11.3	63	P
166	1	02-18-71	36	7	164	45	8:50	13	6.6	28.8	5.1	28.9	164	D
	2	03-25-71	35	11	246	56	9:40	30	5.2	53.5	5.4	42.6	210	D
163	1	01-25-71	12	3	70	52	8:00	16	6.6	30.3	6.5	30.7	70	D
	2	02-15-71	20	5	116	45	3:10	13	14.4	28.8	8.7	29.8	93	D
	3	03-01-71	13	4	115	59	4:00	5	14.1	8.4	10.2	21.8	100	P
	4	03-17-71	16	3	85	75	7:30	9	10.4	12.0				
	5	03-22-71	6	3	60	80	7:00	6	11.3	7.6				
	6	03-27-71	7	3	65	64	5:00	7	12.8	10.9				
	7	03-31-71	3	2	25	36	2:40	4	15.0	11.0	11.0	14.5	76.6	P
	ATE no. 1	04-28-71	28	4	170	140	12:00	7	11.6	5.0				
	ATE no. 2	05-05-71	7	1	15	149	8:30	10	17.4	6.7				
	ATE no. 3	05-24-71	19	1	20	141	15:00	8	9.4	5.6				
	ATE no. 4	06-02-71	8	1	30	139	13:45	6	10.6	4.4	11.8	9.2	70	H

TABLE III

RICHMOND CEREBRAL PALSY CENTER, RICHMOND, VIRGINIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
162	1	03-22-71	30	6	133	36	7:25	0	4.9	0	4.9	0	133.0	
160	1	11-09-70	19	2	127	47	3:00	15	15.3	27.6				
	1	01-14-71	3	2	26	57	5:11	16	16.6	28.0	11.0	28.0	26.0	P
	2	02-09-71	25	4	101	56	3:39	15	16.0	3.9	13.0	27.4	64.0	P
	3	03-04-71	23	6	84	66	6:25	5	10.3	9.1	11.9	20.1	70.3	P
	4	03-23-71	19	4	135	78	7:30		10.4					
	5	04-01-71	9	3	82	81	8:01	7	9.9	7.4				
	6	no info.												
	7	05-20-71	50	2	73	27	2:40	2	9.7	22.2	10.9	17.2	72.0	P

TABLE IV

RICHMOND CEREBRAL PALSY CENTER, RICHMOND, VIRGINIA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
9	M	156	C. P. spast. quad.	D-C* fist	fist	primer	10-22-70
				D-S** in line	head chin		01-15-71
7	M	161	C. P. spast.	D-S in line	fist hand	1	01-11-71
14	M	158	C. P. athetoid	D-C foot	foot	2	10-22-70
10	M	165	C. P. mixed	D-S in line	fist	1	01-12-71
15	M	157	C. P. spast. quad.	D-C foot	foot	2	10-22-70
				D-S in line	fist		01-11-71
18	M	159	C. P. tension athetoid	D-C foot	foot	primer	10-22-70
10	F	166	C. P. spast. quad.	D-S in line	head chin nose	primer	01-12-71
13	F	163	C. P. athetoid quad.	D-C in line	hand fist	1	
16	M	167	C. P. athetoid tension	D-S in line	fore-head	primer	02-19-71
12	M	160	C. P. athetoid quad.	D-C fist	hand (fist)	2	10-22-70
				D-S in line			01-12-70

* D-C - Dual Concurrent

** D-S - Dual Sequential

TABLE V

COASTAL CENTER, SOUTH CAROLINA DEPARTMENT OF MENTAL RETARDATION, LADSON, S. CAROLINA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
135	ATE no. 1	03-16-71	61	26	620	138	10:41	12	12.9	9.4				
	ATE no. 2	03-29-71	11	5	245	142	10:23	6	13.7	4.2				
	ATE no. 3	04-26-71	28	6	385	132	13:46	4	10.1	2.2				
	ATE no. 4	05-11-71	13	4	290	134	10:10	4	13.1	2.9	11.7*	5.9*	273*	P*
137	1	11-16-70	9	4	200	36	13:00	0	2.76	0	2.8	0	200	P
	2	12-03-70		6	315	44	05:30	3	8.0	6.9	4.3	3.7	257	D
	3	12-17-70		8	350	65	19:30	8	3.3	12.3	3.8	7.5	288	D
	1	01-25-71	5	3	95	38	09:36	3	4.0	7.9	3.95	12.6	95	P
	2	02-04-71	10	6	270	43	15:43	0	2.7	0	3.2	3.7	182	P
	3	03-03-71	27	10	425	55	17:55	3	3.07	3.6	3.1	3.6	263	D
	4	03-23-71	19	13	595	74	11:35	2	6.48	2.6				
	5	03-30-71	7	3	175	96	13:45	11	5.7	3.8				
	6	04-13-71	12	8	265	64	16:51	6	4.1	8.7				
	7	04-29-71	15	6	270	58	07:50	4	6.0	6.4	4.5	5.0	299	D
138	1	02-25-71	106	19	685	36	10:35	1	3.4	3.8	3.4	28.0	685	N
	2	03-23-71	26	21	645	45	10:25	7	4.1	13.9	3.8	9.9	665	N

* Results based on tests following interface change

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TABLE VI

COASTAL CENTER, SOUTH CAROLINA DEPARTMENT OF MENTAL RETARDATION, LADSON, S. CAROLINA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
136	1	11-03-70	1	1	48	38	3:45	2	10.1	5.3	10.1	5.2	48	H
	2	11-13-70	10	7	160	47	6:17	1	6.9	2.3	8.1	3.5	104	P
	3	11-19-70	6	18	190	68	10:09	5	6.7	5.9	7.4	5.2	133	P
	4	12-02-70	12	6	300	74	7:57	0	9.9	0				
	5	12-03-70	1	40	40	81	9:50	3	8.4	5.7				
	6	12-09-70	7	4	310	63	7:57	1	8.4	1.5				
	7	12-15-70	6	2	60	35	5:00	2	7.0	5.7	7.9	3.4	158	P
	ATE no. 1	04-21-71	125	40	859	140	21:44	11	6.6	7.3				
	ATE no. 2	05-06-71	14	9	250	134	25:04	3	5.3	.02	7.0	4.1	246	D
139	1	11-03-70	1	1	45	46	5:30	11	8.4	24.1	8.3	23.9	45	D
	2	11-12-70	9	6	390	46	5:30	7	8.4	11.4	8.3	19.6	217	D
	3	11-27-70	15	5	235	115	18:38	70	6.1	60.8	6.7	42.5	223	D
	4	12-17-70	20	9	275	75	10:57	14	7.8	25.3	6.5	36.7	524	N
135	1	11-03-70	1	1	45	35	4:23	4	8.0	11.4	8.0	11.0	45	D
	2	11-09-70	6	3	80	41	4:30	6	9.3	14.3	8.5	13.0	63	D
	3	11-23-70	14	8	325	55	6:34	5	8.2	7.5	8.5	11.4	150	D
	4	12-10-70	16	7	270	73	7:34	5	9.2	7.5				
	5	12-16-70	6	3	160	75	8:01	7	9.2	6.8	9.0	9.7	176	P
	6	01-07-71	2	2	40	57	7:00	12	8.4	13.6				
	7	01-12-71	4	1	60	40	2:54	0	13.4	0	9.8*	12.3*	50*	D*

*Results based on tests following interface change.

TABLE VII

COASTAL CENTER, SOUTH CAROLINA DEPARTMENT OF MENTAL RETARDATION, LADSON, S. CAROLINA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
24	M	136	organic brain damage	D-C fist	fist	2	11-02-70
18	M	139	C. P. mixed	D-C fist	finger	4	11-02-70
27	M	135	organic brain damage	D-C fist D-C finger	fist finger*	7	11-03-70 01-06-71
25	M	137	organic brain damage	D-C foot D-S stag. finger	foot fist fist	4	11-02-70 11-06-70 01-21-71
22	F	138	organic brain damage	D-C foot D-S bi-level	foot hand fist	alpha-bet	11-02-70 11-09-70

* Results based on tests following interface change.

TABLE VIII

BUFFALO PUBLIC SCHOOL NO. 84, BUFFALO, NEW YORK

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
173	1	01-18-71	54	7	245	36	02:00	2	18.0	5.6	18.0	5.6	245	P
168	1	12-11-70	36	7	153	36	03:30	1	10.3	2.7	10.2	3.0	153	H
	2	02-11-71	61	10	185	43	04:35	3	9.4	11.6	9.77	5.0	169	P
	3	03-10-71	27	7	135	61	08:30	4	7.3	6.4	8.44	5.7	157	P
	4	04-22-71	43	5	108	85	08:20	17	7.7	18.5	9.0	11.5	145	D
170	1	11-13-70	8	4	170	43	05:25	6	7.75	14.3	7.9	13.9	170	D
	2	01-04-71	52	11	175	40	05:40	6	7.06	15.0	7.5	14.5	172	D
	3	03-03-71	58	15	103	62	11:30	4	5.57	7.9	6.4	11.0	149	D
167	1	01-08-71	64	11	190	37	01:45	5	21.1	5.4	21.1	13.4	190	P
	2	02-17-71	40	8	160	52	03:30	13	14.0	22.5	16.9	20.2	175	P
172	1	02-18-71	21	5	170	45	05:25	6	8.3	24.4	8.3	13.3	170	D
	2	03-11-71	21	5	175	45	06:15	8	7.2	5.6	7.7	15.5	172	D
196	1	03-12-71	32	5	160	99	35:00	60	3.0	62.3	2.8	66.0	160	D
169	1	01-21-71	76	17	165	38	01:35	6	24.0	10.5	24.0	10.5	165	P

TABLE IX

BUFFALO PUBLIC SCHOOL NO. 84, BUFFALO, NEW YORK

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
16	M	173	C. P. spast. quad.	D-C fist	fist	1.7	11-05-70
12	M	168	C. P. spast. quad.	D-C	fist	2.1	11-05-70
9	F	170	C. P. mixed	D-C	fist	1.0	11-05-70
9	M	167	C. P. mixed	D-C	fist	1.0	11-05-70
12	M	172	C. P. spast. quad.	D-S 2-row	finger	2.0	01-28-71
11	F	196	Dystonia Muscu-larum	D-S 2-row	fist	3.0	02-08-71
8	M	169	C. P. athetoid	D-C fist	fist	2.0	11-06-70

TABLE X

CEREBRAL PALSY SCHOOL, LOUISVILLE, KENTUCKY

Subject No.	Test No.	Date	Days since start or prior test.	No.of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg.of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
180	1	03-15-71	52	14	585	43	06:40	7	6.4	16.3	6.45	16.3	585	N
	2	04-22-71	37	17	710	46	07:00	3	6.6	06.5	6.50	11.0	648	N
	3	05-20-71	30	13	460	70	10:00	8	7.0	13.7	6.70	11.3	585	N
179	1	05-12-71	109	23	1005	37	05:20	3	7.1	07.9	6.90	08.1	1005	D
	2	05-12-71	0	23	675	43	07:30	3	5.7	06.9	6.20	07.5	840	D
177	1	05-12-71	110	41	1205	45	11:45	8	5.2	16.4	3.80	17.8	1205	N
	2	05-27-71	15	9	535	42	09:00	5	4.7	11.9	6.20	14.9	870	N
178	1	05-12-71	110	43	1375	57	10:00	26	5.8	31.0	5.80	31.0	1375	N

TABLE XI

CEREBRAL PALSY SCHOOL, LOUISVILLE, KENTUCKY

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
16	M	180	C. P. athetoid	D-S 2-row	fist	3.5	01-21-71
12	M	179	C. P. tension spast. quad. athetoid	D-S stag. finger	fist	2.0	01-22-71
17	M	177	C. P. athetoid	D-S 2-row	fist	2.0	01-21-71
13	M	178	C. P. athetoid	D-S stag. finger	hand	1.0	01-21-71

"In learning the letter-keying code, the operator associates meanings in terms of graphic symbols or typing functions, with visual, auditory, and kinesthetic information feedback resulting from coordinated movements of the fingers or other parts of the body which actuate the control keys or transducers. Proprioceptive feedback alone, without visual reference, provides virtually unambiguous spatial and relational specification of key positions. By comparison, kinesthetic feedback resulting from use of the standard typewriter keyboard with 49 keys is more equivocal in specifying finger and key positions. Consequently, the "Cybertype" interface may be of value because of its unambiguous coupling characteristic in the teaching of blind children to communicate in written form through the output of print, HAIBRL, or braille. The effectiveness of these systems is revealed by the results of the instructional research programs during the past three years."

TABLE XII

ILLINOIS CHILDRENS HOSPITAL SCHOOL, CHICAGO, ILLINOIS

Subject No.	Test No.	Dote	Doys since stort or prior test.	No.of sessions since stort or prior test.	No. of proctice minutes since stort or prior test	No. of function	No. of minutes	No. of errors	Function rote	Error rote	Cum. ovg. of function rote	Cum. ovg. of error rote	Cum. ovg. of proctice time	Cotogory
147	1	03-03-71		16	130	38	04:30	2	8.8	05.2	8.8	5.2	130	P
	2	03-31-71	28		150	47	08:30	6	5.8	12.7	6.7	9.4	140	P
	3	05-07-71	38		150	59	07:50	4	7.5	06.7	7.0	8.3	143	P
	4	06-04-71	28	13	160	76	12:50	6	5.9	07.8	6.7	8.1	148	P
148	1	03-04-71		16	130	39	03:35	4	10.9	10.2	10.8	10.2	130	P
	2	03-31-71	27		150	n/a*	05:00	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	3	06-02-71	60		150	59	11:00	3	5. 3	07.6	6.7	7.1	143	P
	4	06-09-71	7	10	160	72	16:25	2	4.3	02.7	5.5	5.2	148	P
150	1	03-02-71	29	13	130	39	05:00	10	7.8	25.6	7.8	25.6	130	P
	2	03-26-71	24	13	150	43	06:37	4	6.5	10.2	7.1	17.1	140	P
	3	04-07-71	11	5	150	63	12:30	10	6.5	15.8	6.0	16.5	143	D
	4	05-11-71	39	9	160	74	16:27	7	4.5	9.4				
	5	06-03-71	23		80	76	05:16	6	5.0	7.9	6.4	12.5	134	D
146	1	03-02-71	29	13	130	31	04:00	7	7.75	18.4	7.7	22.5	130	D
	2	03-26-71	24	13	150	43	05:57	2	7.2	4.7	7.4	12.1	140	D
	3	04-07-71	11	5	150	78	13:00	22	6.0	30.5	6.6	20.3	143	D
	4	05-11-71	39	9	160	74	10:25	2	7.2	2.7				
	5	06-03-71	23		80	79	14:40	5	5.6	6.3	6.3	12.4	134	D

*not available.

TABLE XIII
ILLINOIS CHILDREN'S HOSPITAL SCHOOL, CHICAGO, ILLINOIS

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. c.g. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
144	1	02-05-71	4	4	130	36	01:17	1	28.1	2.8	28.0	2.8	130	H
	2	02-23-71	18	9	150	41	01:23	0	29.4	0	28.9	1.3	140	H
	3	03-03-71	8	5	150	60	03:20	6	19.8	10.0	23.3	5.1	143	H
	4	03-16-71	13	5	160	74	03:24	2	18.8	2.7	19.7	6.1	128	H
151	1	02-05-71	4	4	130	37	03:40	1	9.9	2.7	10.1	2.7	130	H
	2	02-23-71	18	9	150	39	03:42	1	15.4	2.5	10.3	2.6	140	H
	3	03-17-71	22	11	150	60	07:50	2	8.4	3.3	9.1	2.9	143	H
	4	03-31-71	14	8	160	75	05:35	0	9.9	0				
	5	04-07-71	7	7	80	75	09:34	0	8.2	0				
	6	no info												
	7	05-26-71	49	14	70	34	04:50	9	8.9	29.1	9.3	4.1	120	P
152	1	02-09-71	8	5	130	34	04:15	2	8.0	5.6	8.0	5.9	130	P
	2	no info												
	3	03-09-71	18	17	150	62	08:40	5	7.2	8.1	7.4	7.2	140	P
	4	04-20-71	32	11	160	83	10:20	5	7.2	8.1				
	5	05-26-71	36	14	80	95	12:31	26	7.6	27.3				
	6	05-28-71	2	2	100	65	12:20	13	5.4	20.0				
	7	06-04-71	7	n/a	70	35	08:42	9	42.0	25.7	6.6	16.0	120	D

TABLE XIV

ILLINOIS CHILDREN'S HOSPITAL SCHOOL, CHIGAGO, ILLINOIS

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
11	M	147	C. P. athetoid quad.	D-C 2-row	fist	1	02-01-71
13	F	148	C. P. athetoid spast.	D-C foot	foot	advanced pre-primer	02-01-71
12	F	150	C. P. athetoid spast. quad.	D-S	fist	1	02-01-71
10	M	146	C. P. athetoid spast. quad.	D-S	fist	1	02-01-71
19	M	144	C. P. quad. mild athetoid	D-C	hand fist	2	02-01-71
20	M	151	C. P. athetoid spast. quad.	D-S	head	5	02-01-71
19	M	152	C. P. athetoid spast.	D-S	fist	?	02-01-71

TABLE XV
OAKMAN SCHOOL, DETROIT, MICHIGAN

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
211	1	04-28-71	33	28	442	37	03:15	2	11.7	05.30	11.4	05.4	442	P
	2	06-04-71	37	32	877	37	07:27	2	06.7	02.05	06.9	05.5	659	D
212	1	03-31-71	7	4	115	46	02:55	2	16.0	04.40	15.7	04.3	115	H
	2	04-27-71	27	9	288	47	03:59	0	11.8	0	13.5	02.1	201	H
	3	05-12-71	17	10	385	55	06:57	2	08.8	03.30	13.6	02.7	262	H
	4	06-07-71	24	7	228	76	05:52	2	12.9	02.60				
	5	06-11-71	4	4	113	94	10:47	6	08.9	05.60	10.4	03.7	226	H
214	1	06-07-71	19	9	242	46	09:55	18	03.7	39.10	04.6	39.1	242	N

TABLE XVI
OAKMAN SCHOOL, DETROIT, MICHIGAN

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
7	M	211	C. P. spast. quad	D-C fist	finger fist	1.1	03-25-71
8	M	212	C. P. tension athetoid quad.	D-C foot	fist	2.1	03-25-71
9	F	214	C. P. quad.	D-S 2-row	finger	primer	05-19-71

TABLE XVII
EASTERN ORTHOPEDIC SCHOOL, GRAND RAPIDS, MICHIGAN

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
216							2 days 50:00							
	1	04-30-71	11	5	110	38	01:30	1	25.3	2.7	25.3	2.6	110	H
	2	06-01-71	31	8	180	42	02:15	6	16.3	14.6	21.3	8.8	145	H
219	1	03-12-71	3	3	105	26	20:00	1	108.0	2.6	108.0	2.7	105	H
	2	03-31-71	19	2	80	43	45:00	6	57.3	11.6	72.9	9.9	93	H
	3	04-08-71	8	3	90	51	55:00	4	55.1	17.5	65.0	8.5	92	H
	4	05-06-71	28	5	155	73	01:15	8	62.5	12.8				
	5	06-01-71	25	3	110	77	01:20	3	55.9	2.7				
	6	06-08-71	7	2	45	67	01:25	7	52.6	10.9	57.8	8.3	98	H
220	1	05-20-71	99	39	845	55	07:00	17	07.0	30.6	7.9	30.6	845	N
218	1	05-18-71	39	11	280	34	05:00	11	07.0	32.3	6.8	32.3	575	N

TABLE XVIII
EASTERN ORTHOPEDIC SCHOOL, GRAND RAPIDS MICHIGAN

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
19	M	216	accident - fracture C4&C5	D-S in line	fist	9	04-06-71
				D-C foot	fist		04-22-71
				D-C fist	fist		05-25-71
20	F	219	Rheumatoid Arthritis	D-C finger	finger	12	03-09-71
16	F	220	C. P. tension athetoid	D-C foot	foot	primer	03-15-71
7	M	218	C. P. spast. quad.	D-S in line	hand fist	primer	02-09-71
				D-S bi-level	fist finger		04-08-71

TABLE XIX
BELLE-WILLARD ELEMENTARY SCHOOL, FAIRFAX, VIRGINIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Catagory
184	1	03-16-71	8	2	59	36	04:53	1	07.40	03.8	07.4	3.8	59	P
50	1	03-18-71	27	6	141	37	03:00	1	12.20	02.7	12.3	2.8	141	H
	2	05-17-71	30	3	49	43	06:51	3	06.40	06.8	08.1	5.0	95	P
38	1	03-08-71	17	2	75	32	02:58	3	10.80	09.4	10.7	9.3	75	H
	2	03-15-71	7	2	55	43	02:57	0	14.30	0	12.7	4.0	65	H
	3	05-07-71	53	4	87	59	04:00	5	15.00	08.3	13.5	6.0	72	H
185	1	03-16-71	11	3	57	35	03:54	0	09.00	0	09.0	0	57	P
	2	04-30-71	44	4	76	43	03:00	2	14.30	04.6	11.3	2.5	67	H
	3	05-21-71	22	4	45	63	04:26	2	14.00	03.3	12.5	2.8	59	H
183	1	03-04-71	16	3	65	39	04:16	3	18.60	07.7	09.1	7.6	65	P
	2	04-19-71	31	3	23	43	03:24	4	12.60	09.3	10.6	8.5	44	H
	3	05-17-71	29	4	28	64	04:16	10	15.10	15.5	12.2	11.6	39	P
199	1	04-20-71	13	1	16	36	03:47	1	09.50	02.8	09.5	2.8	16	P
	2	06-03-71	43	4	70	48	05:29	5	08.70	10.4	09.1	7.0	43	P

TABLE XX
BELLE-WILLARD ELEMENTARY SCHOOL, FAIRFAX, VIRGINIA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
13	F	184	C. P. rotary athetoid	D-S in-line	hand	no info.	03-08-71
13	F	50	C. P.	D-S in line	hand	1	02-19-71
10	M	38	C. P. spast. quad	D-S in line	hand	no info.	02-19-71
27	F	185	C. P. spast.	D-S 2-row	hand	no info.	03-05-71
13	F	183	C. P. athetoid	D-S in line D-S 2-row	hand hand	no info.	03-16-71 03-18-71
11	F	199	C. P. spast. quad.	D-S in line D-S 2-row	hand hand	primer	02-18-71

TABLE XXI

THE WIDENER MEMORIAL SCHOOL, PHILADELPHIA, PENNSYLVANIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
203	1	05-17-71	5	2	55	39	05:01	11	7.7	2.6	6.9	28.0	55	D
	2	06-01-71	14	9	109	51	07:09	10	6.8	19.9	7.3	23.3	82	D
	3	06-15-71	13	9	150	65	07:09	7	8.4	10.7	8.0	18.0	104	D
205	1	05-14-71	3	2	64	37	07:22	3	5.0	5.4	5.0	5.4	64	P
	2	05-14-71	0	3	29	47	07:59	3	5.9	6.2	5.0	5.9	47	P
	3	06-02-71	24	8	215	63	15:41	5	4.3	12.3	4.5	6.8	103	P
209	1	05-26-71	14	6	115	38	03:33	4	10.2	10.5	10.7	10.5	115	P
	2	06-03-71	7	2	55	46	04:55	7	9.3	15.2	9.9	11.9	85	D
	3	06-09-71	5	4	55	60	07:40	13	7.8	20.0	8.7	15.9	75	D
202	1	test invalid												
	2	06-11-71	16	8	125	47	16:25	4	2.7	8.5	2.9	8.5	125	P
207	1	05-17-71	1	1	20	36	02:27	0	15.0	0	14.6	0	20	H
	2	05-25-71	8	3	70	46	03:15	5	14.4	10.8	14.4	6.0	45	H
	3	06-10-71	16	3	55	64	04:30	7	14.4	10.9	14.3	8.2	48	H
204	1	06-02-71	20	6	110	57	08:35	22	7.8	38.7	6.6	39.0	11	D
	2	06-16-71	14	9	150	58	12:30	14	4.6	24.1	5.4	33.9	130	D

TABLE XXII
THE WIDENER MEMORIAL SCHOOL, PHILADELPHIA, PENNSYLVANIA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
10	M	203	C. P. athetoid quad.	D-S in line	hand finger	1.2	05-12-71
12	M	205	C. P. rotary athetoid	D-S in line	hand	2.2	05-11-71
17	M	209	C. P. quad. athetoid	D-S in line	fist	9.4	05-12-71
11	M	202	C. P. mixed	D-S head stylus	finger	1.2	05-13-71
13	F	207	C. P. athetoid quad.	D-S in line	hand	4.0	05-17-71
17	F	204	C. P. athetoid quad.	D-S head stylus	finger	2.2	05-13-71
				D-S 2-row w/overlay	finger		

TABLE XXIII

THE LINDSAY SCHOOL, ST. PAUL, MINNESOTA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Catagory
234	1	05-17-71	6	2	55	38	03:31	4	10.8	10.5	10.8	10.5	55	P
	2	05-26-71	8	3	70	45	04:24	5	10.2	11.1	10.5	10.8	63	P
	3	06-02-71	6	3	30	64	06:16	3	10.2	04.6	10.4	08.1	51	H
239	1	05-14-71	4	3	50	37	02:36	2	04.2	05.4	14.2	05.4	50	H
	2	05-28-71	14	6	85	46	03:08	5	14.6	10.8	14.5	08.4	67	H
244	1	05-18-71	8	4	75	43	06:22	7	01.7	16.3	06.8	16.1	7.5	D
	2	06-01-71	13	5	100	43	07:00	1	06.1	02.3	06.4	09.3	87	P
237	1	05-18-71	7	3	35	37	02:01	1	18.4	02.7	18.4	02.7	35	H
	2	06-03-71	15	4	60	45	03:39	5	12.3	08.9	14.5	07.3	48	H
238	1	05-18-71	7	3	30	39	03:00	3	03.0	05.1	13.0	03.6	30	H
	2	06-03-71	16	4	50	44	03:35	3	13.2	06.79	12.6	07.2	40	H
235	1	05-17-71	8	3	19	35	01:29	1	23.6	02.8	23.6	02.8	19	H
	2	05-21-71	4	2	25	43	03:10	0	19.9	0	21.4	01.3	22	H
	3	06-02-71	12	4	45	60	03:36	1	16.6	01.6	19.0	01.5	30	H
236	1	05-17-71	8	3	7	43	43:00	0	60.0	0	60.0	0	7	H
	2	05-21-71	4	2	40	42	01:59	2	33.1	04.7	31.4	02.3	24	H
	3	06-02-71	12	4	40	61	03:19	1	18.6	01.6	24.4	02.0	29	H

TABLE XXIV
THE LINDSAY SCHOOL, ST. PAUL, MINNESOTA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
14	M	234	C. P. spast. quad.	D-S 2-row	finger	10.0	05-10-71
11	M	239	C. P. spast. quad	D-C fist	fist	5.2	05-11-71
11	F	244	C. P. spast. quad.	D-S in line	fist	2.5	05-11-71
11	M	237	C. P. athetoid quad.	D-C fist	fist	6.0	05-11-71
12	M	238	C. P. spast. quad.	D-S in line	fist	5.0	05-11-71
14	M	235	muscular dystrophy	D-C finger	finger	11.0	05-10-71
14	M	236	muscular dystrophy	D-C finger	finger	9.0	05-10-71

TABLE XXV
THE LINDSAY SCHOOL, ST. PAUL, MINNESOTA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Catagary
240	1	05-20-71	10	3	75	41	03:33	6	11.5	14.6	11.5	14.6	75	P
	2	06-03-71	14	5	75	50	04:49	10	10.4	20.6	10.8	17.6	75	P
245	1	05-19-71	5	3	65	39	01:35	2	24.6	05.1	24.6	05.1	65	H
	2	05-24-71	9	4	80	45	03:00	3	15.0	06.6	18.3	6.6	73	H
233	1	05-17-71	8	4	55		*							
	2	06-02-71	16	5	85	43	04:03	1	10.6	02.3	10.6	02.3	85	H

*no result

TABLE XXVI
THE LINDSAY SCHOOL, ST. PAUL, MINNESOTA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
10	M	240	C. P. spast. quad.	D-C fist	fist	primer	05-11-71
9	M	245	C. P. spast. quad.	D-C fist	fist	2.2	05-16-71
15	M	233	C. P. spast. quad.	D-S 2-row	finger	4.0	05-10-71

TABLE XXVII
THE MOODY SCHOOL, GALVESTON, TEXAS

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Catagory
229	1	04-16-71	3	2	60	39	02:13	4	17.7	10.2	17.7	10.2	60	P
	2	04-29-71	13	6	255	43	03:55	0	11.0	0	13.4	4.9	157	H

TABLE XXVIII
THE MOODY SCHOOL, GALVESTON, TEXAS

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
15	M	229	C. P. mixed	D-C finger	finger	primer	04-13-71
6	M	230	C. P. mixed	D-S in line	fist	labeling	04-13-71

TABLE XXIX
MARQUETTE SCHOOL, MUSKEGON, MICHIGAN

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate	Cum. avg. of function rate	Cum. avg. of error rate	Cum. avg. of practice time	Category
221	1	04-26-71	7	5	135	37	01:55	1	19.3	02.6	19.3	02.7	135	H
	2	05-13-71	17	8	225	47	02:56	4	16.5	08.5	17.7	06.0	180	H
	3	06-01-71	19	8	285	72	05:44	10	11.7	22.8	14.9	09.6	215	H
222	1	04-22-71	4	4	55	27	45:00	3	37.3	11.1	36.0	11.1	55	P
	2	04-29-71	7	5	133	43	01:40	0	26.9	0	28.9	4.2	94	H
	3	05-12-71	13	7	183		04:04	13	18.0	18.1	21.9	11.2	124	P
	4	06-03-71	14	10	305	77	03:06	4	74.8	03.9				
	5	06-07-71	3	3	113	76	03:22	1	23.7	03.7	22.7	07.1	158	H
223	1	04-30-71	10	9	255	47	02:30	12	18.9	08.6	18.8	25.5	255	D
	2	05-27-71	26	13	385	46	08:00	4	05.8	06.7	08.9	17.2	320	N
224	1	04-30-71	11	9	230	35	12:40	2	02.78	08.6	02.9	05.7	230	D
	2	05-27-71	27	11	265	46	10:00	4	04.6	08.6	03.6	07.4	247	D
225	1	04-23-71	5	4	90	37	01:12	1	33.7	02.8	30.8	02.7	90	H
	2	05-05-71	12	7	135	43	02:38	1	16.3	02.4	20.9	02.5	112	H
226	1	05-05-71	16	12	320	33	04:15	0	07.8	0				
	1	05-27-71	14	8	160	40	06:29	4	06.1	10.0	06.1	10.0	160	D

TABLE XXX
MARQUETTE SCHOOL, MUSKEGON, MICHIGAN

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
10	F	221	C. P. quad.	D-C fist	fist	1.5	04-19-71
13	M	222	Bilirubin Encephalitis	D-C fist	finger	1.5	04-19-71
14	M	223	C. P. quad.	D-C finger	finger	3.4	04-19-71
13	F	224	C. P. quad. Mandibular Ankylosis	D-C foot	fist	1.2	04-30-71
12	F	225	C. P. quad.	D-C foot	fist	2.6	04-19-71
6	M	226	C. P. de Lange Syndrome	D-C foot	fist	alphabet	04-19-71
				D-S stag. finger	fist finger		05-17-71

TABLE XXXI
D. T. WATSON HOME FOR CRIPPLED CHILDREN, LEETSDALE, PENNSYLVANIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate
124	ATE no. 1	1970				135	15:00	5	9.0	3.7
	ATE no. 2	1970				136	12:00	4	11.3	2.2
	ATE no. 9	1970				136	11:15	1	12.1	.7
	ATE no. 10	1970				130	16:20	0	25.7	0
	ATE no. 19	May 1971							45.9	1.4
	ATE no. 20	May 1971							50.4	0
123	ATE no. 1	1970				136	22:00	5	6.2	3.7
	ATE no. 2	1970				132	10:00	2	13.2	1.5
	ATE no. 9	1970				136	05:55	1	22.9	.7
	ATE no. 10	1970				130	04:05	0	31.8	0
	ATE no. 19	June 1971							33.9	.7
	ATE no. 20	June 1971							36.3	3.1

TABLE XXXII
D. T. WATSON HOME FOR CRIPPLED CHILDREN, LEETSDALE, PENNSYLVANIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate
127	ATE no. 1	1970				131	05:30	8	24.7	6.1
	ATE no. 2	1970				140	09:00	9	15.5	6.4
	ATE no. 9	1970				136	04:40	1	29.1	.7
	ATE no. 10	1970				130	06:10	0	21.1	0
	ATE no. 19	May1971							26.0	2.0
	ATE no. 20	May1971							28.5	2.4
128	ATE no. 1	1970				134	14:00	1	9.6	.7
	ATE no. 2	1970				134	14:00	2	9.6	1.5
	ATE no. 9	1970				135	05:55	0	22.8	0
	ATE no. 10	1970				130	06:45	0	19.3	0
	ATE no. 16	May1971							32.1	0
	ATE no. 17	May1971							28.3	.7

TABLE XXXIII

D.T. WATSON HOME FOR CRIPPLED CHILDREN, LEETSDALE, PENNSYLVANIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate
125	ATE no. 1	1970				137	12:00	2	11.4	1.5
	ATE no. 2	1970				131	11:00	3	13.1	2.3
	ATE no. 9	1970				135	03:55	0	34.5	0
	ATE no. 10	1970				131	04:00	2	35.2	1.5
	ATE no. 19	June 1971							62.8	0
	ATE no. 20	June 1971							59.6	.8
122	ATE no. 1	1970				131	10:00	7	13.1	5.3
	ATE no. 2	1970				133	08:00	1	16.6	.8
	ATE no. 9	1970				136	08:45	1	15.5	.7
	ATE no. 10	1970				131	07:15	1	16.2	.7
	ATE no. 19	May 1971							21.6	2.0
	ATE no. 20	June 1971							23.8	1.6

TABLE XXXIV
D. T. WATSON HOME FOR CRIPPLED CHILDREN, LEETSDALE, PENNSYLVANIA

Subject No.	Test No.	Date	Days since start or prior test.	No. of sessions since start or prior test.	No. of practice minutes since start or prior test	No. of function	No. of minutes	No. of errors	Function rate	Error rate
129	ATE no. 1	1970				135	23:00	0	5.9	0
	ATE no. 2	1970				135	11:00	3	13.2	2.2
	ATE no. 9	1970				136	07:30	1	18.1	0.7
	ATE no. 10	1970				131	06:05	1	21.5	0.7
	ATE no. 19	1971							35.0	0
	ATE no. 20	1971							36.7	0
126	ATE no. 1	1970				148	24:00	12	6.2	8.1
	ATE no. 2	1970				147	16:00	15	9.2	10.2
	ATE no. 9	1970				136	12:45	2	10.7	1.5
	ATE no. 10	1970				132	08:10	4	16.2	3.0
	ATE no. 19	June 1971							17.3	2.0
	ATE no. 20	June 1971							18.5	0

TABLE XXXV
D. T. WATSON HOME FOR CRIPPLED CHILDREN, LEETSDALE, PENNSYLVANIA

Age	Sex	Subject No.	Disability	Interface	Limb	Reading level	Starting date
12	M	127	C. P.	D-C fist	fist	6.7	1970
		128					1970
19	F	124	C. P.	D-S 4/3 bi-level	finger	second-ary	1970
14	F	123	C. P.	D-C foot	foot	6.1	1970
9	M	129	osteogenesis imperfecta	D-C finger	finger	3.7	1970
13	F	126	C. P.	D-S 4/3 bi-level	finger	7.8	1970
15	F	125	arthrogryp-osis	D-S in line	fist	7.8	1970
12	M	122	C. P.	D-C finger	finger	4.5	1970

THOSE SIXTIES

by

Helen Kern

1

Those Sixties! Oh! those Sixties
They echo through our thoughts
Those ten long years of constant change
That brought forget-me-nots.

2

Those years when a dog named "Snoopy"
Was the mascot of our age,
And those longhaired "Beatles"
Were the teenage rage.

3

A time when transplants
Finally got their start,
And the tune on Barnard's lips
Was, "You gotta have heart."

4

A time when the President
Was shot down in his youth;
It seemed to be a flashback
To Lincoln and Booth.

5

Three men from Cape Kennedy
Won the great race.
Two were the first to touch down
On Tranquility Base.

6

A time when the Kennedys
Tragically lost another.
Bobby will appear in the history books
Along side his brother.

7

The negroes were shocked
With the murder of Martin Luther King.
It's hard to imagine the chaos
One man's death could bring.

8

A time when the hippies
Said, "Love, we need more,"
And they burned their draft cards
Protesting the Vietnamese War.

9

President Nixon and the Underdog Mets
Left in our minds no doubt
That in 1969
They wouldn't strike out.

10

A time when Broadway
Plays were really the hairiest.
Yes, this was truly the dawning
Of the Age of Aquarius.

"Those Sixties," poem
Typed by Helen Kern and five of her classmates on the "Cybertype" writing machine (numerals added).

Appendix B | REFERENCES FOR *Part Five*

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Appendix C | EXPERIMENTAL STUDY

MESSAGE RECEPTION AND COMPREHENSION AS A FUNCTION OF RATE OF PRESENTATION FOR THREE TYPES OF ALPHANUMERIC DISPLAYS.

Introduction

The first phase of this experiment was planned to compare three displays in terms of message reception and comprehension as a function of message transmission speed, for the purpose of ascertaining their relative effectiveness. The second part of this study was planned to compare hearing-impaired and hearing subjects in terms of message reception and comprehension across transmission speeds for each of the three lamp displays. The second phase of the experiment has not yet been conducted. Basically, the determination of the feasibility of the displays would have a bearing on the rates at which handicapped students could receive information either from another individual or a teacher not equipped to use sign language, or from stored tapes which may contain the information desired, such as reference materials from a library. The displays considered had the following characteristics:

1. Display A included 26 independently back-lighted letters, 10 numerals and numerous symbols. Only the 26 letters and 10 numerals were used in the experiment. The display was arranged in a square, its diagonal perpendicular to the horizontal. Only one letter was presented at a time. Each letter appeared at its assigned location on the matrix only while the lamp was excited. More than one letter never appeared on Display A at one time. (See Figure 3, Part Six, Vol. III.)

2. Display B consisted of 8 alphanumeric lamps horizontally adjacent to each other for presentation of letters of a word in sequence. (See Figure 4, Part Six, Vol. III) The letters composing each word remained on the display until they were electrically disconnected or "wiped out."

3. Display C was the initial single alphanumeric segment of Display B. Any of the 26 letters and 10 numerals could be presented, but they appeared at the same location one at a time, each succeeding letter or numeral being presented as the preceding letter or numeral was "wiped out," and only one at a time in temporal sequence. (See Figure 5, Part Six, Vol. III.)

Display specifications are presented in Table I, Section VI, Appendix D, Vol. III.

Experimental hypotheses under consideration were that (1) message reception and comprehension vary as a function of transmission speed for each display; (2) message reception and comprehension differ across displays as a function of transmission speed; and (3) hearing-impaired subjects differ from hearing subjects in terms of message reception and comprehension across displays and transmission speeds.

Each display system had a unique characteristic. The square-shaped Display A (Figure 3, Part Six, Vol. III) required eye movements which essentially scanned the display in many directions for detection of the lighted letter. Display B (Figure 4, Part Six, Vol. III), the eight-frame alphanumeric display, required little lateral eye movements. It was more compatible with horizontal reading in that letters (held at completion of the word for the duration of the final letter) were presented next to each other and were read from left to right. Display C (Figure 5, Part Six, Vol. III), the single-cell, alphanumeric display, required minimal eye movements by presenting letters sequentially in essentially the same position in space. Spelling a word aurally would be an analogous situation,as would signing of the manual alphabet; in each case, the letters were presented one at a time with no (other than cognitive) storage or memory activity.

Independent variables were: (1) display conditions A, B, and C, and (2) rate of message transmission measured in letters or letter equivalents per second (lps), including the following six rates: 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 lps. This is equivalent to 12, 24, 36, 48, 60, and 72 words per minute (where an average word is taken to consist of five letters).

Dependent variables were: (1) message reception or intelligibility measured in terms of the accuracy with which subjects reproduced in written form simple sentences presented at various rates on their lamp displays; and (2) message comprehension measured as to performance in answering multiple-choice questions following each transmitted message.

The data collected and analyzed herein are for Group A (36 Ss with hearing impairments), since experimentation with Group B (36 Ss with unimpaired hearing) has yet to be conducted.

Method

Subjects: Ss in Group A, who were randomly selected, were hearing-impaired sophomore and junior college students from Gallaudet College, Washington, D.C. All Ss could read, and had at least 20/20 corrected or uncorrected visual acuity as measured with a Bausch and Lomb Ortho-Rater™*. They had no major physical disabilities other than hearing and language impairments.

Ss were selected by the criterion that their hearing-language impairments were sufficiently profound to preclude the use of a telephone (even with amplification devices) for communicating. This was determined by simple questioning of each subject-candidate as well as reference to audiological profiles. The possible confounds resulting from differences between congenital, pre-lingual and post-lingual deafness, and moderate, severe, and profound degrees of hearing loss were resolved by random selection procedures. The special characteristics and environment of this sample of subjects attending a college for deaf and speech-impaired students must be considered in any

*Trademark - Bausch & Lomb, Inc., Rochester, New York.

generalizations to the nation's approximately two million people with serious hearing problems (H.E.W. Public Health Service, 1965). It has been reported that about 1% of the population has severe hearing impairments, defined as "frequent difficulty with loud speech" or worse (Zakia and Haber, 1971).

The 36 subjects were divided into 3 groups of 12 each, with each group assigned to a different display. The Ss viewed their particular display from varying reading distances according to individual comfort. All Ss were given two one-hour sessions in the same week, and received monetary compensation for their participation.

Apparatus

1. Displays A, B, and C.
2. Tape recorder and tape-recorded signals for presentation of messages letter-by-letter at various transmission rates.
3. Printed instruction cards.
4. Dictionary of manual signing.
5. Data sheets, question-and-answer forms, pencils.
6. Ortho-Rater.

Every message was tape recorded at each of the six rates. A special tape recording had to be made for each subject-test combination. That is, every test session required a random combination of messages and rates resulting in 24 tapes, 12 for each of the two test sessions (explained below). In addition, there were 13 training session tapes. To facilitate the taping, an automatic tape recording apparatus was constructed for use in this experiment with a resultant shortening of recording time to 1/10th of the original requirement.

Procedure

All subjects were required to pass a vision test on the Ortho-Rater. The test was given at the beginning of the first session and took about 10-15 minutes. One male subject with severe visual impairments was dropped from the list of subjects and replaced by a suitable candidate.

Subjects were divided into three subgroups, each having 12 Ss. Each subgroup was assigned to one of the three lamp display conditions. Ss were seen individually in two sessions given within a week. In the first session, Ss were given practice in receiving messages from their lamp displays at different transmission rates. Performance on these practice trials was recorded to assure that Ss understood the instructions and were familiar with the experimental procedure. The practice session consisted of two sets of trials, with instructions as shown in Section II, Appendix D, Vol. III. In the first set of trials, Ss were shown six simple sentences with each successive sentence presented at an increased rate. Sentences were presented letter-by-letter on the appropriate lamp display. After each sentence, Ss were asked to write the sentence on an answer sheet exactly as it was presented. In the second set of practice trials, Ss were shown six different sentences, each at a different rate but presented in random order. Again, after each sentence, Ss were asked to write the sentence on an answer sheet. (See Appendix D, Vol. III for detailed illustrations of the experimental messages described in this section.)

The second session consisted of experimental trials arranged in two parts. The first part determined message reception or intelligibility as measured by Ss performance in copying the transmitted sentences correctly. Ss were shown six sentences, each at a different transmission rate, according to the independently replicated Greco-Latin Square designs given in Appendix D, Vol. III.

In accordance with these designs, each S was exposed to every sentence and every transmission rate, and across Ss, all six sentences were included at each transmission rate. Therefore, the two independently replicated Greco-Latin Squares, with six Ss each, constituted the sample of 12 Ss for every display condition.

After each sentence was presented, Ss attempted to write that sentence on the answer sheet exactly as it was displayed. There was no time limit. Subjects rarely took more than 30-45 seconds to complete any one sentence.

The second part of the experimental session involved presentation of longer, more complex messages. Six such messages were presented according to the Greco-Latin Square designs previously cited. In this part of the experiment, message comprehension was tested by having Ss answer four multiple-choice questions following each presentation, to determine understanding of message content. Preceding the test sentences, Ss were given practice on a printed message followed by four multiple-choice questions, as well as a taped message presented on the display. (See Appendix D, Vol. III.)

Messages for each session varied in difficulty, as suggested by the Flesch formula (Flesch, 1948) for determining reading level (Appendix D). In the first experimental session, message difficulty ranged from a Flesch score of 49 ("difficult, academic style") to 96 ("very easy, comic strip style"). In the second experimental session, Flesch scores ranged from 59 ("fairly difficult") to 87 ("easy, pulp-fiction"). This range of message complexity provides some assurance that the experimental messages constituted a sample of the kinds of communications which might be encountered in telephone conversations. The factor of message difficulty was controlled across Ss by including every message under each transmission speed.

Prior to experimentation, instructions to Ss, messages, and multiple-choice questions were shown to experts in deaf education to assure that the experimental procedure and materials were suitable for hearing-impaired students.

Results

The first part of the experimental session provided a test of message reception or intelligibility as a function of transmission rate for the three types of displays. Following presentation of each test sentence, Ss were required to write that sentence on an answer sheet exactly as perceived from the display. Answer sheets were then scored for errors in the reproduced messages.

Four main types of mistakes were possible in copying: omissions, substitutions, transpositions, and additions. Since Test I was to be a test of message intelligibility, the presence or absence of sentence parts was considered the critical variable. Therefore, omissions and substitutions were scored as letter equivalent errors to the extent that they violated the veridicality or visual appearance of the message. For instance, if "to" was omitted in a response, S would receive an error score of 2. Similarly, if the word "business" was recorded, instead of "buses" which was transmitted, the error score would be 3. Omissions and substitutions of letters within a word were scored as one error for each incorrect letter. Transpositions of letters and extra letters within a word were generally not scored as errors since they usually did not seriously alter the intelligibility of the word. The error score depended on the value of the transmitted letter functions. Transpositions of words and extra words were not counted as errors.

The error score for each message was then converted into a percentage error score by dividing the number of errors by the total number of letter functions in each transmitted message. Figure 6 (Part Six, Vol. III) depicts the results of Test I. The data are presented in Appendix D of this volume.

At a speed of 12 wpm, there was little difference in the error rates for Displays A and C. At that speed, the lowest error rate was for Display B.

Across message transmission speeds, the error rate for Display B gradually increased from 10% to 25%, but it remained the lowest error rate at each speed when compared to all displays. It is likely that intelligibility did not generally bring about a significant decrement in comprehension until the 20% error level was exceeded.

At speeds of 24 wpm and 36 wpm, the error rate was highest for Display C; but, at the remaining speeds, the error rate was highest for Display A.

For all displays, as message transmission speed increased, there was a general increase in the message reproduction error rate, as anticipated in Hypothesis 2.

The second part of the experimental session provided a test of message comprehension as a function of transmission rate for the three types of displays. Following presentation of each message, Ss were required to answer four multiple-choice questions relating to information provided in the message (Appendix D, Vol. III). Performance was scored as the number of questions correctly answered for each message.

Figure 7 (Part Six, Vol. III) shows the results of this part of the experiment. For the two slowest transmission speeds (12 and 24 wpm), Displays A and B provided the best message comprehension. For faster rates, Display B provided the best message comprehension.

The data presented in Figures 6 and 7 (Part Six, Vol. III) and detailed in Appendix D of this volume, were analyzed by means of six Friedman Analyses of Variance for each of the two test sessions, to determine the significance of differences between displays for each of the six transmission speeds. The results summarized in Table III, Section VI, Appendix D of Vol. III demonstrate that the disparity between displays, as measured by performance, was significant for all conditions but the two slowest comprehension measures. The .05 level of significance, which had been proposed in the experimental design, was exceeded in all other conditions. According to the data and figures, both display readability or intelligibility and message comprehension were facilitated by whole-word presentations (Display B). Surprisingly, comprehension performance for Display B did not change with increasing message display speed. However, for Displays A and C, comprehension clearly diminished with increasing message-display speed, consistent with Hypothesis 2.

Discussion

It would be expected that Display B, which presents a whole word letter-by-letter, would provide the best message intelligibility and comprehension. This is clearly supported by the results, which show the lowest error rate in message reproduction, and the highest comprehension scores, for Display B. The only exception to this rule was for comprehension scores at the two slowest transmission speeds (12 and 24 words/minute) where Display A (letter-matrix display) provided a level of message comprehension as good as, or even slightly better than, Display B.

The results for message reproduction error (Figure 6, Part Six, Vol. III) suggest that Displays A (matrix) and C (single alphanumeric) did not differ at the slower transmission speeds (12 and 14 wpm). At an intermediate speed of 36 wpm, Display C produced a slightly higher error rate, but at the faster speeds (48, 60, and 72 wpm), Display A produced the poorest performance (highest error rate). This latter finding is readily interpretable, since Display A required eye movements about a matrix of sequentially illuminated letters, and a rapid synthesis of words from the individual letters. This task became extremely difficult at the more rapid rates of message presentation. Display C, which presented individual letters sequentially in one location, provided somewhat better message legibility.

It is equally important to note, however, that Displays A and C provided fairly good message reception performance at transmission speeds up to 24 words per minute (Figures 6 and 7, Part Six, Vol. III). Thus, if considerations of portability and economy require it, displays similar to "A" and "C" might be used in a direct line or telephone communication system, and provide acceptable message reception at slow to moderate speeds of message transmission.

The visual reception of sequentially-presented letters, and the synthesis of words and sentences from these displays (particularly Display C) relate to the reception of information from finger-spelling by deaf and hearing-impaired individuals. For this reason, it might be expected that hearing-impaired subjects would demonstrate better comprehension from these displays than would hearing subjects (e. g., Zakia, 1971). This phase of the experiment, which has not yet been performed, would provide comparative data on the sequential, information processing characteristics of hearing and hearing-impaired individuals, in addition to providing a comparison group of hearing subjects for evaluation of the three displays described in this study.

References related to the topic of this study are included in Appendix D of this volume.

Conclusions and Recommendations

This portion of the research has concerned itself with the evaluation of three specific types of displays used in a telecommunication system for the deaf and speech-impaired. The "Cyberlex," which displays the whole-word, is a display which is easier to read and comprehend over the range of ordinary manual typing speeds by hearing-impaired persons tested than the other two types of displays, which present their message contents letter-by-letter.

One conclusion from the first phase of the pilot study is that all three types of displays employed are effective for use by the deaf and speech-impaired when communicating via a "Cyberphone" system, and that future display experiments should be designed to test the merits of "Cyberphones" equipped with solid-state "Cyberlex" displays which offer means for presenting whole-word messages.

It is predicted that data from a group of hearing subjects, as proposed in Part B of the original design, may provide much insight into the information-processing strategies of both populations when they are confronted with visual-verbal material at various levels of difficulty.

> *"Sensory feedback is essential in most learning processes; in the acquisition of reading skills, it is critical."*
>
> --Kafafian. Excerpt from a paper "Man-Machine Systems for Aiding the Learning-Disabled," for The Institute of Electrical and Electronics Engineers (IEEE) 1970 International Convention, New York, N.Y. (Other boxed quotations which follow, unless otherwise noted, are from the same paper.)

Appendix D EXPERIMENTAL STUDY

MESSAGE RECEPTION AND COMPREHENSION AS A FUNCTION OF RATE OF PRESENTATION FOR THREE TYPES OF ALPHANUMERIC DISPLAYS.

Introduction

This appendix includes procedures and data related to subjects' message reception and comprehension as a function of "rate of presentation" for three types of alphanumeric displays. Similar displays are used in the "Cyberphone" portable telecommunications systems for use by deaf and speech-impaired persons and others who wish to communicate with one another beyond visual range, be it in an educational, vocational or social environment, without the aid of special subscriber lines or peripheral central-station equipment.

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SUPPLEMENTARY DATA AND MATERIALS

Section

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SECTION I - Subject Selection Procedures

Selection of Ss was random within the constraints of matching for sex, year in college, and Grade Point Average (GPA). Grade-point assignments were made by selecting randomly Ss within the top and bottom one-sixth of the available population of male and female sophomores and juniors. Because of scheduling and other constraints, these limits were expanded.

The resulting limits were:

High GPA group	= 80.0 to 100.0
Middle GPA group	= 73.7 to 79.9
Low GPA group	= X to 73.6

This method generated twelve categories of subjects, with each category being represented on each of the three types of alphanumeric displays with the same message and rate conditions.

Seniors were substituted for sophomores and juniors when they were not available for classification. This occurred in only two instances. One new student had no previously recorded GPA and was classified in the middle GPA category.

SECTION II - Instructions to Subjects

Practice Session

Hearing-impaired Ss were given printed instructions to read. Separate cards were used for each paragraph below.

Part I

"We are testing an electronic system which will enable hearing-impaired persons to communicate by telephone. This device is light-weight, completely portable, and contained in a slender briefcase. Messages are presented letter-by-letter on a lamp display."

1. "In this experiment, we are testing a lamp display to see how well you and other subjects can read messages presented on the display."

2. Show S the display to which he will be exposed, and explain how illuminated letters or numbers will appear on it.

3. "Your job is to read words from letters presented one at a time. For example, the word 'HELLO' looks like this on display.

4. Transmit the letters H-E-L-L-O at the rate of about one letter per second.

5. "We want you to watch the display and read a sentence which will be presented one letter at a time, word-by-word. As you read the sentence, try to remember it exactly as it is shown to you. After the sentence is presented, we want you to write the sentence on this answer sheet."

6. "First, write your name in this space at the top of the answer sheet."

7. "Now we will begin. The first sentence will be presented very slowly, one letter at a time. Be careful to remember all the words in the sentence so that you can write them on the answer sheet after the sentence is finished."

8. Present first practice sentence at slowest transmission rate.

9. "All right. Now we will try another sentence at a slightly faster speed."

10. Present second practice sentence, and continue until all six sentences have been shown.

Part II

11. "The six sentences you have just finished started with a slow speed and got faster and faster as we went along. This time, I will show you sentences which may be presented at any speed. The first sentence might be shown to you at a slow speed or a fast speed or a medium speed, so watch this display carefully. After the sentence is finished, write the sentence on the answer sheet exactly as you saw it displayed."

12. Present first sentence of Part II.

13. "Now I will show you the second sentence. Remember, it may be presented at any speed, so watch carefully."

14. Continue with all six sentences.

15. "Thank you. That's all for today. When we see you next time, we will continue with the experiment."

16. Remind S of the date and time for his next appointment.

Experimental Session

Part I

17. "Last time, you read sentences shown to you at different speeds. You did not know whether each sentence would be presented at a slow, medium, or fast speed. The same thing will happen this time. Watch the display carefully, and read the words as they are presented letter-by-letter. When the sentence is completed, I will give you a signal and you should write the sentence on your answer sheet exactly as you saw it on the display.

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18. "Here is the first sentence."

19. Continue until all six sentences have been presented.

Part II

20. "In this part of the experiment, you will be shown messages on the display, and then be asked to answer questions about the message. We can practice this procedure by using the message typed on this card."

21. Give S card containing message.

22. "Read the message on this card carefully, then I will give you multiple-choice questions to answer."

23. Allow S about 30 seconds to read the message.

24. Give S an answer sheet containing multiple-choice practice questions.

25. "On this sheet there are four statements or questions relating to the message you just read. Each question contains a blank space with four possible answers. Choose the fill-in answer which is correct on the basis of the message, and circle the number next to that answer. Do this for all four questions."

26. Allow S 1-2 minutes for this task.

27. Then give S the second practice card.

28. "Read this message as before. When I give you a signal, answer the questions relating to this message."

29. The second practice message is presented on the display, and is followed by multiple-choice questions.

30. When S completes this task, explain as follows.

31. "Now the messages will be presented to you letter-by-letter on this display. You should read the message carefully as it is displayed to you. When the message is completed, you will be given questions to answer about the message, similar to the questions you have just answered for practice. As before, each message may be presented at any speed, and you will not know in advance what the message will be."

32. "Here is the first message."

33. After the message is presented, have S answer questions.

34. Repeat procedure until all six messages have been presented.

Cue cards were ready with extra directions for use when problems with the directions arose. These cards were seldom used in the tests.

SECTION III - Messages and Tests

Messages for Practice Session I

A. FOOTBALL IS GOOD EXERCISE BUT ARCHERY IS MY FAVORITE SPORT
(Words=10; Letters=49; Flesch Score=52.9)

B. MY FRIENDS ARE PLANNING TO BECOME EITHER COMPUTER ANALYSTS OR WRITERS
(Words=11; Letters=59; Flesch Score=49.5)

C. THIS STORE HAS AN EASY CREDIT PLAN THAT WE LIKE VERY MUCH
(Words=12; Letters=46; Flesch Score=89.0)

D. YOU SHOULD BE SURE TO READ A CONTRACT WELL BEFORE YOU SIGN
(Words=12; Letters=47; Flesch Score=96.0)

E. I WAS GIVEN A 1600 DOLLAR LOAN BY THE OFFICE OF STUDENT AID
(Words=13; Letters=47; Flesch Score=76.5)

F. THERE IS GOING TO BE A PARTY ON FRIDAY NIGHT AT THE STUDENT UNION
(Words=14; Letters=52; Flesch Score=77.8)

Messages for Practice Session II

A. THE CAMPUS LEADERS MET AND DECIDED TO SUPPORT HIS CAMPAIGN
(Words=10; Letters=49; Flesch Score=61.3)

B. THE ANGRY TEACHER ASSIGNED FOURTEEN HARD MATH PROBLEMS FOR THEIR TEST
(Words=11; Letters=59; Flesch Score=72.6)

C. A BIG CROWD OF ALMOST 9500 FANS MET THE NEW FOOTBALL TEAM
(Words=12; Letters=46; Flesch Score=89.0)

D. THEY HAD HOPED TO GO SWIMMING TODAY BUT IT LOOKS LIKE RAIN
(Words=12; Letters=47; Flesch Score=96.0)

E. YOU MUST SIGN UP IN YOUR HOME COUNTY TO VOTE IN AN ELECTION
(Words=13; Letters=47; Flesch Score=89.5)

F. IT IS REALLY VERY HARD TO FIND A SUMMER JOB WHICH PAYS MORE MONEY
(Words=14; Letters=52; Flesch Score=83.9)

Messages for Test Session I

A. TUESDAY IS A NATIONAL HOLIDAY AND MEETINGS ARE NOT PLANNED
(Words=10; Letters=49; Flesch Score=61.3)

B. A MEETING OF CONGRESS IS EXCITING BECAUSE STATE POLICIES ARE REVIEWED
(Words=11; Letters=59; Flesch Score=49.5)

C. THE BUSES ARE NOT RUNNING TODAY SO I HAD TO WALK DOWNTOWN
(Words=12; Letters=46; Flesch Score=81.9)

D. MY REQUEST FOR A LOAN WAS APPROVED LATE MONDAY BY THE BANK
(Words=12; Letters=47; Flesch Score=89.0)

E. I TOLD HIM TO SEND YOUR NEW BOOK TO 7248 WEST WALNUT STREET
(Words=13; Letters=47; Flesch Score=96.0)

F. SHE WILL INVITE THEM TO COME TO HER HOUSE TO SEE THE ROSE GARDENS
(Words=14; Letters=52; Flesch Score=96.0)

Printed Practice Trial for Test Session II

Message

LETTUCE AND CARROTS DO NOT GROW WELL IN THIS SOIL SO FARMERS PLANT CORN AND PEANUTS TO USE AS FOOD FOR PIGS AND COWS

Questions

(1) SOME VEGETABLES WON'T GROW BECAUSE OF ______________
_THE ANIMALS X THE SOIL _TOO MUCH WATER _ THE INSECTS
(2) THESE FARMERS FEED THEIR ANIMALS ______________
_CARROTS AND CORN _ CARROTS AND PEANUTS X CORN AND PEANUTS
_SOYBEANS
(3) ONE TYPE OF ANIMAL MENTIONED WAS ______________
_HORSES _CHICKENS X PIGS _ SHEEP
(4) THESE FARMERS DON'T FEED THEIR ANIMALS ______________
_ASPARAGUS _ TOMATOES X LETTUCE _ OATS

Taped Practice Trial for Test Session II

Message

FARMING UNDER THE SEA MAY HELP TO PROVIDE FOOD IF OUR NATION CONTINUES TO GROW

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SEAWEED MAY BECOME AS POPULAR AS THE HOT DOG

Questions

(1) ____________ UNDER THE SEA MAY BECOME NECESSARY
__ MINING __ MANUFACTURING X FARMING __ EXPLORING
(2) SOMEDAY PEOPLE MAY LIKE TO EAT ___________ VERY MUCH
__ FISH __ WEEDS __ SEALS X SEAWEED
(3) RIGHT NOW _________ IS A POPULAR FOOD
X THE HOT DOG __ SEAWEED __ HAMBURGER __ SEAWEED CANDY
(4) ____________ CONTINUES TO GROW
__ PLANTS __ THEIR NATION X OUR NATION __ OUR OCEANS

Messages for Test Session II

A. THE MEETING OF THE BASEBALL TEAM IS GOING TO BE HELD IN THE GYM
I CAN STUDY TOMORROW MORNING AND ATTEND THE MEETING TONIGHT
(Words=24; Letters=100; Flesch Score=62.6)

B. THAT COMPANY MADE LESS STEEL THIS YEAR BECAUSE THEY NEEDED TO TRAIN MORE MEN AND HAD TO PAY AN EXTRA 1795 DOLLARS IN TAXES
(Words=24; Letters= 99; Flesch Score=76.7)

C. AFTER CHURCH TWELVE STUDENTS WENT ON A PICNIC IN THE PARK
THEY BROUGHT CAKES OR BREAD OR MEAT OR DRINKS AND SHARED THE COST
(Words=24; Letters=100; Flesch Score=87.3)

D. HE COULD THINK OF LITTLE TO SAY AFTER BEING SELECTED BY THE VOTERS
HE THANKED HIS FRIENDS AND PROMISED TO END THE WAR SOON
(Words=24; Letters=100; Flesch Score=73.2)

E. A YOUNG MAN INVENTED ONE ADDING MACHINE ABOUT 300 YEARS AGO TO HELP HIS FATHER SET TAX RATES ON LAND AND CATTLE MORE EASILY
(Words=24; Letters=100; Flesch Score=59.1)

F. SHE BECAME FOURTEEN AND WENT TO RESIDE IN THE HOUSE OWNED BY HER UNCLE
SHE WORKED AS A CLEANING GIRL INSTEAD OF PAYING RENT
(Words=24; Letters=100; Flesch Score=73.2)

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Multiple-Choice Questions for Messages in Test Session II

A. (1) THERE WAS A MEETING OF THE ________________ TEAM
_TRACK X BASEBALL _ BASKETBALL _ FOOTBALL
(2) THE MEETING ________________
_WAS HELD YESTERDAY MORNING _WAS HELD THAT AFTERNOON
X WILL BE HELD TONIGHT _WILL BE HELD TOMORROW
(3) THE MEETING PLACE IS ________________
_THE LOCKER ROOM X THE GYM _THE LIBRARY _THE TRACK FIELD
(4) I CAN ________________
_ STUDY TONIGHT X STUDY TOMORROW MORNING _PLAY BALL TOMORROW NIGHT _ PLAY BALL TOMORROW MORNING

B. (1) THE COMPANY MAKES ________________
_ IRON _STEERING WHEELS _SEALING WAX X STEEL
(2) THE COMPANY MADE ________________
_ 1000 TONS THIS YEAR X LESS STEEL THIS YEAR _LESS STEEL LAST YEAR _ IRON LAST YEAR
(3) MORE WORKERS ________________
_HAD TO BE FOUND X HAD TO BE TRAINED _WANTED TOO MUCH MONEY _ LEFT FOR JOBS IN TEXAS
(4) ANOTHER PROBLEM IS ________________
_HIGHER LABOR COSTS _HIGHER MACHINERY COSTS X HIGHER TAXES
_HIGHER FREIGHT CHARGES

C. (1) THE PICNIC WAS HELD ________________
_AFTER CLASS _ AFTER THE GAME _ AFTER EXAMS X AFTER CHURCH
(2) THE PICNIC WAS HELD ________________
_ON CAMPUS X IN THE PARK _ AFTER DARK _IN THE PARKING LOT
(3) SOME STUDENTS BROUGHT ________________
X BREAD OR MEAT _ BREAD AND SALADS _DRINKS AND TOAST
_ PRETZELS AND CANDY
(4) THE STUDENTS ________________
_ SPARED NO COST _ STARED AT THEIR HOST _ CARED THE MOST
X SHARED THE COST

D. (1) HE WAS ABLE TO ________________
_TALK ABOUT MANY THINGS _ THINK OF NOTHING TO DO X THINK OF LITTLE TO SAY _THINK OF NOTHING TO ASK FOR
(2) HE WAS SELECTED ________________
_BY THE PRESIDENT _BY LUCK X BY THE VOTERS
_BY A SMALL GROUP OF FRIENDS

E. (1) ________________ INVENTED THE ADDING MACHINE
X A YOUNG MAN _ AN OLD MAN _ A YOUNG LADY _AN OLD LADY
(2) ONE ADDING MACHINE WAS INVENTED ABOUT ________________
_30 YEARS AGO _ 20 YEARS AGO _ 200 YEARS AGO X 300 YEARS AGO
(3) THE INVENTOR MADE IT FOR USE BY ________________
_INTERNAL REVENUE SERVICE _ HIS BROTHER _ HIS SISTER X HIS FATHER
(4) THE INVENTOR'S FATHER ________________
X SET TAX RATES _OWNED A FARM _RAISED COWS _ SOLD LAND AND ANIMALS

F. (1) THE AGE OF THE GIRL WAS ________________
_ SEVENTEEN X FOURTEEN _SEVEN _ FOUR

(2) SHE WORKED AS A ____________

__WAITRESS X CLEANING GIRL __ COOK __ NURSE

(3) SHE WENT TO LIVE ____________

__ IN AN APARTMENT WITH HER AUNT __ IN AN APARTMENT WITH HER UNCLE __ IN A HOUSE WITH HER AUNT X IN A HOUSE WITH HER UNCLE

(4) THE UNCLE ____________

__MADE THE GIRL PAY RENT __ BUILT HOUSES X OWNED THE HOUSE __ PAYED RENT TO A CLEANING GIRL

SECTION IV - Greco-Latin Squares: Test Sessions

Note: Message transmission rates 1(slow) - 6 (fast)
Messages = A - F

Test I

	Order of Presentation					
Subject	1st	2nd	3rd	4th	5th	6th
1	E-5	B-2	A-1	D-4	F-6	C-3
2	D-3	B-1	F-5	A-6	E-4	C-2
3	F-4	E-3	B-6	D-2	A-5	C-1
4	E-2	C-6	A-4	F-3	D-1	B-5
5	D-6	C-5	A-3	E-1	F-2	B-4
6	F-1	C-4	A-2	D-5	B-3	E-6

Test II

	Order of Presentation					
Subject	1st	2nd	3rd	4th	5th	6th
1	F-1	A-6	C-4	D-3	B-5	E-2
2	D-4	A-1	E-3	C-5	F-2	B-6
3	C-6	E-4	D-5	A-2	B-1	F-3
4	E-5	A-3	B-2	D-6	F-4	C-1
5	B-3	C-2	D-1	A-4	E-6	F-5
6	D-2	A-5	F-6	E-1	C-3	B-4

Greco-Latin Squares: Test Sessions (Continued)

Test I

Order of Presentation						
Subject	1st	2nd	3rd	4th	5th	6th
7	F-1	C-3	D-4	E-2	A-5	B-6
8	D-6	A-3	C-2	E-4	B-1	F-5
9	C-5	F-4	A-6	B-2	E-1	D-3
10	D-1	C-6	A-4	F-2	B-5	E-3
11	E-5	A-1	B-3	C-4	D-2	F-6
12	A-2	C-1	F-3	E-6	D-5	B-4

"When researchers achieve a better understanding of the individual's stratification of sensory and motor capabilities, and how these capabilities change with, among others, training, growth, and environmental modifications, educators will be in a better position to aid the learning-disabled and/or physically handicapped student with interfaces that match the automata to the characteristics of the human operator."

Test II

Order of Presentation						
Subject	1st	2nd	3rd	4th	5th	6th
7	B-4	D-2	E-6	F-3	A-1	C-5
8	B-2	A-4	F-5	D-6	E-1	C-3
9	F-1	C-6	A-3	D-4	B-5	E-2
10	C-4	B-6	F-2	A-5	E-3	D-1
11	F-4	B-1	E-5	C-2	A-6	D-3
12	E-4	A-2	B-3	F-6	D-5	C-1

SECTION V - Percentage Error Score for Message Reproduction: Test I

Display A						
	Slow	Message Transmission Rate (lps)				Fast
Subject	1	2	3	4	5	6
1	0.0	16.95	0.0	6.38	91.49	94.23
2	77.97	100.00	80.85	100.00	94.23	100.00
3	0.0	42.55	78.72	82.69	89.80	100.00
4	0.0	42.55	63.46	100.00	100.00	93.48
5	21.28	7.69	24.49	83.05	100.00	100.00
6	40.38	48.98	61.02	93.48	97.87	100.00
7	0.0	51.06	10.87	89.36	100.00	100.00
8	30.51	30.43	67.35	72.34	86.54	95.74
9	10.64	81.36	8.51	86.54	100.00	100.00
10	8.51	13.46	57.45	100.00	98.31	100.00
11	0.0	36.17	66.10	69.57	100.00	94.23
12	21.74	32.65	25.00	86.44	100.00	100.00
Sum	211.03	503.85	543.82	969.85	1158.24	1177.68
Mean	17.59	41.99	45.32	80.82	96.52	98.14
Median	9.58	39.36	59.24	86.49	99.16	100.00

Percentage Error Score for Message Reproduction (Continued)

Display B						
	Slow	Message Transmission Rate (lps)				Fast
Subject	1	2	3	4	5	6
1	20.41	11.86	15.22	17.02	61.70	44.23
2	22.03	2.17	2.13	14.89	19.23	6.12
3	6.52	42.55	57.45	19.23	14.29	22.03
4	0.0	0.0	0.0	0.0	10.17	0.0
5	23.40	7.69	14.29	44.07	4.35	25.53
6	11.54	14.29	33.90	13.04	36.17	27.66
7	1.92	19.15	4.35	21.28	6.12	62.71
8	0.0	10.87	0.0	23.40	17.31	25.53
9	0.0	0.0	21.28	25.00	0.0	0.0
10	4.26	40.38	17.02	21.41	23.73	39.13
11	0.0	0.0	18.64	10.87	31.91	19.23
12	28.26	20.41	38.46	40.68	23.40	38.30
Sum	118.34	169.37	222.74	250.89	248.38	310.47
Mean	9.87	14.11	18.56	20.91	20.70	25.87
Median	5.39	11.37	16.12	20.26	18.27	25.53

Percentage Error Score for Message Reproduction (Continued)

Display C						
	Slow	Message Transmission Rate (lps)				Fast
Subject	1	2	3	4	5	6
1	16.33	44.07	43.48	55.32	85.11	94.23
2	13.56	6.52	68.09	51.06	86.54	65.31
3	21.74	72.34	100.00	63.46	91.84	100.00
4	6.38	51.06	71.15	95.92	89.83	93.48
5	17.02	30.77	28.57	100.00	63.04	97.83
6	11.54	57.14	84.75	65.22	74.47	100.00
7	0.0	53.19	6.52	59.57	100.00	100.00
8	55.93	39.13	75.51	78.72	69.23	100.00
9	42.55	67.80	42.55	38.46	0.0	85.71
10	6.38	11.54	10.64	16.33	100.00	86.96
11	16.33	4.26	55.93	0.0	100.00	82.69
12	0.0	81.63	76.92	100.00	100.00	100.00
Sum	207.76	519.45	664.11	724.06	960.06	1106.21
Mean	17.31	43.29	55.34	60.34	80.01	92.18
Median	14.95	47.57	62.01	61.51	88.19	96.03

SECTION VI-Tables I, II, and III

TABLE I

DISPLAY SPECIFICATIONS

Display	Simultaneous Character Capacity	Character Height	Center-to-Center Spacing of Characters	Character/ Ground Hue	Character Medium	Character Style or Components
A	1	.14 in.	.44 in.	Black on White (Ground Diameter= .305 in.)	Light Diffusing Plastic Cover	Special Design, Similar to "Fortune Bold"
B	8	.625 in.	.81 in.	Orange-Red on Off-Black	8 Nixie Tubes (gas discharge tubes)	13 Straight Line Segments per Cell
C	1	.625 in.	Not Applicable	Orange-Red on Off-Black	Nixie Tube (gas discharge tube)	13 Straight Line Segments

TABLE II

FLESCH SCORES OF "READING EASE." AFTER FLESCH (1948).

"Reading Ease" Score	Description of Style	Typical Magazine	Syllables per 100 Words	Average Sentence Length in Words
0 to 30	Very Difficult	Scientific	192 or more	29 or more
30 to 50	Difficult	Academic	167	25
50 to 60	Fairly Difficult	Quality	155	21
60 to 70	Standard	Digests	147	17
70 to 80	Fairly Easy	Slick-fiction	139	14
80 to 90	Easy	Pulp-fiction	131	11
90 to 100	Very Easy	Comics	123 or less	8 or less

(Note: In scoring practice and test messages, numerals were counted as two syllables.)

TABLE III

ANALYSIS OF VARIANCE, TWO DEGREES OF FREEDOM

	1.0	2.0	3.0	4.0	5.0	6.0
Test I	8.1	11.2	9.5	11.2	17.8	18.7
α	.02	.01	.01	.01	.001	.001
Test II	1.2	1.2	9.5	12.0	15.5	11.8
α	NS	NS	.01	.01	.001	.01

Rates of Message Presentation (lps)

The X_r^2 for Intelligibility (Test I) and Comprehension (Test II) for each rate of message presentation are listed over their respective levels of significance. Only two conditions failed to reach significance at the .05 level or beyond, and are designated NS (not significant). Table values of X_r^2 are:

$$\alpha_{.05} = 5.99; \quad \alpha_{.02} = 7.82; \quad \alpha_{.01} = 9.21; \quad \alpha_{.001} = 13.8.$$

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SECTION VII - Number of Questions Answered Correctly Out of Four: Test II

Display A						
	Slow	Message Transmission Rate (lps)				Fast
Subject	1	2	3	4	5	6
1	4	4	4	3	2	1
2	4	3	3	3	2	1
3	4	4	3	2	2	2
4	3	3	0	2	1	2
5	4	4	3	2	0	3
6	3	3	2	1	1	1
7	4	4	3	4	2	3
8	4	4	3	3	2	1
9	4	4	3	2	0	2
10	4	4	4	4	0	1
11	4	4	2	2	1	0
12	4	3	4	1	3	1
Mean	3.83	3.66	2.75	2.42	1.33	1.50

Number of Questions Answered Correctly Out of Four (Continued)

Display B						
	Slow	Message Transmission Rate (lps)				Fast
Subject	1	2	3	4	5	6
1	4	4	4	4	4	4
2	4	3	3	4	4	4
3	4	1	3	4	3	4
4	4	4	4	4	4	4
5	3	3	4	3	4	3
6	4	4	4	4	4	3
7	4	4	3	4	4	3
8	4	4	4	2	3	4
9	4	4	4	4	4	4
10	3	3	4	4	4	4
11	4	4	4	4	3	4
12	4	2	4	4	3	4
Mean	3.84	3.33	3.75	3.75	3.67	3.75

Number of Questions Answered Correctly Out of Four (Continued)

Display C						
	Slow	Message Transmission Rate (lps)				Fast
Subject	1	2	3	4	5	6
1	4	3	4	3	1	2
2	3	4	2	3	3	2
3	4	2	1	2	1	1
4	4	4	2	0	2	4
5	3	4	1	2	3	2
6	4	2	1	1	0	1
7	2	4	2	3	3	3
8	3	2	3	1	1	2
9	3	2	4	3	2	1
10	4	4	2	4	1	4
11	4	4	3	4	2	0
12	4	3	3	1	3	2
Mean	3.5	3.16	2.33	2.25	1.83	2.0

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> *"Cybernetics, the science of control of man and automata, has taught us the concepts of feedback and purposeful behavior control systems. Using these principles, handicapped persons can be taught to communicate via human-engineered interfaces."*

Appendix E | TESTS

DEXTERITY TEST

This initial test of finger dexterity, developed at C/R/I in 1969, was part of the battery of tests given to subjects in studies described in this report. The test provided an objective measure of hand and finger dexterity in relation to typing potential, in terms of the speed and accuracy with which handicapped and nonhandicapped subjects could strike the keys of a standard electric typewriter.

DEXTERITY TEST*

(To be given on standard electric typewriter)

I. SEQUENTIAL ORDER TEST

Left Hand Test:

Cover all keys except F, D, S, A.

Keys to be hit in order, right to left beginning with index finger:
index = F; middle = D; ring = S; little = A.
Demonstrate hitting all keys in order.
Directions to child: "Do this as quickly as you can."
Time:

Right Hand Test:

Cover all keys except J, K, L, ";"
Keys to be hit in order, left to right beginning with index finger:
index = J; middle = K; ring = L; little = ";"
Directions to child: "Do this as quickly as you can."
Time:

Directions to teacher: If subject is not able to use individual fingers, note which fingers used and any problems.

Teacher's Notes:

*Form No. 107 (June 1969)

II. CONSECUTIVE KEY DEPRESSION TEST

Do not cover keys.
Demonstrate with same placement of fingers as in test I, hitting each key five times consecutively. Point to key; say name of letter. Direct child to hit five times as quickly as possible. Count for child as he depresses keys.

Time: If task is completed in 5 seconds per key, check for those passed. If subject is very slow and time exceeds 5 seconds, note time task required and reasons for slowness.

Right Hand Test:		Left Hand Test:	
index =	J	index =	F
middle =	K	middle =	D
ring =	L	ring =	S
little =	;	little =	A

III. DIGITAL AIMING ABILITY TEST

Cover right side of typewriter (beginning with Y,H,N). Direct child to hit key named, using designated finger. Do not place fingers on keys; child should find and depress keys from starting point, hands in lap or on table; return to start position after key depressed. Teacher should point to key, say letter, and designate finger to be used.

Time: Same as Test II. Check if passed, if missed; note letter struck and why designated letter was missed.

Left Hand Test:

index =	T
middle =	D
ring =	X
little =	Q

Right Hand Test:

index =	B
middle =	U
ring =	K
little =	P

Teacher's Notes:

DEXTERITY TEST – SCORING KEY

I. SEQUENTIAL ORDER TEST -- POSSIBLE SCORE 20

Left Hand Test:

No. of Seconds	Score
11+	0
10	1
9	2
8	3
7	4
6	5
5	6
4	7
3	8
2	9
1	10

Right Hand Test:
(Same as Left, above)

II. CONSECUTIVE KEY DEPRESSION TEST – POSSIBLE SCORE 8
One point for each check

III. DIGITAL AIMING ABILITY TEST – POSSIBLE SCORE 8
One point for each perfect response

TOTAL POSSIBLE SCORE 36

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DEXTERITY TEST

This test developed at C/R/I was adapted from "The Tapping Test" by John C. Flanagan, 1959 (Psychometric Techniques Associates, Pittsburgh, Pennsylvania). It provides an objective measure of dexterity for each finger, as an indicator of potential for typewriting and other tasks requiring finger manipulation, and was effective January 1970.

TAPPING TEST OF FINGER DEXTERITY

Instructions

Materials needed for each test subject are:
- 1 test booklet
- 10 finger-tip pads
- 1 container of paint or ink
- 1 applicator or brush

The test of dexterity requires that an inked pad be attached to the subject's finger tip. Two types of exercises are provided for each finger, both of which involve tapping a single spot of ink or paint inside each of a series of circles inscribed on the test page. In the first exercise, the subject must tap a spot of ink or paint within each circle, working across rows from left to right for a timed 15 second period. In the second exercise, the subject taps a spot in only those circles which do not contain an "X", again working across rows from left to right for a timed 15 second period.

Practice Sessions. Preceding the test series, the subject should be given practice with each finger of each hand. The first two pages of the test booklet are used for this purpose. Begin with the circles on the first page. For this practice session, do not use the fingertip pads. Tell the child:

"THIS IS AN EXERCISE TO SHOW HOW WELL YOU CAN USE YOUR FINGERS. WE WILL START BY GIVING YOU PRACTICE IN USING YOUR FINGERS."

(Show child first page of test booklet.)

"HERE YOU SEE CIRCLES ARRANGED IN ROWS. START WITH THIS FINGER (THUMB) OF YOUR RIGHT HAND AND TAP ONCE INSIDE EACH CIRCLE FROM LEFT TO RIGHT ACROSS EACH ROW."--- (Demonstrate)---"I WILL TELL YOU WHEN TO START AND WHEN TO STOP."

Allow subject about 5-10 seconds with each finger for these practice trials.

If the subject has full use of all fingers, begin with the thumb and proceed to index, middle, ring, and little fingers of the right, then the left hand. If the subject has no use whatsoever of one or more fingers, make note of this and omit these fingers in the test series.

After giving practice with both hands, turn to the second page of the test booklet. Tell the child:

"THIS TIME I WANT YOU TO TAP ONLY THE EMPTY CIRCLES. DO NOT TAP THE CIRCLES CONTAINING AN "X". START WITH THIS FINGER (THUMB) OF YOUR RIGHT HAND AND TAP INSIDE EACH EMPTY CIRCLE UNTIL I TELL YOU TO STOP."

Allow subject about 5-10 seconds with each finger for these practice trials.

On this practice page, omit finger(s) found to be unusable during the preceding practice session. Otherwise, proceed with each finger of right and left hands as before.

Test Session. There are twenty test pages, two for each finger. Begin with the right hand, testing in the order thumb, index finger, middle finger, ring finger, and little finger; then test the left hand using the same finger order. Omit any fingers found to be unusable during the practice session.

Attach a finger-tip pad to the surface of the first finger to be tested (usually the thumb) by peeling off the protective backing to expose the adhesive side of the pad. If the pad does not stick firmly to the skin, scrub the subject's finger with alcohol to remove skin oils, and dry thoroughly. Attach a finger-pad to the skin surface near the finger tip. Locate the pad in the most convenient and comfortable position for each child. For the thumb, the child may find it more comfortable if the pad is positioned on the outside edge of the thumb. Tell the subject:

"IN A MOMENT, I WILL PUT INK (PAINT) ON THIS FINGER PAD AND ASK YOU TO TAP A SPOT INSIDE EACH CIRCLE ON THE PAGE. TRY TO TAP INSIDE EACH CIRCLE WITH THE PAD, LIKE THIS."--- (Demonstrate by guiding child's hand and finger).---"NOW I WILL PUT INK (PAINT) ON THE PAD."

Apply ink or paint to the pad using a brush applicator. The pad should be moist but not saturated, so that no liquid will be squeezed onto the child's finger during testing. Tell the child:

"NOW I WANT YOU TO TAP A SPOT INSIDE EACH CIRCLE. WORK FROM LEFT TO RIGHT ACROSS EACH ROW. GO AS FAST AS YOU CAN, BUT TRY TO MAKE EACH SPOT FALL INSIDE EACH CIRCLE. I WILL TELL YOU WHEN TO START AND STOP."

Using a stop watch, time the subject for exactly 15 seconds, then stop. Turn to the next page. Apply a little fresh ink or paint to the pad if necessary. Tell the subject:

"THIS TIME, TRY TO TAP A SPOT INSIDE EACH EMPTY CIRCLE. DO NOT TAP CIRCLES CONTAINING AN 'X'. I WILL TELL YOU WHEN TO START AND STOP. IF YOU FINISH THE ROWS ON THE LEFT SIDE OF THE PAGE, CONTINUE IMMEDIATELY TO THE TOP ROW ON THE RIGHT SIDE OF THE PAGE AND KEEP WORKING UNTIL I ASK YOU TO STOP."

Again, time the subject for 15 seconds.

Remove the finger pad and discard it. Scrub with alcohol the next finger to be tested, apply a new finger pad, and proceed as before. Continue until all fingers have been tested.

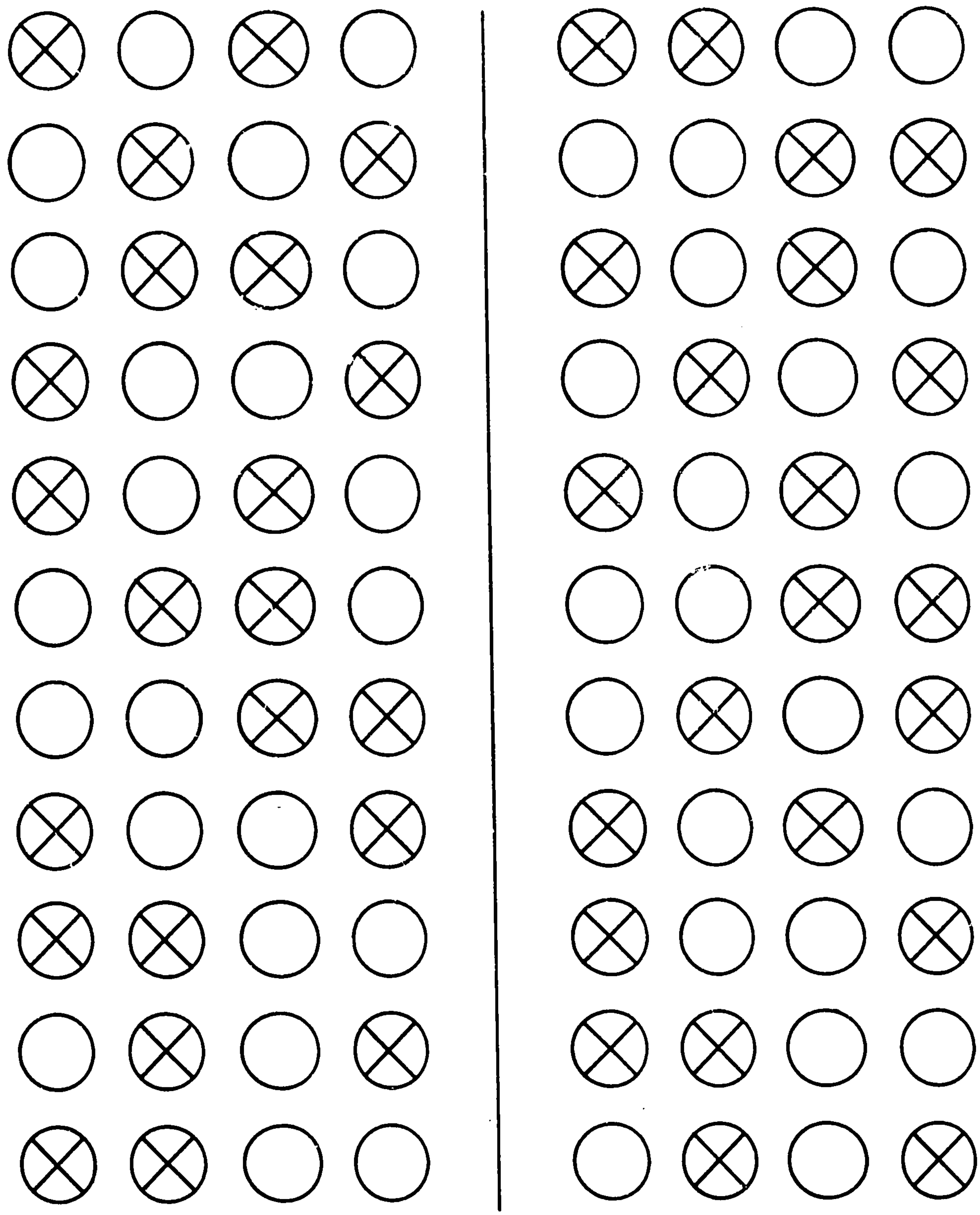
At the top of each test page, write in the spaces provided the hand (right or left) and finger being tested. Write the child's name, the experimenter's name, the date, and the testing location in the spaces provided on the front page of the test booklet. Also, record any comments about the test procedure, fingers omitted from testing, procedural errors or changes, etc., in the space provided for that purpose.

Scoring. For each test page, count the number of circles containing a spot and record that number in the space at the top of the page. Do not count circles for which less than half of the spot lies inside the circle.

C/R/I

Tapping Test of Finger Dexterity

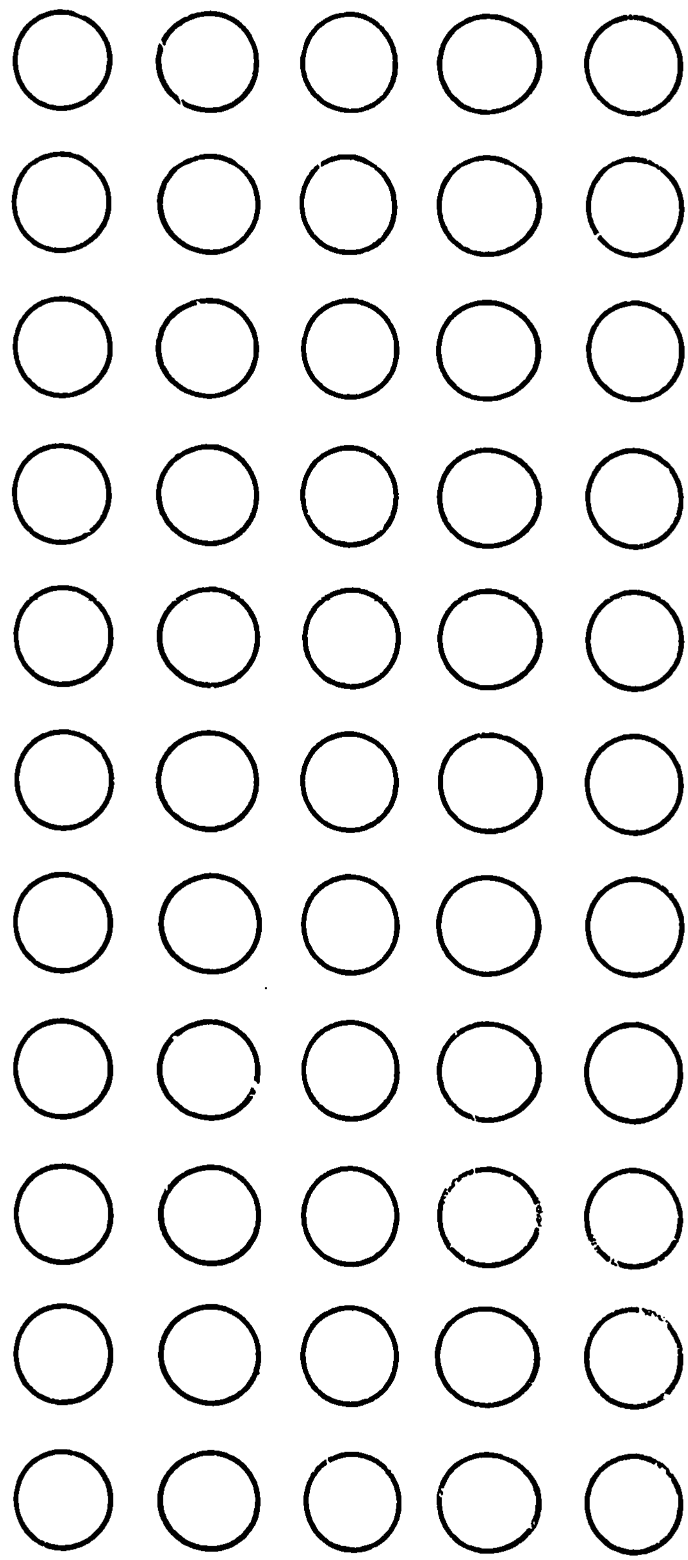
Hand | Finger | Score



C/R/I

Tapping Test of Finger Dexterity

Hand | Finger | Score



Appendix J INSTRUCTIONAL PROCEDURES

INTRODUCTION TO CYBERTYPE™ † INSTRUCTIONAL MANUALS*

<u>Introduction</u>

Physically handicapped children and children with neurological dysfunctions are often unable to provide the muscular coordination and dexterity necessary to communicate in written form, either by handwriting or by operating the 49 keys of an ordinary electric typewriter. These handicaps, especially when accompanied by language impairments and specific learning disabilities, severely impede further development of intellectual and verbal potentialities. As a result, many multiply handicapped individuals, especially children who potentially have the intellectual competence to become self-sufficient contributing members of society, are institutionalized because their motor capabilities appear too limited for independent and practical functioning.

In spite of the apparent hopelessness of many children with multiple handicaps, it has been demonstrated that it is often possible to employ cybernetic systems which permit use of the individual's remaining motor capabilities. (C/R/I Interim Report, 1968 and C/R/I Second Report, 1970.)

Cybernetics Research Institute (C/R/I) is presently conducting research for the purpose of studying severely disabled students' ability to communicate by means of the CYBERCOM™ †family of man-machine systems. Children who have the cognitive ability but whose other disabilities preclude cursive writing or operation of ordinary typewriters are being studied through observation and testing. Where possible, man-machine systems are provided to the students with interfaces which match the students' remaining performance characteristics, thereby enabling them to operate electric writing machines and/or other communication and control systems.

The materials presented in the C/R/I Instruction Manual are also intended to serve the teacher of exceptional children as an introduction to a teaching guide for "Cybertype" man-machine communications systems, and to provide him with an organized program of instruction for these systems together with appropriate training, testing and exercise materials. The C/R/I Manual is also intended for use as a guide in selections of the appropriate interface or "keyboard" and special instructional materials, if necessary. Substitute exercises and other special materials, if needed, should be determined by the teacher or researcher.

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*The instructional materials contained in this Appendix represent a condensed version of the educational research materials developed during the course of the study.

† Trademark, Cyber Corp., Washington, D. C.

Description of Basic Cybertype Keyboards or Interfaces*

The basic characteristics underlying the "Cybertype" system involve the concept of "dual-input." That is, instead of requiring operation of one key at a time to produce typed letters, symbols, or functions, as with an ordinary typewriter keyboard, the "Cybertype" systems operate from dual-inputs which may be bilaterally or unilaterally controlled.

Two inputs must be provided, that is, two keys (or one key which serves the purpose of two keys) are operated at one time, or they may be operated in sequence. Although dual-input operation may seem unusual at first, as compared to single-input operation, dual-input systems offer the advantages of simplified keyboard arrangement and flexibility permitting interface matching to the performance characteristics of the human operator. Another advantage, and an important one, is that the keying code is easy to remember. With a little practice, the users do not have to refer to charts or marked keys once they have learned the code. Only two basic coding relationships are necessary to remember, e.g., 1 and 1 for the typewriter "space" function, 1 and 2 for the letter E, 1 and 3 for the letter T, 1 and 4 for the letter A, etc.

Interface Configurations

One configuration of the 14-key "Cybertype" keyboard interface consists of 14 finger or prostheses-operated keys, arranged in two groups of 7 keys each, as shown in Figure 1. Typically, key-tops on this type of interface are 1/2 x 1/2 inch in size, with a lateral separation between keys of one inch center-to-center. For purposes of identification, keys are numbered from 1 to 7 in right and left hand banks (see Figure 1). This numerical identification of keys should be remembered, since it will be referred to frequently in this Manual. Some keyboard interfaces include an ON/OFF toggle switch and pilot light, as shown in Figure 1.

The 14-key keyboard is electrically connected to an electric typewriter which provides the printed output. Each letter, symbol or function to be produced is assigned to a pair of keys, one key in each of the two banks.

In this configuration of the dual-input interface, two keys are operated together using a finger of the right hand for the keys identified as the "Function Keys" or the right bank of keys, and a finger of the left hand for the left bank identified as the "Control Keys." It has been found that many students who lack the manual coordination and dexterity necessary to strike individual keys on the 49-key interface of an ordinary typewriter, can, with little difficulty, strike pairs of keys on the 14-key,

*The term "interface" here refers to the keyboard or control mechanisms which are the point of contact between user and typewriter. In the case of an ordinary electric typewriter, the keys of the 49-key keyboard may be identified as the "interface." With a "Cybertype" system, which is for a typewriter or other office or computational machines, the 14-key, 7-key, or 2-key keyboards or single-key control, or other interface configurations constitute the "interface."

dual-input interface, using one finger of each hand, prostheses, or other parts of the body when larger keyboards are used. The small area to be covered, the minimum number of keys on the interface, the large key-tops and spacing of keys, the ease of learning the keying positions, and the minimum coordination required, bilaterally or unilaterally, are all factors which may contribute to the ease with which the "Cybertype" can be operated by individuals who are physically and/or neurologically disabled, but who have the cognitive and sensory capabilities.

Interface Coding

The code assigning letters to pairs of keys of most of the interfaces is based on the frequencies of letter usage in the English language.‡ Although various studies have revealed slight differences in letter frequencies, the "Cybertype" code described in this Manual is based on the following order of letters from most frequent to least frequent:

E T A O N I R S H D C L M U F P Y B G W V J K Q Z X

For a right hand dominant individual, each of the six most frequently used letters (E-T-A-O-N-I) and the typewriter "space" function can be produced by activating one key on each side of the keyboard. As shown in Figure 2, these letters and functions are produced by activating Key No. 1 of the left bank of keys, combined with individual keys of the right bank. For identification and descriptive purposes as noted earlier, the seven keys on the left side of the interface are referred to as "Control Keys" and the seven keys of the right group are referred to as "Function Keys" (Figure 1).

The assignment of certain typewriter symbols, such as "!" and "+" depends on the model of typewriter used with the "Cybertype." The code for numerals, symbols, and functions shown in Figure 3 applies to the IBM*™ Selectric" typewriter with "Prestige Elite," "Courier," "Letter Gothic," or "Delegate" type styles. The code for the IBM Models C and D differ slightly.

Through the use of a "code-reversal junction box," which connects the interface(s) to a "cybertypewriter," the key assignments for left and right-hand key groups can be interchanged, for operation by a left-hand dominant individual.

This Instruction Manual is meant for right-hand dominant individuals, and the "Control Keys" on the left side of the interface and "Function Keys" on the right side should be "reversed" if the students are left-handed. Thus, for a left-hand dominant student, the teacher may use the "code-reversal junction box" in place of the usual junction box, thereby shifting the "Control Key" positions to the right side and the "Function Keys" to the left side of the "Cybertype" keyboard. It is important to note that no data is available at this time to support this reversal and teachers may be guided accordingly.

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*Trademark - International Business Machines Corporation, Armonk, New York.

‡For other EPSILONTAUS, see this Volume, Part Nine, page 135, Table XXVI

Other Interface Configurations

Interface configurations other than the 14-key, finger-operated keyboard are employed where they more effectively match the remaining performance capabilities of the individual. For example, many persons lack the coordination and dexterity necessary to operate keys with their fingers, but retain some control to provide gross motor coordination in hands and arms. They may be provided with "fist-controlled" interfaces, one configuration of which consists of 14 large keys with wide spacing, and key-tops with a diameter of one inch and a lateral separation between keys (center-to-center) of two and a quarter inches (see Figure 4). This configuration can be operated with the parts of the upper limbs, e.g., thumbs, fingers, fists, or heels of the hands.

Another type of interface, the "foot-keyboard," consists of key-tops with a diameter of one and a half inches, and a center-to-center lateral separation of three inches (Figure 5). These interfaces can be operated with the fists, heels of the hands, or other parts of the body by persons whose manual coordination is not sufficient for the smaller fist keyboard. In addition, they can be operated with the feet by individuals with virtually no ability to coordinate arm movements, or by upper-arm amputees. For foot-operation, the interface is placed in an appropriate position, either on the floor or on a stand, with the user seated in a chair adjusted to the proper height so that the weight of the legs is supported by the edge of the seat, and the feet "float" just at the level of the key-tops. In this position, keys may be actuated by simple toe depression.

Since the configuration or spatial arrangement of keys in these interfaces is similar to that shown in Figure 1, the letter-keying code is as shown in Figures 2 and 3.

The Cybertype Unilateral Keyboards

Individuals who are unable to provide controlled bilateral coordination in arms, legs, or other parts of the body, employ the dual-input sequential interfaces, which consist of seven typing "Function Keys" and a "reset" or "correction" key. These interfaces require the use of only one part of the body, such as the tongue, a single limb or other portion of the body which can be controlled.

The 7-key keyboards, two versions of which are shown in Figure 6, may be operated by actuating two keys, constituting a pair, sequentially. The first key depressed may be considered to correspond to the left bank or the "Control Key" side of a 14-key interface, and the second key depressed to the right bank or "Function Key" side of a 14-key interface. Thus, striking Key No. 1 followed by Key No. 2 will produce the letter "E." As with a 14-key interface, there are 7 x 7 or 49 possible pairs of dual-inputs which allow production of all the characters and functions available on the typewriters used. See Figure 6.

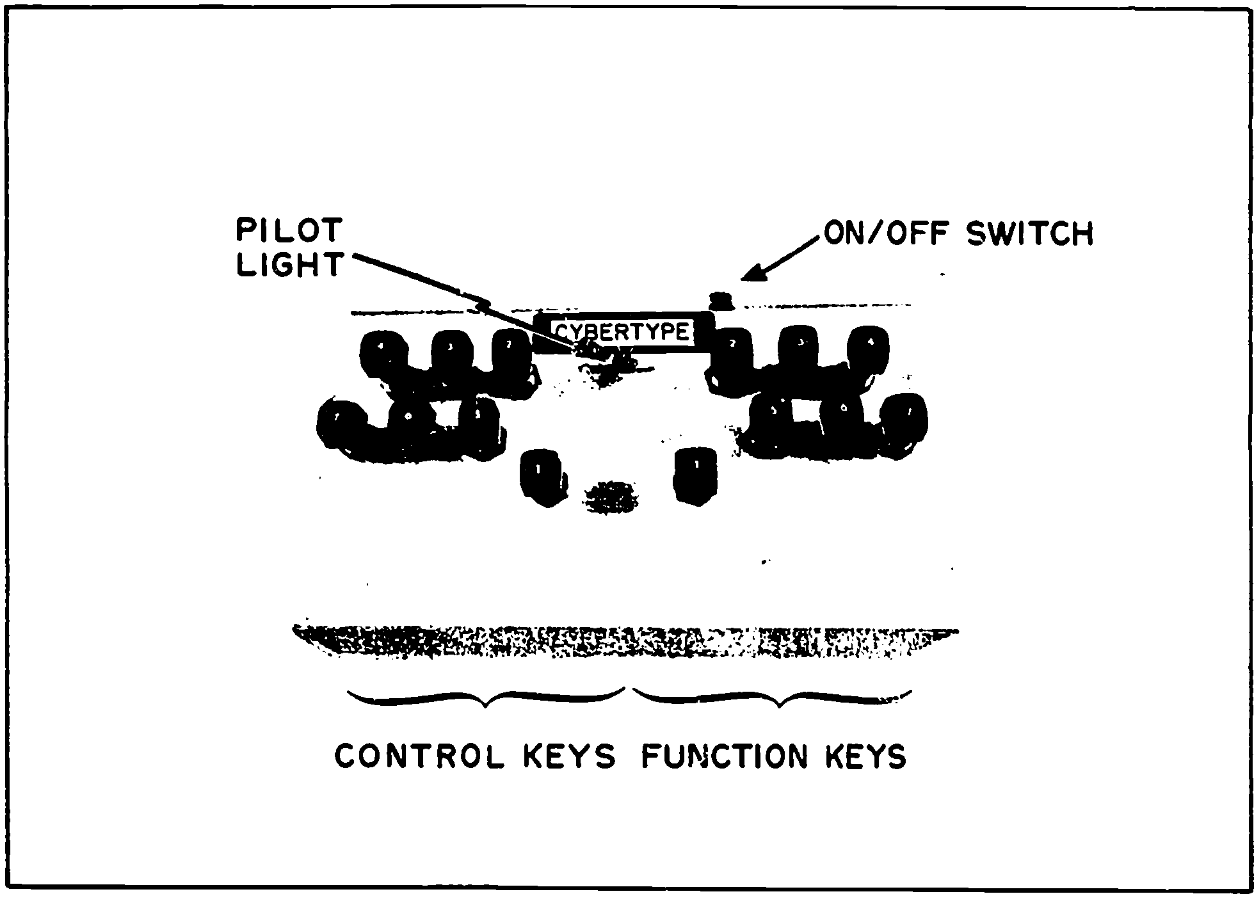


FIGURE 1

"CYBERTYPE," 14-KEY, DUAL-INPUT INTERFACE FOR FINGER OPERATION

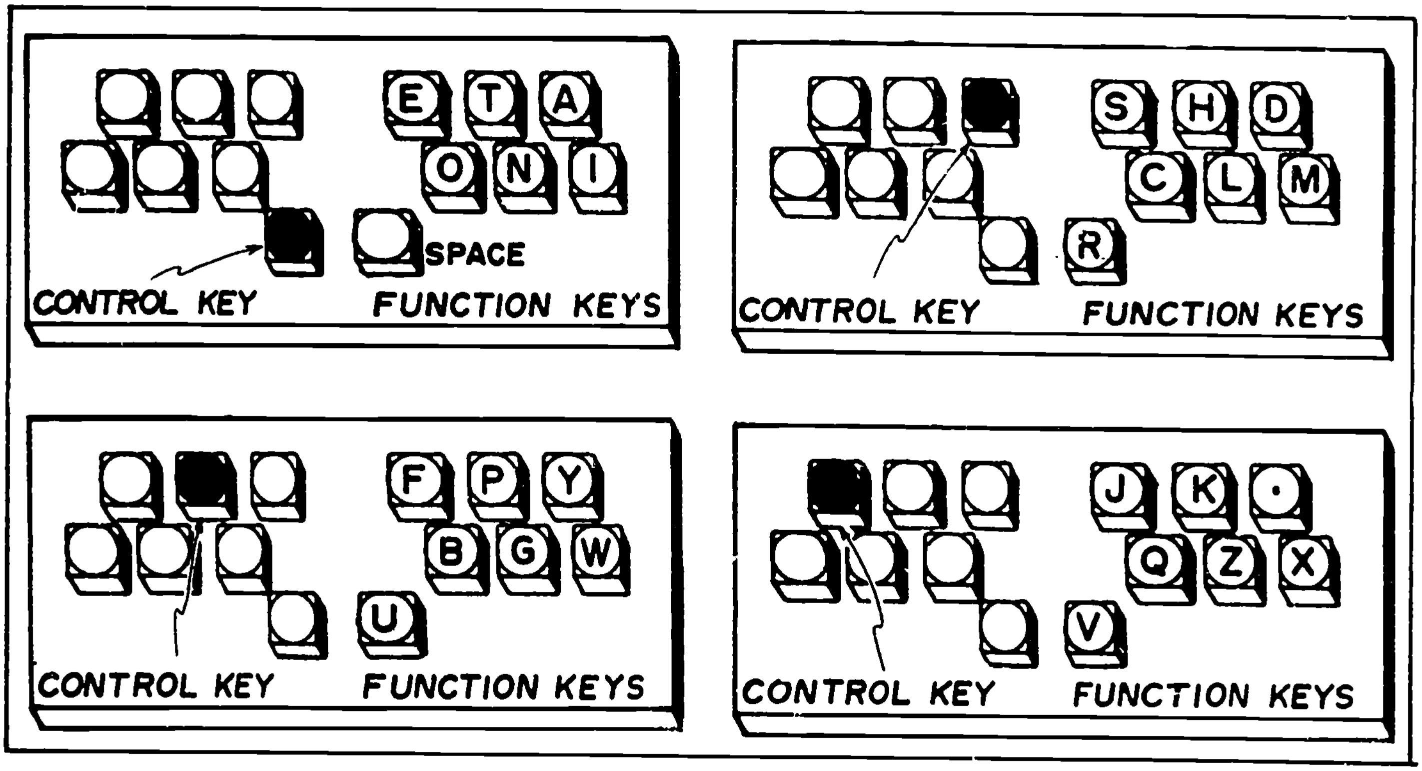


FIGURE 2

KEYING POSITIONS FOR LETTERS, TYPEWRITER SPACE, AND PERIOD WITH THE "CYBERTYPE," 14- KEY INTERFACE AND IBM MODEL C.

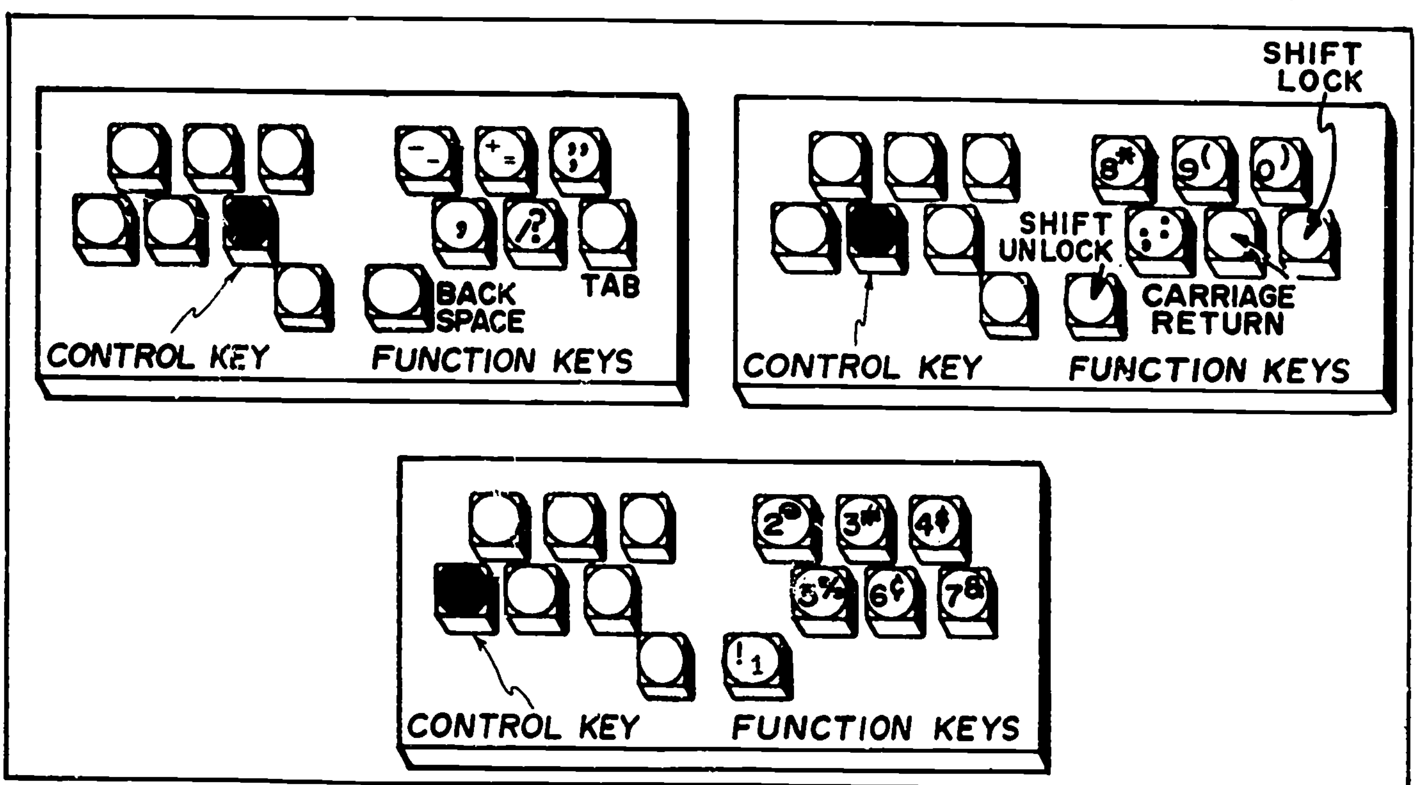


FIGURE 3

KEYING POSITIONS FOR NUMBERS, SYMBOLS, AND TYPEWRITER FUNCTIONS WITH THE "CYBERTYPE,"14-KEY INTERFACE AND IBM MODEL C.

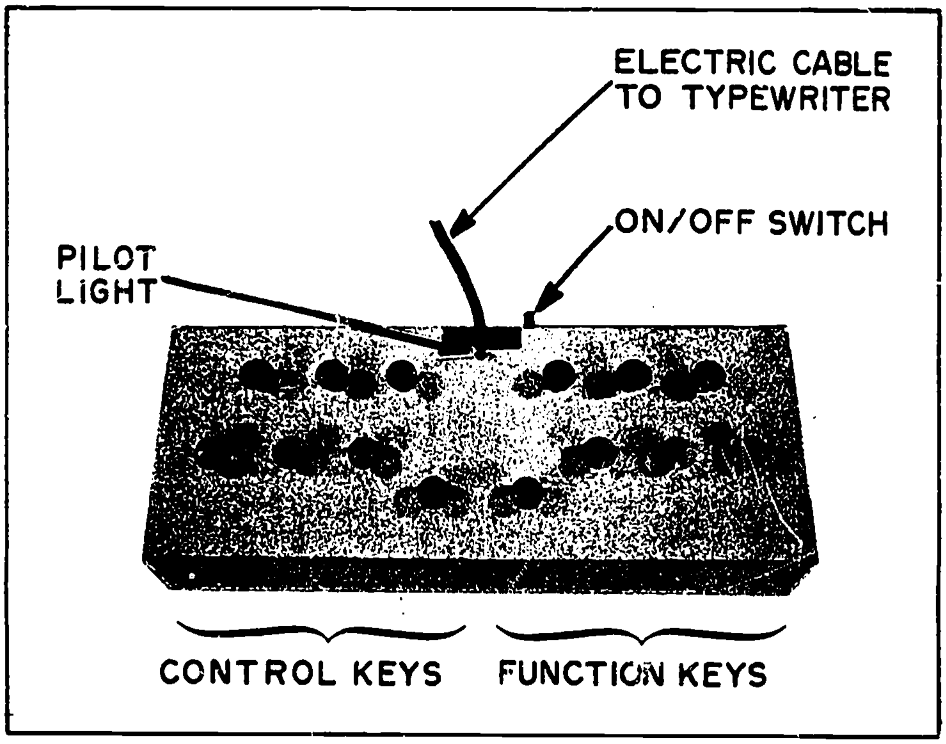


FIGURE 4

"CYBERTYPE," DUAL-INPUT INTERFACE FOR FIST OR HAND OPERATION

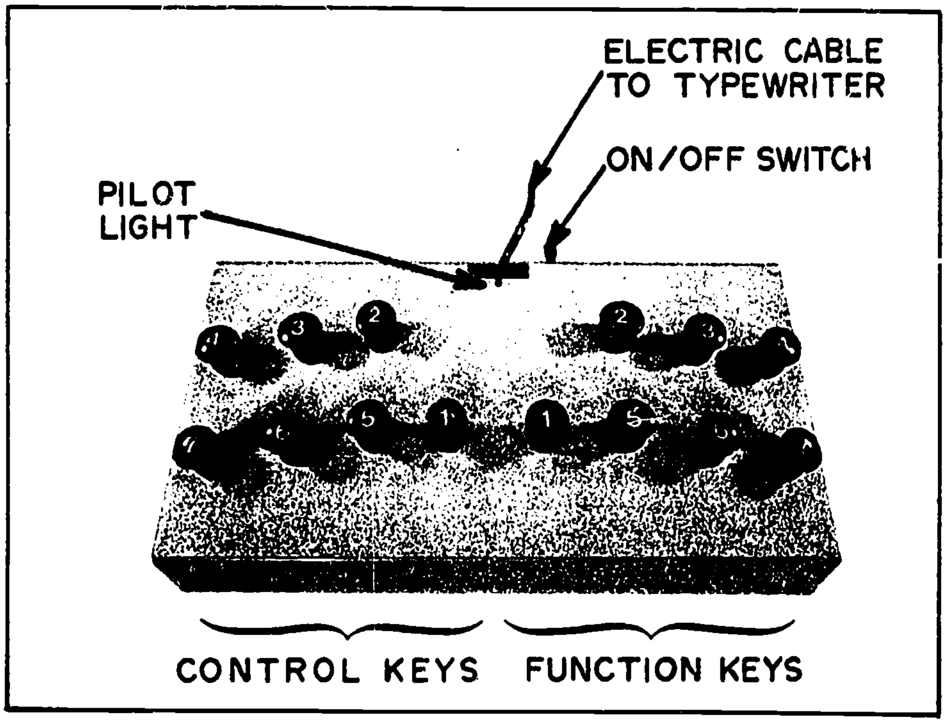
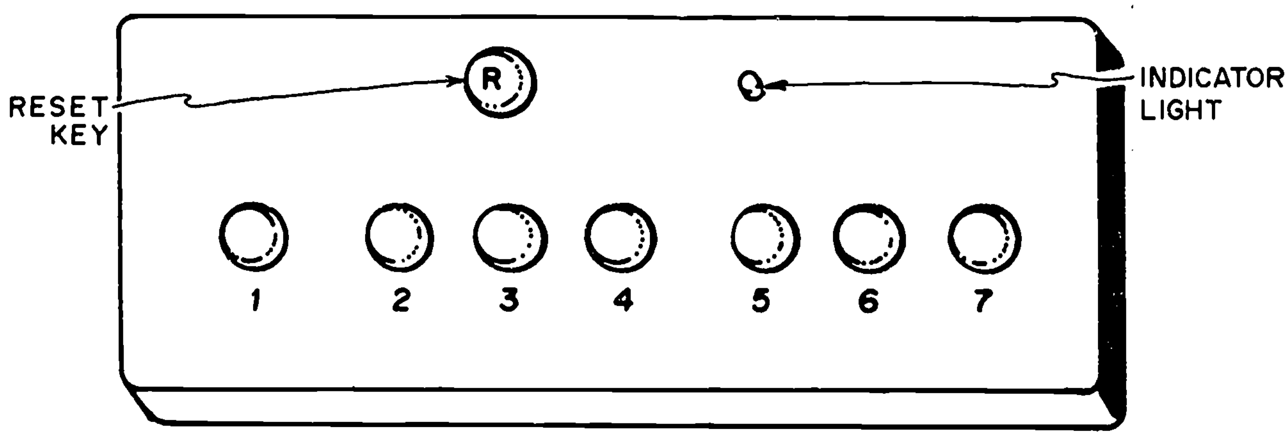
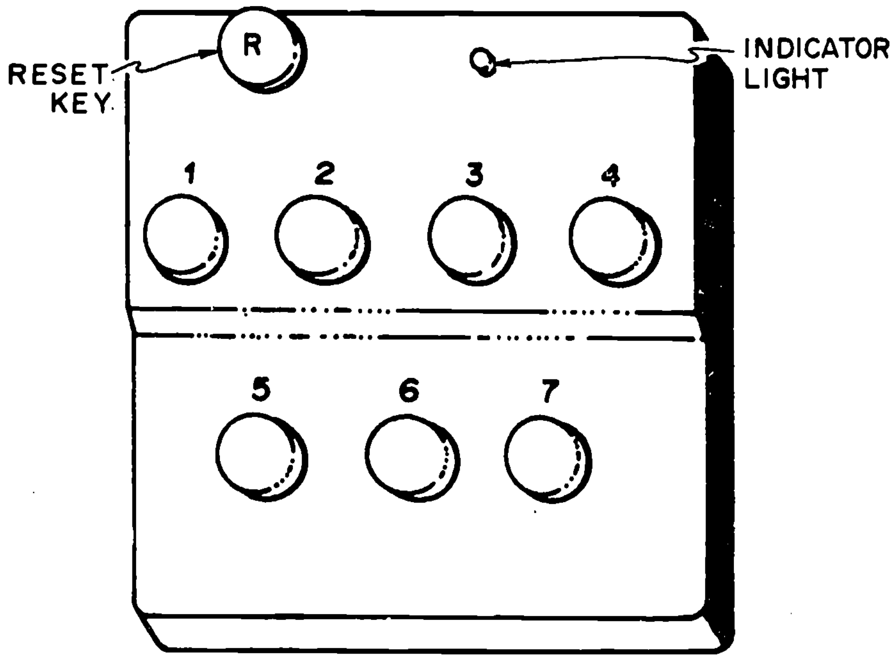


FIGURE 5

"CYBERTYPE," DUAL-INPUT INTERFACE FOR FIST OR FOOT OPERATION



a) Dual-Input Sequential Interface: Single Row



b) Dual-Input Sequential Interface: Double Row

FIGURE 6

"CYBERTYPE," DUAL-INPUT SEQUENTIAL INTERFACE
FOR OPERATION WITH A SINGLE LIMB

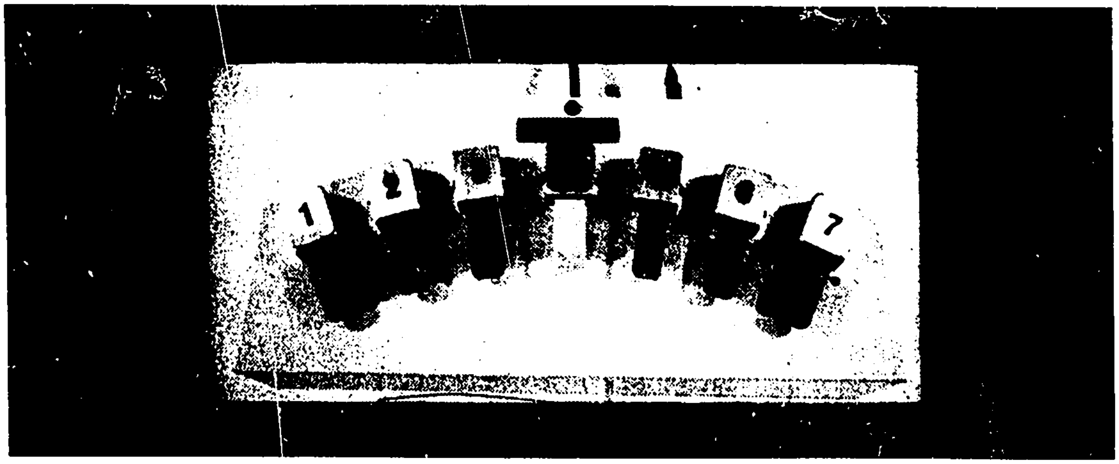


FIGURE 7

7-KEY, DUAL-SEQUENTIAL INTERFACE

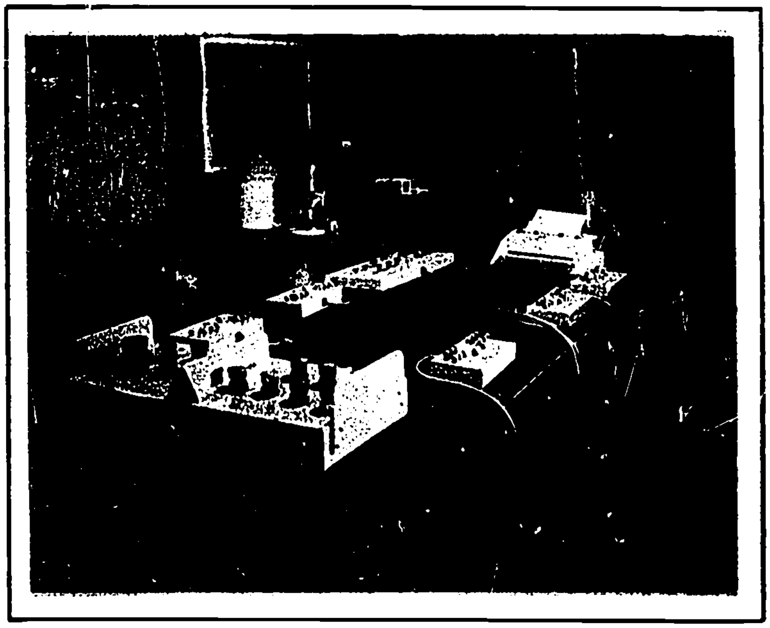


FIGURE 8

A VARIETY OF "CYBERTYPE" INTERFACES
CONNECTED TO A SINGLE ELECTRIC TYPEWRITER FOR GROUP INSTRUCTION

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CYBERTYPE

DUAL-INPUT CYBERCODE

Letter-Keying Code for the 7-Key Dual-Sequential Transfer Code
(For IBM Model C Electric Typewriters)

Control Key* "First-Key" Position	Function Key** "Second-Key" Position	Typewriter Function And Keying Codes: Upper Case	Lower Case	
1	1	Space		1,1
1	2	E	e	1,2
1	3	T	t	1,3
1	4	A	a	1,4
1	5	O	o	1,5
1	6	N	n	1,6
1	7	I	i	1,7
2	1	R	r	2,1
2	2	S	s	2,2
2	3	H	h	2,3
2	4	D	d	2,4
2	5	C	c	2,5
2	6	L	l	2,6
2	7	M	m	2,7
3	1	U	u	3,1
3	2	F	f	3,2
3	3	P	p	3,3
3	4	Y	y	3,4
3	5	B	b	3,5
3	6	G	g	3,6
3	7	W	w	3,7
4	1	V	v	4,1
4	2	J	j	4,2
4	3	K	k	4,3
4	4	. Period	.	4,4
4	5	Q	q	4,5
4	6	Z	z	4,6
4	7	X	x	4,7

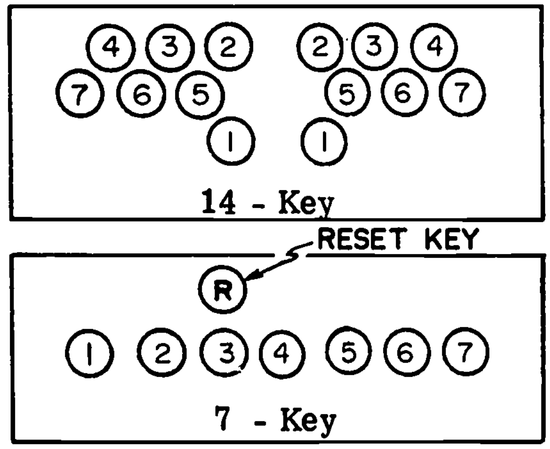
CYBERTYPE

DUAL-INPUT "CYBERCODE" (cont.)

Letter-Keying Code for the 7-Key Dual-Sequential Transfer Code
(For IBM Model C Electric Typewriters)

Control Key* "First-Key" Position	Function Key ** "Second-Key" Position	Typewriter Function And Keying Codes: Upper Case		Lower Case	
5	1		Back Space		5, 1
5	2	_		-	5, 2
5	3	+		=	5, 3
5	4	"		'	5, 4
5	5	,	Comma	,	5, 5
5	6	?		/	5, 6
5	7		Tab		5, 7
6	1		Shift Unlock		6, 1
6	2	*		8	6, 2
6	3	(		9	6, 3
6	4	)		0	6, 4
6	5	Colon :		Semicolon ;	6, 5
6	6		Carriage Return		6, 6
6	7		Shift Lock		6, 7
7	1	!		1	7, 1
7	2	@		2	7, 2
7	3	#		3	7, 3
7	4	$		4	7, 4
7	5	%		5	7, 5
7	6	¢		6	7, 6
7	7	&		7	7, 7

* Code description equivalent to left side of 14-key "Cybertype" keyboard.
** Code description equivalent to right side of 14-key "Cybertype" keyboard.
(See Appendix F, Instructional Procedures or Volume V, C/R/I Final Report, 1971.)



Outline showing key-identifications
7 and 14-Key Keyboards

If the incorrect "Control Key" is depressed inadvertently, the "reset key," which is located near the rear edge of the interface as shown in Figure 6, may be struck in order to clear the system immediately. After the "reset key" is depressed, the correct first key of the key-pair can be actuated, followed by the keying of the second key of the key-pair assigned to the desired letter. If there is an error on the first key struck, "automatic correction" may be achieved without use of the "reset key." All that is required is that the user wait until the red "indicator light" located on the keyboard goes out.

The red "indicator light" (shown in Figure 6) is always illuminated upon initial striking of the first key of each key-pair keying combination. When the second key of the key-pair is actuated, the typed response or typewriter function occurs and the "indicator light" goes out by itself.

The letter-keying code for the 7-key, dual-sequential interface is equivalent to that for the 14-key systems, and is shown in Figure 7. The 7-key interface configurations offer considerable flexibility and can be operated not only with a fist, foot or tongue, but also with a "unicorn," a helmet-mounted stick, or "mouth stick." The interface shown in Figure 6b (4 keys in the upper row, 3 keys in the lower row) consists of somewhat larger key-tops and is suitable for operation by persons who have limited control.

The styles and types of keyboards or interface configurations for use with the "Cybertype" writing machines are almost unlimited. Variations of muscle and body-controlled transducers or keyboards operable from signals generated by the central nervous system, tongue-controlled keyboard, "joy-stick," glove, and lever-actuated switches, together with numerous other interface configurations operable with the aid of prostheses or ortheses can be selected to match the remaining motor capabilities of the disabled person.

Organization of Lesson Plans

This Instruction Manual is organized into 15 lessons. Each lesson should generally last about one hour, and one lesson should be given each day, four or five days a week. This is based on the experience of teachers who have had a high degree of success with their students, all of whom have been children with multiple impairments.

When working with a group of students, a prerequisite is that the teacher, with the aid of each student, select the appropriate interface out of the set of interfaces provided with the system. If only one writing machine in the classroom is available, all of the students' and the teacher's interfaces may be connected to it, as shown in Figure 8. Children may be introduced as a group or individually to the teacher's demonstration of the keying positions of the appropriate keyboard or interface. They should practice operating the interface selected for their use following the procedures enacted by the teacher.

During these group practice sessions, those interfaces which are not used to operate the "cybertypewriter" are either disconnected from the junction box or if equipped with switches, they are turned off. Each student can then be given individual attention in practicing the exercises which accompany each lesson with or without activating the "cybertypewriter." At individual practice sessions the student's interface switch is connected to the junction box or turned "on," so that the desired exercises are typed.

In the meantime, other students whose interfaces are turned "off" are not precluded from practicing; they may practice their exercises by "keying" their interfaces, even though no typewritten output is obtained. Ordinarily, more than one "Cybertype" should be in the classroom, and the teacher can observe each member of the group and obtain typewritten copy for each student in the group by looking at the monitor "Cybertype."

Cyber-Circus Story

The Appendices to this Manual include a "mnemonic" or memorization aid called the "Cyber-Circus Story." The characters and events in this story are related to letters and symbols and to their "Cybertype" keying positions. This story has power to be a valuable aid to memorization with the subjects tested. It appears to develop enthusiasm and to increase the student's motivation in learning to use the "Cybertype" and perform more effectively in their other activities. The story is compatible with the lesson plans in this text.

Supplementary Materials in Instructional Materials Vol's, IV, V, VI, VII.

Volumes IV, V, VI, VII, include "Supplementary Material"sections which provide practice exercises to be used in augmenting the exercises included with each lesson. The teacher may review the Supplementary Materials section and select appropriate exercises which would serve as additions to the regular lesson plans.

It is recognized that students' age levels, cognitive, motor, and sensory capabilities contribute toward their rate of progress. The teacher is encouraged to constantly consider these factors and employ a teaching plan which will have the greatest probability of being effective for a particular student or group of students. It should be remembered that all of the experimental instruction materials were developed for a research study and evaluation program, whose principal objective was to determine the feasibility of the CYBERCOM man-machine communications systems.

The "E-T-A" EPSILONTAU Chart

The "E-T-A" EPSILONTAU Chart* consists of a sequence of letters of the English alphabet derived from a composite of letter-frequency analyses (C/R/I Interim Report, 1968) of English language texts. Its purpose is to acquaint the learner of "Cybertype" interfaces or keyboards with the letters of the alphabet, sequentially commencing with letters E, T, A, etc., in order of decreasing frequency usage.

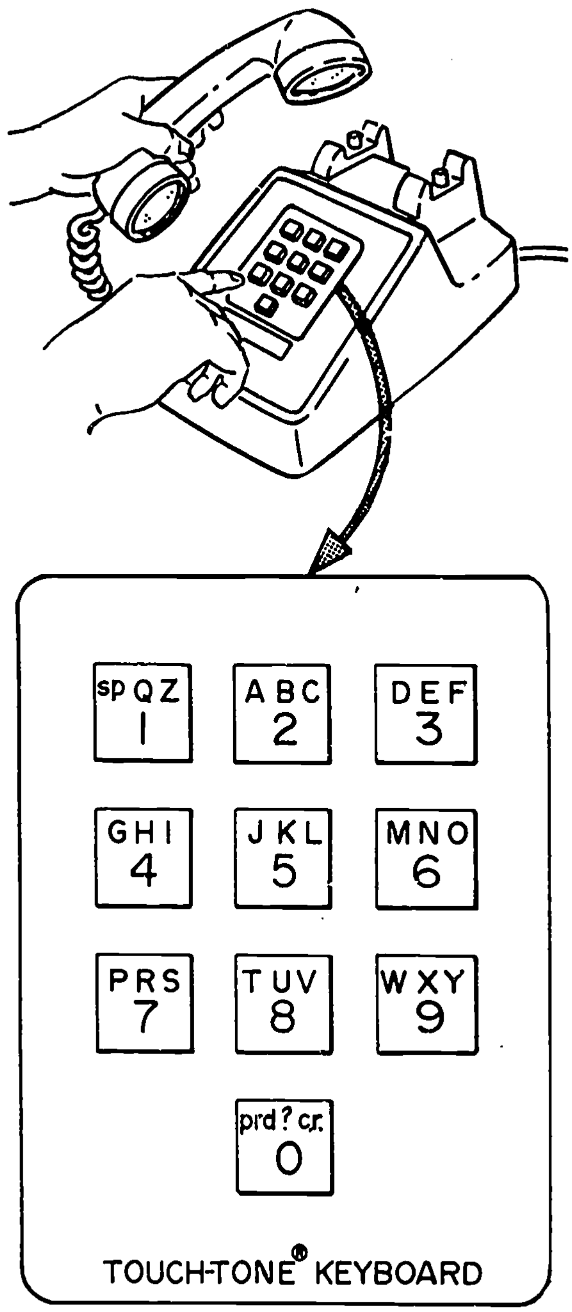
It has not been determined whether more rapid learning of keying codes with retention and reinforcement through introduction of the most frequently used letters is accomplished by introducing letters in this manner, rather than A, B, C, etc.

The "space" function appears initially in the chart since it is most frequently used when typing.

EPSILONTAU CHART

"Space"	H	B
E	D	G
T	C	W
A	L	V
O	M	J
N	U	K
I	F	Q
R	P	Z
S	Y	X

*For other EPSILONTAUS, see this Volume, Part Nine, page 135, Table XXVI



sp = space
prd = period
c.r. = carriage return

upper shift = 8,5
lower shift = 5,5

CHARACTER/ FUNCTION	KEYING SEQUENCE
A	2,1
B	2,2
C	2,3
D	3,1
E	3,2
F	3,3
G	4,1
H	4,2
I	4,3
J	5,1
K	5,2
L	5,3
M	6,1
N	6,2
O	6,3
P	7,1
Q	1,2
R	7,2
S	7,3
T	8,1
U	8,2
V	8,3
W	9,1
X	9,2
Y	9,3
Z	1,3
1 ±	1,4
2 @	2,4
3 #	3,4
4 $	4,4
5 %	5,4
6 ¢	6,4
7 &	7,4
8 *	8,4
9 (	9,4
0)	0,4
back space	7,5
carriage return	0,3
period	0,1
question mark	0,2
space	1,1
upper shift	8,5
lower shift	5,5
tab	4,5
' "	1,5
comma	2,5
- —	3,5
; :	6,5
= +	9,5

FIGURE 9. "CYBER-TONE" TRANSFER CODE

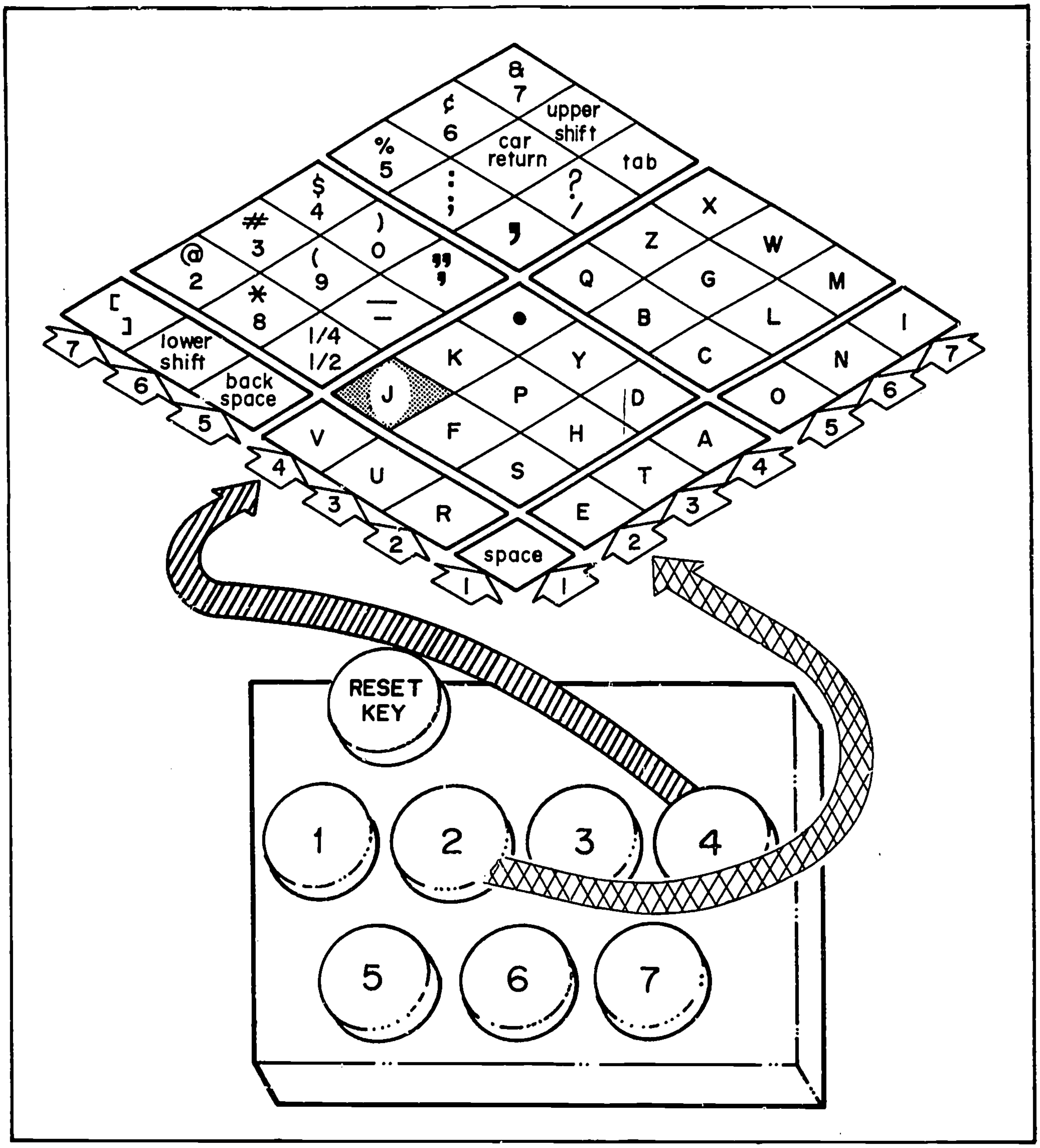


FIGURE 10

KEY POSITIONS FOR THE LETTER "J," USING A UNILATERALLY CONTROLLED "CYBERTYPE," KEYBOARD. KEY NUMBER 4 IS STRUCK INITIALLY, FOLLOWED BY STRIKING KEY NUMBER 2.

First Key 1	Lower	Upper
1	Space	
2	e	E
3	t	T
4	a	A
5	o	O
6	n	N
7	i	I

Second Key 1	Lower	Upper
1	Space	
2	r	R
3	u	U
4	v	V
5	Back Space	
6	Lower Shift	
7*	1	!

First Key 2	Lower	Upper
1	r	R
2	s	S
3	h	H
4	d	D
5	c	C
6	l	L
7	m	M

Second Key 2	Lower	Upper
1	e	E
2	s	S
3	f	F
4	j	J
5*	-	_
6	8	*
7	2	@

First Key 3	Lower	Upper
1	u	U
2	f	F
3	p	P
4	y	Y
5	b	B
6	g	G
7	w	W

Second Key 3	Lower	Upper
1	t	T
2	h	H
3	p	P
4	k	K
5	=	+
6	9	(
7	3	#

First Key 4	Lower	Upper
1	v	V
2	j	J
3	k	K
4	● Period ●	
5	q	Q
6	z	Z
7	x	X

Second Key 4	Lower	Upper
1	a	A
2	d	D
3	y	Y
4	● Period ●	
5	’	”
6	0	)
7	4	$

C/R/I

First Key 5	Lower	Upper
1	Back Space	
2*	-	_
3	=	+
4	’	”
5	, Comma ,	
6	/	?
7	Tabulator	

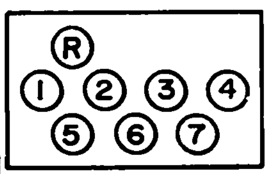
Second Key 5	Lower	Upper
1	o	O
2	c	C
3	b	B
4	q	Q
5	, Comma ,	
6	;	Colon:
7	5	%

First Key 6	Lower	Upper
1	Lower Shift	
2	8	*
3	9	(
4	0	)
5	;	Colon:
6	Carriage Return	
7	Upper Shift	

Second Key 6	Lower	Upper
1	n	N
2	l	L
3	g	G
4	z	Z
5	/	?
6	Carriage Return	
7	6	¢

First Key 7	Lower	Upper
1*	1	!
2	2	@
3	3	#
4	4	$
5	5	%
6	6	¢
7	7	&

Second Key 7	Lower	Upper
1	l	I
2	m	M
3	w	W
4	x	X
5	Tabulator	
6	Upper Shift	
7	7	&



7-KEY INTERFACE SHOWING ASSIGNED NUMBERS AND THE RESET KEY "R".

NOTE:
LOWER = LOWER CASE & LOWER SHIFT POSITION.
UPPER = UPPER CASE & UPPER SHIFT POSITION.
* = VARIABLE, DEPENDING ON TYPEWRITER.

THE OVAL KEYS SHOW THE UNILATERAL "CYBERTYPE" CODE. THE TOP PORTION REPRESENTS THE LEFT BANK OF THE TRANSFER CODE, AND THE BOTTOM PORTION REPRESENTS THE RIGHT BANK OF THE TRANSFER CODE.

FIGURE 11. CHARACTER/FUNCTION UNILATERAL TRANSFER CODE (FOR IBM MODEL C ELECTRIC TYPEWRITERS)

LEFT BANK

4

	Lower	Upper
1	v	V
2	j	J
3	k	K
4	● Period ●	
5	q	Q
6	z	Z
7	x	X

3

	Lower	Upper
1	u	U
2	f	F
3	p	P
4	y	Y
5	b	B
6	g	G
7	w	W

2

	Lower	Upper
1	r	R
2	s	S
3	h	H
4	d	D
5	c	C
6	l	L
7	m	M

7

	Lower	Upper
1*	1	!
2	2	@
3	3	#
4	4	$
5	5	%
6	6	¢
7	7	&

6

	Lower	Upper
1	Lower Shift	
2	8	*
3	9	(
4	0	)
5	;	Colon :
6	Carriage Return	
7	Upper Shift	

5

	Lower	Upper
1	Back Space	
2*	–	_
3	=	+
4	'	"
5	, Comma ,	
6	/	?
7	Tabulator	

1

	Lower	Upper
1	Space	
2	e	E
3	t	T
4	a	A
5	o	O
6	n	N
7	i	I

RIGHT BANK

2

	Lower	Upper
1	e	E
2	s	S
3	f	F
4	j	J
5*	–	_
6	8	*
7	2	@

3

	Lower	Upper
1	t	T
2	h	H
3	p	P
4	k	K
5	=	+
6	9	(
7	3	#

4

	Lower	Upper
1	a	A
2	d	D
3	y	Y
4	● Period ●	
5	'	"
6	0	)
7	4	$

5

	Lower	Upper
1	o	O
2	c	C
3	b	B
4	q	Q
5	, Comma ,	
6	;	Colon:
7	5	%

6

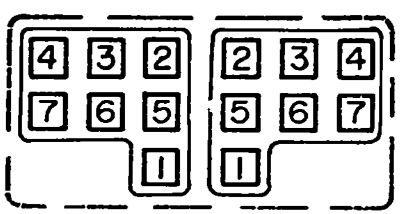
	Lower	Upper
1	n	N
2	l	L
3	g	G
4	z	Z
5	/	?
6	Carriage Return	
7	6	¢

7

	Lower	Upper
1	l	L
2	m	M
3	w	W
4	x	X
5	Tabulator	
6	Upper Shift	
7	7	&

1

	Lower	Upper
1	Space	
2	r	R
3	u	U
4	v	V
5	Back Space	
6	Lower Shift	
7*	1	!



14-KEY INTERFACE, SHOWING LEFT AND RIGHT KEYBANKS WITH ASSIGNED NUMBERS.

NOTE:

LOWER=LOWER CASE & LOWER SHIFT POSITION.

UPPER=UPPER CASE & UPPER SHIFT POSITION.

● =VARIABLE, DEPENDING ON TYPEWRITER.

FIGURE 12. CHARACTER/FUNCTION BILATERAL TRANSFER CODE (FOR IBM MODEL C ELECTRIC TYPEWRITERS)

LEFT BANK

4

	Lower	Upper
1	v	V
2	j	J
3	k	K
4	• Period	•
5	q	Q
6	z	Z
7	x	X

3

	Lower	Upper
1	u	U
2	f	F
3	p	P
4	y	Y
5	b	B
6	g	G
7	w	W

2

	Lower	Upper
1	r	R
2	s	S
3	h	H
4	d	D
5	c	C
6	l	L
7	m	M

7

	Lower	Upper
1*	]	[
2	2	@
3	3	#
4	4	$
5	5	%
6	6	¢
7	7	&

6

	Lower	Upper
1	Lower Shift	
2	8	*
3	9	(
4	0	)
5	;	Colon:
6	Carriage Return	
7	Upper Shift	

5

	Lower	Upper
1	Back Space	
2*	!	Degree°
3	–	_
4	'	"
5	, Comma	,
6	/	?
7	Tabulator	

1

	Lower	Upper
1	Space	
2	e	E
3	t	T
4	a	A
5	o	O
6	n	N
7	i	I

RIGHT BANK

2

	Lower	Upper
1	e	E
2	s	S
3	f	F
4	j	J
5*	!	Degree°
6	8	*
7	2	@

3

	Lower	Upper
1	t	T
2	h	H
3	p	P
4	k	K
5	–	_
6	9	(
7	3	#

4

	Lower	Upper
1	a	A
2	d	D
3	y	Y
4	• Period	•
5	'	"
6	0	)
7	4	$

5

	Lower	Upper
1	o	O
2	c	C
3	b	B
4	q	Q
5	, Comma	,
6	;	Colon:
7	5	%

6

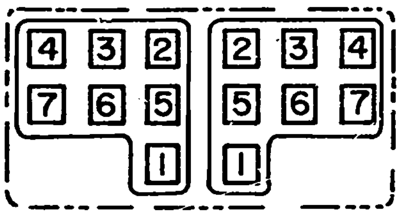
	Lower	Upper
1	n	N
2	l	L
3	g	G
4	z	Z
5	/	?
6	Carriage Return	
7	6	¢

7

	Lower	Upper
1	i	I
2	m	M
3	w	W
4	x	X
5	Tabulator	
6	Upper Shift	
7	7	&

1

	Lower	Upper
1	Space	
2	r	R
3	u	U
4	v	V
5	Back Space	
6	Lower Shift	
7*	]	[



14-KEY INTERFACE, SHOWING LEFT AND RIGHT KEYBANKS WITH ASSIGNED NUMBERS.

NOTE:
LOWER = LOWER CASE & LOWER SHIFT POSITION.
UPPER = UPPER CASE & UPPER SHIFT POSITION.
* = VARIABLE, DEPENDING ON TYPEWRITER.

FIGURE 13. CHARACTER/FUNCTION BILATERAL TRANSFER CODE (FOR IBM SELECTRIC TYPEWRITERS WITH PRESTIGE, ELITE, COURIER, LETTER GOTHIC, OR DELEGATE TYPE)

LEFT BANK

4

	Lower	Upper
1	v	V
2	j	J
3	k	K
4	• Period	•
5	q	Q
6	z	Z
7	x	X

3

	Lower	Upper
1	u	U
2	f	F
3	p	P
4	y	Y
5	b	B
6	g	G
7	w	W

2

	Lower	Upper
1	r	R
2	s	S
3	h	H
4	d	D
5	c	C
6	l	L
7	m	M

7

	Lower	Upper
1*	1	±
2	2	@
3	3	#
4	4	$
5	5	%
6	6	¢
7	7	&

6

	Lower	Upper
1	Lower Shift	
2	8	*
3	9	(
4	0	)
5	;	Colon :
6	Carriage Return	
7	Upper Shift	

5

	Lower	Upper
1	Back Space	
2*	!	Degree°
3	–	_
4	,	"
5	, Comma	,
6	/	?
7	Tabulator	

1

	Lower	Upper
1	Space	
2	e	E
3	t	T
4	a	A
5	o	O
6	n	N
7	i	I

RIGHT BANK

2

	Lower	Upper
1	e	E
2	s	S
3	f	F
4	j	J
5*	!	Degree°
6	8	*
7	2	@

3

	Lower	Upper
1	t	T
2	h	H
3	p	P
4	k	K
5	–	_
6	9	(
7	3	#

4

	Lower	Upper
1	a	A
2	d	D
3	y	Y
4	• Period	•
5	,	"
6	0	)
7	4	$

5

	Lower	Upper
1	o	O
2	c	C
3	b	B
4	q	Q
5	, Comma	,
6	;	Colon :
7	5	%

6

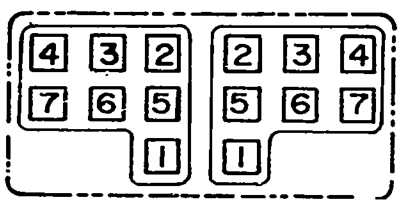
	Lower	Upper
1	n	N
2	l	L
3	g	G
4	z	Z
5	/	?
6	Carriage Return	
7	6	¢

7

	Lower	Upper
1	i	I
2	m	M
3	w	W
4	x	X
5	Tabulator	
6	Upper Shift	
7	7	&

1

	Lower	Upper
1	Space	
2	r	R
3	u	U
4	v	V
5	Back Space	
6	Lower Shift	
7*	1	±



14-KEY INTERFACE, SHOWING LEFT AND RIGHT KEYBANKS WITH ASSIGNED NUMBERS.

NOTE:

LOWER = LOWER CASE & LOWER SHIFT POSITION.

UPPER = UPPER CASE & UPPER SHIFT POSITION.

* = VARIABLE, DEPENDING ON TYPEWRITER.

FIGURE 14. CHARACTER/FUNCTION BILATERAL TRANSFER CODE (FOR IBM SELECTRIC TYPEWRITERS WITH SCRIPT, ORATOR, OR LIGHT GOTHIC TYPE.)

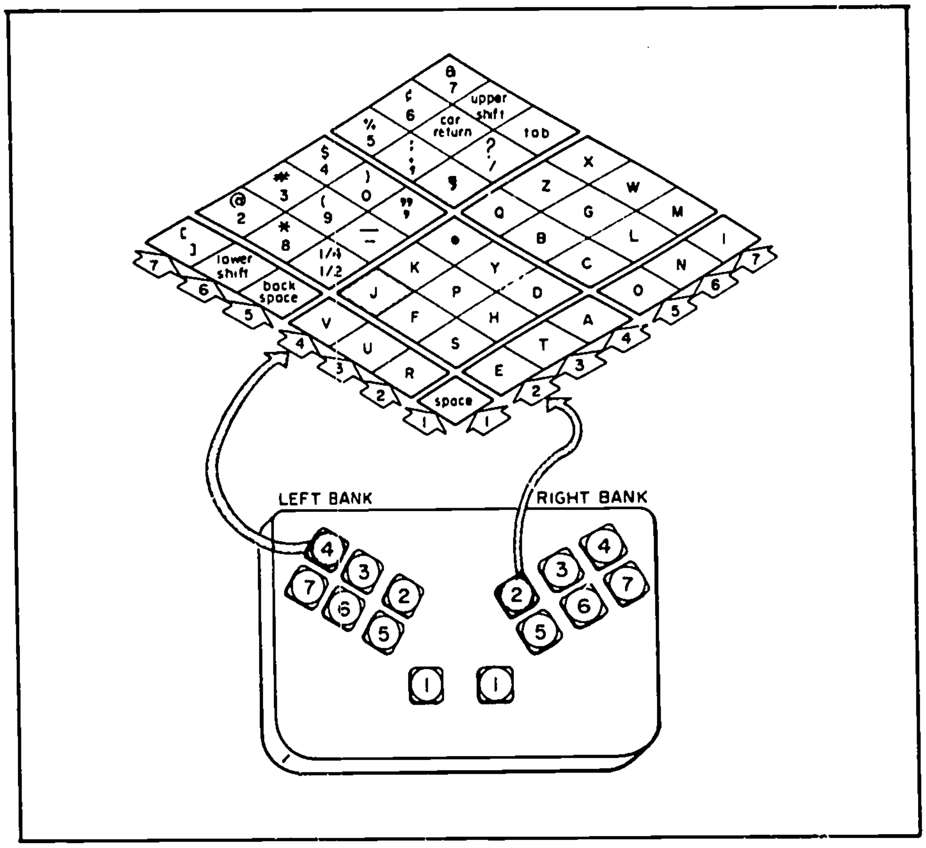


FIGURE 15 CHARACTER/FUNCTION BILATERAL TRANSFER CODE (SHOWING KEYING POSITION FOR THE LETTER J)

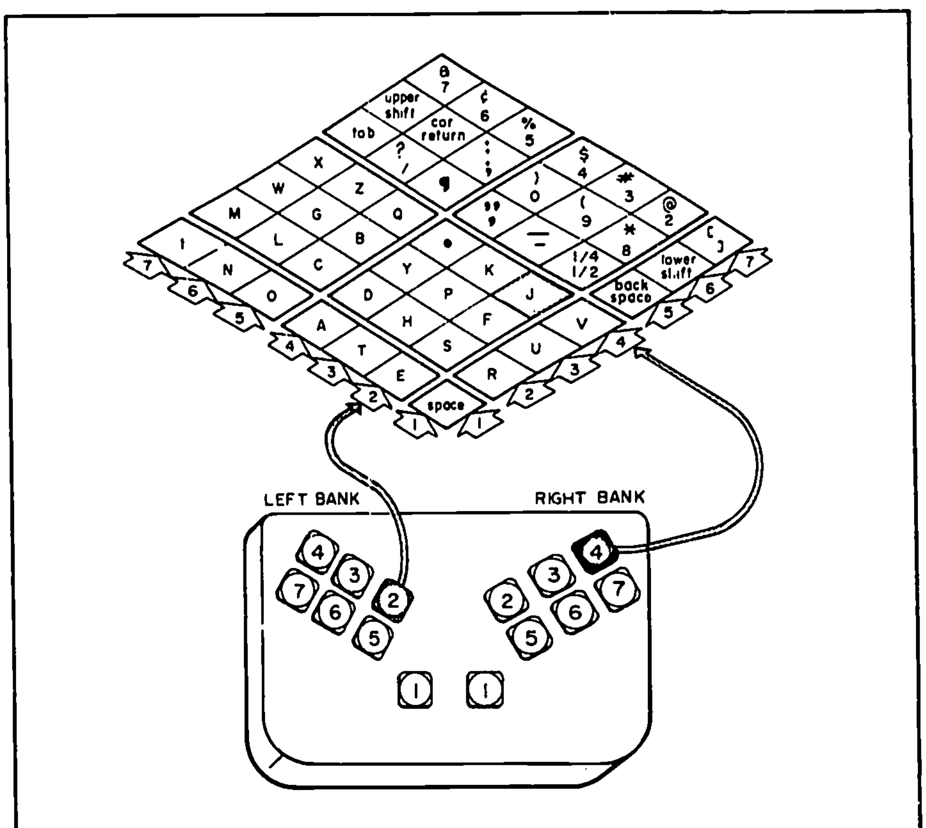


FIGURE 16. CHARACTER/FUNCTION BILATERAL TRANSFER CODE FOR LEFT HANDED SUBJECT (SHOWING KEYING POSITION FOR THE LETTER J)

Appendix G CHILDREN'S HANDWRITING AND TYPING SAMPLES

This Appendix contains several samples of handwriting and daily typing papers taken from files at C/R/I for about 80 subjects in the studies described in the C/R/I Second Report.

Typed samples of work (figures 1-9) in this Appendix were produced on 14-key, bilateral-input interfaces. They have been included to illustrate the effectiveness of these man-machine communications systems in the education of the handicapped.

234567890234567890234567890,

Will you be my valentine

NEYXN SMEO

TODD

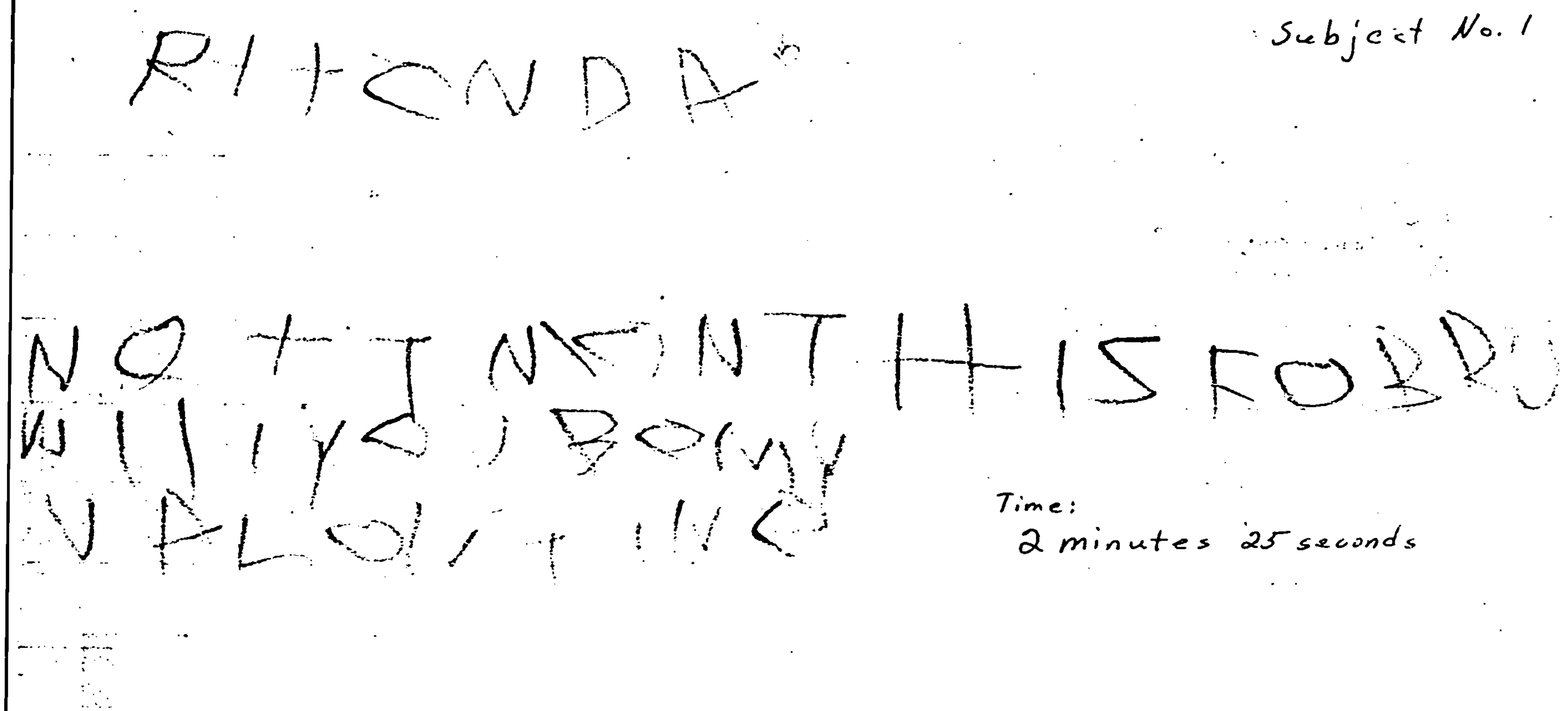
TOADAY I GOT MY TROPHY.

I ADM HAPPY THAT I HAVE IT.?

AN ANT ATE AN ONION. A RAT
THE CAT CHASES A RAT.
HELLLLO HELLO HELEN CCALLS.

THE MELN RODE HOME.
RUTH INSURED HSHER COAT.
SFABLLE FOOTOOBALL

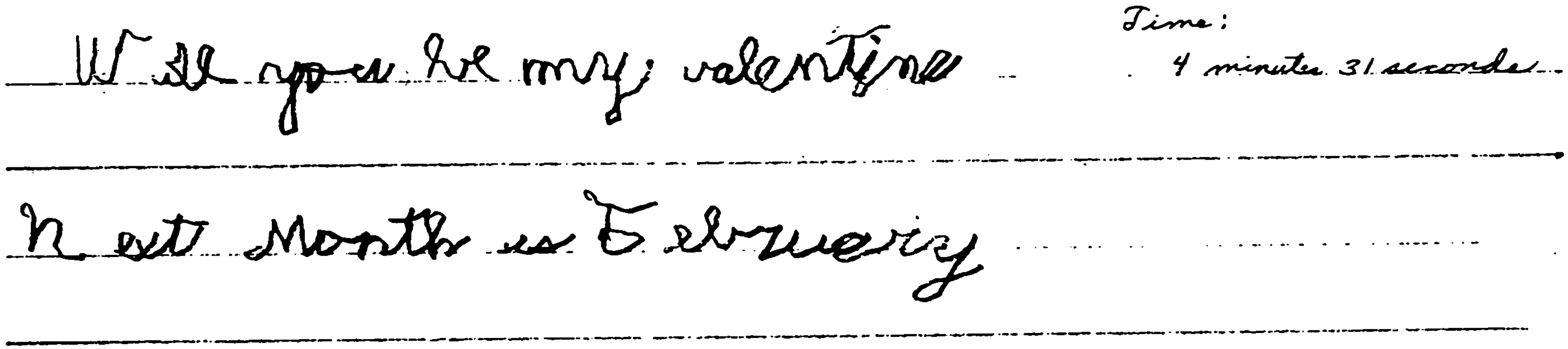
Figure 1. Typing Samples - Subject No. 15



RHONDA CYBERTYPE

VERY FUZZY JANE JIMMY PAJAMAS
NEXT MONTH IS FEORUARY X WILL YOU OU MY VALENTINE.

Figure 2. Handwriting and Typing Samples - Subject No. 1



fbpgpg

PAUL ATE A GREEN PEAR.

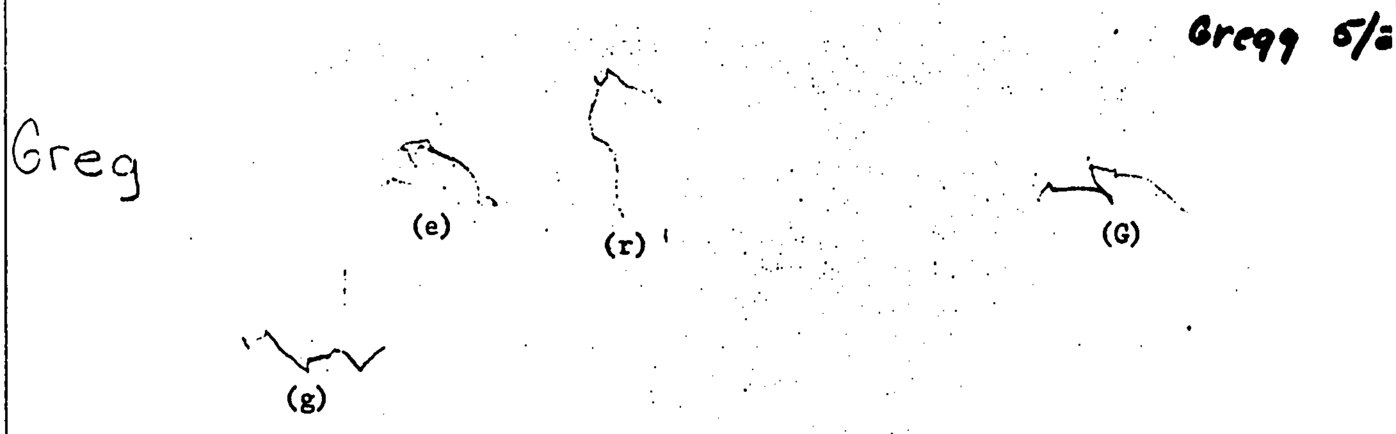
PUFF CAN RUN FAST.

GAIL HIGGER GETS GREEN GRAPE GUM.

PLEASE PASS PAUL THE GRAPES.

MERRY CHRISTMAS
HAPPY NEW YEAR
U
Frances put a bun here.

Figure 3. Handwriting and Typing Samples - Subject No. 16



(NOTE: Subject was asked to print his name - Greg - within this space)

```
 GREG JOHN
KIK IKIK,I KIK
I KI
IK,ILJ
KITE  TAKE      ? KATE
KITTEM



 T       I ANM A KITTEMN

I CAN'T MAKE UP MUY MIND.

                         1+1=2  ¢c
```

Figure 4. Handwriting and Typing Samples - Subject No. 19

art

Next Month is February.

Will You Be my Valentine.

Ner

Subject No. 29
Case Study

HANDWRITING SAMPLE

Subject No. 29
Case Study

STUDENT'S PAPER--5/18

ARt

vjqkz.xkz.qjqjk.xzkqzkqzkjjq.xkzruvywf

SCWXV.U.

3

NEXT MONTH IS B FFEBRUARY.

WILL FGYOU BE MY VALENTINE.

NEXT MONTH IS FEB

Figure 5. Handwriting and Typing Samples - Subject No. 29

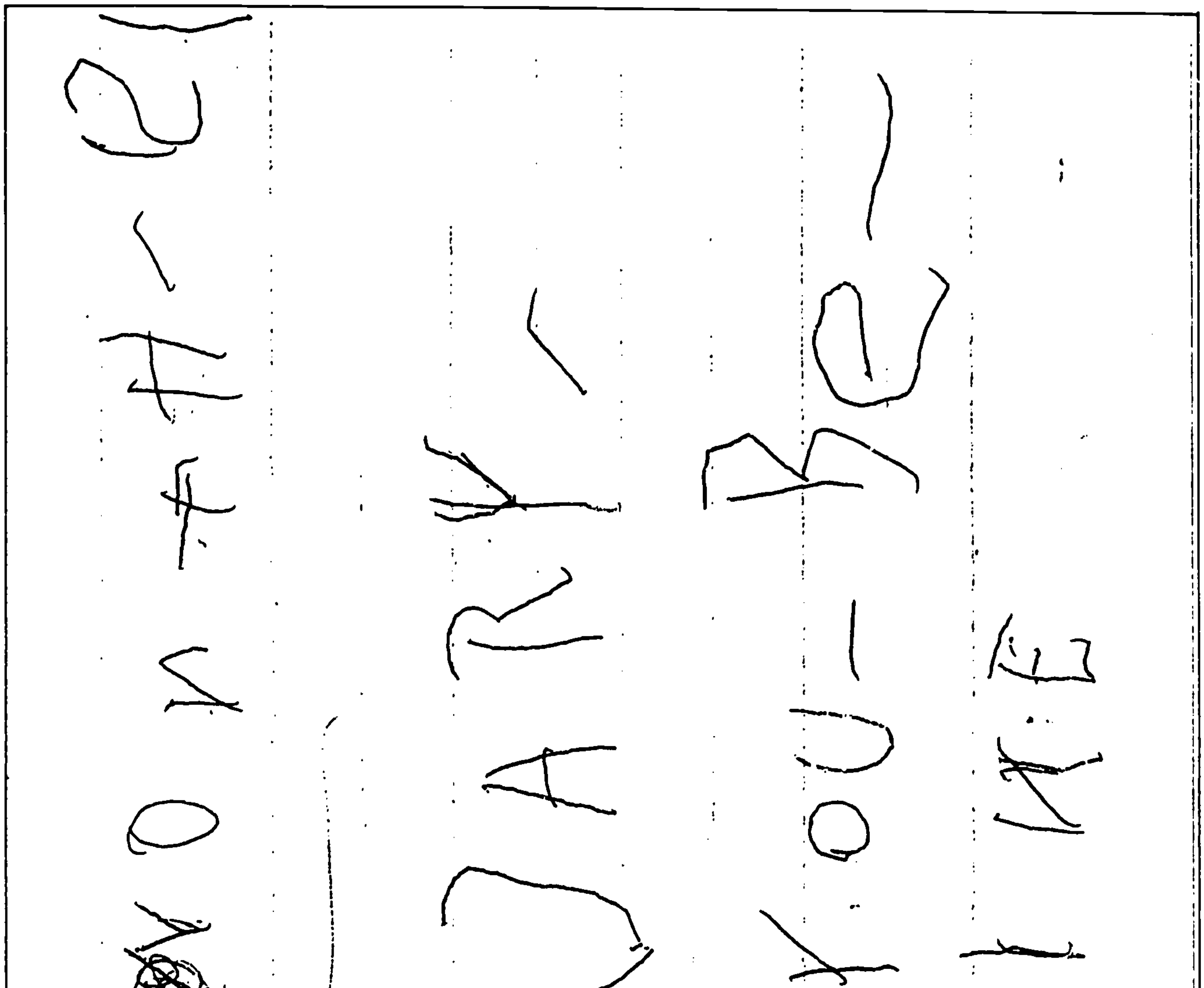


Figure 6. Handwriting Sample - Subject No. 30

253

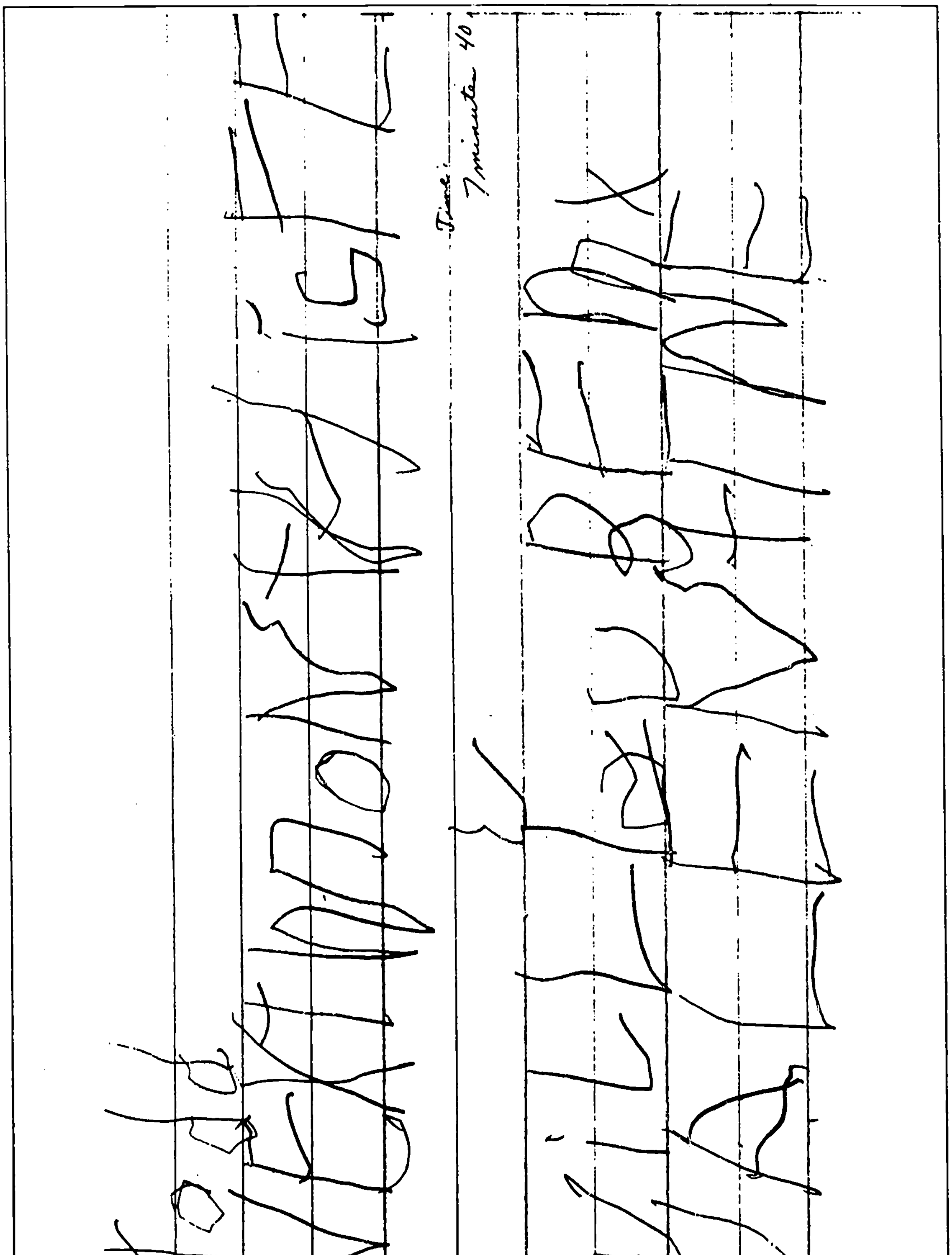


Figure 7. Handwriting Sample - Subject No. 15

KIM

ONCE UPON A TIME, LONG, LONG AGO, IN A FARAWAY LAND OF PALM TREES AND COCKATOOS, THERE LIVED A // FROG. NOW THIS WAS A SILLY LITTLE FROG. EVERYBODY CALLED HIM KINGPRINCE OF THE FROGS. HE WAS A FAT LITTLE FROG BECAUSE HE ATE TOO MUCH.

AND THE LATTLE COCKATOO WENT FLYING BY.

HI FATSO HAHA! YOU'RE SO FAT, WITH THOSE SHRIMPY LEGS OF YOURS.

AND THE FROG WENT SWIMMING ACROSS THE POND SAYING HAHA, YOU CAN'T SWIM.

Teacher's Note: This clever fairy tale is symbolic of the subject's own diminutive size but spunky nature and pride in what she can do.
The beginning lines (to double bars) were prepared by the teacher. The story was recorded by the teacher and typed by the subject from dictation.

Figure 8. Creative Work — Subject No. 14

BARTEY

THE K
I
N
G MDOESN'T SAY PHLEASE OR THANK YOU

THE
Q
U
E
E
N

G
N
I
K

E
H
T

O
T

N
A
E
M

S
WA

E
H
S

Teacher's Note:

In this paper, a subject with little physical strength used spacing as an expressive device to fulfill the assignment of writing a story entitled "The Funniest Thing". In this way he was able to write a complete and expressive story in only 3 sentences.

Figure 9. Creative Work - Subject No. 38

Appendix H INDIVIDUAL AND GROUP INSTRUCTIONAL PROGRAM

C/R/I is currently conducting an individual and group instructional research program at the D.T. Watson Home for Crippled Children, in Leetsdale, Pennsylvania. Eight severely handicapped children are being taught to communicate through writing with the use of bilateral-input keyboard systems. These children either cannot produce cursive handwriting or can do so only with extreme difficulty. Their attempts to operate any style of typewriter have not been successful.

Each child has been provided with a "Cybertype" keyboard interface configured to match his remaining motor capabilities. The 14-key finger-operated interface has been provided for five of the children who have sufficient motor coordination to operate the keys with at least one finger or knuckle on each hand (Subjects 122, 125, 126, 128, 129).

The remaining three children are not capable of operating keys with their fingers, and special interfaces have been constructed at C/R/I's laboratories for them. One child (Subject No. 123) is a diplegic with upper limb involvement, who has good control of feet and legs. This child uses her feet to operate a "pedal" interface consisting of 14 large keys appropriately spaced (see plate 2a, Volume I, Part Two). The child sits in a chair which supports her legs so that her feet "float" closely above the 14 key tops. Two keys are then activated concurrently by simple toe depressions, one from each foot.

Another child, (Subject No. 124) is a quadriplegic who can provide enough motor coordination in arms and hands to strike the large keys of the pedal interface (placed on a table) with the heels or sides of her hands. This subject has never been able to express herself in writing throughout her 16 years at the Home. She has considerable intellectual potential as evidenced by her poem "Those Sixties." Five of her classmates who are also subjects in this study shared with her the joy of having her poem reproduced, each typing an assigned verse on "Cybertype." Helen, the author (Subject No. 124) typed the title and the first three stanzas, Diane (Subject No. 128) typed stanzas 4 and 5, Andrea (Subject No. 129) typed stanza 6, Tony (Subject No. 127) typed stanza 7, Veronica (Subject No. 125) typed stanza 8, and Donnie (Subject No. 122) typed the last two stanzas. Her classmates were particularly pleased to be a part of the "show." The poem, as actually typed on "Cybertype," is reproduced in Appendix A.

A third child (Subject No. 127) is able to operate a "fist interface," consisting of 14 keys which are larger than the keys of the finger-operated interface but smaller than the keys of the pedal interface (see plate 3b, Volume I, Part Two). This youngster is also typing successfully by operating pairs of keys with his two hands.

Most of the children are instructed in groups by Mrs. Anna Mae Gallagher, a senior member of C/R/I's special education staff, who is in residence at the school during this program. Four of her subjects are instructed together as a group, consisting of three children (Subjects 122, 125, and 126) operating the standard 14-key interfaces, and one child (Subject No. 127) using the fist interface. Two of the children (Subjects 128 and 129), using the standard 14-key interface, are taught together as a pair. The remaining two children, Subject No. 123 using the pedal interface with her feet, and Subject No. 124 using the pedal interface with her hands, are seen individually.

Each child has received 1 hour of instruction each day, 4 days per week. The "Cyber-Circus Story," developed by Mrs. Gallagher (Kafafian, 1968), is used as a learning aid. The association of circus acts and participants as related to the keying combinations for the various letters, symbols, and typing functions provides unique and exciting instructional materials which the children really enjoy.

Instruction began on January 12, 1970, and the children learned the keying positions for all letters within 2 weeks. Keying positions for numerals, symbols, and typing functions were also learned very quickly.

Sample work sheets from the sixth work of instruction, shown in figures 1 – 8, demonstrate that the children have developed considerable skill in using their interface systems for communicating. These results are particularly encouraging in view of the fact that previously these children had been virtually incapable of communicating through writing in any form, and in some cases their verbal communication comes about with difficulty.

On February 19, 1970, about 5 weeks from the commencement of the program, one of the physicians on the staff of the D.T. Watson Home observed the children in this program and made evaluative comments and recommendations. Excerpts from his evaluations are given below.

> Subject No. 122. "Donnie is primarily an athetoid patient and in the four weeks that he has been working on the "Cybernetics Board," [14-key "Cybertype" keyboard] he has developed a very marked improvement in control and is now able to type without making too many mistakes.... It is extremely important that the "Cybernetics Board" be firmly attached to the table, because this boy does hang on to the board to control his athetoid movements.... I also think that it is important that this boy be close enough to the table so that he does not have to lean forward and thus have his body out of balance, which could very well increase the athetoid movements and fatigure. I think that Donnie is doing well enough with the "Cybernetics Board" that in another 6 to 8 weeks, perhaps we can try him on a regular typewriter and see how well things are going at that time."
>
> Subject No. 123. "Carolyn is using her feet in typing but has been keeping her shoes on and has not developed much speed and coordination in her typing because she has to continually look at the words she wants and then look down at her feet and see what buttons she wants to push. She is using the [pedal interface] with the big knobs and she types fairly well with this board. I am recommending that we have Carolyn remove her shoes and socks and type in her bare feet....I think that with some training in her bare feet, this girl will learn to type much faster and will not have to continually look down at her feet to see where she is placing them.... A "Cybernetics Typewriter" ["Cybertype"] for this girl is almost a must. She has no fine control of the upper extremities and is not able to do any kind of writing. Her speech is fairly good, but she does have difficulties in coordinating tongue, throat, and mouth muscles in her speech program and would tire rather quickly if she had to talk for long periods of time."
>
> Subject No. 124. "From the physical therapeutic standpoint, according to Mrs. Gallagher, Helen when she started out, would take almost an hour to type one sentence, and now she is able to type a full letter in approximately a half hour. Also, the control of the arms is improved. With the right arm she has fairly good control and uses the palm of the hand on the large knobs of the [pedal interface]. On the left side, she is using the loaded cuff or the side of the hand, the ulnar side, to press the buttons down."
>
> Subject No. 125. "Veronica (recently) had hand splints made and checked out.... Rather than discontinuing Veronica, I would like to recommend that we try [her] on the Cybernetics Program [C/R/I] with the hand splints on to see if after a few sessions she might not get just as good control this way as she has without the splints.... According to Mrs. Gallagher, Veronica has done exceptionally well in her typing this way, and she feels that it would be a shame not to have her continue in the program."

Donnie Alleen February 17, 1970

Please ask dad for a cake.

Vanilla is my favorite flavor.

Think and work, Jake.

Work and think, John.

Every one loves to win.

WE We work to succeedd.

We listen and then we learn.

Winners are workers.

Observations

Anna Mae Gallagher.

I wish I had a picture of Donnie when he realized that he typed seven sentences and had no shiversx (double letters). I am giving lessons on finger control and it is paying off with their work. This is one of Donnie's best papers.

Figure 1. Typing Sample - Subject No. 122

Carolyn M. Brownee February 16, 19700

She lost her shoe.

Are the shells here?

Ellen's shells are here..

A lassie ran to Roni.

I see a tosn tire.

He has i an increase.

Dad is seen at the dam.

TThe doll cost a dime.

Daniel is a radio man.

Dad is a democrat.

Mother has a red shoawl.

Mother served hot rolls.

Paul eats green grapes.

Father bought eggs for Pam.

yellow flowers

Observations

Anna Mae Gallagher

This was one of Carolyn's good days. She loves to typewrite and shows it when in class. With twelve perfect sentences, I think she did well. She has several small errors on the entire paper. Carolyn has an hour class (individual), thus she can accomplish more than the other children.

Figure 2. Typing Sample - Subject No. 123

D. T. Watson Home
Leetsdale, Pennsylvania
February 19 , 1970

Mr. William E. Harrison
2746 Eighth Street
ERie, Pennsylvania

Dear Sar

My father was called to Chicago yesterday. He asked me to let you know that he cannot meet you on Wednesday of next week as planned.

Sincerely yours

Miss Helen Kern

Observations

Anna Mae Gallagher

Helen was determined to complete a letter today. It was too much of a struggle for her but she would not give up. Just as she was finishing her letter, Dr. Rex Newton came in to evaulate Helen's physical and educational results by using the Cybernetics cybertype. I was so glad Helen had an opportunity to complete her letter. She could not sign it, thus, I left it unsigned.

Figure 3. Typing Sample - Subject No. 124

Veronica Labish February 16, 1970

James came quickly.

The blue jay is not qquiet.

Gerald made a square.

Jahn and Jane play croquet.

Paul please pass the grapes.

Franis has a big pig to sell.

Observations

Anna Mae Gallagher

Veronica is one of my best students. It is unusual for her cte make an error. To see her deformed hands in action, one would wonder how she could have such beautiful papers.

Figure 4. Typing Sample - Subject No. 125

Katie 67Lozow February 177, 1970

Please ask dad for a cake.

Vannilla is my ffavorite flavor.

Think aa and work, JJake.

Work and think,, John.

Every one loves to win..

Observations

Anna Mae Gallagher

Three sentences without doubling words is success for Katie. She is trying very hard and I think in time, all will be well for her. She is a very nervous child and has extremely jittery fingers.

Figure 5. Typing Sample - Subject No. 126

Tony Miralles February 17, 1970

Please ask dad for a cake.

Vanilla is my favorite flavor.

Think and work, Jake.

Work and think, John.

EO Every one loves to win.

We work to succeed.

We listen and then we learn.

Winners are workers.

Observations

Anna Mae Gallagher

Tony has a grand paper. His one error was the fault of his flailing fists. He tries very hard and is a darling boy. When he has a good paper, he smiles all over his face. "Tomorrow, I'll have no errors," is usually what he says after reading over his paper.

Figure 6. Typing Sample – Subject No. 127

Diane E.. Provan February 17, 1970

Think and work, Jake.

Work and think, John.

Every one lovess to win.

Please ask dad for a cake.

Vanilla is my favorite flavor.

Did youfind the exit door?

Dad's tuxedo is here, Roy.

He had a sneezing spell.

She rode her bike home.

Kathryn saw grazing cattle. I did too.

January 22, 1970 July 4, 1776

March 17, 1970 June 31, 1970

84 27 19 36 50 258 146 370 904

. , ? 's n't " "( ) ° _ _

ISN"T AREN"T WASN"T BOY"S BOYS" GIRL"S GIRLS" isn

isn't aren't wasn't boy's bb boys' girl's girls'

Observations

Anna Mae Gallagher

Diane had class alone today as Andrea's chair needed more repair. Diane has a perfect paper and learned many of the punctuation marks. She retains what is taught and never seems to forget. She types slowly owing to her condition but she is accurate.

Figure 7. Typing Sample - Subject No. 128

Andrea Yeager February 16, 1970

James came quickly.

The blue jay is not quiet.

Gerald made a square.

John and Jane play croquet.

He requested a jump act.

Mother served hot rolls.

FRANK EATS GREEN GRAPES.

Observations

Anna Mae Gallagher

Andrea came in her new chair today. She was so delighted and wanted me to notice the large tires on her chair. She was singing all the time she was typing. With all this, Andrea made no errors. I am pleased and full of wonder at this youngster's progress.

Figure 8. Typing Sample – Subject No. 129

Subject No. 126. "Katie has been on the "Cybernetics Typewriter" ["Cybertype"] now for a month. She has learned hand control from this, in that when she first started, she did not release the fingers and consequently would get a repetition of one letter several times so that the typing was not meaningful.

She has now developed a technique of pushing down and a very accentuated type of release which has helped her in typing, and she is no longer making the repetition of letters. I have noticed in the program that Katie is keeping her head in flexion so that she can see the board of the wheelchair table, and I think it would be most important to put the "Cybernetics Board" [14-key keyboard] up on an inclined plane of perhaps 50° to 55° so that [the subject] will hold her head up while she is doing her typing."

Subject No. 127. "This 12-year old boy has been working on the (program) for about a month, and during that time he has shown very marked improvement in his ability to control his hands. He is using the intermediate board with the buttons approximately 7/8 of an inch in diameter and about 3-½ inches apart, and in using this board he is able to control his hands quite well now. . .I certainly think that for Tony this is a very definite means of communication because his writing is extremely difficult. He is not able to keep the letters within the lines on the paper, and he prints rather than writes."

Subject No. 128. "Diane is 9 years old and is in the third grade. . . .it is amazing to watch this girl type with absolutely no help from Mrs. Gallagher. . In watching her write, she still is printing and she is able to keep the letters within the lines on the paper, but it is extremely slow and she certainly would have considerable difficulties in writing any length of a report or letter, whereas with the "Cybernetics Typing" [Dual-Input] she could go right along without too much difficulty. I am in hopes that as time goes along, this girl will develop enough finger dexterity that we can consider a regular typewriter, but I feel this is months or maybe several years away yet."

Subject No. 129. "Andrea is 8 years old and has severe osteogenesis imperfecta. . . She found that by putting a thimble on the left thumb she could control the distal phalanx of the thumb enough to get pressure [to] push down on the keys. On the right hand she uses the thumb at times and at times uses the middle finger to press the keys down. . .I am amazed at how well this girl has learned to master the "Cybernetics Board" [14-key]. She needs no help in her typing, and she has come a long way in the past month. . . . In her new chair, she has good posture, and the only recommendation that I would have at this time would be to lighten the spring load on the "Cybernetics Key Board". . . . I had Andrea write, and she writes left-handed. She prints and her letters are extremely large; and it takes her a considerable time, so I feel for Andrea that the Cybernetics typing ["Cybertyping"] is almost a must for her to be able to communicate, except vocally."

Partial Subject List

Subject Number	CA (yrs-mos)	Diagnosis	Study
1	10-2	CP (Cerebral Palsy), Athetoid	C
2	6-5	Alleged Thalidomide	C,F
3	10-1	CP, Spastic	C,F
4	8-9	CP	C
5	11-8	CP, Left Hemiplegic	C
6	6-2	Dermatomyositis	C
7	6-10	Crouzan's Disease	C,F
8	10-8	CP	C
9	7-6	CP	C,F
10	9-3	Post Polio	C
11	9-11	CP	C
12	6-4	CP	C
13	10-3	Muscular Dystrophy	C
14	10-2	CP, Rigidity	C,F
15	9-9	CP, Birth Accident	C,F
16	12-9	Brain Damage	C,F
17	6-7	Congenital Malformations of Foot and Hip	C
18	8-10	Post Polio	C
19	7-2	CP, Spastic	C
20	9-4	CP, Athetoid	C
21	12-7	CP, Athetoid	C
22	10-9	Nephrosis	C
23	10-11	CP	C
24	10-6	Muscular Dystrophy	C
25	13-8	Post Polio	D
26	13-3	CP	D
27	6-1	Postencephalitis	D
28	8-5	CP	D
29	11-7	Muscular Dystrophy	D
30	7-7	CP	D
31	8-0	Arthrogryposis	D
32	7-8	CP	D
33	Adult	Bilateral Amputee	SPC
34	13-10	CP	P,F
35	9-1	Thalidomide Syndrome	P,F
36	11-2	CP	P,F
37	8-3	Congenitally Armless	P,F
38	8-3	CP	P,F
39	6	Bilateral Amelia, Femoral Deficiencies	SPC
40	15	CP, Athetoid Quadriplegic	SPC
41	13	Quadriplegia, Polio	SPC
42	17	CP, Spastic Quadriplegic	SPC
43	9	Polio, Scoliosis	SPC
44	9	CP	SPC
45	9		
46	9		
47	Adult	Deaf	SPC
48	Adult	Deaf	SPC
49	16		
50	10	CP, Spastic, Quadriplegic	SPC
51	11	Rubella	SPC
52	15	Retrolental Fibroplasia	SPC
53	16	Retrolental Fibroplasia	SPC
54	16	Retrolental Fibroplasia	SPC
55	14	SLD (Specific Learning Disorders)	L
56	8	CP	L
57	11	SLD	L
58	8	SLD	L
59	10	CP	L
60	14		F
61	6	Congenitally Deaf	L
62	8	SLD	L
63	11	SLD	L
64	6-3	(See footnote 1.)	C
65	7-0		C
66	9-7		C
67	10-0		C
68	7-5		C
69	7-3		C
70	10-8		C
71	10-0		C
72	5-10		C
73	10-8		C

Partial Subject List (con't)

Subject Number	CA (yrs-mos)	Diagnosis	Study
74	12-6		C
75	7-3		C
76	10-4		C
77	9-7		C
78	10-5		C
79	7-6		C
80	10-7		C
81	9-0		C
82	5-11		C
83	10-7		C
84	7-6		C
85	10-8		C
86	10-2		C
87	10-5		C
88	12-10		C
89	10-1		C
90	7-8		C
91	9-10		C
92	10-0		C
93	10-2		C
94	9-9		C
95	7-3		C
96	12-11		C
97	11-9		C
98	6-8		C
99	7-2		C
100	16	Congenital Glaucoma	SPC
101	Adult	Blind Amputee	SPC
102	14	CP	SPC
103	Adult	Totally Paralyzed	SPC
104	10	Minimal Cerebral Dysfunction	G
105	12	Torticollis	G
106	10	(See footnote 2.)	G
107	11		G
108	13		G
109	14		G
110	14		G
111	19		G
112	8		G
113	14		G
114	6		G
*			
122	12	CP	W
123	14	CP, Rigidity	W
124	19	CP, Spastic Ataxic Quadriplegic	W
125	13	Arthrogryposis multiplex congenita	W
126	11	CP, Spastic Paraplegic Flexion contractures of hips and knees	W
127	12	CP, Athetoid Quadriplegic	W
128	8	CP, Spastic legs	W
129	7	Osteogenesis Imperfecta (weighs 23 lbs.)	W

C	Comparison Study
D	Diagnostic Exploratory Study
F	Follow-Up Studies
G	Group Instructional Procedures
L	Learning Disabilities Study
P	Pilot Study
SPC	Special Projects and Case Studies
W	D. T. Watson Home for Crippled Children Study

[1] Subjects 64-99 used in the Comparison Study are nonhandicapped.

[2] Subjects 106-114 used in Group Instructional Procedures are nonhandicapped.

* Subjects 115 through 121 not included.

OVERVIEW

Initially, this study program focused its objectives toward improving the education of disabled persons possessing cognitive abilities and language comprehension through the use of CYBERCOM™*, a unique family of man-machine communications and life-support systems. One thesis of this study is that information acted upon by living and non-living systems has significance to the user, whether man or automata, only when there is linguistic commonality, meaning and understanding of the information together with a medium with sufficient bandwidth capability to permit transport of the information in a pre-determined code, knowledgeable to sender and receiver alike. A further premise is that information interacting in a goal-oriented cybernetic system yields, by virtue of its stability, entropy, and other characteristics, positive and negative feedback. When this feedback is properly programmed, governed, and adapted through appropriate transfer functions and interfaces by the human controller and his automata, extensions to the boundaries of the system's original goals are achieved in a manner enhancing that system's purposeful behavioral objectives and usefulness to the human controller and society. Newer, richer and more beneficial dialogue and relationships are thus established.

This relational philosophy of the content, the program, or the information interaction includes man/man, man/machine, machine/man, and machine/machine and leads to consideration of the extent to which components or subsystems of the human controller (i. e., his automata and environment, his identity, capabilities, language, the automata's compatability, its contents, its programs and capacity, life-support needs, and conditions of environment in which man and machine can effectively perform) may be better understood, assessed, and interrelated -- in terms of survival, behavioral, maintenance, and performance requisites -- through prescribed matching and coupling techniques. A better understanding of these considerations would hopefully lead to the governing of both living and non-living systems in what, many will agree, has been a hostile world for the disabled person and his family, be he physically and/or neurologically impaired, debilitated because of disease, or aged.

Shortly after engaging in this study, it became apparent that the classroom was only a fragment of the disabled person's total environment. His needs were more basic, and were often misunderstood. A search in school records for information about the student frequently proved futile. Records were either lost, incomplete, or had never existed at all. Furthermore, the high turn-over rate of school personnel, both professional and non-professional, made the search for information

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*Trademark, Cyber Corp., Washington, D. C.

more difficult. School personnel were interviewed in regard to the students who were candidates for this research program; in many cases, the teachers thought their non-vocal students could spell and read. Subsequent tests and observation revealed, however, that this was not the case. Of particular significance was the fact that some children had learned to communicate in spite of their total lack of reading and writing skills by correctly interpreting the body movements and facial expressions of their parents and teachers. In other instances, the creative capabilities of particular students went undiscovered until a means was introduced which allowed them to communicate.

The situation is analogous to viewing an iceberg from a steersman's coign of vantage. The main body of the iceberg is concealed, and visual examination of the exposed surface yields limited information; yet, in reality, the frozen structure embodies a great deal more relevant information, as continuous probing, observation, and measurement beneath the surface of the sea reveals.

This phenomenon may be further compared to an educational system in which the teacher represents the steersman and the disabled student represents the partially exposed structure. Upon preliminary examination of this embodiment, in which the individual involved is labeled "handicapped," the teacher, with the help of others, must provide a decision anent the particular course to be pursued. What is being said is that gross physical handicaps are readily detected because of their blatancy, especially where they interface awkwardly or prominently with the teacher and the environment. Many times the educational course of direction becomes set, although information on which this direction was predicted subsequently proves inadequate, because of other significant components in the living structure which were not originally detected, e.g., learning disabilities, patterns of emotional disturbance, and characteristics of exceptional brilliance. In most cases, there are few early inputs from the handicapped human controller concerning the unique details of his state for the layman to properly evaluate. Hence, a potential dilemma for student, teacher, and investigator.

Present procedures for providing guidance to parents of disabled children and handicapped adults who wish to extend their education, are further complicated by a morass of entropy. People who send disabled members of their families from one special school or institution to another generally find them understaffed and unequipped with communications and life-support systems essential for the disabled person to better couple himself to his environment and to perform and express himself as his peers. More problems arise if school buildings are not adequately designed to provide for an individual's hygienic, communications, and mobility needs. It soon becomes apparent to the observer that provisions for appropriate feeding, furniture, guide rails, ramps, elevators, hoists, wheelchairs, audio and visual aids in classrooms, bathrooms and recreational facilities, among others, leave much to be desired. It is certainly more than an accommodation or rooming facility that is needed; indeed, the disabled person's identity with society is lost. Confronted with vacillating policies and a "supporting" staff which changes many times within one semester, administrators, teachers, and therapists who have been professionally trained, find the textbook citations remote from the reality of their classrooms. Fortunately, there are schools and institutions which have recognized their own inadequacies, and have endeavored to correct the situation, but these institutions are too few.

There is a genuine need for the involvement of all citizens, not merely the parents of handicapped children or the school administrators and teachers. For the day will arrive when these children will be exposed to and expected to function in a world which is not preoccupied with their life-support problems and personal needs.

This study has exposed far more compelling and perplexing questions demanding answers than had previously been contemplated. For example, man-machine and life-support means to aid in solving the problems concerning a disabled student's general cleanliness and personal hygienic needs are critical and cannot be neglected. They must be resolved prior to his admittance to a school system; both are prerequisites for classroom dialogue and the functioning of a healthy human being in any environment. It is desirable for a student to toilet himself with a minimum of human assistance and to be able to move about easily. Both enhance his dignity and well-being. It is often the manner in which a disabled child is treated that makes him handicapped. School administrators, special educators, physicians, counsellors, therapists, and many others in daily contact with these problems know this, and they have recognized that society can no longer avoid the disabled person's needs; their voices must be heard. The personal considerations of the disabled cannot be dismissed, shunned, or discussed in a covert manner.

There are feasible transformations related to the objectives of this work to assist disabled persons which may appear mundane from a technological and scientific overview but, in fact, may be intrinsically structured and thus preclude operational implementation and utilization in view of their social and economic constraints. For example, it is possible to automate and convert audible, but distorted speech of the speech-impaired individual, or transpose the punctographic writing of the blind, into intelligible synthesized speech. The sounds of speech generated by speech-impaired persons, and the ambiguous tactile coding used by the visually impaired may be converted into algorithms, which can be processed and delivered in "real-time" as audible speech, typewritten print-out, or on alphanumeric whole-word, phrase, and sentence displays.

Cybernetic "intelligence" automata are in daily use for data processing of linguistic, pictorial, and pattern recognition and comprehension tasks. Computer applications of this nature are commonplace in commerce, in the military, in research, and in other programs. Our organizational resources and knowledge of electronics, mechanics, and computer technology are enormous. Yet, the special and general educational communities are reluctant to vigorously pursue, exploit, and adopt these technologies, except in isolated applications. Is it because they were once drawn into the "teaching-machine era," a period which promised to solve "all" learning and teaching problems while, at the same time, seemingly discrediting the student's need for human teachers? Even today, some vestiges of this position remain, and the lay educator appears to be at a standstill, principally through reference to the automata's poor record, which resulted from, among others, improperly designed equipment and inadequately programmed materials. It is time that the spokesmen for man-machine educational systems clarify that these systems can effectively utilize properly designed programmed materials, need not be costly and complex, and are not intended to replace teachers. The fact is that the growing population of disabled and also non-handicapped persons will eventually be compelled to interrelate with a teacher who is assisted by the interfaces, the programs, the central computing and processing centers and other services offered from these man-machine educational and life-support information systems.

The educational community need not wait to adopt the advances of the last two decades, but may utilize this available new technology, and embrace the cybernetic philosophy of McCullough, Bigelow, Von Foerster, Ross Ashby, Weiner, and others. Will the extension of academic curricula to include more concentration on computer and engineering sciences, physiology, pediatrics and other related disciplines offer viable programs to aid the handicapped? Through access to information processing plants, great strides in the efficient use and transfer of information can be achieved via interfaces matching the user's capabilities.

Thus, the one example cited for utilizing cybernetic systems in the conversion of "speech-impaired" signals and punctographic patterns into synthesized speech via computer transmutation is not without validity, and, indeed, is within our present technological possibilities. With adequate motivation and support, informed sociologists and educators, with the aid of physicians, psychologists, physiologists, neurologists, engineers, mathematicians, and computer scientists can make contributions heretofore unachievable in the educational community. But, the resources presently allocated for life-support endeavors to aid the disabled are meager. If we consider, gambling and surveillance industries and observe how effectively their managing directors utilize and exploit two decades of electronic and computer technology, it should be neither surprising nor amazing, but embarrassing. Just where is our sense of equity? It appears even with solutions as demonstrated in this study, the problem prevails; this combined with a pervasive public ignorance of the need for the well-being of the disabled are primary barriers to implementation of viable programs. Because of the public's general lack of awareness, the handicapped become the victims of self-fulfilling prophesies; they are labeled handicapped, therefore, they are handicapped and "there's nothing much that we can do about that."

How may these obstacles be diminished or nullified? Perhaps, options in the form of tax write-offs could be increased to encourage traditional profit-element motivation to the businessman, thereby leading to more industrial participation in providing solutions to the problems of the disabled. The refractory policies of academe must also be opened to promote a positive liaison with administrators and researchers. Legislation and appropriations which are the result of a "let's-feel-sorry-for-the-disabled-today" attitude, or legislation which has been addended to unrelated programs as a last resort to gain public sympathy for the handicapped is unfair in that it deprives this population of the respect it deserves. Legislation and appropriations to provide long-range governmental support of research, and implementation of viable programs in the form of overt participation by the government with industry, academic and non-profit organizations are needed with no tie-ins.

Let new mandates initiate recognition of the equality and rights of the handicapped.

SYNOPSIS

Innovative man-machine systems were studied for the purpose of determining their effectiveness in an educational environment for handicapped students in critical need of a means of communication.

The disabilities of students were nominally classified into four broad categories, where one or more of the following criteria prevailed:

1. Inability to communicate in any effective written form due to severe physical and/or neurological dysfunctions.

2. Deaf and/or speech-impairments which preclude the establishment and maintenance of "live" communications beyond tactile or visual range.

3. Blind or visual impairments with inability to learn to use braille.

4. Multiple impairments including "learning disabilities," which in some cases involve the absence of both written language comprehension and knowledge of language structure, but possession of minimal motor control capability and sufficient cognitive and sensory abilities to understand, respond to, and carry on dialogue via drawings or pictures and/or spoken or prerecorded audio messages.

For those students who have language skills, comprehension and knowledge of language structure, but who are constrained from effectively writing with or operating a standard typewriter keyboard or other such mechanism, "Cybertype," a remote control electric typewriter equipped to operate from various interfaces or "keyboards," was employed in the study together with innovative instructional materials, written in English, designed around an epsilontau notation, a scientific sequential arrangement of the letters used in a language based on frequency of usage. In addition to an English epsilontau, such arrangements for the Arabic, Armenian, French, German, Hebrew, Italian, Portuguese, Russian, and Spanish languages were presented.

Types of interfaces used with the electric writing machines employed varied depending on the student's particular disability and needs. One type consisted of two sets of a minimum number of keys, one set for each hand, prosthesis, or orthesis; these were made available to subjects who had bilateral control capability. Other interfaces for unilateral operation were used by subjects with limited control capability. The bilaterally controlled interfaces are operable by simultaneously striking two keys, using a common dual-input epsilontau keying code or "Cybercode." The unilaterally controlled interfaces are for use by subjects who have unilateral control of at least one portion of their body, e.g., the tongue, one hand, arm, foot, leg, or prosthesis. The unilaterally controlled interfaces are operable by means of the same "Cybercode" as prescribed for other interfaces. Thus, numerous "keyboard" configurations can produce the desired outputs through use of the same dual-input coding.

One great advantage of the "Cybertype" is the common dual-input code used for programming electric writing or other machines. This property of the system is of enormous value to the teacher and the handicapped student. It is for this purpose that the following emphasis is directed. Firstly, a common dual-input coding is used that permits the exchange of keyboards, especially where matching and coupling of another style interface to the specific performance capabilities of each individual may become necessary. Secondly, a common programming code eliminates the necessity for the teacher to learn a "new" typing procedure for each student who uses a different style keyboard. Thirdly, if a specific interface used by a handicapped person has to be exchanged for a new one more suited to the requirements of that person's capability, the student does not have to learn a new code.

"Cybertype" interfaces employed in this program include the following configurations, and combinations thereof, all of which can be used with alphanumeric "Cyberlamp" or "Cyberlex" whole-word displays, or standard electric typewriters equipped with means for operation of each key or function, or "input/output" and "ball" style typewriters and teleprinters provided with electro-mechanical means, and converters controllable through an appropriate electronic logic circuitry.

1. A bilaterally controlled single or two section dual-input interface, with two groups of keys or controls which may be mounted on the user's body, a desk, table, or other structure, e.g., the arms of a wheelchair.

2. A unilaterally controlled dual-input interface accessible to a single portion of the user's body such as the user's arm, tongue, or any other such portion of the body which can be controlled.

3. A "keyless" typewriter or machine keyboard with a dual-input interface consisting of a lever or levers or "joy sticks." These interfaces are for use by blind or visually impaired individuals who find it difficult to locate a position, but who can easily establish orthoganal references and differentiate displacements from a fixed referent from which keying positions are related. They are also for persons with cerebral palsy, muscular dystrophy, or other such debilitating conditions, and for persons who cannot effectively operate or manipulate regular typewriter keys, but whose body movements permit operation of lever mechanisms.

4. A dual-input finger, foot, or fist-operated interface consisting of various combinations of large keys or levers depending on the user's capability and needs.

5. A conductive metal plate interface used with contacts on the fingers or gloves. Control is initiated by touching the finger or glove contacts to the conductive plate.

6. A glove interface with keying means built into the gloves where control is accomplished by touching appropriate finger contacts with other parts of the glove, body, or structure.

7. A combined tongue and body operated dual-input keyboard.

The program included the study of a number of exploratory procedures with hundreds of subjects having language comprehension who were selected for the following purposes:

1. To investigate the relative efficacies of the disabled person's ability to couple himself to a "Cybertype" interface and to use it to communicate through use of a single dual-input code, "Cybercode," with instructional materials based on epsilontau, the sequential arrangement of letters in accordance with frequency of usage.

2. To study feasibility of integrating man-machine communications systems into the classroom for individuals whose handicaps precluded other modes of effective writing and communication.

3. To measure the performance of handicapped students who were taught to communicate with these man-machine aids.

4. To study instructional materials in English based on the introduction of letters according to an innovative epsilontau.

5. To develop and provide evaluative procedures for handicapped students who potentially can benefit from the use of man-machine communications systems.

6. To consider the potential educational value of telecommunications systems, i.e., the benefits derived from using telephones, TV, FM, and standard radio broadcasts, by those individuals having language comprehension, but who are totally deaf or have severe hearing impairments, lack functional speech or are deaf/blind.

7. To develop new punctiform tactile writing systems for individuals who cannot learn the present braille code.

8. The study also included proposals for future programs in man-machine communications and life-support systems for use by handicapped persons. The latter were briefly considered after learning that many disabled persons, otherwise refused admittance to schools, would gain acceptance if there were basic aids available to meet their critical life-support needs. These aids would be valuable not only in permitting these handicapped persons to gain entrance to schools, but also in helping them in their social, home, rehabilitation, and vocational environments.

The following conclusions were drawn as a result of this research program:

1. For students in the group identified as physically and/or neurologically impaired, the study yielded data and gave insight into their ability to use, in a classroom, a communication system employing "Cybertype," an electric typewriting machine, operable from any of innumerable configurations of interfaces, keyboards, or controls which can be "coupled to" or "matched with" the user's remaining motor, sensory, and cognitive functions.

2. For those students identified as deaf and speech-impaired, portable "Cyberphone" telecommunications aids permitted them to use telephones. These

individuals can be provided with portable means to communicate among themselves or with other persons who are not deaf or speech-impaired.

3. The persons identified as blind or visually impaired could utilize "Cyber-Brailler" with "Cybertype," a combination electric braille writer and electric typing machine. Sighted persons could use the system for written communications with the blind, or vice-versa. In addition, the study involved the development of HAIBRL, a new, unambiguous punctographic tactile reading-and-writing system for use by the blind and visually impaired, as well as others in need of a tactile means of communication. Essentially, HAIBRL is an unequivocal system which is rich in patterns. Unlike braille, which is highly ambiguous and has only 63 patterns (31 of which are ambiguous), HAIBRL contains unambiguous pattern variety and was developed after learning that only a small percentage of the blind learn braille and that a need exists for a more viable tactile system for the blind.

4. For those persons without, or with limited, language comprehension and knowledge of language structure, the "Cyber-Go-Round," an automated audio and/or visual aid system was introduced at the C/R/I Field Centers to explore its utility. It too is capable of being operated by interfaces which match with the disabled person's control capability. Communication is possible via information in picture or print form with access to a reasonably large storage-bank of messages.

5. The study considered life-support and communications systems which use FM, TV, and standard radio broadcasts for transmission of information for use by deaf and deaf/blind individuals in future programs.

The study program encompassed the development of policy, operational procedures, and the establishment of a resourceful network of C/R/I Field Centers throughout the nation. To this end, professional personnel were engaged and instructed to train others in C/R/I systems and technologies. Special educators introduced the man-machine systems to the C/R/I Field Centers, together with evaluative materials developed by C/R/I psychologists and special educators. Not only did the Field Centers serve as a source of subjects for testing, but they also provided valuable inputs and significant insights relative to the needs of the disabled population.

In addition, "Cybertype" man-machine writing systems were provided to the Field Centers for use in the national pilot training and data collection program. Dissemination of project activities was maintained through lectures, presentation of papers at numerous professional societies, and demonstrations at institutions, colleges, universities, and service organizations. In response to an invitation from the Council for Exceptional Children (CEC), demonstrations and lectures covering this study were made at numerous conferences. Dissemination of C/R/I research reports through ERIC and C/R/I were made possible through the support of the Bureau of Education for the Handicapped.

The C/R/I Lecture Series was conducted during the study, and many of these presentations were video-taped. Eminent special educators, scientists, and scholars from the United States and abroad served as participants, and the exchange of knowledge resulted in a better understanding of the handicapped individual's needs.

The study also covered the development of the C/R/I Inquiry Form and a

Capabilities Inventory Form, and use of experimental instructional materials.

Significantly, the data collected up to the time of the study's discontinuance, revealed that 60% of the first group tested (representative of hundreds of thousands of severely disabled individuals in the United States who cannot write) benefited from electric writing machines employed in their classrooms.

The study also confirms that the hearing-impaired in the second group, (a large segment of the more than two million individuals with no hearing capability, together with the hundreds of thousands of individuals afflicted with cerebral palsy who although not deaf have severe speech impairments) could potentially utilize telephones and radios as a means of communication. Thus, this population would for the first time benefit from use of telephones, educational and commercial TV, and standard radio broadcasts.

It has been reported that of the approximately one million persons in the United States who cannot read language with or without glasses, less than 35 thousand use braille proficiently. Hence follows the projection that even a small percentage of this population, included in the more than 960,000 blind and visually impaired in the U.S. who cannot use braille, are viable candidates for a more effective tactile means of communication. Moreover, according to information available from the American Printing House (Louisville, Ky.), the American Foundation for the Blind (New York, New York), and the Division for the Blind and Physically Handicapped (Library of Congress, Washington, D.C.), there will be increasing numbers of multiply handicapped blind and visually impaired individuals as a result of rubella epidemics. Also, advances in science, technology, medicine, and hospital care have extended the lives of persons who ordinarily would not still be alive. These multiply impaired individuals will require communication systems that they can learn to use without difficulty.

This study has clearly demonstrated in a classroom environment that the majority of severely disabled students who have language comprehension and knowledge of its structure, but who cannot write or type, can now learn to communicate through use of man-machine systems with interfaces coupled to their capabilities.

This program opens new areas for exploration by providing tools for those persons affiliated with educational, service, voluntary and fraternal organizations which serve the handicapped. Moreover, educators, physicians, neurophysiologists, therapists, and vocational and rehabilitation counselors, together with parents, their families, and the disabled persons themselves, whose self-development and self-realization remain to be enhanced, can now benefit from the implementation of these findings.

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Strengthen ye the weak hands, and make strong the feeble knees.

Say to them that are of a fearful heart, Be strong, fear not...

Then the eyes of the blind shall be opened, and the ears of the deaf unstopped.

Then shall the lame man leap as a gazelle and the tongue of the mute sing...

Isaiah 35: 3-6
circa 725 B.C.