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A STUDY OF PROGRAMMED INSTRUCTION IN BRAILLE.

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DESCRIPTORS- *BLIND, ADULTS, BLIND CHILDREN, *READING ASSIGNMENTS, TACTILE ADAPTATION, AUTOINSTRUCTIONAL AIDS, *BRAILLE, *TEACHING MACHINES, SELF PACING MACHINES, LITERATURE REVIEWS, COMPARATIVE ANALYSIS, INDIVIDUAL CHARACTERISTICS, EXPERIMENTAL GROUPS, CONTROL GROUPS, LONGITUDINAL STUDIES, WISCONSIN, TACTUAL DISCRIMINATION PROGRAM, BRAILLE TACHISTOTACT, BRAILLE TAPE READER,

THE PURPOSES OF THE PROJECT WERE TO (1) DESIGN A SELF-PACED TEACHING DEVICE FOR THE BLIND WHICH WOULD ALLOW THE EVALUATION OF SYSTEMATIC TRAINING IN PREREADING TACTUAL DISCRIMINATION AND BRAILLE CHARACTER DISCRIMINATION AS BOTH RELATE TO SUBSEQUENT ABILITY TO LEARN TO READ BRAILLE SYMBOLS, (2) DESIGN AN ELECTRONIC AUTOMATED DEVICE WHICH ALLOWS THE TACHISTOSTATIC OR MOMENTARY PRESENTATION OF BRAILLE SYMBOLS, AND (3) DESIGN A SELF-PACED METHOD OF MOVING A TAPE OF BRAILLE SYMBOLS BENEATH STATIONARY FINGERS. THE THREE DEVICES DESIGNED AND BUILT WERE (1) A TACTUAL DISCRIMINATION DEVICE -- A MODIFIED CODE OSCILLATOR ABOUT 1" BY 2" BY 4" WITH A SMALL EARPHONE AND STYLUS ATTACHED, (2) A BRAILLE TACHISTOTACT -- AN EXPERIMENTER-CONTROLLED MACHINE-PACED DEVICE TO FACILITATE INCREASES IN THE SPEED OF RECOGNITION AND ACCURACY OF DISCRIMINATION OF INDIVIDUAL BRAILLE CONFIGURATION, AND (3) A BRAILLE READER WHICH MOVES BRAILLE ON A TAPE FROM RIGHT TO LEFT ACROSS AN EXPOSED PRESENTATION WINDOW. DURING THE 2 YEARS OF THE PROJECT (1963-65), A TOTAL OF 54 CHILDREN IN GRADES 3 THROUGH 9 AND 66 ADULTS WERE INVOLVED IN CONTROL AND EXPERIMENTAL GROUPS TO DETERMINE THE EFFECTS OF THE AUTOMATED SELF-LEARNING DEVICES. ALL THREE WERE FOUND TO ENHANCE THE BLIND PERSON'S RATE OF READING BRAILLE. (PS)

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This study was undertaken to ascertain the effectiveness of programmed instruction to the process of braille reading for blind children and adults. An attempt was made to transfer the technological aspects of programmed instruction to the area of braille reading - an area which had previously received little attention from a research and demonstration point of view.

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We hope that this study will make some small contribution to research concerning rehabilitation of the blind.

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CHAPTER I

INTRODUCTION

It is common knowledge that we are living in an era of rapid technological and socio-cultural change. Indeed, it is now respectable for historians to be involved in contemporary events which only ten years ago were the exclusive domain of the newsman or sociologist. A classic example is the Manchester affair in relation to the biography of John F. Kennedy. Given this rapidity of change, the individual, to remain abreast of developments, is forced to assimilate information at an ever increasing rate. The blind, lacking a major modality for the monitoring of human change, are being increasingly disadvantaged, for the nature of their disability is such as to block adequate assimilation of information, particularly of an educational or vocational nature which even the non-handicapped person often has difficulty handling.

Methods, using the auditory modality for informational input, such as the sighted assistant and talking book, are currently used. However, it remains for the tactual modality and its attendent symbol system, braille, to bear the burden of informing the totally blind about his environment and, more important, allowing him to obtain the skills necessary for independent and productive living. Thus, any attempt which allows the blind to more effectively use the braille symbol system must be considered highly desirable from a rehabilitation standpoint. That such a need exists is readily apparent.

Frequently, educational retardation is to be found among blind adolescents with a gap of three to four years being reported by workers in the field. This retardation can be attributed to the slow braille reading rate of the blind. The average blind high school senior reads braille at about 90 words per minute compared with the 250 words per minute of the sighted senior and 150 words per minute for the partially sighted large type reader. There is evidence to indicate that once the blind leave their training institutions, their use of braille rapidly decreases. In the adult blind, it is estimated that only some three to ten percent read braille although some 43 percent are capable of doing so. In a stagnant society such a state of affairs could be viewed with equanimity. However, in a progressive society characterized by change and the attendant need for education in technical and cultural innovation, it could be very detrimental.

It seems necessary therefore, as a consideration in the educational and vocational adjustment of the blind, that studies be undertaken and techniques be developed to:

a) Increase the reading speed of the functional braille reader.

b) Determine optimum ways of presenting the braille symbols to both the beginning and functional braille reader.

c) Devise techniques which will motivate the adult blind to regularly read braille.

d) Develop programs which will allow the newly blinded adult to learn braille.

Rationale for the Study

The obvious limitations imposed by loss of visual acuity makes the problem of vocational and educational achievement in the blind a particularly challenging area of concern. Moreover, facilitation of the educational, habilitative and rehabilitative process requires the development of effective and supplementary techniques to expedite the learning of the braille symbol system. For, most aspects of education and rehabilitation are highly dependent upon the adequate development of braille as a tool for the acquisition of information and communication.

The development of new ideas and techniques in braille instruction has been hampered by a number of factors. The extensive results of research in learning have not found their way into the normal classroom let alone into the teaching of the blind. The very nature of the institutional settings in which the blind learn braille are such as to resist innovative pedagogical methodology. There appears to be little unanimity of opinion regarding how the blind tactually perceive and associate braille and geometric configuration. Another factor which mitigates against new techniques of braille instruction is the lack of commercial interest in the area. This lack of interest can be attributed to the small number of blind in the general population. The Review of Educational Research (1963, p. 40) has provided a succinct statement of conditions in the field, "Since Maxfield's (1928) book, no comprehensive treatment of braille reading, writing or methods by which it is taught has been written".

A number of experts in the field (Lowenfeld, 1956; Meyerson, 1953; Kirk and Weiner, 1963; Ashcroft, 1962) have been aware of the situation for some time and have indicated a need for studies and programs encompassing the application of what we already know about braille instruction with a blending of new ideas as they prove feasible and productive. In summary, the present study was predicated upon the assumption that increased facility in learning braille and increased rate of reading braille can be significant factors in alleviating the debilitative effects of impaired vision in educational and vocational adjustment. The study was designed to evaluate the feasibility of using electronic automated learning devices as adjuncts to the teaching of braille skills to blind children and adults.

Purpose of the Project

It is of some interest to imbed the purposes of the project within a conceptual framework in order to better see where we have been and where we have yet to go. Table 1 depicts Egon Guba's schema of processes related to and necessary for change in education. Within the context of this schema, the present project cannot, in a strict sense, be called research. Rather, the project started in the invention phase. Findings from research in programmed learning and electronics allowed the formulation of a solution to the problem of increasing braille reading speed. The components of the inventions were engineered or designed into innovative instructional packages. A detailed description of the several machines occur later. The diffusion stage encompassing dissemination and demonstration occurred in the process of getting the personnel involved at the institution where the study took place. Within the adoption phase, this study only went as far as the trial stage. Results of the study will show, in part, that the stages of installation and institutionalization should be considered.

The specific purposes then of the project were:

1. To design a self-paced teaching device which would allow the evaluation of systematic training in:

   a) Pre-reading tactual discrimination, and

   b) Braille character discrimination as both relate to subsequent ability to learn to read braille (designated Machine I).

2. To design an electronic automated device which allows the tachistostatic or momentary presentation of braille symbols. Such a device allowed the investigation of optimum presentation time of braille symbols, the relative difficulty of recognizing braille symbols, and the feasibility of using this device in a training sequence whose effects should transfer to traditional braille reading (designated Machine II).

3. To design a self-paced method of moving a tape of braille symbols beneath stationary fingers. This device allowed the comparison of the reading speeds associated with the moving tape and the traditional method. It also allowed an investigation of the transfer effects, to traditional braille, of a prolonged training program using the moving tape device (designated Machine III).

Definition of Terms

The following terms will be encountered in reading this report and are defined now to enhance comprehension of a fairly technical subject:

Blind - The clients used in this study met the following criteria of blindness. Visual acuity in the better eye with best correction does not exceed 20/200 or a defect in the visual field so that the

TABLE 1

A CLASSIFICATION SCHEMA OF PROCESSES RELATED TO AND NECESSARY FOR CHANGE IN EDUCATION

	RESEARCH	DEVELOPMENT		DIFFUSION		ADOPTION		
		INVENTION	DESIGN	DISSEMINATION	DEMONSTRATION	TRIAL	INSTALLATION	INSTITUTIONALIZATION
OBJECTIVE	To advance knowledge	To formulate a new solution to an operating problem or to a class of operating problems, i.e., to innovate	To order and to systematize the components of the invented solution; to construct an innovation package for institutional use, i.e., to engineer	To create widespread awareness of the invention among practitioners, i.e., to inform	To afford an opportunity to examine and assess operating qualities of the invention, i.e., to build conviction	To build familiarity with the invention and provide a basis for assessing the quality, value, fit, and utility of the invention in a particular institution, i.e., to test	To fit the characteristics of the invention to the characteristics of the adopting institution, i.e., to operationalize	To assimilate the invention as an integral and accepted component of the system, i.e., to establish
CRITERIA	Validity (internal and external)	Face Validity (appropriateness) --- Estimated Viability --- Impact (relative contribution)	Institutional Feasibility --- Generalizability --- Performance	Intelligibility --- Fidelity --- Pervasiveness --- Impact (extent to which it affects key targets)	Credibility --- Convenience --- Evidential Assessment	Adaptability --- Feasibility --- Action	Effectiveness --- Efficiency ---	Continuity --- Valuation --- Support
RELATION TO CHANGE	Provides basis for invention	Produces the invention	Engineers and packages the invention	Informs about the invention	Builds conviction about the invention	Tries out the invention in the context of a particular situation	Operationalizes the invention for use in a specific institution	Establishes the invention as a part of an ongoing program; converts it to a "non-innovation"

widest diameter of vision subtends an angle no greater than 20 degrees. A person with 20/200 visual acuity is able to see at 20 feet objects that a person with 20/20 or normal vision sees at 200 feet.

Braille - Braille is a raised dot, punctiform, system of reading and writing employed by the blind. Braille includes a literary code and a special code for the writing of music, mathematics and scientific formulae. The literary code, as it is now officially approved, consists of three grades; I, II, and III.

Grade I Braille - This grade of Braille consists of the letters of the alphabet, marks of punctuation, numbers and composition signs that are peculiar to Braille, e.g., capital sign. Words written in Grade I Braille are fully spelled.

Grade I 1/2 Braille - This grade of Braille, used in the United States from 1917 to 1932, includes the signs of Grade I Braille plus 44 of the contractions found in Grade II Braille.

Grade II Braille - This grade of Braille, English Braille -- American Edition, 1959, includes all of the symbols of Grade I Braille plus 189 contractions and short-form words. Grade II Braille, with the exception of punctuation marks, numbers and some composition signs, is the medium employed in this study.

Grade III Braille - This grade uses the symbols of Grade II and more than 500 short-word forms. This system is utilized by a limited number of people.

Cell - The dots used in Braille are grouped in rectangular cells, three-dots high and two-dots wide. To facilitate description in reading, the dots are numbered downward on the left 1, 2 and 3, and on the right downward 4, 5 and 6:

1 • • 4

2 • • 5

3 • • 6

Character - Characters are made by using one dot or two or more dots in various combinations within the cell. Sixty-three combinations of dots or characters are possible: six 1-dot characters, fifteen 2-dot characters, twenty 3-dot characters, fifteen 4-dot characters, six 5-dot characters and one 6-dot character.

Symbol, sign - These terms are synonymous, as used in this study, to represent individual letters, part-words and whole words and may consist of one or more characters.

Contraction - Symbols may represent contractions, a shortened expression of a sequence of two or more letters. Contractions may consist of one or more characters and may represent part-words or whole-words. Upper-cell contractions use dots 1 and 4, the two top dots in the cell; lower-cell contractions use dots 2, 3, 5 or 6.

Configuration - Configurations are made up of a uniform pattern of dots which remain the same in regard to alignment and extension. These patterns assume a different position through rotation or reversal within the cell itself. The sixty-three characters of the Braille cell can be reduced to nineteen configuration patterns.

Functional Braille Readers - refers to blind children or adults who have mastered the mechanics of braille reading to the extent that they can derive meaningful information from it.

Measure of Braille Reading Performance - refers to the Science Research Associates stories produced in Braille and equated for individual reading achievement levels to evaluate:

1. Braille Reading Rate - which refers to the total number of words read orally and correctly by a subject over a specified period of time.

2. Errors - which refers to the mispronunciation of words.

3. Additions - which refers to the placement of any additional words into the context of the material.

4. Retracings - which refers to the process of the predominant finger or fingers used in the reading process reverting to a specific braille cell (letter or contraction) either to check whole or part word recognition.

5. Skipping - which refers to the omission of a single word in the context of a group of words.

6. Omission - which refers to the omission of more than a single word in the context of a group of words.

7. Vertical Movements - which refers to the finger or fingers used in the reading process moving in an up and down or circular movement over a braille cell.

Subjects - abbreviated to S(s) refers to the blind adults and children comprising the study population.

CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature considers those studies which provided guidelines to machine design and program development using these machines. Specific areas covered are tactual perception and its relationship to braille reading, factors which affect the structure of braille and aids and devices which have been developed to help the blind read braille.

Tactual Perception and Braille Reading

A large amount of literature from a variety of diverse sources is available in the area of tactual and kinesthetic perception. The majority of this literature is presently being published by the Russians and is not readily available in English translation. Also, a considerable amount of that which is available is not directly applicable to the problems involved in the improvement of braille reading skills. It also appears that a great deal of the information on tactual perception is grounded in visual perception studies and the studies often employ sighted adult subjects. As direct application of these materials and findings to the present investigation is a doubtful issue, this section of the review is limited to those tactual perception studies directly applicable to the problems associated with the development of reading skills in the blind.

Worschel (1962) states that the research of Merry and Merry, Cutsforth, Worschel and Drever has pointed to the fact that the reading process for the blind is similar to that of the sighted. There exists a relationship between tactual and visual perception and reading ability. A 1951 study by Worschel proposed to investigate the tactual perception of good and poor readers on certain tests. The rationale for this study was the probability that if visual perception and imagery are necessary for the development of reading ability in the sighted, tactual perception must be of equal importance for the blind.

In this study, two groups of twenty-five children (grades 2-6), blind before the age of eighteen months were administered experimental tests. These tests consisted of three simple and three complex tactual perception tasks (sorting, matching and figure background discrimination). The groups were determined by ability as demonstrated on the Paragraph Meaning Section of the Stanford Achievement Test. No significant differences were found on the three simple tasks but significant differences in favor of the good readers were found on the complex perception tests. As no definite relationships were found between performance on these tasks and MA, CA, IQ, or reading achievement, it was suggested that increased neural sensitivity and better development of gross and/or fine motor coordination might be affecting these variables. The author suggested the investigation of these factors and an effort to find ways of stimulating increased ability to perceive tactually.

Nolan (1958) discussed the relationship of intelligence and physical ability in learning to read. He stated that certain physical abilities must be present as well as the appropriate maturation level achieved before the child can begin reading. In the case of the blind child, the sensory capacity (tactual) to discriminate small differences in the form of symbols that represent the spoken language must be present. Some of the factors proposed for study of the relationship between tactual perception and beginning reading were: the ability to recognize whether simultaneous or successive simple tactual stimuli are identical or different, the ability to manipulate tactual forms presented simultaneously and successively, and the ability to perceive and reproduce tactual patterns.

Burklin (1932) found that touch span of the finger differs according to strength, based on individual developmental differences, age and sex. The touch span of readers from 11 to 19 years of age were found to vary from 6-18 mm's in length and 6-12 mm's in width. He concluded that it is not always possible for young readers to cover a braille character with light pressure and vertical position.

A study of pressure used in braille reading (Holland, 1934) indicated that the pressure range within which braille cells can be identified is narrow and requires highly developed tactile perceptual judgment. It was stated that too little pressure does not stimulate a sufficient number of nerve endings while excess pressure creates a general tension which negates discrimination ability. The author further stated that perceptual judgment can be improved and developed with practice, citing as evidence studies of two point limen perception by Volkman, Tichener, Tawney and others. It was concluded that increased perceptual acuity achieved through practice diminished rapidly with disuse and that the dependence of braille on a six point limen precluded a widespread proficiency in braille reading ability.

Masuda (1963) rep[illegible] a study investigating the effects of training on the perception of [illegible] figures. Eighteen students, 12-19 years of age, were divided i[illegible]ups. One-half of the group was trained for two weeks on percep[illegible]ividual braille figures. The remaining students served as [illegible]s and received no training. A post test indicated a figure [illegible] speed 35% faster than that of the control group. The effect [illegible] was still observed on a fifty-day retention test was greatest for [illegible]s of average intelligence.

A series of studies by Morris and Nolan (1960, 1961, 1963) in the use of illustrative materials indicated the ability of blind students to perceive areal type tactual patterns using Virkotype (plastic ink embossed) point and line presentation and later vacuum formed plastic symbols. The results of studies using braille readers in grades 4-12 indicated that grade level differences existed in the ability to differentiate symbols. Recent work has been concerned with initial learning and retention of labels for the various materials presented in this form as well as the minimum sizes for areal tactual symbols. Future research in the development of adequate symbolic presentation of non-verbal tactual communication, as reported in the 1964 Annual Report of the American Printing House Department of Educational Research, is aimed toward evaluation of symbols now used in embossed maps, an increase in number of discriminable symbols that can be reproduced in vacuum form plastic, and further study of size and legibility variables.

In another series of investigations aimed at the development and validation of a roughness discrimination test, Nolan and Morris (1960a, 1960b, 1965) were concerned with developing a means by which braille reading readiness could be determined. They state:

> In the case of braille reading the stimuli encountered are tactual in nature; therefore, the development of ability to utilize the tactual receptors and hands in a coordinated fashion is critical to the reading process. The Roughness Discrimination Test (RDT) was devised as a tool for measuring the development of this ability. The rationale justifying its use as a reading readiness test is that a person must be able to interpret tactual stimuli if he is to learn braille. (1965)

The final form of the RDT was composed of sixty-nine cards each of which contained three similar and one different square of sandpaper ranging in grit size from 24 to 600. The task is to identify the one which is different. A split half reliability coefficient .94 was achieved for the test and it was found to correctly predict whether a student, at the end of the year, would be in the upper or lower half of the group tested, i.e., predicting that seventy percent of the time in terms of oral reading errors and seventy-five percent of the time when speed of reading was the criterion. The findings of the studies indicated that the RDT was useful in evaluating readiness ability and predicting the degree of success in beginning braille readers.

In relating tactual sensing and perception to braille reading it may be important to first consider the process of reading in itself. Harris (1962) defined reading as ". . .the meaningful interpretation of printed or written verbal symbols". Gray (1960) proposed four components relevant to the interpretation of printed matter. Listed in sequential order these are: (1) word perception, (2) comprehension of ideas represented by words, (3) reaction to these ideas, (4) assimilation or integration of the ideas with previous knowledge and experience. While components 2 through 4 are based primarily on number 1, and each successively on the preceding, a more basic or primary step necessarily anticedes whole-word perception. The more basic component is the perception, discrimination and integration of individual symbols (or letters) which culminate in the perception of the total word.

In considering braille reading, the primary concern is with the more basic perceptual skills needed to acquire information through the tactual symbol system. The development of these skills is necessarily related to the system itself and to the mechanics of its use. The secondary concern is with the information processing components of reading as listed by Gray and is dependent on the primary perceptual skills.

Blend (1946) in a comparison of the reading processes of blind and sighted children states that: "the final results are the same - the mechanics only differ. . .While braille is necessarily a slower medium," he states, "the sense of touch is but another entrance to the mind".

Ashcroft (1960) suggests, on the basis of his study, that the same psychological processes were found in braille and sight reading; that is, the perception of information through a symbol and the comprehension and retention of this information in the mind.

The mechanical differences in perceiving the symbol appear, however, to present a rather severe handicap for the blind reader. A braille reader is involved in a more severely delineated process of perception, discrimination and integration of individual symbols into total word perception, and for the same reason a more delineated process of integrating whole words into sentences. The touch reader perceives in sequence, the component individual symbols which form the whole word, while the sighted individual perceives the whole word simultaneously, drawing on conformation cues as well as individual letters.

Nolan (1960) discusses this problem in terms of a cue-reduction process meaning the refinement of the skill through the elimination of waste motion. This concept implies that the less complete the pattern of stimulation from the word symbol required for the perception of it, the more skilled and efficient the reader. In visual reading this is precipitated by cues of beginning and ending letters, small groups of letters perceived as a unit and the overall shape form of the word. The other influence in the efficient reading of printed matter by the sighted is the perceptual span, or the number of word symbols perceived as a unit. This is a problem area in terms of application to braille reading. The scanning ability of the visual reader also enables him to integrate individual words into instantaneously perceived phrases. The scanning ability further endows certain words with one of a choice of meanings due to the immediately perceived relationships between the particular word and those which precede and follow it. As this may not be possible to a great extent in the tactual system, the print reader has a distinct advantage in obtaining meaning. In this regard, Ashcroft (1962) mentions that the touch reader draws far less on contextual clues to word meaning than the sighted reader.

One approach to the problems of tactual perception and its effect on braille reading has been concerned with the symbol system itself. In this regard, we have seen the acceptance of Grade II Braille introductions in the primary grades in lieu of a progressive program of Grade I (each letter and punctuation mark as an individual configuration presentation and all words spelled in full) to Grade I 1/2 (Grade I and the 44 Grade II contractions) to Grade II Braille (Grade I plus 189 contractions and short form words representative of 200 more letters or whole words).

Biggs (1950), on the basis of observations, suggested that the early introduction of Grade II Braille was advantageous in that it eliminated the need for re-learning, led to shortened word length, was beneficial to the threshold attention span of the young child and beginning braille reader and did not prove detrimental to the learning of spelling and writing.

Hooper (1946) showed that 144 of the 189 Grade II contractions and short form words were already being used in primary grade reading vocabulary tests before this early introduction of Grade II Braille was finally accepted.

It would appear that fewer discrete stimuli to be additively processed into the perception of the whole word would be a distinct advantage in the braille reading process. There has been some feeling that the present Grade II system is inadequate and inefficient. Recent impetus has been added to the study of this problem of braille characters and contractions as a function of the attempt to design a direct print-out braille translation device.

Staack (1962a, 1962b) designed a computer program to analytically study and evaluate Grade II Braille to determine the ability of this code to reduce the bulk of material, to effect the readability of braille and to be translated mechanically. The study indicated that some Grade II Braille contractions are not achieving their primary purpose of reducing space used and thereby make reading of braille more rapid. Some recommended changes were tested on a sample of blind people and results of reading tests and subjective comments indicated that the proposed changes, once accepted as standard, would not burden the reader and would produce positive and lasting effects on reading speed.

Henderson (1961) studied specific misperceptions in a study using primary and intermediate level word discrimination tests administered to children in grades 1 through 6 at a residential school for the blind. She found that added dot errors were more frequent than missed dot errors in primary level children and that substitutions in the final position were more frequent than medial or initial substitutions. Reversal errors were the second most frequent type of error for both age groups. Vertical alignments were more frequent than horizontal alignment errors.

Kederis (1963) used 18 male and 18 female braille readers of fourth grade and above reading ability (as measured by a Grade II Braille Editions of Gray's Oral Reading Paragraphs) in a study of the legibility characteristics of braille configurations. A single configuration presentation task was employed and legibility ranking was in terms of time needed for correct identification. The number of dots was determined to be the major criterion of legibility. An order of threshold values for each configuration was established. Rank order of characters was more comparable to that of Uniform Type Committee than that of Burklin (1932). Missed dot errors were found to be the most important error type. The shape of the stimulus configuration and the incorrect response configuration were, in most cases, found to be similar.

Nolan (1964) discussed two studies done at the American Printing House for the Blind. One study attempted to determine the effect of number and position of dots on the recognition of braille words in contracted and uncontracted form. The first study employed 15 "fast" and 15 "slow" readers. The effects of both number and position of dots on recognition thresholds were significant, but the "precise effects of these facts were not clear since variation in the factors combined in a complex way".

Other studies reported by Nolan (1964) concerned the influence of contractions upon recognition thresholds for five character words presented on a tachistoscopic device. Variables investigated were: a) number of contractions within the word, b) two-dot high versus three-dot high contractions versus lower cell contractions and c) the position of the contraction within the word. It was determined that two-cell contractions required longer recognition time than one-cell contractions. The number and position of dots in braille words were found to have significant effects upon recognition time, word familiarity, position and the type of contractions combined in complex ways to effect recognition time. These studies raised some questions regarding the whole word approach to teaching reading to blind children. Further investigations were suggested on these same factors presented in context.

Hanley (1965) constructed an individual, diagnostic test of braille perceptual skills. The testing materials included three functional measurements:

1. An objective record of the frequency of braille misperception.

2. A profiled analysis of perception errors (seven theoretical categories).

3. A five-level scaled measure of letter and/or word knowledge.

Five presentation modes and two forms, each testing different sets of symbols were employed. The tests were individually administered to 192 blind children, grade levels 2 through 5 from residential and public school classes. The 48 children from each grade level were equally distributed according to sex, type of school and test form. Reliability coefficients established for all levels and forms were high and fairly comparable. A Chi-square item-analysis was made to determine discriminatory ability of the items on all levels and both forms.

The relationship of performance to the variables of grade, form, sex, etc., were in general, positive. Of particular interest is the finding that individual characters tended to arrive at the same point of relative difficulty under all modes of presentation implying that factors inherent within the characters affect their legibility. Hanley suggests that the items on the Diagnostic Tests of Perceptual Skills should be further analyzed, incorporated into reduced test forms and standardized on a representative population. He further indicates his belief that the test "enables the teacher or clinician, when initiating remedial instruction in braille, to set more exact goals than are now possible".

The various factors considered in the development of this diagnostic device are those that are functions of the symbol system and the basic cognitive and physiological readiness skills involved in reading. They appear to be very similar to those mentioned in the references to Gray, Michelson, Ashcroft and Nolan, among others.

The studies pertaining to tactual sensing and the braille reading process exhibit several trends. One is a concern for the development of tactual discrimination tests having as their goal diagnosis of deficits and strengths. A second concern in the isolation of those factors in braille perception which relate to adequate reading. However, very few studies are mentioned which have as their goal the training in perception of braille or training in tactual sensing, per se. While single-minded pursuit of conceptually uncomplicated problems does add to our store of knowledge, such strategies offer the practitioner little in the way of solving his immediate problems. Rather, it would seem that an approach which combines diagnosis with remediation, one flowing after the other, would circumvent these objections. Such a consideration lay back of the development of Machine II, a tachistotactic diagnostic and remediation device used in the present study. So-called Machine I, while used more sparingly and less sophisticated than Machine II, was developed within the same conceptual framework.

Factors Affecting the Structure of Braille

Relevant research studies since the official adoption of Grade II Braille in the United States (in 1932) have been primarily centered on the mechanics of braille reading. Burklin (1932) published his experimental study on braille reading in German in 1917 (translated in English in 1932). He found that the vertical arrangement of six dots is the best possible arrangement for braille reading and that the readability of the letters of the alphabet is not determined by the number of dots, but by their characteristic formation. In addition he found that all fingers could be used in the reading process, but that the first and second fingers of both hands were the preferred ones.

Fertsch (1947) investigated the problem of handedness and hand dominance in braille reading. By using the Shank Test of Reading Comprehension and evaluating the performance of each hand separately, she determined the hand dominance of 33 blind boys and 30 blind girls of average or above average intelligence. Motion picture records of the reading performance were obtained during both oral and silent reading to determine the method of reading. On the basis of performance when the blind children read with each hand separately, readers were classified into "right-dominant", "left-dominant", and "hands equal" groups. The "hands equal" group which contained fewer poor readers than the other two groups read faster and a larger number of braille cells with the hands functioning independently. The "right-dominant" group read almost as many braille cells with their hands separate, read almost as fast as the "hands equal" group, and contained an equal number of good and poor readers. The "left-dominant" group read a small amount of material with the hands functioning independently, read the slowest of the three groups, and contained twice as many poor readers as good readers.

Fertsch (1942) in another study attempted to isolate, measure, and evaluate some of the factors involved in braille reading. The Ss selected from grades 3 to 11 of a residential school and of average mental and reading ability, were administered the Otis Classification Test and the Monroe Silent Test. The results indicated statistically reliable differences between the rates of silent and oral reading for all readers. Good readers when reading either silently or orally were less variable within their group than were poor readers. Finger movements of the good braille readers were independent of each other in the reading process and, any retracing movements were made with their left fingers only. Regressive movements with the main reading fingers on both hands were characteristic of poor readers. The reading habits became established by the time the pupil had reached the third grade and seemed not to change noticeably with an increase in reading experience.

Both Burklin (1932) and Fertsch (1942) describe finger movements in great detail. Two types of movements were detected. One finger (usually the right index finger) was used for synthesis (an overall view of the word; the other finger usually the left index finger) was given the task of analysis. In Burklin's study the use of the opposite finger (left instead of right) was noted a function of the educational techniques sometimes used in teaching braille in European countries. Circling (vertical rather than horizontal) movements occurred more often among poor readers. In some cases the better readers read one-half of the line with each finger. Usually the other fingers remained a short distance above the page. Also in some cases a kind of "span vision" was made through the use of the idle extra fingers. It was noted that the better readers were able to anticipate word endings and thoughts. This is analogous to the better sighted readers. The better readers employed a light, fluent touch and kept the fingers at an acute angle to the page. The speed of the braille readers was approximately one-third as fast as sighted readers.

Of particular interest are Burklin's findings (1932), in which he indicates that optimal tangibility does not depend on the number of dots in a character as much as on the simplicity of the geometrical form. In all he pointed out 37 upper cell symbols which are symmetrically opposed and the cause of frequent confusion to readers.

Holland (1934) investigated the relationship of pressure to speed in braille reading. Seventeen slow and 17 fast readers, selected from grades 4 to 10 on the basis of photographic records of finger movements, were utilized as Ss. Each subject was instructed to read just as he normally would read, read a practice selection and an experimental selection taken from the Stanford Achievement Reading Test. Time and pressure were recorded using a Kymograph. The results indicated that fast readers tended to use less pressure while reading braille than did slow readers. The correlation between speed and pressure was .27. The amount of pressure varied within a given line, and pressure at the beginning of the line was less than at the end. The faster readers showed less variation and the poorer readers tended to increase the amount of pressure as they read through a paragraph.

Holland and Eatman (1933) attempted to discover the differences in performance of good and poor braille readers and to analyze the reading procedures of individual Ss. Twenty-eight children, four each from grades 3, 4, 6, 7, 8, 9 and 11 (two of which from each grade had been rated as good readers and two as poor readers), read selections from the Stanford Achievement Test at the eight-year-old level of difficulty. A constant-speed camera was used to photograph the hands of the readers at the rate of one frame per 20 seconds. These pictures were projected on the reading material, the position of fingers was marked, and the reading rate was calculated.

The measures taken were: a) the total number of exposures per line, b) the average number of braille cells read by the left and right hands independently, c) the time spent by Ss at the beginning and the end of each line, d) the number of regressive movements, and e) the time spent by Ss in return sweeps to begin a new line of reading. Results indicated that the performance of poor readers was more variable than that of good readers. Great variability existed in hand performance, finger preference, and in coordination of hand movements for both. Good readers read more material with the right hand, and the amount of material read by the left finger was less than that read by the right finger. Good readers spent less time at the end than at the beginning. The majority of regressive movements were made by the left hand and, the good readers made fewer regressive movements than did the poor readers. Six to seven percent of the reading time was spent making return sweeps, with the good readers spending less time than the poor readers.

In a more recent study Ashcroft (1960) studied the oral reading performance of children reading braille in order to identify errors and classify these according to type, frequency, and grade level. Seven-hundred forty-eight tactual braille readers of both sexes in grades 2 to 6 and who did not possess additional handicaps were required to read 12 simple passages of graded reading difficulty designed to include almost all of the 189 signs, abbreviations, and contractions of braille. The material was presented individually and errors were recorded verbatim according to a standardized procedure. The results indicated eight types of errors relating to the use of braille by the Ss. The types of errors together with their percentage of occurrence were: missed dots, 16 percent; ending problems, 15 percent; reversals, 13 percent, added dots, 13 percent; association, 12 percent; gross substitutions, 21 percent; up and down alignment, 9 percent.

From the standpoint of the mode of braille spelling, the order of categories of orthography involving the most to least number of errors was: short form words, multiple cell contractions, combinations of orthography, lower cell contractions, upper cell contractions, full spelling, and alphabet abbreviations. The first three categories above included only 28 percent of the total number of words, but contributed 46 percent of the total number of errors.

From the behavioral standpoint the eight error types could be classified as problems arising from perception (missed dots, added dots, and ending problems); problems of orientation (reversals, vertical and horizontal alignment); and problems of memory (association errors and gross substitutions).

In this exhaustive study Ashcroft makes many recommendations in regard to methods of teaching braille, materials to be used in learning braille, and suggested braille code revisions. Two of his recommendations are appropriate to this proposed study: 1) reading braille should apparently emphasize the development of an optimum attention or anticipation span in functional braille readers which may in turn contribute towards further development of their reading ability and 2) methods of testing an accelerated optimum rate of reading braille with regard to efficient comprehension by the comparison of the effectiveness of different methodological testing approaches should be investigated.

Meyers, Ethington, and Ashcroft (1958) compared the readability of braille in which the spacing between dots within cells, between cells and between lines was varied over three distances for each. One hundred and eight blind children in grades five to twelve were divided into 27 groups of four. Each child was matched with others of his same reading ability.

Each subject read silently for two 50-minute periods on successive days eight chapters of the Black Arrow. The time spent to read each page was recorded for each subject. At the end of the second day a 30-item comprehension test was administered. Each group read one of 27 possible combinations of braille produced by varying the space between dots, (.80", .090", .100") the space between cells (.123", .140", .160") and the space between lines (.163", .220", .300"). The underlined values represented those of standard braille.

The results indicated the average speed for standard braille was 68 words per minute. The dot spacing of .080" was inferior to .090" or .100", there being no difference between the latter two. Cell spacing of .123" or .140" was more readable than .160". The line spacing of .220" was more readable than either of the other values.

This study effectively demonstrates that there is little room for improvement in the dimensions of braille printing.

Several studies have been conducted comparing learning achieved through listening with that achieved through braille reading. Enc and Stolurow (1960) tested the hypothesis that comprehension of auditory information is positively correlated with word rate within limits due to the effect of temporal contiguity. Twenty-three seventh and eighth grade blind children ages 13 to 17 years with IQ's ranging from 89 to 144 were used as Ss.

Ten 1300-1400-word stories were recorded at slow (174 W.P.M.) and fast (211 W.P.M.) word rates. A 20 item multiple choice comprehension test was available for each. The Ss were divided into three groups. Groups I and II alternated in hearing the fast or slow version of an identical story which was changed every day for 10 days. Group III read the story traditionally in braille. Children in groups I and II were tested for retention of story content immediately after the story and again twenty-four hours later. Group III was tested similarly at the same times.

The results indicated that the groups which heard the stories scored significantly higher on the test than the group which heard no stories. For nine out of ten stories the group hearing the faster story received a significantly higher test score after hearing. The test means for 13 out of 14 children listening to fast stories were higher than those listening to slow stories.

Lowenfeld (1945) compared the comprehension of children reading braille materials to the comprehension of children listening to stories in grades 3, 4, 6, and 7. The reading of the braille material took three times as long as listening to the story. The comprehension of recorded materials was significantly superior to the comprehension of braille materials for children in grades 3 and 4. For grades 6 and 7, no difference was found in the comprehension of stories. Comprehension of testbook materials was significantly greater for braille reading.

Nolan (1962) used matched groups of Ss in grades 6-12 and had them read in braille or listen at normal rates to a short passage of scientific material for 2, 4, or 5 consecutive days. On the final day a comprehension test was administered and no differences were found in amounts of learning achieved by either of these two methods.

Bixler et al. (1961) in another study of this subject utilized groups of children in grades 6, 7, and 8, and exposed them to materials commonly found in 7th grade literature and science texts. Some groups read the material in braille and others listened to it at rates of 175, 225, 272, or 375 words per minute. Immediately after exposure comprehension for the materials was measured by multiple-choice tests.

Analysis of the results showed no significant difference in comprehension between literature presented through braille reading and listening at 225 words per minute. For scientific material there was no significant difference between comprehension achieved through braille reading and that achieved through listening at 275 words per minute. Students in the study read the brailled literature at 70 words per minute and the brailled scientific material at 57 words per minute.

In summary, it would seem that the present structure of the braille code will remain as is, unless some unforseen breakthrough occurs in terms of information theory or technological spinoff from the space race. Moreover, the studies reviewed suggest that while input using the auditory modality can result in faster comprehension of uncomplicated material than the tactual modality, complex scientific and technical material seems to be better assimilated by the blind using braille. Errors associated with perception, orientation and memory have loomed large as impediments to effective braille reading. A number of workers (Ashcroft, 1960; Cruickshank, 1959; Nolan, 1962) recommend the need to evaluate the reading process of braille whereby consecutive stimuli are provided for the finger tips by a continuous moving line of braille. On an a priori basis, such a device should allow the memory span for tactual perceptions to increase and the blind person's spatial and orientational deficiencies would be under a degree of control. Such a device (designated Machine III) was developed for the present project and provided data for the evaluations recommended.

Braille Learning Aids

Many of the numerous devices designed to assist in the education of the blind by scanning print and conveying content held great promise of becoming functionally effective. Unfortunately, over a period of years they did not prove to be so.

In 1913 the "Optophone" was designed to scan printed matter by a perforated disc operating upon photocells producing musical sounds corresponding to the characteristics of the letters scanned. Then the Radio Corporation of America perfected a device enabling some readers to read 25 words a minute of simple printed matter. The "Visagraph" in the late 1920's was developed to make an enlarged embossed copy of print material.

Zworykin and Pike (1946) worked on a recognition reading machine that pronounced the name of each letter. It was functionally feasible from an engineering standpoint but proved extremely complex and costly.

Another type of reading machine was in effect an electronic computer which recognized each letter of the alphabet and then selected a recording of that letter sound. One basic restriction of all these devices was their limitation to full spelling or Grade I Braille. One recent development reported by Staack (1962) revealed that a machine translation group at the Massachusetts Institute of Technology has developed a programming language named "COMIT" from their braille contraction studies. This may eventually lead to computer transcription into Grade II (contracted) braille.

Various optical probes, for scanning printed matter, such as those developed by Professor Thomas Benham of Haverford College and Dr. Clifford Witcher of the Massachusetts Institute of Technology in 1955 were never proven practical enough to be functional aids to the blind.

Of the numerous attempts to develop reading machines to scan print and convey the content to the blind, none were sufficiently useful to justify their adoption in competition with the "Talking Book" or "Braille" in spite of the fact that the latter are restricted to specially prepared materials.

International Business Machine Corporation has programmed an I.B.M. 704 Electronic Computer to convert original ink-print text into braille code. With automation such as this in the process of producing reading materials in braille, the increase in number of books available to the blind should at least partially solve the inadequacy of sufficient materials.

While some devices of the present may eventually lead to a point where they are practical, it seems necessary to presently recognize their worth in experimentation, but to honestly accept the fact that, at this point, few have contributed to improving the methodology of braille instruction. Size and cost are prohibitive factors, but conceivably a functional reading machine (readout device) might eventually be invented to display braille.

A Braille Ad Hoc Committee reported by Staack (1963) represented the American Printing House for the Blind, the Veterans Administration, the Massachusetts Institute of Technology, the International Business Machines, the American Foundation for the Blind and 14 technological researchers who decided that machine translation of braille had reached the production-feasibility stage. They expressed their intent to further implement effective and efficient means of educating the world's blind population. The problem of producing cheap computers appears to be solvable within the next three year period. This would create a need for a suitable output machine, produced at a reasonable cost, that could hopefully display to the blind the world's literature at their fingertips. It is felt that this could conceivably be an endless self-erasing tape.

Ashcroft (1959) conducted a study using an IBM reading device consisting of an endless belt with pins that were raised or lowered to form braille cells. Information was relayed from an IBM computer serving as a storage device. Nine adult braille readers were given from two to twenty hours practice on the machine. Pretraining reading speeds for conventional braille ranged from 43-165 WPM while post-training speeds for similar material ranged from 81-215 WPM. An indirect finding of this evaluation was that a median increase in reading speeds for conventional braille of about twenty-five percent resulted.

Nolan (1962) also used the IBM Braille Reader programmed to accept information from IBM equipment. He matched two groups of 15 Ss each by reading grade level representing a cross section of grades nine through 12. His results were successful but restricted due to the mechanical unreliability of the equipment and the limitation of the overall speed of presentation. This intensified an interest in developing a more efficient and effective means of introducing braille.

Bliss (1961) in a study at the Massachusetts Institute of Technology developed an air-driven finger stimulator communication device via the tactile and kinesthetic senses that appeared to have some potential application in the teaching of typing. It moved the fingers horizontally and vertically assimilating all finger movements as are normally made on a regular typewriter keyboard. This device involved a sequential programming on a punched paper tape. The tape, acting as valves, controlled the flow of air to a complicated system of bellows. These bellows permitted movement of the keys in all directions. Introducing braille in a readout device using a pneumatic presentation method, for the present project, was given serious consideration. However, it was found to be too complex and more costly than other methods under consideration.

Nolan (1962) used a device known as a tachistotactometer that was capable of presenting a single line or cell at a time. He found he could present braille at speeds fast enough for successful diagnostic evaluation of cell perception. However, he did not find its use as an instructional device capable of producing a significant difference in braille reading ability after 20 treatment periods.

Two simple techniques used with the deaf-blind were cubes placed on a board to convey numbers and talking gloves where each finger bore letters and numerals with a seeing person merely touching the appropriate fingers. These give rise to a more complex educational device such as the "Teletouch", a special communicator developed and manufactured by the American Foundation for the Blind. Depressing keys on a double keyboard, such as found on either a regular or braille typewriter, resulted in an instantaneous projection of a braille cell. The deaf-blind person tactually perceived this cell in a small display area on the back of the device.

Upon examination of the communication aid, it became even more evident that a braille cell might be presented in such a manner in one of the educational devices for this project. It was decided that an electro-mechanical device, using tachistoscopic principles for single cell presentation, was feasible.

Zahl (1950) stressed that devices for the blind should never be regarded as more than aids. When techniques and knowledge can replace them, every encouragement should be given to their discard. This has been true in the past. Various devices have been discarded when something more functional came into use. But it is important to point out that while some of the devices appeared functionally acceptable, in a mechanical or electro-mechanical sense, their full application was never investigated, modified or transferred for other purposes. It appeared that the devices were often discarded before full utilization of their functions had been determined.

In summarizing the area of braille teaching aids, there appeared to be few other than the typewriter and the talking book that have made any great contribution to improving instruction for the blind. Certainly, the functional effectiveness of these devices contributed to their success.

Research supporting the use of "thermoform" materials resulted in the use of this medium in the present experiment. It proved very readable, durable, and reasonable in cost.

Size and cost remain as prohibitive factors limiting most of the educational devices developed for use by the blind. It was felt that eventual simplification, reduction in size and cost of some of the current educational devices may be possible.

Certain electronic devices have successfully served as storage mediums reducing the bulkiness of braille materials. As these are perfected there will be a demand for the development of readout devices to serve and display information in braille.

Lack of success in the area of teaching devices and readout devices establishes a need for research in this area.

CHAPTER III

METHODOLOGY

The review of the literature has indicated that much needs to be done in helping the blind to alleviate the far-reaching effects of their impairment. Specifically, knowledge of an engineering and educational nature must be brought together and fused into meaningful educational programs and techniques which will facilitate the blind's acquisition of braille reading skills. Secondly, the literature suggests that further delineation of the salient parameters involved in braille reading is required.

Instrumentation

The devices which were developed for this project incorporated the basic elements of programmed instruction:

a) that responses were required of the learners thereby insuring active participation and maintaining interest on the part of the learner.

b) construction of the machines was such as to allow the learner to proceed systematically, independently and at his own pace through the instructional materials.

c) immediate reinforcement in the form of auditory feedback was a feature on two of the machines with social approbation being built in as a reinforcer on the third machine.

All three of the devices described below were conceptualized, designed and built within the context of the present project. The time, money and effort involved in the construction and maintenance of these units was probably at least half of that expended in the project as a whole. The units are quite functional and adequate for experimental use. However, it is felt that quantity use of them in an institutional or classroom setting should be preceded by a certain amount of redesigning to insure compactness and more reliability.

Machine I

This educational device (see Appendix A) is a modified code oscillator about 1" x 2" x 4" with a small earphone and stylus attached. It uses a number of programmed instructional materials especially prepared on a thermoform press which offers each subject the opportunity of a multiple choice response. The correct response is indicated by applying the stylus to a small circular patch of conductive paint which results in a pleasant sound heard through the earphone. A matching color, but in non-conductive paint under the incorrect responses, does not produce any sound. The subject then knew he had made a wrong response.

The response items are placed symmetrically below each item so the subject can accurately indicate his choice. The paint, both conductive and non-conductive, is placed in an elevated and indented circle, which is easily identified because of placement and elevation.

The programmed instructional materials of 200 frames used with this machine were oriented toward developing and increasing tactual and kinesthetic discriminatory abilities. A wide variety of materials with variable dimensions of shape, size and texture were presented. Complexity increased from more gross discriminations involving first, basic geometric shapes, then form, to texture (fabric), and finally, braille configurations.

The programs were introduced in a linear fashion enabling each subject to make an active response, progressing at his own individual speed and receiving immediate feedback as to the correctness or incorrectness of his response.

Each subject was able to maneuver the program and apparatus from frame to frame with little difficulty. Two storage areas were conveniently located for the subject to accept a new frame, dispense with it and move to the next.

Machine II - Braille Tachistotact

The tachistotactic discrimination device (Appendix B) employed in this study was an experimenter-controlled, machine-paced device designed to facilitate increases in the speed of recognition and accuracy of discrimination of individual braille configurations. It consisted of three component parts.

The Console Unit. This unit contains the mechanism necessary for the control of readiness, presentation and response interval timing as well as a number of recording devices. The control panel of the console exhibits the following:

1. A power on-off switch and red indicator light.

2. A reset control switch which returns the stopping switch in the program unit to position #1.

3. A start switch which starts the timers and program sequence.

4. A six-light panel. Each light on this panel is connected to the corresponding response relay enabling the experimenter to observe the exact response pattern of the subject.

5. The three times which may be set by the experimenter are operated by a coincidence circuit using 23 six pole double throw relays.

   a) The readiness timer controls the time between the last response and the next stimulus presentation. The range is from 0-60 seconds.

   b) The presentation timer controls the length of time the braille configuration is exposed to the subject. The range is from 0-1 second.

   c) The response timer controls the time allowed for the subject to respond. The range is from 0-60 seconds.

6. A running time meter. This records the total active machine time for the total program.

7. A total response counter. This records the total number of responses of the subject.

8. A correct response counter. This records the total number of correct responses.

The Program Unit. This unit employs a 52 panel, six deck stepping switch, each deck corresponding to a solenoid or pin in the presentation unit and three female cinch Janes connectors with one hundred contacts in each. The program is wired on the male cinch Janes connectors which are easily snapped into place on the outside of the program unit. In this manner power is supplied to only those contacts which correspond to the presentation pins which the programmer wishes to be presented.

The Presentation Unit. This unit, the only part of the device with which the subject comes in contact, presents to him a stimulus response panel made up of a presentation plate and six response keys. The presentation plate, a braille head from a Perkins Brailler, presents the preprogrammed stimuli in the form of blunt metal pins which project .015 inches above the surface. The apertures through which the pins project are arranged in two parallel vertical columns approximately consistent with the standard braille cell measurements. Each individual pin is raised by a L-shaped lever operated by a solenoid and energized by the completion of the circuit in the program unit. Adjacent to the stimulus plate and arranged similarly in the six dot braille cell pattern are six response keys with an overall measurement of 1 1/4" x 2"; each key being 1/4" in diameter and 1/4" in height, undepressed. The length of time the pins remain exposed is controlled by the presentation timer. The response keys are connected to the coincidence circuit in such a manner that only when all of the correct keys are depressed will a correct response be recorded and the program advance to the next braille configuration. If at any time during the response sequence an incorrect key is depressed, a relay is tripped making a correct response impossible for that presentation. In this case, the discontinuous or response timer starts the readiness timer and the sequence is repeated. If a correct response is registered, a solenoid on the stepping switch is energized, stepping it to the next position. A correct response is then recorded on the correct response counter and the next pre-programmed configuration is presented.

Machine III - Moving Tape Braille Reader

This device introduces braille on a tape which moves from right to left across an exposed presentation window (see Appendix C). The presentation window through which the tape passes is a 7" x 3/4" cutout in the 2" x 12" finger rest plate. The presentation rate of the braille tape may be varied from 0 to approximately 500 words per minute. The device was designed so that Ss fingers are able to remain stationary.

An endless self-tightening rubber belt pulls the braille tape through the presentation area. On each end of the finger rest plate is mounted a 6" reel support arm at a 45° angle. A reel filled with braille tape is fed into the right side, across the presentation area, and wound on the left reel, which is operated by the drive shaft rotating the presentation belt. The drive shaft is operated by a variable speed zeromax transmission which is powered by a 1/4" horsepower electric motor. The entire drive mechanism is mounted in rubber on a 14" x 12" x 1/4" base plate and an aluminum cover that extends 8" above the mounting plate is mounted on the base plate.

The variable speed selector extends up through the top of the aluminum cover and is easily accessible to the operator. Movement of the selector lever from right to left increases the rate at which the braille characters are exposed to the presentation area. A toggle switch is used for starting and stopping the machine and is placed in the upper right end of the machine cover.

Materials

The printed materials programmed into braille tapes and traditional braille reading materials encompassed reading ability levels which extended from beginning reading ability, grade level 2.0, to the proficient reading ability level, grade level 13.0. The materials were categorized into graded vocabulary and interest levels for all

Ss. Materials from Science Research Associates Reading Laboratories[1] were used. The reading materials were prepared on special master papers by a braille transcriber certified by the Library of Congress, and reproduced on a thermoform press machine to insure that the materials were durable and tactually pleasant to all Ss.

The Thermoform Braille Duplicating machine is a vacuum forming machine especially designed for this purpose. Transcribed braille materials on any embossed matter become the mold which is laid on a perforated platter and through which air will flow when subjected to a vacuum from its underside. A sheet of thermoplastic film (Brailon) is clamped tightly over the mold (the original copy of brailled paper). Heat is applied by moving electrically heated coils over the plastic until it reaches its distortion (softening) temperature. At this point the vacuum pump is activated which results in the drawing down of the plastic sheet so that its surface conforms to the embossed braille dots on the paper. The heat source is then removed and the pump stopped. The plastic cools almost immediately and remains formed to the configuration of the mold. Upon unclamping the removal it presents an identical copy of the brailled matter.

The control group materials were prepared in traditional braille form, while the experimental group materials were cut into strip form and butted together into tapes and placed on a reel for use with the experimental Ss on the braille tape reader. Examples of the stimuli materials used in this experiment are presented in Appendix C.

The availability of materials was virtually unlimited and a wide variety of written material was prepared for presentation on machine III. Programming principles were employed in presenting comprehensive check test questions followed by a blank tape space during which a covert response could be made before the answer was provided on the tape. The speed of operation of this Tape Reader could be adjusted either by the subject or experimenter.

Over two miles of thermoformed plastic tape were prepared encompassing all ability levels extending from beginning braille to Grade II braille. Each foot of tape contained about 10 or 11 words. These materials were categorized into graded vocabulary and interest levels. Resources used in the production of these tapes include reading material provided by Science Research Associates, Reader's Digest, and other resources. A total of fifty stories were prepared on tape of varying levels of reading difficulty covering a wide variety of high interest factual, fictional, and recreationally oriented material. High interest, low vocabulary materials were prepared for those adults with limited reading ability. The materials were introduced in a sequential fashion.

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[1]Materials were reproduced in braille form with the permission of the Science Research Associates Company, dated November 1, 1963.

Strategy of the Study

The general approach of the subject to facilitating braille reading the visually impaired consisted of the following elements: design and engineering of instructional devices to be used in the study; longitudinal programming with these devices with both adults and children; and cross-sectional studies with children alone. Specifically, the project employed the following design:

Adults. Insofar as possible, all blinded adults in the state of Wisconsin were contacted and asked to participate in the project. Random assignment of this pool of subjects to an experimental and a control group was then undertaken. The experimental group received a training program over the period of the project utilizing the three instructional devices which had been developed. The control group received instructions through the traditional methods. The same material was presented to both groups.

Children. All children and adolescents at the Wisconsin School for the Visually Handicapped were assigned to an experimental and a control group. The experimental group received intensive training on Machine III (Moving Tape Braille Reader) supplemented by individualized remediation efforts using Machine II (Braille Tachistotact). The control group were instructed in the traditional manner and both groups used the same curriculum materials.

The basic dependent variables in the study were rate of braille reading and errors. Detailed analysis of the diagnostic endeavors using Machine II allowed the delineation of some of the parameters in braille reading. Specific details of the procedure and hypotheses to be tested are indicated later.

Adults - Subject description and procedure

Subjects. The salient characteristics of the adult Ss in the four programs initiated during the course of the project are shown in Table 2. The ratio of females to males ran about two to one. Ages ranged from 19 to 67 years. The figure of 66 participants includes some people who were counted twice. However, if they were assigned to the experimental or the control group on a given session, on subsequent sessions in which they participated they received the same group designation. Most of the participants became involved in the project while attending summer school at the Janesville School for the Visually Handicapped sponsored by the State of Wisconsin Division of Vocational Rehabilitation. Other Ss were contacted in their homes and asked to participate. During the project, additional Ss were worked with but attrition and lack of pre- and post-scores resulted in the reduced N which is reported on here.

Out of the pool of Ss generated for the four programs, one-half were randomly assigned to the experimental and one-half to the control group with the exception of those who had already been given a group designation from a previous session.

TABLE 2

CHARACTERISTICS OF ADULT SUBJECTS INVOLVED IN PROGRAM

OVER THE TWO YEARS OF THE PROJECT

		1963 Summer	1964 Summer	1964-65 Winter	1965 Summer
Experimental	Age	53.7	45.4	49.7	50.7
	IQ*	107.2	114.1	109.0	109.0
	N	13	10	3	6
Control	Age	48.6	58.2	45.7	47.8
	IQ*	107.0	108.3	116.2	107.1
	N	16	6	5	7
Total N		29	16	8	13

*IQ scores based on verbal part of the Wechsler Adult Intelligence Scale.

The comparative data presented in Table 3 are based on the 29 Ss used during the summer program of 1963 and are considered representative of the total pool of Ss. The selection factor (selection of younger clients because of rehabilitative potential) accounted for the inclusion of a sample having a mean CA 20 years lower than the mean CA for the state (Table 3). This also affected the mean age of onset of blindness. The diabetically induced blind were over-represented in the research sample because diabetes was a cause of early blindness among these subjects. A lower proportion of males was the only other difference of significance between the sample under study and Wisconsin's adult blind population.

A further characteristic of the Ss, one which covaried with years of blindness, was that of braille reading ability. That is, the recently blinded were poor or non-readers while the group blinded for some time were fairly proficient. A previous analysis (Stockton, 1965) of a portion of the data indicated that this variable did not have a significant effect on the dependent measures considered here.

Procedure. The basic aim of this study was to introduce a wide variety of techniques and materials with the hope that different approaches would create significant gains in braille reading. It was assumed that a curriculum approach could be patterned through the use of programmed materials in braille to provide optimum learning regardless of individual differences.

During the program phases all subjects received a total of fifty, 50 minute periods of instruction on a twice daily schedule. Twenty-five periods of traditional instruction and traditional materials were employed. The other twenty-five periods involved a differentiation of instruction using the three machines.

In an attempt to keep any "Hawthorne Effect" (Cook, 1962) to a minimum, the same instructor employed traditional instructional methods for both the control and experimental groups during their first hour of instruction while additional licensed instructors of the blind rotated between the experimental and control subjects during the second hour of instruction.

During this second hour, the experimental subjects were exposed to three levels of training: (1) pre-reading and initial reading training on a series of graphic tactual discriminations graded for difficulty level, followed by a program of braille character discriminations using a self-paced teaching (Machine I) and program display apparatus; (2) a program of momentary or tachistotactic presentation of braille symbols through use of an automated learning machine (Machine II) designed to increase accuracy and speed of recognition; (3) a program of braille on tape using a tape reader (Machine III) where the speed was controlled by either the subject or the instructor.

TABLE 3

COMPARISON OF THE VITAL STATISTICS OF THE SUMMER 1963 BLIND POPULATION IN THE STATE OF WISCONSIN AND THE SAMPLE UNDER STUDY

	Study Sample	Wisconsin[1]
INCIDENCE OF BLINDNESS		
Male	35.5%	52.8%
Female	64.5%	47.2%
Chronological Age (Mean)	46.4	66.4
Over 55	32.3%	66.6%
Between 16-35	22.6%	11.1%
Age of Onset (Mean)	29.8	44.0
Blind after 30	54.8%	67.0%
Blind at birth	22.6%	16.0%
White Race	96.8%	97.1%
Gainfully Employed	25.8%	28.6%
Totally Blind	12.9%	20.0%
Legally Blind	87.1%	80.0%
CAUSE OF BLINDNESS		
Infectious Disease	6.4%	6.0%
Accident	6.4%	8.0%
Other Disease	19.3%	16.0%
Diabetes	19.3%	7.5%
Unknown	48.6%	62.5%

[1] "Services to the Blind in Wisconsin," State Department of Public Welfare, 1961.

Control subjects were exposed for an equal amount of time for the learning of braille, but they received the same basic materials through traditional instruction without the aid of the automated devices.

Assessments

The following measures were obtained on the subjects.

1. A pre- and post-braille reading test, measuring speed and accuracy, developed from Science Research Associates material. Counting devices were used for tabulating errors, retracings, up and down movement of fingers, additions, omissions and faulty transfers from line to line.

2. Pre- and Post-Tactual Discrimination Tests were developed to measure the tactual discrimination ability of non-braille and beginning braille readers.

3. A recognition test was developed from a random assortment of braille configurations (alphabet, punctuation and contractions) as a final assessment device to determine accuracy and speed of perception.

4. The Wide Range Reading Test was administered orally to assess word recognition ability.

5. Unstructured pre- and post-reactions on instructional techniques, materials, and teaching machines were recorded and evaluated.

A detailed analysis of the various dependent measures was done previously using the Ss of the summer 1963 program. These findings are summarized in Appendix D. The present paper gives the results of the analysis of the performance of all Ss in all four programs using the following dependent measures: reading speed, errors, retracings and up and down movements of fingers. In addition, the narrative reactions of the Ss are considered in some detail.

Children - Subject selection and procedure

Subjects. The children selected for the study were resident students at the Wisconsin School for the Visually Handicapped who met the following criteria:

1. Have a central visual acuity of 20/200 or less in the better eye after all possible correction.

2. Pursue their education chiefly through the use of braille and other special equipment.

3. Are between the ages of 9 and 18 years chronological age.

4. Are elementary and junior high school students (grade 3 through 9).

5. Do not have any additional handicapping conditions that would significantly affect their reading behavior, i.e., perceptual motor deficiencies, emotional involvements, etc.

A total of 54 children became involved in the project in a sequential manner. That is, during the 1963-64 school year 30 pupils in grades 4 through 8 were chosen and randomly assigned to an experimental and a control group; 15 per group. The following year, the grades sampled were extended to the 3 through 9 range. Ss from the previous year remained in their respective groups and additional pupils were randomly assigned to the experimental and control groups to bring the N of each up to 27.

Table 4 displays the relevant characteristics of the sequentially formed groups. These data are consistent with the research results obtained by Hayes (1942) and Lowenfeld (1945) which suggest that with respect to the intelligence and mental age levels of a large number of blind children tested over a twenty year period that the mean IQ and MA levels fell between 108 and 92 with mental ages paralleling intellectual development. Inspection of Table 4 indicates that the intellectual and mental age levels of both the experimental and control groups falls within the ranges obtained by Hayes and Lowenfeld. Table 4 indicates from their grade placement and chronological ages that the present Ss also exhibit an age and grade retardation. On the basis of the consistency between these data and previous research findings and of the non-biased admittance requirements at the Wisconsin School for the Visually Handicapped, it is not unlikely that the sample employed in the present study is reasonably representative of the total blind population in residential schools.

<u>Procedure</u>. The procedural aspects of the project as it dealt with the children were in two sections related to the two machines which were used. Machine III, the Braille Tape Reader, was used with all experimental Ss throughout the two years of the study. During the second year, the experimental group was then broken into a so-called experimental and control group with respect to the remediation activities undertaken with Machine II, the Braille Tachistotact.

<u>Procedure using Braille Tape Reader (Machine III)</u>. Two examiners were required to administer the braille reading measures of speed and comprehension. One examiner measured the oral responses of the subject while the other examiner measured the tactual responses. Prior to the test the following instructions were given verbally to each S.

"We would like to find out some things about how you read. We are going to give you a story to read

TABLE 4

CHARACTERISTICS OF EXPERIMENTAL AND CONTROL GROUPS

FOR THE SCHOOL YEARS, 1963-64 AND 1964-65

		1963-64 School Year		1964-65 School Year	
		Experimental	Control	Experimental	Control
CA	Range	144-209	146-232	110-212	114-205
	Mean	166.3	174.3	153.2	158.8
IQ	Range	65-145	65-124	65-145	65-140
	Mean	106.1	96.8	103.7	97.9
Grade	Range	5-8	5-8	3-9	3-9
	Mean	6.2	6.6	6.2	6.5
N		15	15	27	27

> (appropriate level material) and as you read it out loud to us we are going to watch your finger movements and listen to how you read out loud. These are the things about how you read that we want to know. Read as fast as you can without making mistakes."

While the S reads the test material out loud from a braille copy, one examiner followed the reading process using a print copy of the material noting all verbal responses including the number of words read correctly, errors made, additions, skippings and omissions. The other examiner used mechanical counting devices to measure tactual responses including retracings and vertical movements made by the subject in the testing situation.

The recognition measure of braille configurations was administered by a single examiner after giving the subject the following instructions.

> "In front of you is a sheet of paper with braille symbols on it. The first two lines have letters on it; the third and fourth lines have punctuation marks on it and each punctuation mark has a 'for' sign in front of it so you can tell when a new punctuation sign is coming. The fifth and sixth lines have contractions and whole word signs. We want you to read each line on the page out loud to us. Read as fast as you can without making mistakes."

The examiner followed the S's progress on a braille copy labeled in print noting correct and incorrect responses. A stop watch was used to measure the time required to complete the task.

The dominant method of imagery was evaluated in a single session by the subject verbally responding to the stimulus words and phrases, with the examiner recording responses on a protocol sheet. Throughout the testing sessions, examiners were assigned to the testing situations randomly.

The experimental laboratories used in this study were two vacant classrooms in the unused annex section of the school which at this time was not being used for either classroom or recreation space by other school groups.

Both the experimental and control Ss received three fifty minute treatment periods per week over a 14 week period the first year and a 27 week period the second year. The treatment periods were scheduled at variable times spanning the regular school day to distribute the number of Ss, both experimental and control, that were being sequenced through the programmed and traditional braille materials at any given time.

All Ss were escorted by experimenters to the treatment rooms; separate rooms were used for each group of Ss. At the conclusion of the treatment period all Ss were returned to their respective classrooms by the experimenters.

The control Ss began, at the first treatment period, to read the traditional braille material, while the experimental Ss received approximately two hours of instruction on the braille tape reader. This instruction given to each experimental subject included:

1. A general orientation to the size, shape and extraneous parts of the machine.

2. Individual subject reading positions including finger placement in the presentation area of the finger rest plate and the length of the exposed presentation area following the flow of the braille tape.

3. Operation of the toggle switch which started and stopped the machine and operation of the variable speed selector for movement of the braille tape across the exposed presentation area.

4. Trial reading on the appropriate level materials to actuate a high and low level range in reading speed.

5. Verbally answering any of the numerous questions that the Ss were likely to ask about the reading material or the machine.

The experimental treatments were presented according to the following standardized technique:

Control group. Prior to the arrival of the Ss at the treatment room the appropriate reading materials were laid out for them along with the individual folders containing all previous information on the material that the subjects had already read and a stop watch. Upon arrival the subject began reading the material. The experimenter started the stop watch and noted on the progress chart the material being presently read. Upon completion of the reading the experimenter stopped the watch and verbally questioned the subject on the content of the material. After noting the number of errors in comprehension of the material on the S's protocol sheet the next story was given to the S and the stop watch was again started. At the conclusion of the treatment period the total actual reading time was then recorded in the appropriate place on the protocol sheet.

Experimental group. Prior to the Ss arriving at the treatment room the braille tape was placed on the right reel arm of the braille tape reader threaded through the presentation area and anchored to the left (rewind) reel arm. The individual folders containing previous reading information and a stop watch was also laid out. Upon arrival the S started the machine by pressing the toggle switch and adjusted the variable speed selector to accommodate his individual reading speed. As a guide, if the major fingers used in the reading process were approximately in the middle of the 12" exposed presentation area the reading speed was deemed adequate. If, however, after beginning the reading processes, the finger placement was to the extreme left of the center of the presentation area the experimenter adjusted the variable speed selector to a more desirable speed. Conversely, if the fingers were to the extreme right of the center of the presentation area the experimenter increased the speed of the braille tape by adjusting the variable speed selector.

Upon completion of the reading task the machine was turned off by the experimenter, without moving the variable speed selector, so the verbal questions could be administered without any extraneous interruptions. Following the administration of the comprehension questions and recording the responses, the machine was rethreaded as previously described, and the S resumed reading the next sequence of material. Simultaneously with the S beginning reading the experimenter again started the stop watch to maintain an accurate actual reading time. Weekly evaluation of the reading speed of each subject was undertaken to make the reading process on the tape reader sufficiently motivating to increase the scanning ability of the Ss.

Procedure using Machine II. The study was divided into two phases: Phase I was concerned with the collection of normative data on (1) the relationship between stimulus presentation time and the number of errors; (2) variation in error count for each letter which would lead to a ranked order of difficulty for the twenty-six letter configurations. The entire group of twenty-six Ss was used in the collection of normative data. All Ss were introduced to the device (Braille Tachistotact, Machine II) and allowed to examine each component and its operation, within the realm of his understanding. Subsequently, the S had contact with the presentation unit only.

The stimulus presentation time was varied on ten trials from one second to one-tenth of a second in decreasing order. Readiness and response intervals were arbitrarily held constant at four and six seconds respectively. Table 5 a) shows the frequency with which the letters appeared in the program. A priori knowledge of a letter difficulty determined its frequency. During this phase of the study, the experimenter advanced the program after errors, rather than allowing the missed letter to be represented. Each S received one trial a day for ten days, four experimenters worked with the Ss without regard to continuity of experimenter-subject combinations. Two Ss were run simultaneously on two identical machines in the same room.

The program presentation to each S was as follows:

> "Let's practice a few letters. Please show me what you would do if you felt an a, an x, a b! (no specific letters were used) Now we will begin. Are you ready?" ("Yes") At this point the experimenter would start the machine. "You may begin."

TABLE 5

FREQUENCY OF APPEARANCE OF BRAILLE LETTERS IN PHASE I AND II

OF MACHINE II PROGRAMS

a) Phase I - Normative study of error frequency

Letter	Initial Study	Repli- cation	Letter	Initial Study	Repli- cation	Letter	Initial Study	Repli- cation
A	1	1	J	3	3	S	3	1
B	2	1	K	5	1	T	5	1
C	1	1	L	3	1	U	9	1
D	3	1	M	2	2	V	3	1
E	4	4	N	4	3	W	7	1
F	3	3	O	2	2	X	7	1
G	3	1	P	1	4	Y	7	1
H	2	2	Q	3	3	Z	5	3
I	3	3	R	5	2			

b) Phase II - Frequency of letters entering into remediation program

Letter	Frequency	Letter	Frequency	Letter	Frequency
P	20	F	9	H	6
R	12	Q	9	S	6
Z	12	E	9	T	6
N	10	J	8	W	5
I	10	V	8	M	5
O	10	Y	6		

No reinforcement other than that provided by the machine was provided. An individual record of the errors made on each letter on each trial was kept for the twenty-seven Ss. It was from the raw data on Program I that the remediation program was developed. As the frequency of appearance of the letters in Program I varied, the percentage of possible errors for each letter for all 27 Ss on the total of the scores for the presentation time intervals of .6 second to .1 second inclusive was used to determine the relative degree of difficulty of each configuration.

Phase I of the Machine II procedure was replicated with the following goals in mind.

1. As with the initial study, optimal presentation time (between .10 and 1.00 second) of Braille configurations was sought.

2. Also, as with the initial study, the relative difficulty of the 26 letters was sought.

3. In addition, analysis was done to determine the exact nature of these errors (transpositional, reversal, etc.).

Modification in aspects of the design resulted in a more sophisticated study in the replication. Twenty Ss were randomly selected from the population of the Wisconsin School for the Visually Handicapped at Janesville (not necessarily Machine III Ss). Two each were selected from each grade three through eleven. The nine boys and eleven girls were then randomized into two groups of ten each - each group containing one child from each grade. The Ss were all functional Braille readers (having used Braille for two years), and a measured IQ of at least 85. None of the subjects had any known accompanying physical handicap that would influence their performance.

The design was two replications of a 10 x 10 Latin Square Design with the rows corresponding to subjects; the columns, successive trial periods; and the cells, speed of presentation (.1, .2, .3, ..., .9, 1.0 sec.).

The Ss were run twice per day for five days with an added day for machine orientation. Some variation resulted due to conflicting academic class schedules, and, since participation was voluntary, an occasional pep talk to Ss who may have missed one of their scheduled runs was required.

Each trial consisted of a warm-up run of sixteen presentations of a Braille letter at the presentation speed of the subsequent trial. Forty-eight letters were presented and each of the twenty-six letters appeared at least once. Table 5 b) shows the frequency with which the letters appeared in this program.

The Ss were tested two at a time (two different Machine II's) by two of four experimenters. The experimenters randomly changed on the machines and on the Ss. No specific instructions were found to be appropriate for all subjects due to their wide age range. However, it was definitely stressed to all that their performance in the experiment would in no way reflect in their academic grades. They were instructed that they would find some trials more difficult than others, and they were instructed to attempt their best. Each S was seen for at least fifteen minutes. The record run programs consisted of three plugs - each with sixteen configurations of different letters. The three plugs were randomized for each S's different trials.

<u>Phase II</u> of the study used 26 of the 27 Ss who participated in Phase I. These 26 Ss were randomly divided into two groups of 13 Ss each. The groups were formed by taking a list of the Ss in alphabetical order by grade level and assigning every other S to the experimental group beginning with the first S. The 17 most difficult letters determined by the initial study of Phase I were included in the Phase II program. Table 5 b) shows the frequency with which these 17 letters occurred. The more difficult the letter, the more frequently it occurred. The 151 braille letter configurations in this program were arranged in an order from <u>less</u> to <u>more</u> to <u>less</u> difficult and within this ordering in a manner to allow practice with those letters confused with those of similar configuration or frequently reversed. This arrangement permitted initial and final success and a repetition of difficult triads of letters with similar configurations.

Each of the Ss in the experimental group received nine training periods of fifteen minutes each on the discrimination machine. Program II was used during each period and if completed before the end of the training period it was repeated. The settings for the readiness and response intervals were again held constant at four and six seconds respectively.

Stimulus presentation times were as follows:

Remediation periods 1, 2, 3 - .3 second

Remediation periods 4, 5, 6 - .2 second

Remediation periods 7, 8, 9 - .1 second

Verbal presentation of the remediation program to the experimental Ss was similar to that used in Phase I. During the timed fifteen minute period S was discouraged from talking and was given no verbal reinforcement, either positive or negative. During the training phase of the study, the experimenter did not advance the program upon receipt of an erroneous response. When an incorrect response was registered, the same stimulus configuration was represented until a correct response was elicited. If S exceeded the arbitrary limit of five consecutive errors on a single configuration, the experimenter then advanced the program to the next stimulus configuration. Total training time was two hours and 15 minutes. The limitation on the amount of total remediation time allotted was a function of scheduling the study within the time permitted by the regular school program.

The control Ss also received nine timed fifteen-minute training periods. The materials used for this group consisted of Program II prepared in traditional braille form on thermoplastic film (Brailon). The S was presented the materials in the following manner:

> "Here are some braille letters for you to read. I would like you to practice reading them to yourself until I tell you to stop." If the child became bored and asked why he was reading these letters, the experimenter would say: "When you are very sure of the letters and can recognize them quickly, it may help you to read braille better."

Evaluation of Treatment and Remediation Effects

At specified intervals throughout the project, measures indicative of improved braille reading were obtained. Following is a description of these variables.

1. The Wechsler Intelligence Scale for Children (Verbal Scale) and the Wechsler Intelligence Scale for Adults (Verbal Scale) were used to measure IQ. These instruments were selected for use in this study because of their extensive use in the mental testing of both blind children and adults. This testing was a pre-study measure only, and was not readministered during the remainder of the study.

2. Dominant method of imagery (Griffitts Test) to measure the relationship between the method of imagery and the dependent braille reading variables. The previous reliability of this instrument was .79.

The effectiveness of the training program on traditional braille reading was measured by the following tasks:

3. Traditional Braille Reading Tasks. A five-minute oral reading task using material adapted and transcribed into traditional braille from Science Research Associates was used to determine the functional braille reading level of the child. Measurements on the basis of this reading were number of braille words read in specified time, errors and retracings. The specific braille materials read were appropriate to the reading level of each S.

4. Braille Configuration Recognition Task. This included letters and punctuation marks and was used to measure the improvement in perception of configurations. The measurement was in terms of errors.

5. The Ammons Wide Range Vocabulary Test. This test produced in braille was used to measure changes in reading achievement on a grade level basis. This is a word recognition task.

All of the forementioned measures were administered on an individual basis to both the experimental and control Ss in a private testing situation which was free from extraneous distortions. Graduate students trained in test administration administered the psychological examinations without regard to grouping (experimental or control).

A detailed analysis of the data collected during the 1963-64 school year has been provided by Flanigan (1965). The summary of this dissertation is provided in Appendix E. This report presents the effects of the Machine III in terms of reading speed only, the main thrust of this program. The data related to Machine II is presented in somewhat more detail.

CHAPTER IV

RESULTS

Clarity of Exposition can be achieved if the results are presented in three sections:

1. Adults' longitudinal results

2. Children's longitudinal results

3. Children's diagnostic-remediation results

Within these sections can be encompassed the findings of the project and, in addition, such a breakdown provides a framework for the discussion.

Results from longitudinal study of adults

This aspect of the project was concerned with ascertaining whether the braille reading of blind adults could be improved using three ancillary teaching devices which were designed to incorporate the main elements of programmed instruction. These devices, designated Machines I, II and III, are described in Chapter II.

In four successive instructional phases, varying numbers of blinded adults in the state of Wisconsin were randomly assigned to an experimental and a control group within each instructional phase. Pre- and post-indices of adequacy of traditional braille reading were obtained. These indices, based on five minutes of reading included: number of words read correctly, number of errors, number of horizontal retracings and vertical movements. A level of confidence of .05 was used to reject the null hypothesis (Ho).

A composite format for the data was obtained by finding the difference between the pre- and post-measures on all Ss in the four phases of the study on each of the four measures. Table 6 to 7 present distributions of these difference scores for each of the four measures for the experimental and control groups. The Kalmogorov-Smirnov two-sample test was used to determine whether the samples of experimental and control group differences had been drawn from the same population, i.e., whether there was a statistically significant ($p < .05$) difference between the two groups. Operationally, the test determines whether the largest difference (D) between two sample cumulative distributions is evidence for rejecting Ho, the hypothesis of no difference. The χ^2 is used to test for the significance of this difference.

TABLE 6

ADULT Ss: DISTRIBUTIONS OF PRE-POST DIFFERENCES OF VERTICAL MOVEMENTS OF EXPERIMENTAL AND CONTROL GROUPS

Interval	Experimental f	Control f
30+	1	3
20:29	1	3
10:19	1	3
0:9	5	13
-1:-9	8	7
-10:-19	6	2
-20:-29	0	1
-30	1	0
Median	Σ -3	4

$$\chi^2 = 4D^2 \frac{n_1 \cdot n_2}{n_1 + n_2} \quad \text{where } D = .339$$

$$= 6.16,\ p<.05,\ df = 2$$

TABLE 7

ADULT Ss: DISTRIBUTIONS OF PRE-POST DIFFERENCE OF HORIZONTAL RETRACINGS OF EXPERIMENTAL AND CONTROL GROUPS

Interval	Experimental f	Control f
20+	2	2
10:19	0	0
0:9	5	17
-1:-9	7	10
-10:-19	7	1
-20:-29	4	1
-30	1	0
	26	31
Median	Σ -8	31

$$\chi^2 = 4D^2 \frac{n_1 \cdot n_2}{n_1 + n_2} \quad \text{where } D = .397$$

$= 8.94$, $p < .01$, $df = 2$

Table 6 and 7 indicates that we could reject Ho with respect to the number of vertical movements and horizontal retracings which occurred in five minutes. That is, the median reduction in vertical movements for the experimental group was three while the median increase for the controls was four (see Table 6). The obtained χ^2 of 6.16 was significant at less than the .05 level (see Table 7).

No significant difference in words read in five minutes or errors was found between the two groups (see Tables 8 and 9). However, differences that did exist favored the experimental group. For instance, the median increase in words read in five minutes for the experimental group was 13 while for the control it was 7. Similarily, the median reduction in errors for the experimental was two while for the control it was zero.

Reactions of adults to program

During the first instructional program (Summer, 1963), subjective reactions to the program and the three machines were obtained. Second and twenty-second day unstructured reactions to the program are shown in Tables 10 and 11. The three to one ratio of positive to negative responses (including constructive criticisms) was about equal for both groups. However, more responses were recorded for the experimental group than the control group. This was probably due to an exposure of a wider variety of techniques and educational devices. It may be noted that a general increase in all responses probably resulted from better rapport with the experimenters as well as a better understanding of the materials, techniques and equipment.

The principal negative responses, for the control group, concerned the "thermoform" or plastic pages, but these were less prevalent after the subjects got used to them. It is interesting to note that this was not a source of complaint for the experimental group.

The principal negative response for the experimental group concerned the easy nature of the Machine I program. The very nature of programmed materials and their low error rate seemed to play a part in this reaction.

Some of the subjects were annoyed by the noise the machines made. This was a disturbing factor to some but was corrected somewhat during the course of the summer. It was interesting to find the absence of some responses that were expected. There were some difficultires in the initial feeding of the tape into the tape readers and Machine II, in its initial design, was not sufficiently reliable to permit uninterrupted use on a day-to-day basis. It required occasional repairs or adjustment. The positive attitude of Ss concerning these devices appeared to overshadow any negative concern they might have had as a result.

TABLE 8

ADULT Ss: DISTRIBUTIONS OF PRE-POST DIFFERENCES OF WORDS READ IN FIVE MINUTES OF EXPERIMENTAL AND CONTROL GROUPS

Interval	Experimental f	Control f
50+	6	2
40:49	1	0
30:39	1	3
20:29	2	2
10:19	4	6
0:9	5	11
-1:-9	2	5
-10:-19	2	0
-20:-29	1	3
-30	2	0
	26	32
Median	Σ 13	7

$$\chi^2 = 4D^2 \frac{n_1 \cdot n_2}{n_1 + n_2} \quad \text{where } D = .207$$

$$= 2.47,\ 30 > p > .20,\ df = 2$$

TABLE 9

ADULTS Ss: DISTRIBUTION OF PRE-POST DIFFERENCES OF ERRORS OF EXPERIMENTAL AND CONTROL GROUPS

Interval	Experimental f	Control f
10:14	1	0
5:9	1	3
0:4	8	15
-1:-4	11	13
-5:-9	2	1
-10:-14	2	0
-15	1	0
	Σ 26	32
Median	-2	0

$$\chi^2 = 4D^2 \frac{n_1 \cdot n_2}{n_1 + n_2} \quad \text{where } D = .181$$

$$= 1.90, \; p > .30, \; df = 2$$

TABLE 10

SECOND AND TWENTY-SECOND DAY EXPERIMENTAL GROUP REACTIONS TO PROJECT BY FREQUENCY OF RESPONSE RELATED TO MACHINES AND PROGRAMS

Context of Response	Reaction to #I Pre	Post	Total	#II Pre	Post	Total	#III Pre	Post	Total	Cumulative Total
Enjoyable, likable, fun, good	6	6	12	5	4	9	6	6	12	33
Increase reading speed	0	1	1	2	4	6	5	7	12	19
Interesting, fascinating	2	1	3	5	2	7	4	1	5	15
Easy, not difficult	5	3	8	1	2	3	1	3	4	15
[1]Too easy, better for kids	9	4	13	0	0	0	0	2	2	15
Tells me right from wrong	1	1	2	2	4	6	0	0	0	8
Increase finger sensitivity	1	1	2	1	2	3	1	0	1	6
[1]Not sure of worth	1	1	2	0	1	1	1	2	3	6
[1]Noise bothers me	0	0	0	0	2	2	1	2	3	5
[1]Can't retrace	0	0	0	0	0	0	2	3	5	5
[1]Cell should stay up longer	0	0	0	2	2	4	0	1	1	5
Need more practice	2	0	2	2	0	2	0	0	0	4
Like holding hand in one spot	0	0	0	0	0	0	1	2	3	3
Challenging	1	0	1	1	1	2	0	0	0	3
[1]Hard	0	0	0	1	1	2	0	1	1	3
[1]Trouble hearing sound	2	0	2	0	0	0	0	0	0	2
[1]Can't figure out mistakes	0	0	0	1	1	2	0	0	0	2
[1]Trouble distinguishing shapes	1	1	2	0	0	0	0	0	0	2
[1]Tiring, fingers tired	0	0	0	0	0	0	0	2	2	2
Not Tiring	0	0	0	0	0	0	1	0	1	1
[1]Long Procedure	0	1	1	0	0	0	0	0	0	1
Sequence good	1	0	1	0	0	0	0	0	0	1
I don't lose my place	0	0	0	0	0	0	0	1	1	1
Positive	19	13	32	19	19	38	19	21	40	110
Negative	13	7	20	4	7	11	4	12	16	47
Total	32	20	52	23	26	49	23	33	56	157

[1]Negative responses

TABLE 11

SECOND AND TWENTY-SECOND DAY CONTROL GROUP REACTIONS TO PROJECT BY FREQUENCY OF RESPONSES RELATING TO INSTRUCTION

Response	Pre	Post	Total
Interesting stories, material	6	5	11
Happy to be participant	3	4	7
Enjoyable, likeable, fun, good	3	3	6
Opportunity to practice	1	3	4
Helpful	1	3	4
Liked the plastic sheets	1	3	4
Wanted to know more about experimental group	0	4	4
[1]Difficult to feel Braille on finger	2	1	3
[1]Disliked plastic sheets	2	1	3
[1]Dots rounded too much	1	1	2
Learn to read faster	1	1	2
Learned a lot	0	2	2
[1]Work too hard	0	2	2
[1]Didn't learn much	0	1	1
Challenging work	0	1	1
[1]Not enough help	0	1	1
Progressing	0	1	1
[1]Sweaty fingers	1	0	1
Found no printing errors	0	1	1
Experimental would be more interesting	0	1	1
Positive	16	32	49
Negative	6	7	13
Totals	22	39	61

[1]Negative response

Experimentals Ss had negative feelings toward the structured limitations placed upon them by the programming and equipment in the learning situation. This was intentional on the part of the experimenter as an attempt was made to correct and reduce the negative braille reading factors while emphasizing the positive aspects. This, of course, was of less concern to the beginning braillers and of more concern to those experienced braillers who had acquired what we considered to be "bad habits".

The increase in total number of responses, as well as a continuing three to one supporting ratio for this project by the treatment groups seemed to be indicative of lasting approval and interest. There was an observable decrease in the frequency of negative responses on the part of the experimental group.

Many of the experimental subjects were impressed by the immediate feedback contingent upon their responses. This appeared to be especially true with the automated braille tachistotact (Machine II).

When the experimental group was asked specifically to rank their preference for the three educational devices (Table 12) the Moving Tape Reader received highest preference. Machine II and accompanying program was closely ranked as second choice, while Machine I ranked a poor third.

Polling the subjects in regard to the last place ranking of Machine I (with accompanying program) revealed that they enjoyed the programmed materials and felt they profited from their use. However, when asked to make a preference, they chose one of the other two devices and accompanying programs. They indicated their third place ranking did not mean they were opposed to the device or program.

Results from longitudinal study of children

During the school years 1963-64 and 1964-65 blind Ss attending school were involved in the project. During the first phase 30 Ss (15 experimental and 15 controls) were involved, with the experimental group receiving 14 weeks of training on the moving tape braille reader (Machine III). During the second phase (1964-65) the numbers in both groups were increased to 27 and the instructional period lasted for 27 weeks. Also, during the second phase, 26 of the experimental group were involved in a study concerned with the diagnostic-remediation capability of the Tachistotact. The results of this endeavor are reported in the next section of this chapter. Moreover, for a detailed analysis of some tangential variables using Machine III, the Braille Tape Reader, the reader is referred to a Ph. D. dissertation by Flanigan (1965).

TABLE 12

RANKED PREFERENCE FOR THREE EDUCATIONAL DEVICES

	Number Ranking First	Second	Third	Weighted Preference[1]
Machine I	1	3	11	40
Machine II	6	7	2	26
Machine III	8	5	2	24

[1]Weighted preference = Σ frequency of choice x rank (lower the score, the higher the preference).

The primary emphases of this aspect of the study were twofold:

1. To ascertain if blind children, already reading braille could read faster using the Braille Tape Reader, and

2. To ascertain if training on the Braille Tape Reader resulted in increased reading speed with traditional braille.

The answers to these two questions are graphically displayed in Figures 1, 1a and 1b. The bi-weekly points for the experimental (hollow circles) and the control (asterisks) groups represent average reading speeds based on daily measurement over two-week periods. The last point is based on a three-week average because of the odd number (27) of weeks involved. The experimental group's points represent tape reading speed while the control group's represent traditional reading speed.

Both groups display quite similar trends. An initial depression in reading rate is followed by a marked spurt in rate which in turn is followed by a leveling off in rate. The salient feature here is that the tape reading speed is uniformly faster. The depression-spurt phenomenon, uniform for both groups, would seem to suggest that an initial anxiety and/or confusion associated with involvement in the study may have dissipated in the first few weeks thereby allowing reading rates to reflect more normal capabilities by the sixth week.

The points associated with pre-, post-, and follow-up of program I and pre-, intermediate, post-, of program II reflect average traditional reading rate scores at these six points. It is of interest to note that at both post and follow-up points of program I, the experimental group was reading traditional braille 15 to 20 words per minute faster than the control group. At this point in time, it would seem that transfer from the tape reader to traditional braille was occurring. However, at the post-test of program II, a cross score has occurred and the control group is reading some 15 words per minute faster than the experimental group. Explanations of this phenomenon were hard to generate and no attempt was made to do so. Rather, it was assumed that marked error in measurement was evident and practical rather than statistical significance should be considered.

In an attempt to delineate broad trends in the data, a straight line fit was made of the data for all four lines. Figure 2 presents this endeavor and presents quite clearly the following conclusions:

1. Over the course of the two school years (from 6th week on), the experimental group using the Braille Tape Reader averaged 105 words per minute. This rate was on the average 26.6 words per minute faster than the 78.5 words per minute attained by the control group.

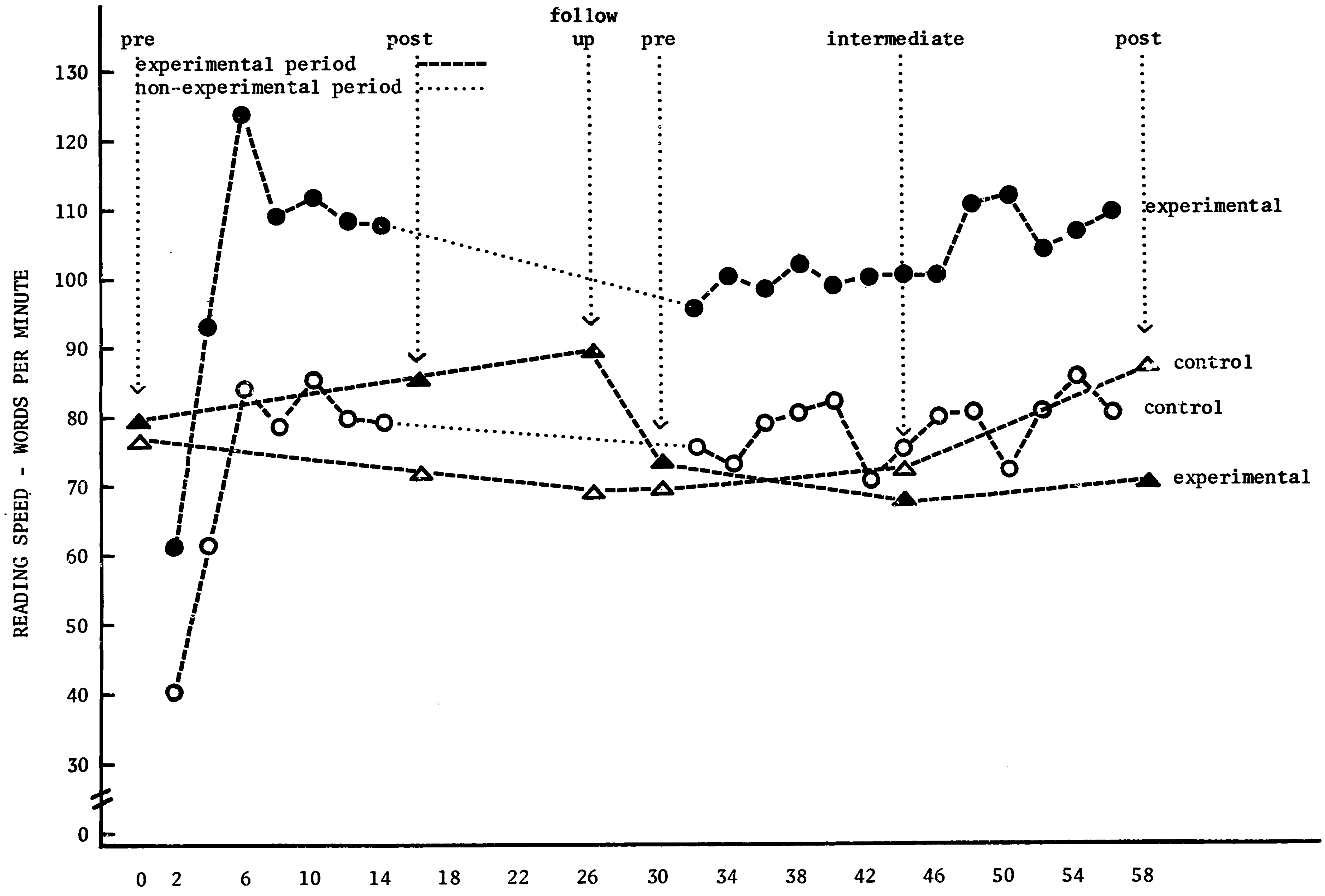

Fig. 1 Reading speed of experimental and control groups over the course of the study.

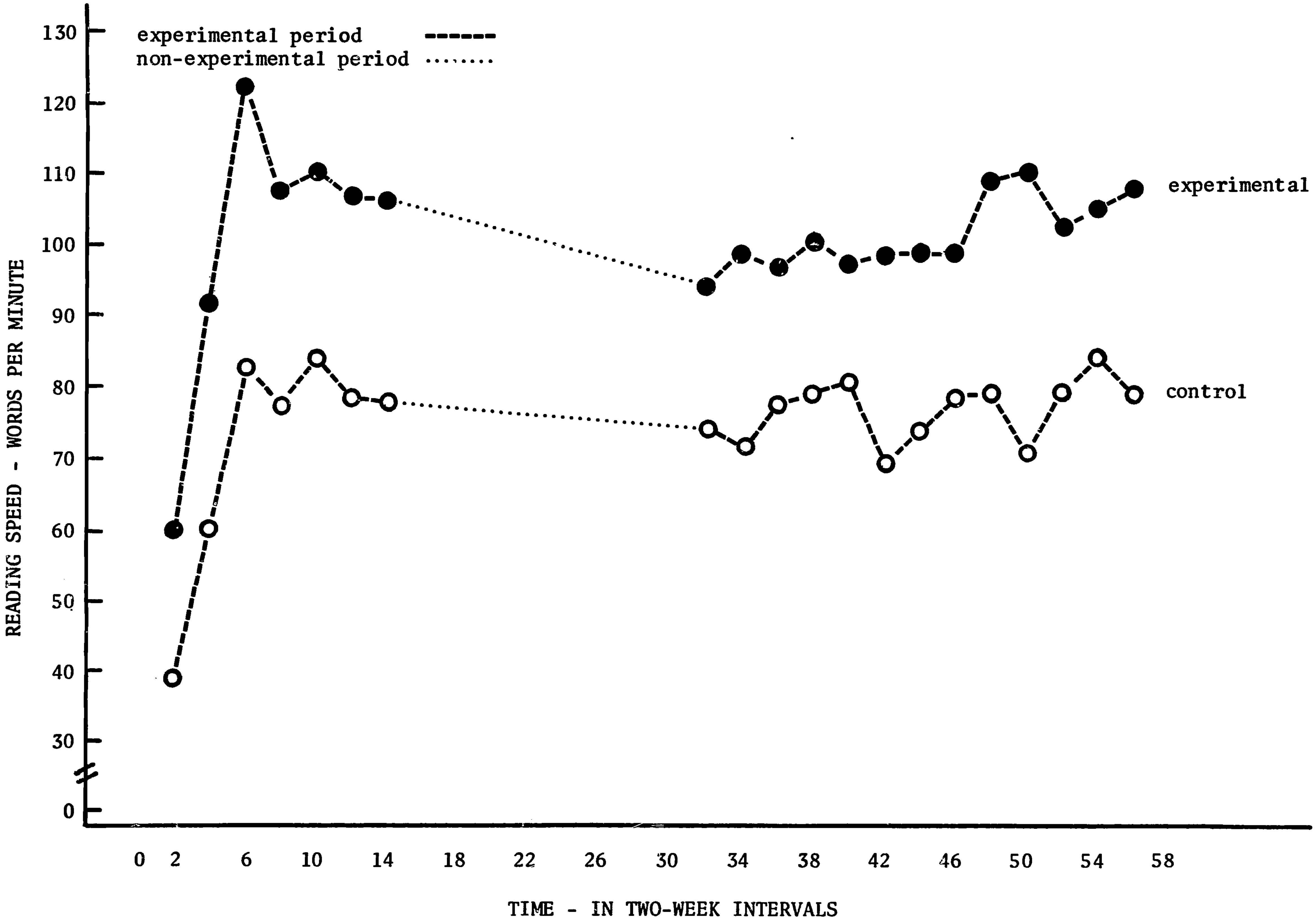

Fig. 1a Reading speed of experimental (using tape reader) and control (using traditional method) over the course of the study.

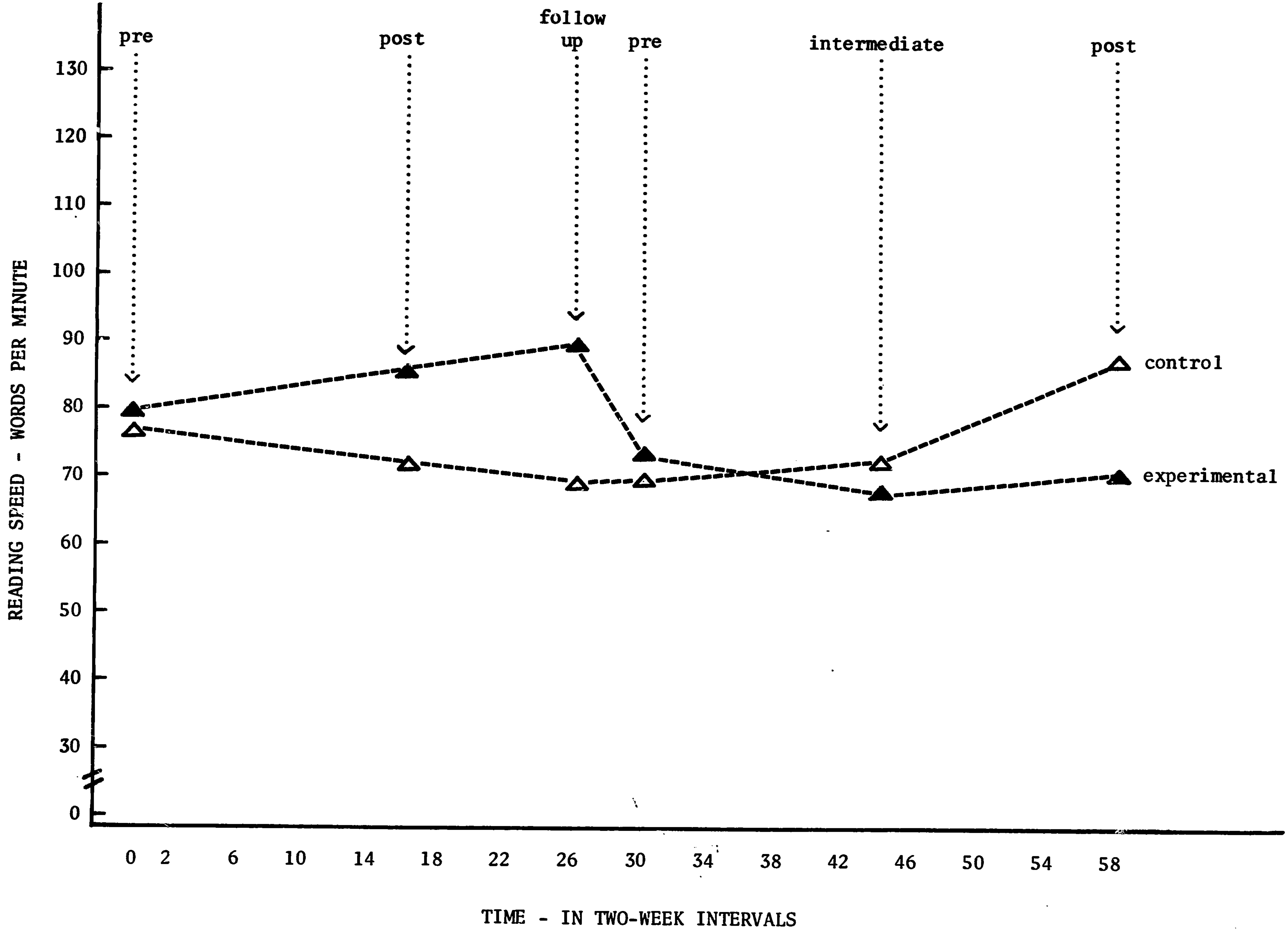

Fig. 1b Reading speed of experimental and control groups in traditional braille as dependent measure at selected periods throughout study.

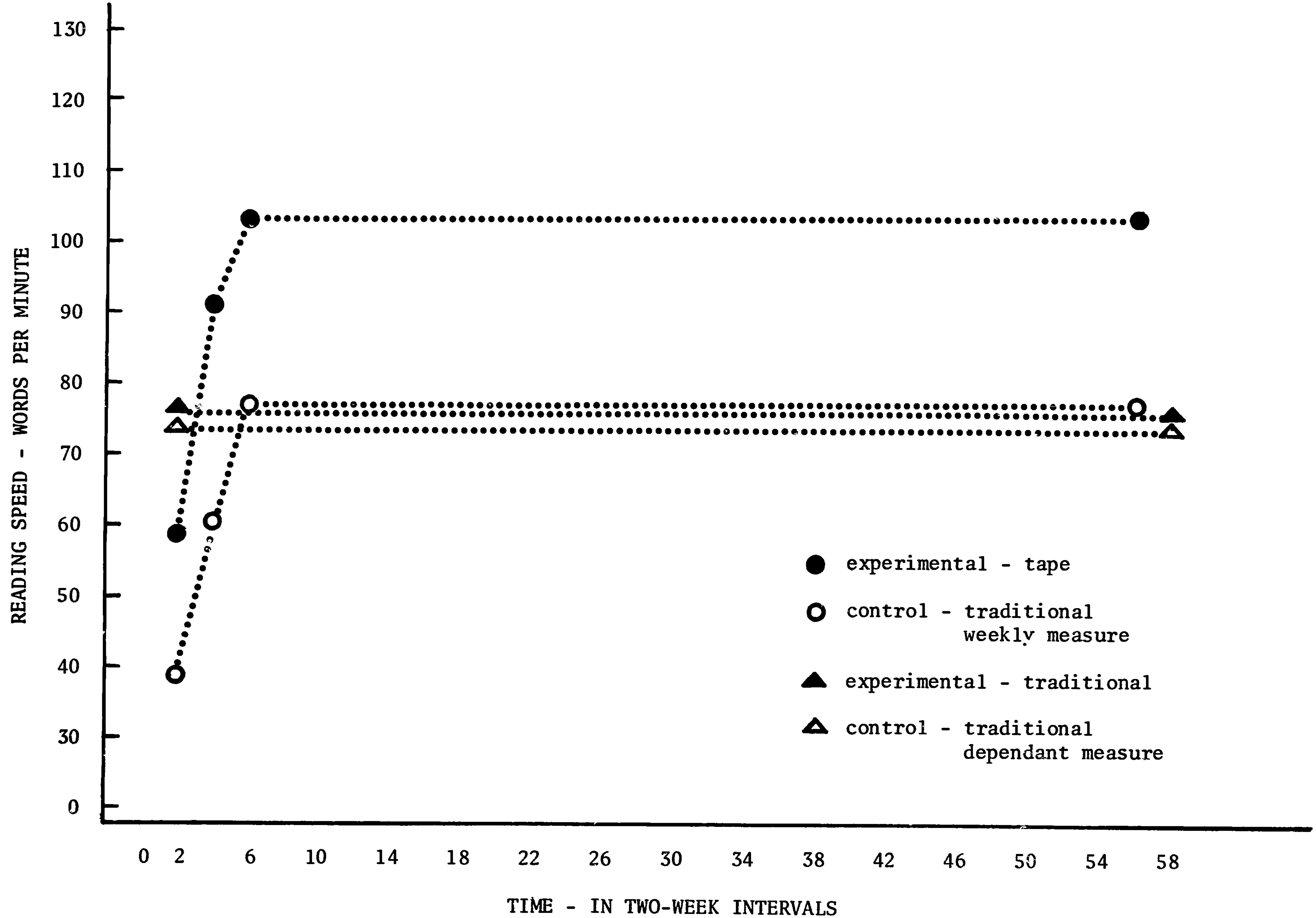

Fig. 2 Straight-line fit to observations from week 6 to week 58 of the project contrasting tape reading speed of experimental group with traditional reading speeds of both experimental and control groups.

2. The so-called dependent measures of the study, pre-, post-, etc., used traditional braille and very nearly coincided (experimental average = 77, control average = 76) with one another as well as with the average weekly measure (78.5). It was therefore concluded that little, if any, permanent transfer occurred between training on the tape reader and traditional braille reading.

Results from diagnostic-remediation program

The purpose of this aspect of the project was to: a) determine the optimum presentation time of the braille alphabet; b) determine the most difficult letters for the blind to detect; and c) using these most difficult letters and the least adequate presentation time develop a remediation program. To achieve these goals, Machine II, the Tachistotact, was used. The 27 Ss comprising the experimental group being exposed to the moving tape reader, were involved. All of these were used to determine optimum presentation speed and the most difficult letters. An experimental group composed of 13 Ss of the 26 was given the remediation program. The remaining 13 made up a control group. The experimental group received nine fifteen minute periods of training on the Tachistotact.

A study replicating the investigating of (a) and (b) above was also done. This study used 20 Ss in elementary and secondary grades from the same school, some in the project, some not. The remediation aspect was not replicated.

Figure 3 shows the relationship between mean number of errors, made on all letters as a function of presentation time in tenth of a second. It is apparent that the two studies do not provide an exact replication of one another. It can be noted, however, that beyond .5 seconds the error rate mounts quite rapidly. The increment associated with an interval of one second is noticeable in both studies. Thus it would seem that the optimum presentation time of braille letters on the Tachistotact lies somewhere between .5 and .9 seconds.

Table 13 presented the difficulty ranking across times and Ss of the letters for the initial study and its replication in relation to the difficulty ranking obtained by Kederis (1963) and Burklin (1932). The agreement in the four studies is not very adequate. In the initial study and the replication agreement was reached on only seven letters (P, R, Z, J, S, T, Q) falling in the upper 50% with respect to difficulty. Agreement was reached that seven letters (U, X, B, C, K, L, A) were in the 50% least difficult group. When compared with the other two workers in terms of the upper half of difficulty agreement was found for only R, Z, and T. In the easier group of letters, agreement was found only with respect to X, B, C and L. It is apparent that little agreement exists as to the difficulty of the braille configurations. This suggests that a host of

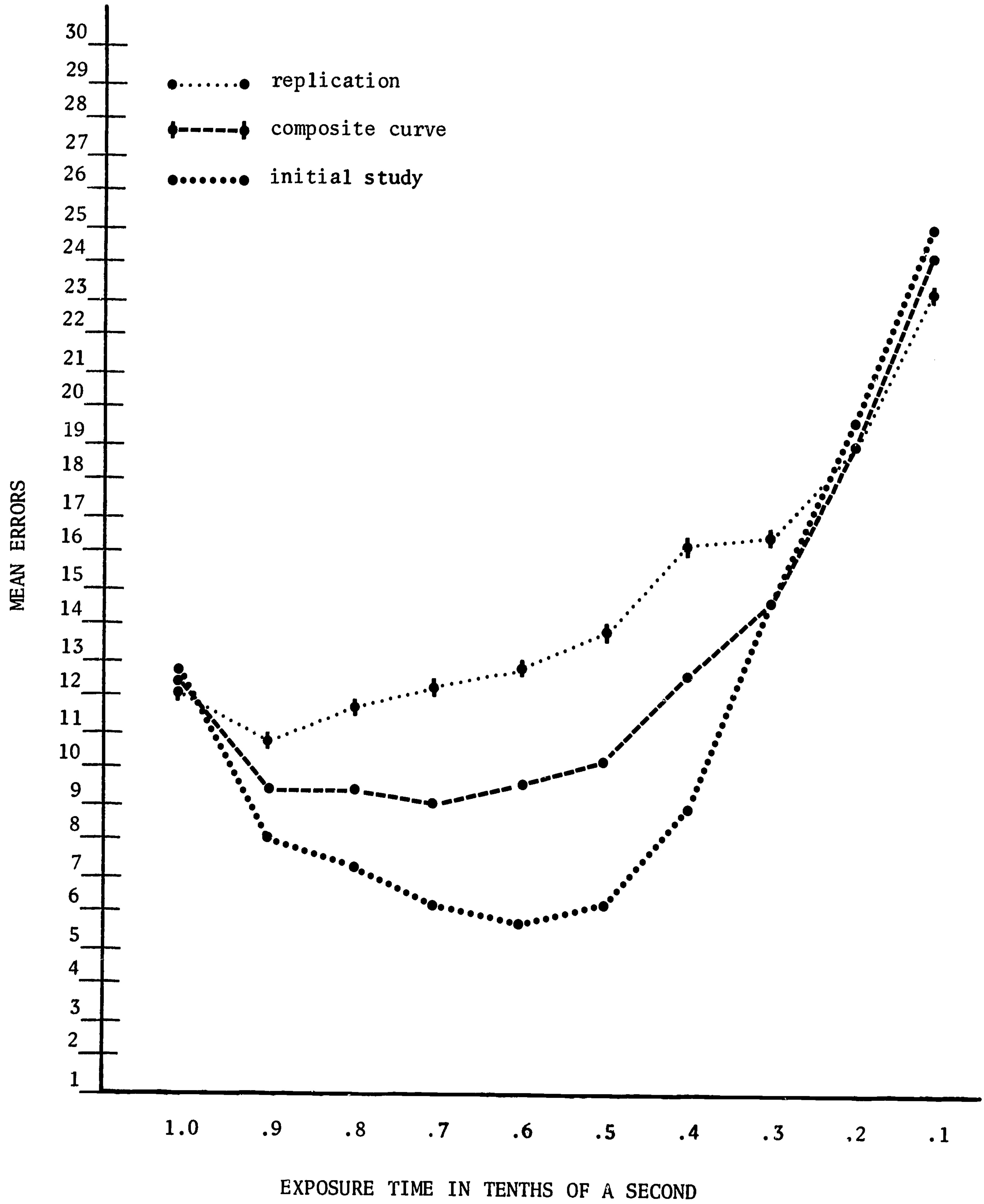

Fig. 3 Mean number of errors as a function of exposure time of braille letters.

TABLE 13

RANK ORDER OF DIFFICULTY OF 26 BRAILLE LETTER CONFIGURATIONS AS FOUND BY KEDERIS, BURKLIN AND INITIAL AND REPLICATED STUDY OF THE PRESENT PROJECT

Rank	Initial Study	Replication	Keden	Burklin
1	P	T	N	Y
2	R	Q	R	J
3	Z	Y	S	Z
4	N	W	M	M
5	F	D	I	D
6	J	S	Y	O
7	S	Z	T	H
8	O	V	W	N
9	I	R	K	V
10	M	G	U	Q
11	T	J	Z	F
12	Q	H	P	R
13	E	P	A	T
14	V	F	O	U
15	Y	N	J	P
16	H	I	V	C
17	W	E	F	S
18	D	X	G	F
19	U	U	D	X
20	G	O	H	K
21	X	M	E	L
22	B	B	X	W
23	C	L	C	B
24	K	K	B	I
25	L	C	Q	C
26	A	A	L	A

factors may be interacting to cause this lack of agreement. Actually, with diagnosis and remediation as the goal this lack of agreement should not loom as a large problem. For, ideally, each child should have an individualized remediation program based on his individual difficulties. Unfortunately, in this study, cost factors and effort involved presented an individual approach to remediation. Rather, one remediation program based on group deficiencies was used and must be considered a shortcoming of the study.

Table 14 shows the configuration of the most difficult and most easy letters along with the most common errors made. No clear patterning existed in these errors. Indeed, because of this and the potential errors in the observations, the reader is referred to Appendix F where an error analysis by letter is shown. Subsequent studies can use this data for comparative purposes, and detailed discussion at this time seems premature.

The remediation program consisted of the 17 most difficult letters determined on a group basis. It was hypothesized that systematic training on these more difficult letters would result in an increased reading speed for the experimental group as contrasted with the control group who did not receive it. A 2^2 repeated measures analysis was done on a number of dependent variables with the two factors being groups, experimental and control, and trials, pre- and post. The dependent variables entering into these analyses derived from both tape and traditional reading were: reading speed, errors, additions, skippings; as well as retracings and a cell test using traditional braille. The independent measures did not have a significant effect on any of the dependent measures except rate of reading traditional braille.

Table 15 a) and b) displays the analysis of variance table showing the significant components as well as the mean scores associated with the significant effects. The significant trials effect indicated that both groups showed an increase from pre- to post measurement. The significant Ss effects one expects in an experiment and merely underlines a first law of psychology, i.e., people are different. The significant group x trials interaction indicates that the rate of increase from pre- to post was not the same for the two groups. Inspection of the interaction table (Table 15 b)) shows a mean increase of 28.6 words for the experimental group from pre- to post-testing while the control group increased 11.0 words. Whether the differential increase of 17.6 words is other than statistically significant requires some consideration. Since the remedial program consisted of only nine fifteen minute sessions, i.e., 2 1/4 hours, such an increase in relation to effort can be deemed of practical significance also.

TABLE 14

CONFIGURATION OF THE LETTERS CAUSING THE MOST AND LEAST DIFFICULTY ACCORDING TO INITIAL STUDY AND REPLICATION

	Most Difficult	Most Common Error		Least Difficult	Most Common Error
P	● ● ● o ● o	● ● ● o o o	U	● o o o ● ●	● ● o o ● o
R	● o ● ● ● o	● ● ● o o o	X	● ● o o ● ●	● ● o o ● o
Z	● o o ● ● ●	● ● o ● ● o	B	● o ● o o o	● o o ● o o
J	o ● ● ● o o	● o ● ● o o	C	● ● o o o o	● ● ● o o o
S	o ● ● o ● o	● o o ● o o	K	● o o o ● o	● o ● o o o
T	o ● ● ● ● o	● ● ● ● ● o	L	● o ● o ● o	● o ● o o o
Q	● ● ● ● ● o	● ● ● ● o o	A	● o o o o o	● ● o o o o

TABLE 15

(a) SOURCE TABLE FOR ANALYSIS OF VARIANCE OF TRADITIONAL READING RATE SCORES

(WORDS PER FIVE MINUTES)

Source	df	SS	MS	F
Between Ss	25	1,316,324	52,653	
Within Ss	26			
Trials	1	5,101	5,101	17.35**
Groups x Trials	1	9,715	9,715	33.04**
Ss/Groups x Trials	24	7,065	294	
Total	51			

**Significant at .01 level

(b) TABLE OF MEANS OF SIGNIFICANT EFFECTS

	Pre	Post	Σ
Experimental	333.2	361.8	347.5
Control	325.4	336.4	330.9
Σ	329.2	349.4	

CHAPTER V

DISCUSSION

This project has demonstrated that a need can be identified, in this case the need of the blind person to increase his braille reading skills; that engineering technology and psycho-educational principles can be brought together in the development of innovative devices which can, in part, meet this need. The devices so developed in the present study were a Tactual Discrimination Program, for early training of the tactual modality, a Braille Tachistotact, for diagnosis and remediation of difficulties in the perception of braille symbols and the Braille Tape Reader, for more efficient and faster reading of Braille.

The results of the project have shown that blind adults involved in training programs utilizing all three devices did benefit. A significant reduction in vertical movements and retracings was found. Three findings were reflected in an increased reading rate and reduction in errors. The latter findings were not statistically significant but from a practical viewpoint do point to the further use of these devices, albeit with some caution and concern for continuous evaluation of their effect. The results also indicated that the adult blind responded favorably to the use of these devices. This latter finding is a crucial one in terms of the schema of change depicted in Figure 1. For, in terms of the criteria of adequacy demand by the schema, we may assume that the credibility and convenience of the devices has been demonstrated. The evidential assessment has been noted with respect to reading speed.

With respect to the children and adolescents involved in the project, a number of findings were evident. Use of the Braille Tape Reader, for instance, resulted in a reading average of 26 words per minute faster than that for the traditional method of moving the fingers across the page. The evidence did not suggest that this increased rate transferred to the reading of braille in the traditional manner. Such a transfer would have been desirable, for most braille materials available are amenable to the traditional reading approach only.

The Braille Tape Readers developed in this project must be considered crude approximations of the more efficient, reliable, cheaper and compact models which a little additional engineering could produce. Such refined models could then be considered valuable adjuncts in the braille instructor and rehabilitationist's repertoire. Also, with little additional effort, braille tapes could be manufactured by residential schools or agencies for the blind in much the same way they were in this project, but covering subject matter materials with more specificity. Alternatively, or in conjunction, some materials center could provide broadspectrum curriculum materials. The devices used to make the tapes in this project - thermoform press, scissors and glue - could be amalgamated into one efficient unit with little difficulty to be used by either the teacher or the materials center.

Of more immediate import is the fact that the 10 Braille Tape Readers developed in the project along with the tapes containing the SRA instructional materials are in the process of being installed in the library at the Wisconsin School for the Visually Handicapped. The person responsible for the machines at the School has already been involved in the project and is familiar with the machines. Concomitant with the installation of the machines there is occurring an intensive effort to make the instructors aware of the machines and their potential as adjuncts in the teaching process. This is being accomplished by a presentation of the findings of the present project, and by the development of tapes containing content which the instructors consider relevant to the learning process of the blind. It is hoped that interest in the machines can be maintained by both the instructors and the students. This task will be the direct responsibility of the on-site individual.

Tactual Discrimination Device (Machine I) would seem to have great potential for exploration with the younger child in particular. Present thinking indicates that the preschool blind youngster in the state should be identified and the units placed in the homes of these children. Since there are not enough of these units to go around at the present time, we are in the position to generate a control group thereby allowing us an adequate means of evaluating its effectiveness. Such an undertaking would require monies not presently available in the state budget. Thus, outside financing has to be sought.

The 13 students involved in the diagnostic-remediation efforts associated with the Tachistotact (Machine II) demonstrated an increase in reading speech in traditional braille of 5.7 words per minute over the nine weeks during which the pre-post indices of effectiveness were obtained. This increase in reading rate was 3.5 words per minute faster than a control group evaluated over the same period. Such a differential increase was of statistical significance and can be considered of some practical significance also since during the evaluation period only nine fifteen-minute periods of remedial instruction were given to each child.

Of interest was the finding that the diagnostic-remediation attempts with the Tachistotact did not differentially effect the tape reading speed of the two groups. This suggests that diagnostic endeavors with the unit could be beneficial only for the process of reading braille in the traditional manner.

With the 20/20 vision of hindsight, the following observations can be made with respect to the diagnostic remediation effort using the Tachistotact. In developing the remedial program in the present study, the 17 most difficult letters as defined by the groups of 26 children was used. Our results indicate that such a strategy did produce beneficial results. However, it seems not unlikely that remediation programs based on the individual rather than the group error profiles may have had even better results. Such strategy would have involved an effort, however, somewhat beyond the design of the unit used in the present study.

The Tachistotact was used to determine optimum presentation time and most frequent braille errors. Replication of this aspect of the study produced quite variable results thereby negating definitive statements in this area. In general it can be noted that the optimum presentation time fell between .5 and .9 seconds. Such information is useful in future uses of the machine.

The design of the Tachistotact as used in the present study must be considered a first approximation to a more sophisticated unit having the following characteristics:

1. In general, the next generation of this type of machine should have a random access memory and a limited computer capacity. Such a configuration would allow the blind child, on his own, to respond to preprogrammed braille configurations with type and patterning of errors being stored in the memory. Programs could be written which analyzed these errors and generated a remedial program based on them. The child could then practice on this program systematically eliminating error. Such an approach would require minimal instructional time.

2. The unit as a whole should be miniaturized with an emphasis on modular construction. Both this suggestion and (1) may be feasible in view of the NASA-VRA "technology transfer" project which includes the regional rehabilitation center for Research and Training at the University of Wisconsin.

3. The presentation of the braille configuration tactually should be accompanied by an auditory representation of the letter. It is assumed that a multimodality presentation of the stimulus would enhance learning. Similarly, immediate auditory feedback defining the type of error in the remedial phase would be desirable. The units used in Omar Moore's Responsive Environments Project could serve as models for these modifications.

4. It would seem desirable that the Tachistotact have built into it the capacity to offer variable types of reinforcement suitable to blind children in addition to the auditory signal used in the present study. The exact nature of these reinforcements would comprise an area of investigation on its own.

In sum, the machines developed for use in the present study have been demonstrated to be important adjuncts to the process of educating the blind child and adult. All three apparently can enhance the blind person's rate of reading braille. However, it has been noted that these machines must be considered a first generation of more sophisticated units which can provide valuable additions to the repertoire of the instructor and rehabilitationists of the blind.

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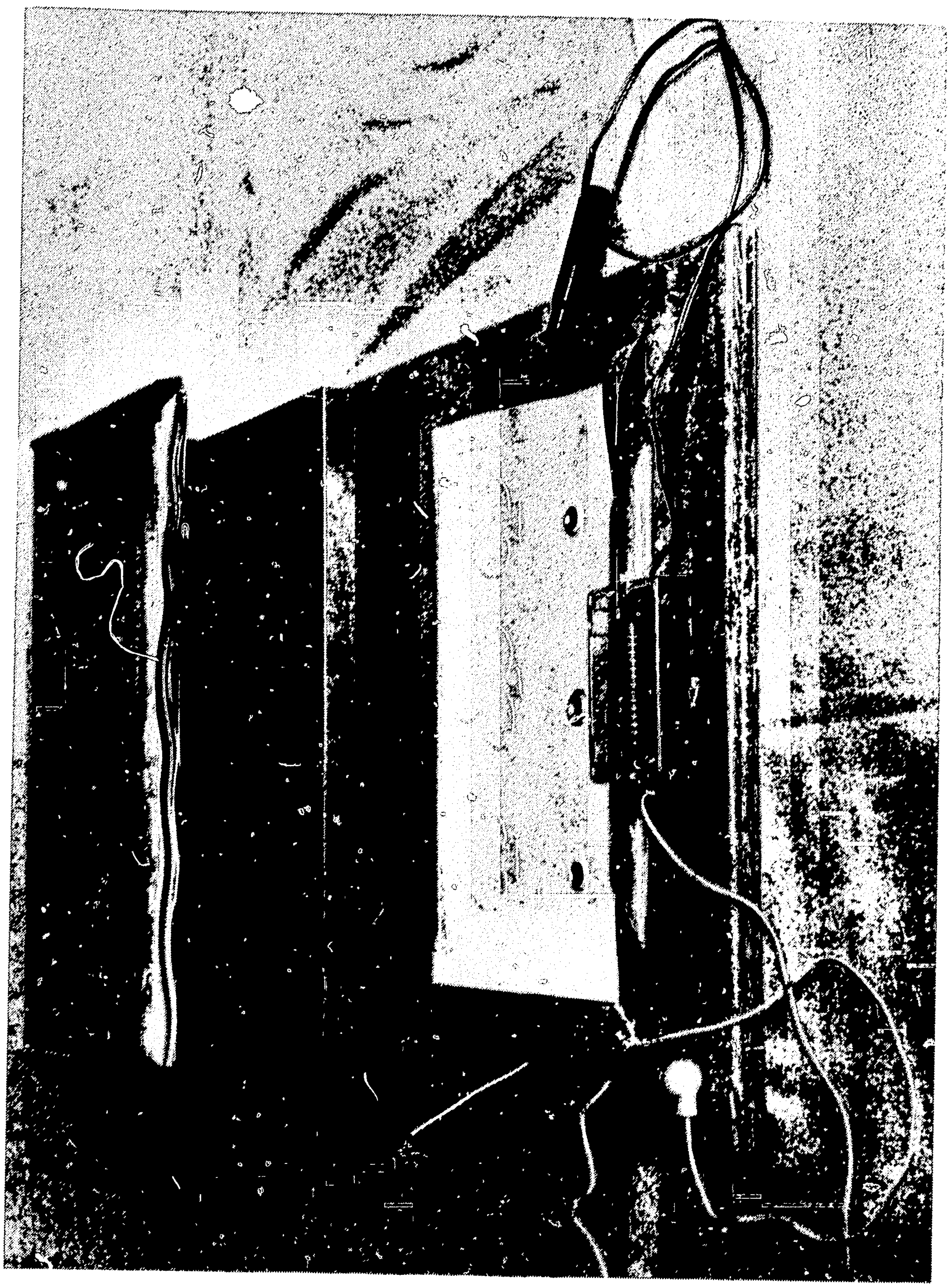
APPENDICES

APPENDIX A

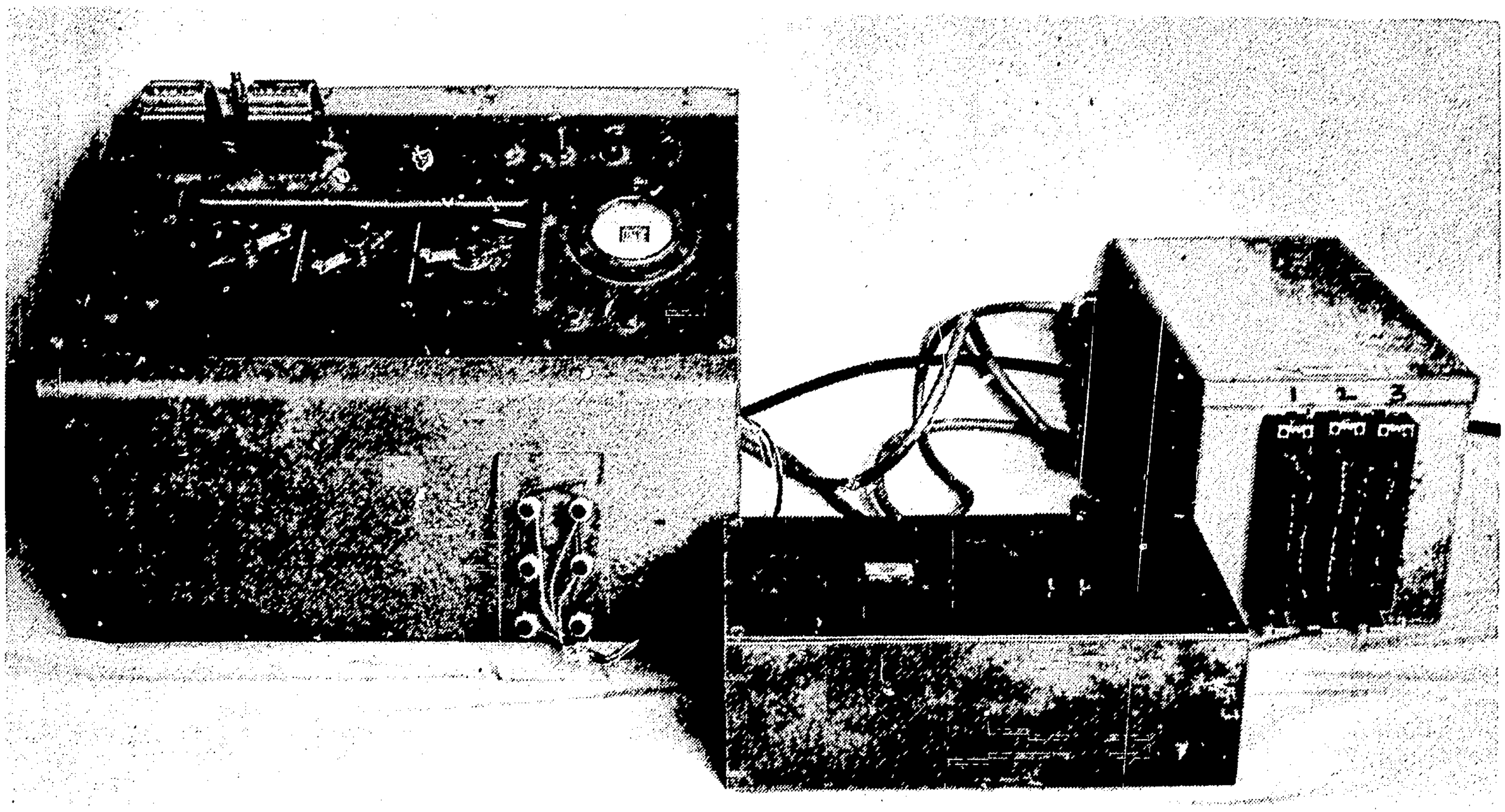
TACTUAL DISCRIMINATION DEVICE



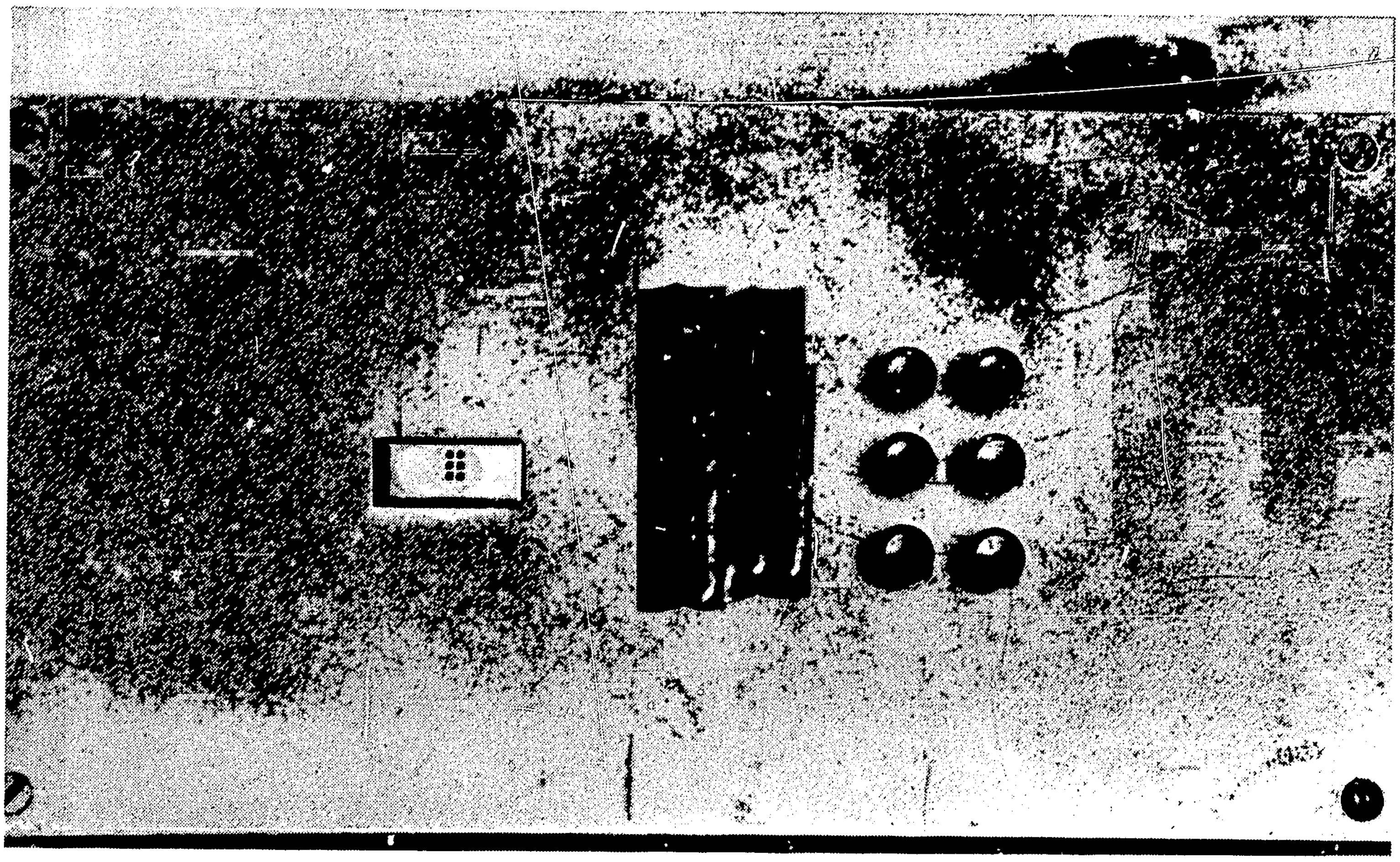
TACTUAL DISCRIMINATION DEVICE

APPENDIX B

BRAILLE TACHISTOTACT



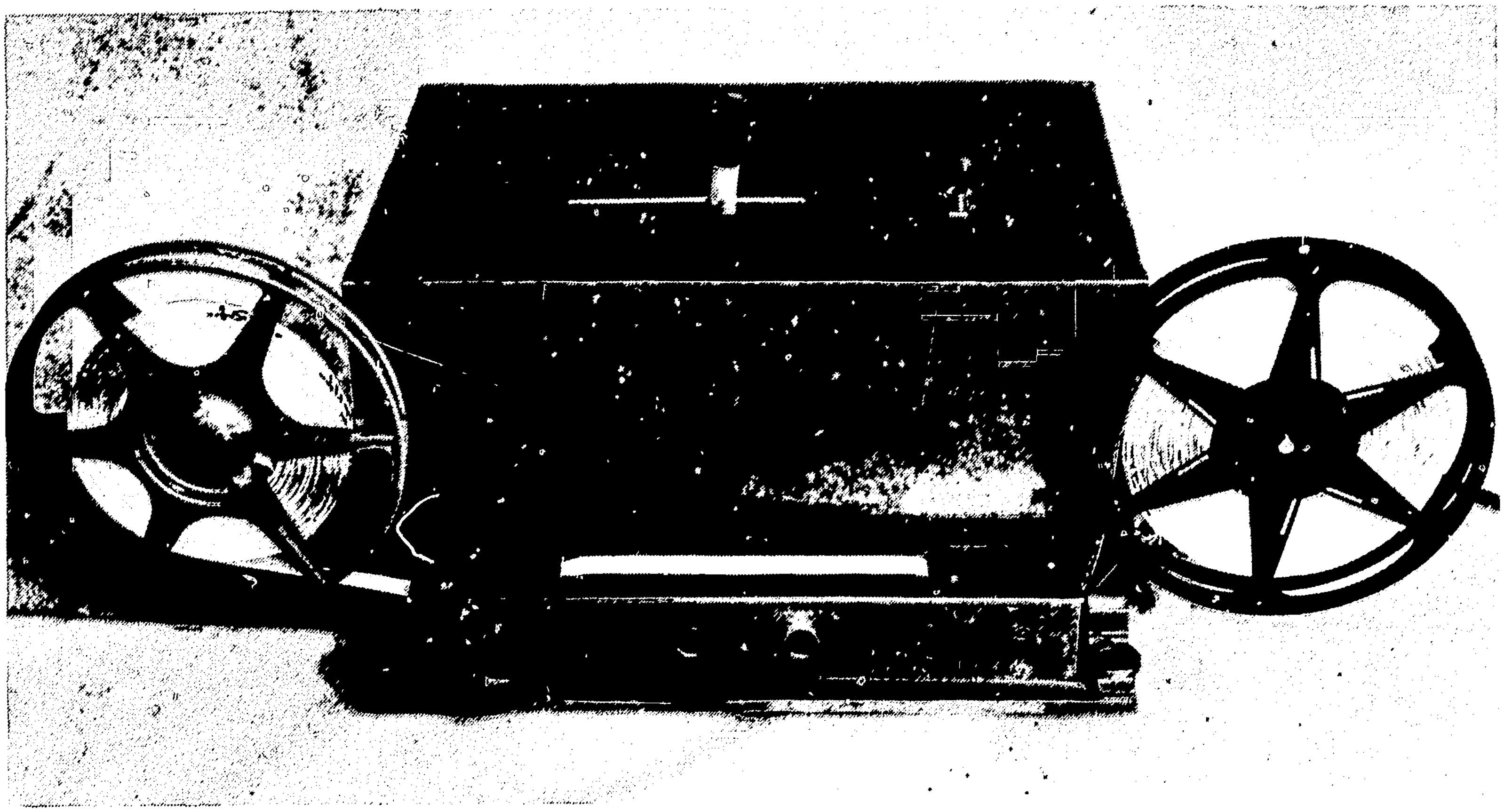
PROGRAMMING AND CONTROL APPARATUS



SUBJECT PANEL

APPENDIX C

BRAILLE TAPE READER



BRAILLE TAPE READER

APPENDIX D

SUMMARY OF STUDY ANALYZING SUMMER 1963,

RESULTS FOR ADULT PROGRAM

The following results were evident in this investigation:

1. All groups and levels improved in braille reading ability, but the experimental group made more obvious gains.

2. A significant decrease in braille reading errors occurred within the experimental group.

3. The experimental subjects had a significant decrease in their number of retracing movements as a result of the treatment under investigation.

4. The experimental group demonstrated a significant decrease in up-down movements resulting from the experimental treatment.

5. The Tactual Discrimination Test gain scores favored the experimental subjects at the .15 level of significance. When initial test variations were covaried, results were near nonsignificance. However, from inspection of the scores, the trend favored the experimental subjects.

6. The Cell Test results revealed that the experimental group could tactually discriminate single cells correctly at a faster rate than the control group at both levels at the end of the treatments period.

7. Examination by inspection of the directional trends of all measures revealed that the experimental group exceeded the control group on desirable aspects of braille reading.

8. Comparisons of all beginning (non-braillers) on all measures, revealed that the experimental treatment group had the same general pattern of desired differences and trends had been found for the experimental subjects having varied initial levels of braille reading ability.

9. The experimental subjects ranked the tape reader best, automated tachistoscopic device and the self-paced auditory reinforcement device in that order of personal preference.

10. Both the control and experimental subjects exceeded their conventional material reading rate when switched to a tape reader after less than one hour of practice.

11. There does not appear to be any significant loss or gain in comprehension between reading either a braille book in conventional format or a braille tape reader, but a saving of time (efficiency) seems to be evident when utilizing the tape.

From Stockton, 1965.

APPENDIX E

SUMMARY OF STUDY ANALYZING RESULTS

FROM 1963-64 SCHOOL YEAR PROGRAM

The results of this experiment suggest the following conclusions:

1. The use of automated self-learning device (braille tape reader) does influence the braille reading mechanics of functional braille readers, resulting in positive transfer of these mechanics to the traditional method of braille reading.

2. Remediation of these mechanics and other elements of traditional braille reading requiring repetitive learning can be more quickly and effectively taught by programmed instruction as an adjunct to conventional instruction.

3. The braille reading achievement levels of functional braille readers can be increased by the utilization of materials geared to the specific reading levels of these children when they are systematically and repeatedly presented with programs contributing to reading proficiency.

4. An accelerated rate of braille reading (moving tape method) with regard to the efficiency of comprehension compared positively to the conventional method of braille reading and comprehension.

5. The use of certain specific variables (additions, omissions, and skippings) in the traditional braille reading process were insufficient to determine experimental treatment effects.

6. The braille reading behavior of blind children on the braille tape reader was also positively influenced through the provision of appropriate programmed materials and the moving tape method of braille reading.

7. Some provision needs to be made by educators to bring about increased depth in instructional techniques and reading materials for blind children in order to increase the possibility that the child will develop a level of braille reading skill that is adequate to meet his communication needs.

8. A great amount of attention must be given to the unique problems of the blind in the adoption of programmed materials. When these concerns are undertaken programmed instruction has significant resources for instructing blind children.

9. The specific problems of beginning braille readers may be amenable to positive change by the utilization of training programs constructed around specific areas of difficulty to blind students, particularly when students are systematically and repeatedly presented with programs when the same errors occur.

From Flanigan, 1965.

APPENDIX F

ERROR ANALYSIS BY LETTER

Letter	Total Errors	No. of Subjects Erring	Most Common Errors to 50%	No. of Common Errors	No. of Subjects Making Common Errors	No. of Subjects Making 50% of all Errors
A	9	5	12	7	5	2
B	20	12	15	5	4	3
			24			
			1			
C	13	7	124	4	4	3
			1	2	2	
			24	2	2	
D	47	17	124	15	5	5
			245	6	5	
			12	4	3	
E	130	17	24	60	7	4
			14	14	5	
F	119	19	14	26	11	4
			145	13	6	
			1234	10	7	
			245	8	6	
			1245	7	6	
			125	6	3	
G	38	13	245	4	3	4
			124	8	5	
			12345	5	4	
			1345	4	1	
			145	4	3	
H	80	16	124	11	6	3
			245	11	5	
			145	9	3	
			1245	7	6	
			24	5	2	
I	101	18	15	31	8	3
			1	12	5	
			124	11	5	
			14	8	5	
J	122	17	125	17	5	3
			124	14	9	
			24	12	8	
			145	11	4	
			1245	8	5	

Letter	Total Errors	No. of Subjects Erring	Most Common Errors to 50%	No. of Common Errors	No. of Subjects Making Common Errors	No. of Subjects Making 50% of all Errors
K	20	9	12	8	3	2
			136	3	3	
			134	2	2	
			24	2	2	
L	21	10	12	8	4	3
			124	2	2	
			1234	2	2	
			24	2	2	
			13	2	2	
			2345	2	1	
M	51	15	13	9	5	3
			136	5	3	
			1234	4	4	
			123	4	2	
			12	3	1	
N	115	19	1245	11	4	4
			13456	10	8	
			1356	10	9	
			1234	9	4	
			1235	8	3	
			134	8	8	
			145	7	3	
O	59	14	1345	6	3	3
			134	6	1	
			125	4	3	
			1235	4	4	
			245	3	3	
			1356	3	2	
			123	3	1	
P	156	19	124	28	9	4
			134	20	9	
			12345	16	8	
			2345	13	9	
			1235	11	6	
			1245	9	6	
Q	171	19	1245	39	13	4
			124	19	11	
			1345	13	10	
			12356	13	3	
			1235	12	5	
			1234	11	7	
			13456	11	5	
			2345	10	8	

Letter	Total Errors	No. of Subjects Erring	Most Common Errors to 50%	No. of Common Errors	No. of Subjects Making Common Errors	No. of Subjects Making 50% of all Errors
R	86	18	124	18	9	5
			1245	9	5	
			135	9	6	
			12345	8	5	
S	47	15	24	11	7	4
			124	9	4	
			1234	5	4	
T	62	16	12345	9	6	4
			1245	7	5	
			1235	6	5	
			234	5	4	
			1234	4	3	
			1345	4	2	
			2456	4	3	
U	30	11	134	8	4	3
			13	4	3	
			1236	3	3	
V	46	12	1234	11	5	3
			125	8	6	
			123	5	4	
W	54	16	1245	7	5	4
			123	7	5	
			1235	4	2	
			13456	5	3	
			1356	3	2	
			125	3	2	
			1234	3	2	
			1245	3	2	
X	30	11	134	6	5	3
			1235	3	1	
			1236	2	2	
			1345	2	2	
			1234	2	2	
			14	2	2	
Y	54	17	1356	8	8	5
			1345	8	7	
			12345	5	4	
			1346	4	4	
			1234	4	3	
			12345	4	3	
Z	142	19	1345	23	11	3
			12356	16	2	
			1245	14	7	
			13456	12	4	
			12345	10	4	