DOCUMENT RESUME

ED 121 043 EC 082 764

AUTHOR	Kershman, Susan M.; Hart, Verna
TITLE	A Hierarchy of Tasks in the Development of Tactual Discrimination. Final Report.
INSTITUTION	Pittsburgh Univ., Pa.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
BUREAU NO	443AH50044
PUB DATE	Aug 75
GRANT	G00-75-00357
NOTE	154p.; Print in some tables is excessively small and figures may not be clear. Some of the print in the text is marginal
EDRS PRICE	MF-$0.83 HC-$8.69 Plus Postage
DESCRIPTORS	*Blind; Braille; *Cutaneous Sense; Discrimination Learning; Exceptional Child Research; Primary Education; Reading Readiness; *Sensory Training: *Sequential Learning; Tactile Adaptation; *Tactual Perception: Visually Handicapped
IDENTIFIERS	Optacon

ABSTRACT

A hypothesized hierarchy of tasks in the development of tactual discrimination (an essential skill for reading) was tested in 60 blind primary level children. For five braille and five Optacon (optical to tactile converter) sequences, Ss were asked to identify the different stimulus from the four presented. Scalogram analysis was used to examine the results using a variety of criteria of mastery for all tasks. Results validated the hypothesized sequence of tasks and indicated that many first grade and most second grade Ss completed at least half of the simple discriminations given on the Optacon. Data supported the suggested use of raised line forms in Optacon readiness materials. (Four appendixes include a 40-page review of the literature.) (CL)

FINAL REPORT

Project No. 443AH50044

Grant No. G00-75-00357

A HIERARCHY OF TASKS IN THE DEVELOPMENT OF TACTUAL DISCRIMINATION

Project Directors: Susan M. Kershman/Verna Hart

August, 1975

U.S. DEPARTMENT OF

HEALTH, EDUCATION, AND WELFARE

Office of Education

TABLE OF CONTENTS

	Page
Summary	1
I. INTRODUCTION	5
A. Definitions	15
B. The Hierarchy	19
C. Statement of the Problem	23
1. Hypothesis	24
2. Limitations of the Study	26
II. METHOD	27
A. Subjects	27
B. Materials	32
C. Administration	41
D. Data Analysis	45
III. RESULTS	49
A. The Hypothesis	49
B. Additional Analyses	62
IV. DISCUSSION	83
A. Suggested Further Research	87
Appendices	90
Appendix A	91
Appendix B	132
Appendix C	134
Appendix D	135
References	137

LIST OF TABLES

Table		Page
1	Schematic Diagram of the Hierarchy of Tasks in the Development of Tactual Discrimination.	20
2	Distribution of Subjects by Sex, Grade Levels and School Placements	29
3	Mean Ages of Subjects by Grade Levels and School Placements	31
4	Sample of All the Items for One Task of the Hierarchy	38
5	Sample of Items Administered for Each Task of the Hierarchy	39
6	Hypothetical Data for a Perfect Scale.	46
7	Hypothetical Data for a Scale with Scaling "Errors".	47
8	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A; Criterion of Mastery: 4 or more	52
9	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A; Criterion of Mastery: 5 or more	52
10	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A; Criterion of Mastery: 6 or more	53
11	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A; Criterion of Mastery: 7 or more	53
12	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A; Criterion of Mastery: 8	54
13	Summary of Coefficients of Reproducibility for the Braille Sequence Scalograms.	56
14	Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B; Criterion of Mastery: 4 or more	57

15	Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B; Criterion of Mastery: 5 or more	57
16	Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B; Criterion of Mastery: 6 or more	58
17	Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B; Criterion of Mastery: 7 or more	58
18	Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B; Criterion of Mastery: 8	59
19	Summary of Coefficients of Reproducibility for the Optacon Sequence of Scalograms	61
20	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Residential and Day Programs; Criterion of Mastery: 4 or more.	63
21	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Residential and Day Programs; Criterion of Mastery: 5 or more.	63
22	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Residential and Day Programs; Criterion of Mastery: 6 or more.	64
23	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Residential and Day Programs; Criterion of Mastery: 7 or more.	64
24	Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Residential and Day Programs; Criterion of Mastery: 8.	65
25	Summary of Coefficients of Reproducibility for the Braille Sequence Scalograms, by Residential and Day Programs	66
26	Scalogram of Results for Tasks 1, 2 3B, 4B, 5B, by Residential and Day Programs; Criterion of Mastery: 4 or more.	67
27	Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Residential and Day Programs; Criterion of Mastery: 5 or more.	67

28 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Residential and Day Programs; Criterion of Mastery: 6 or more. 68

29 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Residential and Day Programs; Criterion of Mastery: 7 or more. 68

30 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Residential and Day Programs; Criterion of Mastery: 8. 69

31 Summary of Coefficients of Reproducibility for the Optacon Sequence Scalograms, by Residential and Day Programs 70

32 Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Grade Levels; Criterion of Mastery: 4 or more 71

33 Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Grade Levels; Criterion of Mastery: 5 or more 71

34 Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Grade Levels; Criterion of Mastery: 6 or more 72

35 Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Grade Levels; Criterion of Mastery: 7 or more 72

36 Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A, by Grade Levels; Criterion of Mastery: 8 73

37 Summary of Coefficients of Reproducibility for the Braille Sequence Scalograms, by Grade Levels 75

38 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Grade Levels; Criterion of Mastery: 4 or more 76

39 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Grade Levels; Criterion of Mastery: 5 or more 76

40 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Grade Levels; Criterion of Mastery: 6 or more 77

41 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Grade Levels: Criterion of Mastery: 7 or more 77

42 Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B, by Grade Levels: Criterion of Mastery: 8 78

43 Summary of Coefficients of Reproducibility for the Optacon Sequence Scalograms, by Grade Levels. 79

44 Summary of Children in Each Grade Level Passing Optacon Performance 81

45 Comparison of Total Scores for Two Orders of Administration of Tasks 82

LIST OF FIGURES

Figures		Pages
I	Task 1: Platform and Sample Shapes	33
II	Task 2: Platform and Sample Shapes	35

A HIERARCHY OF TASKS IN THE

DEVELOPMENT OF TACTUAL DISCRIMINATION

Project Directors: Susan M. Kershman, Ph.D./Verna Hart, Ph.D.

SUMMARY

Tactual experience is seen as an important prelude to reading tactile materials whether they be braille, tactile maps or inkprint read via the Optacon. In the wide range of possible tactual experiences, discrimination skills are seen as a particularly important component in the task of reading tactile materials. Experiences in tactual discrimination tasks are therefore considered beneficial for young blind children before they are introduced to the reading of tactile materials.

The problem of this investigation is the hierarchical ordering of tasks in the development of tactual discrimination for the instruction of young blind children.

It was hypothesized that: <u>given the same question form in each instance ("Find the one that is not the same") and requiring the same response in each case (touching the figure and saying "This one!"), basic tactual discrimination skills using the following numbered materials are acquired in the order 1, 2, 3A, 4A, 5A or 1, 2, 3B, 4B, 5B</u>:

1. Large solid geometric shapes;
2. Flat (puzzle pieces) figures smaller than (1) above;

3A. Embossed dot geometric figures smaller than (2) above;

3B. Raised line geometric figures smaller than (2) above;

4A. Embossed dot line figures;

4B. Raised line segments;

5A. Braille figures;

5B. Inkprint figures presented on the Optacon.

The sequence of skills hypothesized to be in hierarchical order was based on results of related research as well as on several generalizations from the early development of tactual skills.

The subjects of the study were sixty blind children, twenty in each grade level from kindergarten through second grade in residential and day program facilities for the visually handicapped in the northeast quadrant of the United States. All children in the study had vision in the range between light perception/projection and total blindness with no other recorded sensory, physical or intellectual handicapping conditions. All the subjects in this study had visual impairments before the age of five years. Because of the relatively few numbers of children meeting the above criteria, there was no attempt to match groups from residential and day programs except by grade level. There were 29 boys and 31 girls, ranging in age from 4 years 1 month to 11 years 8 months. At the kindergarten and grade one levels, there was no statistically significant difference in the mean ages of children in residential and day programs.

Second grade children in residential program facilities were significantly older than their counterparts in day programs.

All materials were prepared specifically for use in this study. In general, as the child proceeded through the tasks of the hierarchy, the materials given to him were smaller than in the previous task. Within each task, stimuli were as much like each other as possible in weight, size and texture.

All subjects in this study were tested individually by the same experimenter. The same simple verbal instructions and encouragements were given to all children.

Scalogram analysis was used to examine the results using a variety of criteria of mastery for all tasks. These analyses validated the hypothesized sequences of tasks.

Additional scalogram analyses of the collected data were attempted to reveal differences in the order of emergence of tactual discrimination skills between children in residential schools and children in public day facilities. For the braille sequence of tasks, coefficients of reproducibility for children in residential facilities showed a wider range than the coefficients for children in day facilities although all coefficients for both groups supported the hypothesized hierarchy. For the Optacon sequence of tasks, there appeared to be no difference in the range of coefficients for these two groups.

For both the braille and the Optacon sequences, scalogram analyses by grade levels, using a variety of mastery criteria showed that increasing numbers of children in the successive grades were able to master the tasks.

The tactual discriminations on the Optacon, considered separately, were not beyond the capabilities of most of the second grade children in the study.

The implications of this study for instructional purposes were discussed and recommenoations were made for future research in this area.

I. INTRODUCTION

Historically, a workable system of reading and writing has always been seen as a precondition to the systematic education of the blind. Efforts to enable blind persons to read and communicate in writing both with each other and with seeing individuals date back over many hundreds of years and continue today with the help of modern technology. The development of tactile reading materials has been accompanied by the attempt to preserve the closest possible analogy between the means of educating the blind and the sighted. The expression of this philosophy in recent modern day practices in special education gives emphasis and priority to the integration of blind children into regular classrooms.

According to a recent survey, the majority of blind children begin braille instruction in the first semester of the first grade of school (Lowenfield, Abel and Hatlen, 1969). Recent studies in the teaching of reading to visual readers have suggested that an earlier start may be better than a later one (Chall, 1967). At the very least, it is felt that experience can be provided for even a very young child ". . . which will enable him to adapt readily to the reading situation"

(Tinker, 1974, p. 22). For the sighted child, there are numerous approaches to beginning reading. Aukerman (1971) analyzed and clarified over 100 reading readiness programs which are now available for the English-speaking sighted child. For the blind child, however, there appears to be a paucity of suggestions in the literature and virtually no apparent systematic or commonly accepted procedures for introducing the young blind child to braille reading.

In 1973, Cardinale conducted a survey on the methods of teaching braille reading to blind children attending the elementary departments of 19 residential schools for the blind. This survey compared the use of tactual experience with that of concept development, aural language and hand coordination for braille reading readiness. Responses indicated that teachers used tactual experience most frequently compared with the other techniques as a prelude to teaching braille reading. Several authors have made suggestions to parents and to other teachers on the basis of classroom or resource room experiences for preparing the blind child for braille reading (Benton and Ellis, 1956; Elms, 1959; Kenmore, 1957; Kurzhals and Caton, 1974; Kurzhals, 1966; Liguori, 1956; Pittam, 1965; Wegehoft, in press). To date, most of these suggestions remain unvalidated and unincorporated into a program of tactile reading readiness.

A significant increase with age in sensitivity to texture has been reported by Gliner (1967) in both sighted and blind children.

Nolan and Morris (1965) developed and validated the Roughness Discrimination Test (RDT), a sandpaper test requiring the child to identify one item which is unlike others in an array of four. Predictive validity of the test for the first grade was determined by correlating RDT scores obtained during the initial two months of the first year of school with reading criteria (reading-error and reading-time) obtained during the final two months of the same school year. Concurrent validity for the second grade was determined by correlating RDT scores and reading criteria obtained at the same sitting during the first two months of the second year of school. Low validites were determined and no relationship was found between the ability to discriminate degrees of roughness of sandpaper and chronological age. Ability on the RDT was significantly and positively associated with grade level, up to the fourth grade.

Predictive tests, however, are of little value to teachers faced with the problems of teaching complex skills. A low RDT score does not suggest any particular approach to remediation, nor a way of preventing the predicted difficulty in reading. The RDT, in short, has become a tool of research in braille reading readiness, rather than a teaching device for classroom use.

In 1956, a meeting of teachers of blind children from several geographic regions took place and resulted in the production of three Touch and Tell volumes, intended as readiness books for future braille readers (Duncan, 1974). Remarks by teachers in the survey by Lowenfeld, Abel and Hatlen (1969) suggested that the Touch and Tell books were not in particularly wide use. One possible reason for this is that these volumes represent an edited collection of teachers' ideas for materials, rather than a detailed description of what to do with them. Also, the value of the Touch and Tell approach has apparently not been demonstrated in the professional literature. The organization of the three volumes is centered around four elements: left-to-right sequencing; size and geometric form discriminations; and exercises in finding one different item in an array of identical items. While these tasks may appear obviously related to later skills in reading braille, there has thus far been no validation apparently reported for the sequence of exercises of the three volumes. What appears to remain to be established is whether all the steps are necessary, whether performance on one is predictive of performance on another task, whether tasks are ordered from simple to complex or whether there is any evidence for the relevance of these tasks to the later processes of reading braille. In short, the Touch and Tell books represent an apparently unvalidated sequence of skills which may or may not be organized in keeping with up-to-date instructional practices.

In 1972, the Annual Review of Psychology, Glaser and Resnick described a new trend in research, the analysis and investigation of the instructional process, called "instructional psychology." Experimental, social and developmental psychologists in increasing numbers, according to Glaser and Resnick (1972), are espousing the notion that psychological analysis is appropriate to the development of procedures for optimizing learning. This is clearly a departure from traditional "educational psychology," the theoretical or empirical description of learning. The latter is descriptive, while instructional psychology is prescriptive; it sets up rules concerning or specifying the most effective ways of achieving knowledge of mastery of skills. These rules include: (a) analysis of the task/skill; (b) assessment of entering behavior of the learner; (c) design of the instructional environment; (d) assessment of specific instructional effects and (e) evaluation of generalized learning outcomes. These steps correspond nicely with those described by DeCecco (1968) as the steps teachers need to take in teaching skills to their students. Because it can be data-based, this prescriptive technique of instructional research appears to have the possibility of meeting the accountability needs of teachers.

Instructional psychology also allows researchers to deal with learning tasks that are typically more complex than those usually studied in the learning laboratory. As a result, much more emphasis is reportedly being placed on a description of the properties of what is learned, the analysis of a specific complex task.

Task analysis is a process as yet relatively undefined (Glaser and Resnick, 1972). It has been described as "attempting to define clearly what it is that an expert in a subject matter domain has learned" (Glasser and Resnick, 1972, p. 209). As such, it separates the skilled from the unskilled performer. Stated in behavioral terms, Glaser and Resnick's definition of task analysis involves describing mastery of performance in small steps in temporal order. Resnick, Wang and Kaplan (1970, pp. 7-8) defined task analysis as a description of "the actual steps involved in skilled performance of the tasks." For the present purposes, this definition of task analysis will be used.

Task analysis has been used to describe the component steps of using an Optacon, which is a new machine designed to enable blind persons to read print materials. A complete description of the Optacon will be found in Appendix B. Since the machine first became commercially available, field experience and Optacon training has been mainly with adult or adolescent readers (Moore and Bliss, 1975). In view of the independent and immediate access to print which the Optacon affords, its use is currently being extended to young blind children. The freedom from special materials which is possible with Optacon use can enhance the young blind child's possibilities for integration in the regular classroom. Yet there is little experimental research to show at what age or grade level young blind children are capable of the simplest tactual discriminations that need to be made for beginning Optacon use. Nor is there any research to give direction to a program introducing reading via the Optacon to young blind children.

Authors from Telesensory Systems, Inc. (TSI) described the task of Optacon reading as including the following basic components: muscular coordination, orientation concepts, two-handed coordination, attention span, language skills, motivation, persistence, mechanical aptitude, and three components directly related to tactile skills; tactile sensitivity, tactile resolution, and tactile image perception (TSI, 1973). These components were considered the important capabilities in Optacon reading and good indicators of potential for Optacon training. What is missing from this list, however, is the element of interpretation of the tactile image (unless this is subsumed under tactile image perception); that is, the definitive element of the process of reading. This is probably because neither the Optacon itself, nor the TSI Teaching Guidelines (1973) were prepared with the young blind child or the non-reader in mind.

It can be seen that implicit in the steps of the task analysis are assumptions about the characteristics of the learner as well as the processes available at different stages of learning and development (Glaser and Resnick, 1972). For example, from the perspective of the very young partially seeing child, the first step in a writing exercise (as terminal task) is likely to be "pupil locates the pencil." From the perspective of the sighted child, this first step is presumed and less likely to be listed at all.

In addition to the implicit assumptions about the learner, a task analysis has implicit assumptions about the structure of the discipline in question (Glaser and Resnick, 1972). Since advanced knowledge structures may not be good structures for elementary learning (Glaser and Resnick, 1972), instructional psychology research has begun to focus increasingly on the development of units, structures and sequences which serve to facilitate learning to a novice. To do so, a second level of analysis is utilized. Each component of the task analysis can theoretically be analyzed in a "component analysis." The organization of educational objectives is based on the inferred processes which underlie successful performance of each task in the task analysis. In other words, each task in a task analysis may, in turn, be considered a terminal task for a component analysis.

Gagné (1965) contributed a major effort on categorizing tasks according to learning requirements. The eight varieties of learning described by Gagné (1965) were considered to be in hierarchical order, that is, the simpler ones are prerequisite states for learning the more complex types. Since Gagné introduced this approach, learning hierarchies have been used as a tool for instructional technology, particularly in designing instructional sequences and curricula.

Prerequisite behaviors are not actually performed in the course of the performance of the terminal task of a component analysis. They are, however, thought to facilitate learning of a higher skill. If, for example, A is prerequisite to B, then learning A first should result in positive transfer when B is learned. Anyone able to perform B, should also be able to perform A as well.

In summary, principles of instructional psychology, specifically task and component analyses, can be applied to the problem of the development of tactile reading readiness materials. The question being asked in a task analysis is: what are the actual steps involved in skilled performance of the task? A complex task is thereby broken into simpler tasks and these are listed in temporal order. To determine tasks prerequisite to these component (simpler) tasks, the question being asked is: "In order to perform this behavior, which simpler behavior(s) must a person be able to perform?" (Resnick, Wang and Kaplan, 1970, p. 8). While tactual experience is seen as important and necessary to the later reading of the tactile materials, the sequence of development of tactual discrimination skills has not been reported in the literature reviewed.

Currently available from the American Printing House for the Blind is a series of Tactual Discrimination Worksheets designed to provide visually handicapped children with experience and training in tactual discrimination. What appears to be needed by curriculum designers and teachers of blind children is concrete evidence for the ordering of tactual discrimination tasks. In this way, a sequence of lessons can be developed, based on the natural emergence of the specific discriminations required for the later reading of tactile materials. A review of related literature (See Appendix A) was undertaken in order to collect whatever information is available on the development of tactual perception skills in young blind children.

It is noted that the relevance of tactual discrimination skills is not limited to the blind population. Others, such as learning disabled or mentally retarded children may well profit from the use of tactile materials for learning in a multisensory manner. The present study is concerned with blind children because they are primarily tactually-oriented learners.

A. Definitions

The words "tactile" and "tactual" are used according to the distinctions proposed by Schecter (1973).

<u>Tactile</u>: Perceptible by the touch, capable of being felt or touched, tangible. Schecter's (1973) example is raised line drawings. These present tactile information. Hence we may speak of tactile materials or tactile tasks.

<u>Tactual</u>: Of or pertaining to the sense, or the organs of touch; producing the sensation of touch; used for medial or physiological contexts. Hence we may speak of tactual perception, tactual discrimination or tactual skills.

<u>Tactile sensitivity</u>: is defined as the ability to feel/report/interpret a sensation received through the sense of touch. One measure of sensitivity is the pressure threshold, that is, the threshold above which pressure or contact on the skin is sensed or reported by subjects. Another measure of tactile sensitivity is the numerical

value of the pressure above which sensation is reported or interpreted by subjects.

Tactile resolution: is defined as the minimum spatial separation at which two points can be distinguished from one. In the neurological examination of children, Paine and Oppé (1966) point out that one must first ascertain that the patient knows the difference between one and two. Suggested instruments for measurement include the caliper-type, points of a compass, a bent paper clip or a piece of wire.

Temporal numerosity: refers to the way in which rapidly presented sequences of sensory stimuli are perceived (White and Cheatham, 1959). The sequence of studies reported by these authors dealt with the number of light flashes perceived visually, the number of tones perceived auditorily and the number of contacts (made by a thumbtack under the subject's thumb) perceived by the subject. Indices of temporal numerosity included those reported by subjects and those measured by electrophysiological techniques.

Active touch: is defined by Gibson (1962) as what is ordinarily called touching. The impression on the skin is brought about by the perceiver himself. Active touch is exploratory and combines the sensory data from the feeling of movement and the feeling of contact. It may also involve input from the skelto-muscular system.

Passive touch: is defined by Gibson (1962) as being touched. Impressions on the skin are brought about by some outside agency. Gibson (1962) calls this a receptor sense.

Complexity: is defined as dependent on the number of different stimuli and responses possible in a given block of time and space (DeCecco, 1968).

Discrimination is defined as the noticing of differences. According to Gibson (1969), "a discrimination experiment involves a noticing of differences between two (or more) stimuli presented simultaneously or in immediate succession. Immediate succession is intended to mean succession within a time interval short enough so that the chance of new interpolated stimuli is negligible" (p. 174).

Distinctive features: Pick (1965) defines distinctive features as dimensions of difference which distinguish and provide contrasts among objects. The hypothesis developed by E. J. Gibson's (1969) work is that improvement of discrimination consists of learning the distinctive features of the objects to be discriminated. The function of practice according to this point of view is to enable subjects to respond to an increasing number of stimulus variables and to discover which of these variables are "critical" in the sense that they serve to distinguish between one object and another.

A hierarchy is defined for purposes of the present study as a set of tasks showing sequenced dependencies (Glaser and Resnick, 1972). As such, a hierarchy has implications for curriculum design as well as for the psychological analysis of the acquisition of complex behavior. Studies of transfer relationships postulate that two tasks are hierarchically related if one task produces positive transfer to the other, that is, if learning the subordinate task as a prerequisite results in fewer trials to learn the superordinate task. Psychometric studies, like the present one, utilize scaling data to indicate the extent to which performance on lower order tasks can reliably be predicted from information on performance on higher order tasks.

B. The Hierarchy

Using the generalizations about the progressions in development and the results reported in the related literature for specific stimulus forms, a hierarchy of tasks in tactual discriminations was constructed. Table 1 shows a schematic diagram of the tasks hypothesized to be in hierarchical order, with tasks 5A and 5B representing the terminal and most difficult tasks in the sequence.

The first task in the hierarchy describes a level of behavior "which can be assumed in most of the student population in question" (Resnick, et al, 1970, p. 9). Steps upward in the hierarchy represent an attempt to introduce decreasing size and increasing complexity into the particular stimulus forms utilized. Research (Ewart and Carp, 1963; Nolan and Morris, 1960) has suggested that the discrimination of three-dimensional forms in task 1 covers a range from easiest (the ball) to more difficult (the pyramid).

For task 2, developmental data provided information on the range of difficulty of manipulation of the stimulus forms. The round puzzle piece of the formboard is the first to be inserted, at 18 months, by the normal child. By 24 months, the child can insert the three forms: the circle, the square and the triangle (Gesell and Amatruda, 1947).

Research reported earlier (Merry and Merry, 1933) supported the use of the particular raised dot and raised line geometric forms used in tasks 3A and 3B. Of the 43 raised line letters, numbers and geometric forms which were tactually discriminated by sighted adult

Table 1

Schematic Diagram of the Hierarchy of Tasks

in the Development of Tactual Discrimination

Task	Stimuli	Response
Task 5A Braille	Stimuli: Braille configurations corresponding to letters L (⠇); C (⠉); and contractions ST (⠌); and OW (⠪).	Response: as in Level 1
Task 5B Optacon	Stimuli: inkprint line segments; vertical line, horizontal line, circle, open circle.	Response: Preferred index finger on Optacon, child says "This one."
Task 4A	Stimuli: Embossed Dot Line Figures; vertical line, horizontal line, diagonal line (/); angular line (<).	Response: as in Level 1
Task 4B	Stimuli: Raised Line Segments; vertical line, horizontal line, closed circle, open circle (C).	Response: As in Level 1
Task 3A	Stimuli: Embossed Dot Geometric Forms; circle, square, triangle, rectangle.	Response: as in Level 1
Task 3B	Stimuli: Raised Line Geometric Figures; circle, square, rectangle, triangle.	Response: As in Level 1
Task 2	Stimuli: Planed Figures: circle, square, rectangle, triangle.	Response: as in Level 1
Task 1	Stimuli: Solid Forms: ball, cube, rectangular block, pyramid.	Response: Exploration using both or either hand; touching the object with preferred hand, child says "This one."

subjects (Austin and Sleight, 1952a), the circle, square, rectangle and triangle as well as the vertical line and crescent (open circle) all met the 90 per cent criterion for discriminability.

Vertical and horizontal lines were shown to be distinguishable for children ages 3 1/2 to 8 1/2 (Gibson, 1969). Field testing of angular raised dot figures in the Tactual Discrimination Worksheets showed a statistically significant difference, by grade level, in the abilities of students to discriminate angular figures (Caton, 1974). This prompted the use of the diagonal and angular lines of task 4A. Pick and Pick (1966) found that judgments for breaks in lines and closed lines were the easiest discriminations to be made by both blind and sighted children. Therefore, the vertical, horizontal, closed circle and open circle line segments were chosen for stimuli for task 4B.

Stimulus forms in tasks 5A and 5B were chosen partly for their transferability from earlier tasks. The diagonal and angular lines of task 4A were changed to ST (.˙) and the OW (·⁚) contractions that are used on conventional braille. Each of the figures used for Optacon items do appear in conventional print. Each of these tasks, 5A and 5B, represented a terminal behavior for one branch of the hierarchy. Tasks below 5A and 5B in the hierarchy were hypothesized to be prerequisite to them.

Throughout the hierarchy, the question form, "find the one that is not the same," remains constant. The use of this question form is suggested by research by Birch and Lefford (1963). In a paired-comparison study of intersensory geometric form recognition, haptic-kinesthetic judgments of non-identical forms tended to be superior to the visual-kinesthetic judgments. In the judgment of identical forms, visual-kinestic and haptic-kinesthetic judgments were of the same order of difficulty. Since the hierarchy is designed for use with visually handicapped children, and the task in question is closely parallel to Birch and Lefford's haptic-kinesthetic task, it was felt that judgments of non-identity were more appropriate than matching to a stimulus or finding two identical items. Further, Carrow (1968) has shown that by the age of six years, 60 per cent of children comprehend the linguistic forms "alike" and "different." Finally, in the field-testing of Tactual Discrimination Worksheets, item difficulties for three question forms were compared (Caton, 1974). Between the highest item difficulty index (88.26 for matching to a stimulus) and the lowest (93.32 for finding figures which are different), there was only a 5.94 per cent difference, indicating that most blind children between kindergarten and grade three can deal with these question forms.

In order to maximize the possibility of testing skills in tactual discrimination rather than conceptual or linguistic development, an attempt was made to minimize changes in the response pattern with the upward steps of the hierarchy. The progression through tasks 1, 2, 3B, 4B and 5B however reflects the progression discussed earlier from the use of active touch to the use of passive touch.

C. Statement of the Problem

The area of concern of the present study was the development of tactual discrimination skills in young blind children. The relevance of the study is not limited to the blind, however, but may be applied to other children who benefit from tactual learning. The specific problem of the study was the hierarchical ordering of tasks in the development of tactual discrimination, a component skill of reading tactile materials.

Tasks in tactual discrimination are seen as an important prelude to the teaching of braille. However, there is as yet no validation of the order in which such tasks should be taught. Similarly, tactual discrimination skills are an important component in the preparation for Optacon use. Yet, to date there is little experimental evidence to show at what age or grade level young blind children are capable of the simplest tactual discriminations required for Optacon use. There is little research to give direction to a program introducing reading via the Optacon to young blind children.

Viewing tactual discrimination as a major component in the later reading of tactile materials, and based on research in related literature, a sequence of tasks in tactual discrimination was proposed to be in hierarchical order, from easy to more difficult.

The purpose of the present study was to validate the order of tactual discrimination skills by the use of scalogram analysis. Scores on the tasks were examined for "scalability," that is, the extent to which tasks can be arranged in an order such that passage of a certain test reliably predicts passage of all tests lower in the scale (Resnick and Wang, 1969).

1. Hypothesis

The following hypothesis was tested:

Basic tactual discrimination skills as defined by the following numbered, behavioral objects are acquired in the order 1, 2, 3A, 4A, 5A or 1, 2, 3B, 4B, 5B: (See diagram on p. 55.)

1. Given four solid objects (a ball, a cube, a rectangular block, a pyramid) in a row, three of which are identical, the child will correctly indicate discrimination by touching the object that is "not the same" as the others. The child will say "This one."

2. Given four flat (puzzle pieces) figures (a circle, a square, a rectangle, a triangle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the object that is "not the same" as the others. The child will say "This one."

3A. Given four embossed dot geometric figures (a circle, a square, a rectangle, a triangle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

3B. Given four raised line geometric figures (a circle, a square, a rectangle, a triangle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

4A. Given four embossed dot line figures (a vertical, a horizontal, a diagonal, an angular line) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

4B. Given four raised line segments (a vertical line, a horizontal line, an open circle, a closed circle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

5A. Given four braille figures in a row (corresponding to the letters C and L and the contractions ST and OW) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

5B. With the child's preferred index finger on the array of the Optacon, with the Automatic Page Scanner set at a fixed, slow rate of presentation, given four line figures (a vertical line, a horizontal line, an open circle, a closed circle) in a row, three of which are identical, the child will correctly indicate discrimination by saying "This one," as the one figure that is "not the same" appears.

In addition, the following questions were investigated: (1) Does analysis by school program reveal differences in the emergence of these skills between residential and day program children? (2) Does analysis by grade level reveal the emergence of these skills as blind children progress through the school system? (3) At what grade level(s) can most blind children successfully perform the simple tactual discriminations presented on the Optacon? (4) Was there an effect of administering the tasks in two orders, (parts A first/parts B first) to the children?

2. Limitations of the Study

It should be noted that the branching of the hierarchy is not intended to show the equivalence of perceptions of braille or raised dot figures to those of Optacon or raised line figures. Rather, the relationship of each of these to tasks lower in the hierarchy is in question.

The validation of the order of tasks in the hierarchy is also limited to the testing of these skills at a given time in a child's academic life. No attempt was made to teach children who were unable to give a correct response. The sequence of tasks in the hierarchy is not presumed to be "natural" in the sense of "unlearned." Rather, the relationship of dependence shown between tasks in the hierarchy demonstrated how under existing cultural and educational conditions, one task was mastered before another. Thus, the actual sequence of acquisition of these skills over a period of time has been inferred, even if it is not observed directly.

A third limitation of the study is presented by the noise made by the Optacon each time the camera moved across a letter. Because this noise is unavoidable, the task involving the Optacon (5B) may be said to involve auditory as well as tactual discrimination. It was not possible to control the acoustic conditions of each of the testing sites.

It is also understood that while this study attempted to validate the sequence of skills in the proposed hierarchy, the relationship of these skills to the later reading of tactile materials remains to be investigated.

II. METHOD

A. Subjects

The sample of children who were tested is representative of those children among the entire blind population for whom tactual readiness materials are appropriate. The subjects were sixty blind children, twenty in each grade level from kindergarten through grade two in public and residential schools in the northeast quadrant of the United States. According to the 1974 American Printing House for Blind registration of blind braille-reading children in kindergarten through second grade in the United States, about equal proportions of such children are educated in their home communities as are educated in residential schools. Accordingly, ten children in each grade level were drawn from day schools and ten from residential schools. In the cases of ungraded schools, the children's braille reading scores or teacher's judgments were used as indicators of grade level.

The following criteria were applied to all children:

(1) Only children with vision in the range between total blindness and light perception or light projection were included. Any child who "eyeballed" the materials was excluded from the study.

(2) Only blind children with no other recorded sensory, physical or intellectual handicapping conditions were included.

(3) Only children with onset of visual impairments before the age of five years were included. According to Lowenfeld (1973), children who become blind before that age do not have a workable visual memory, that is, are primarily tactually-oriented.

Directors of programs for the visually handicapped were contacted individually in an effort to locate children who met the above criteria. It was necessary to travel to 9 states to locate the required number of children. Personnel in the field of vision is in addition 5 states were contacted but lacked children meeting the necessary criteria. Thus, because of the relatively few numbers of these children, there was no attempt to match groups from day and residential programs except by grade level. Permission to test was obtained from parents or from the agencies for each child. All testing was accomplished following the Department of Health, Education and Welfare Protection of Human Subjects guidelines.

A total of 69 children were tested, with 9 children being eliminated because of the applied criteria or because they could not be given all the tests. There were 29 boys and 31 girls in the entire sample. The distribution of subjects by sex, grade level and school placement is summarized in Table 2. The distribution of subjects by the agency through which they were located is summarized in Appendix C.

The children ranged in age from 4 years 1 month to 11 years 8 months. The ages of all children are reported in Appendix D. The mean ages of children in each grade level by school placement is

TABLE 2

Distribution of Subjects by Sex,

Grade Levels and School Placements

Grade Level	Day School		Residential School		
	Boys	Girls	Boys	Girls	Total
Kindergarten	6	4	7	3	20
Grade One	4	6	6	4	20
Grade Two	4	6	2	8	20
Total	14	16	15	15	60

summarized in Table 3. A two-tailed test was used to determine that there was no significant difference in the mean ages of children in residential and day programs at the kindergarten or first grade levels. Second grade children in residential programs were significantly older than their counterparts in day programs.

TABLE 3

Mean Ages of Subjects

by Grade Levels and School Placements

	Residential		Day		
	Mean	s.d.	Mean	s.d.	t
Kindergarten	6.96	1.86	5.84	1.11	1.632
Grade 1	7.77	0.62	7.37	0.90	1.169
Grade 2	9.05	1.35	7.76	0.97	*2.456

*p = .05, 18 df, two-tailed test

B. Materials

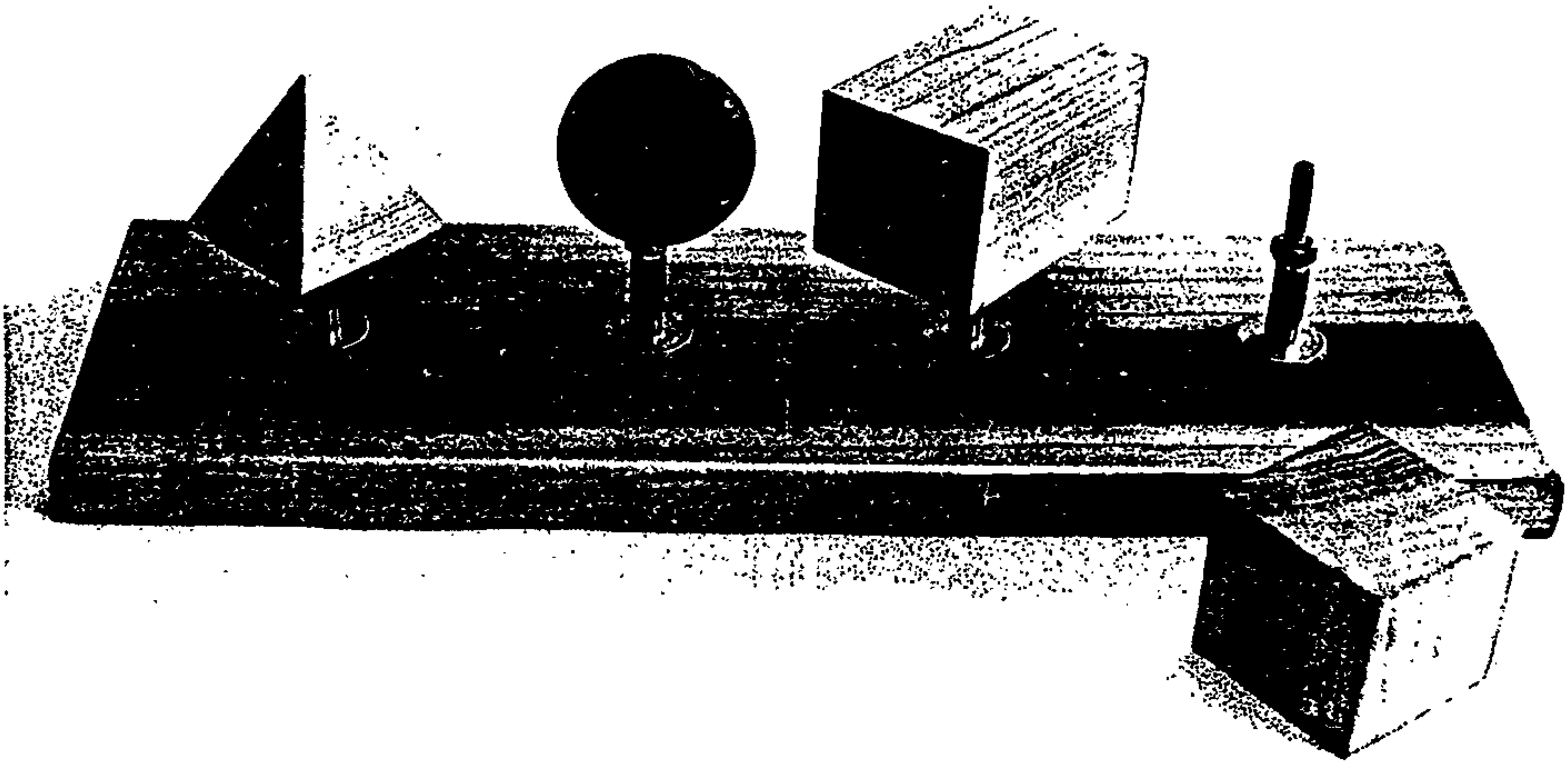
All materials were prepared specifically for use in this study. All materials for tasks 1 and 2 were made of hardwood. For task 1, a platform was prepared (5" x 15½" x 3/4" [.1270m x .3937m x .01905m]), with four holes drilled through it at equal intervals. Through these holes, ¼" carriage bolts were countersunk, pointing upwards. Each bolt had a metal washer, one inch of ¼" seamless metal tubing and a nut on it, to hold the bolt in place.

Three identical wooden pieces of each of the four shapes for task 1 were prepared. Shapes for task 1 were cut with 2-inch (.0508m) square bases for the square, the rectangle and the pyramid. The diameters of the wooden balls were also 2 inches (.0508m), and was the height of the four-sided pyramid. The length of the rectangle was 3 inches (.0762m). A ¼" hole was centered in the bottom of each wooden piece, so that each piece would sit on any bolt protruding from the platform, at the same height as other pieces. Figure I shows the platform and sample shapes for task 1 materials.

The platform for task 2 (4" x 12" x 3/4" [.1016m x .3048m x .01905m]) was drilled at equal intervals so that sections of dowel, implanted in the base (3/16" dowel) and sections of dowel implanted in the puzzlepieces (5/16") would interlock. In this way, each puzzle piece fit any of the four positions on the platform, but only in one direction.

Figure I

Task 1: Platform and Sample Shapes



Three identical pieces of each of the four shapes for task 2 were prepared. All pieces were ½" (.0127m) in height. The bases for the square, the rectangle and the triangle were 1½ inches (.0381m). The diameter of the circle was also 1½ inches (.0381m). The length of the rectangle was 2 1/8 inches (.05398m). The triangles were equilateral. Figure II shows the platform and sample puzzle pieces for task 2 materials.

The platforms were finished with varnish; all wooden shapes were oiled.

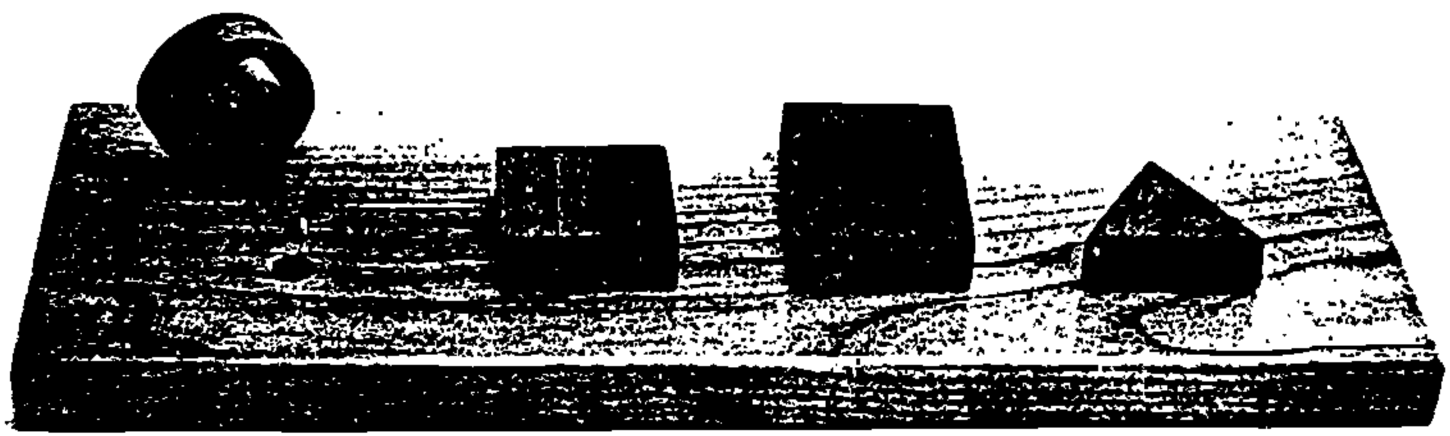
All materials for tasks 3A, 4A, 5A, 3B and 4B were prepared on heavy-weight Braillon. Raised-dot figures (Levels 3A, 4A) were made using a single-dot embosser on pre-marked, evenly spaced dots. A template was used to pre-mark the dots at 1/8" (.05398m) distance from the center of one dot to the center of the next.

Items for task 5A, the braille configurations, were prepared on a standard Perkins Brailler. Raised line figures (Levels 3B and 4B) were prepared on a Thermoform machine, using 18-gauge wire shapes. Three identical wire pieces of each shape were prepared, then set down in centered, evenly spaced positions on the Thermoform machine, using the 8½ x 11 frame. Dimensions of the shapes were 1¼" bases (.03175m) bases for the square, rectangle and triangle; 1¼" (.03175m) diameters for the circles. Triangles for tasks 3A and 3B were equilateral. Dimensions were the same for raised-dot as for raised-line shapes.

The straight lines for tasks 4A and 4B were 1¼" (.03175m) for both vertical and horizontal lines. Angular figures (task 4A) were pointed

Figure II

Task 2: Platform and Sample Shapes



to the right and were 60 degree angles of two $1\frac{1}{4}$" lines. Open and closed circles (task 4B) were made by using the same wire forms as for task 3B; the openings, placed on the right, for the open circles were 7/8 of an inch (.022225m).

Materials for the Optacon (task 5B) were prepared on an Olivetti electric typewriter (Editor 2) with Elite Correspondence Gothic type. This type does not have any decorative horizontal markings on the letters. For the vertical line, the capital i was used; for the horizontal line, the underlining key was used, but the carriage was moved, so that this line appears in the middle of the line (like a dash) relative to the other letters. Capitals c and o were used for the open and closed circles respectively. A sheet of items was prepared so that each item appeared five times on a line. In this way, repeated presentations could be given for the same item, without having to reposition the camera, placed in the Automatic Page Scanner.

Given four different stimuli such that each one is compared with the other three, the number of possible combinations of stimuli with each other is twelve. Table 4 shows these combinations using the braille code character names for ease of illustration. Of these 12 possible items for each task of the hierarchy, eight items summarized in Table 5, were given. By the use of these items, each stimulus figure is compared with two others. Correct responses appear once in positions (1) and (4) and three times in positions (2) and (3).

Table 4

Sample of All the Items for

One Task of the Hierarchy

Positions	1	2	3	4
Items 1	L	ST	ST	ST
2	OW	L	OW	OW
3	C	C	L	C
4	L	L	L	ST
5	ST	OW	OW	OW
6	C	ST	C	C
7	ST	ST	OW	ST
8	C	C	C	OW
9	OW	L	L	L
10	ST	C	ST	ST
11	OW	OW	C	OW
12	L	L	L	C

Table 5

Sample of Items Administered

for Each Task of the Hierarchy

Positions		1	2	3	4
Items	1	L	ST	L	L
	2	L	L	OW	L
	3	ST	C	C	C
	4	C	OW	C	C
	5	ST	ST	L	ST
	6	ST	ST	ST	C
	7	OW	L	OW	OW
	8	OW	OW	C	OW

In this way, more weight is given to those items where three identical figures do not appear in a row.

With eight items in each of the eight tasks of the hierarchy, each child was given 64 items in all.

C. Administration

All subjects in the study were tested in the latter half of the academic year. Each child was tested individually by the same female experimenter.

Three children were used for pilot testing. The purposes of the pilot testing were: (1) to establish the procedures and verbal instructions to be used in testing; (2) to determine the optimum settings for the Optacon and Automatic Page Scanner; (3) to determine the maximum time for testing each child.

The administration of all testing was carried out as follows: After a three-minute familiarization period between the child and the experimenter, the following instructions were given:

> I am going to show you a toy with four parts to it. Each time I show it to you, three of the parts will be exactly the same. One part is not the same.
>
> In order for me to be sure that you feel all four parts, I want you to count them as you feel them. You may feel them with either hand, or with both hands. Make sure you feel all four of the things I show you. After you feel them, show me the one part that is <u>not</u> the same. You can show me which one by touching it and saying "This one."

When necessary, the child's hands were then guided to the shapes on the task 1 platform. Also, whenever necessary, prompting was used, such as "Here's one. Here's two. You show me three" etc.

The same verbal instructions were given to all subjects. The expression "not the same" was used consistently and was not rephrased.

Children were not asked to name the shapes or the braille letters or contractions.

Children were not told whether their answers were correct, nor was there any time limit. When children asked whether their answers were correct, they were told that the experimenter could not say, but that they could check the item again if they so desired. Children were also told that they would receive M & M candies after each toy or group of materials. This was to help keep the children (especially the younger ones) attending to the task. At the seventh item in each task, the child was told: "There are two more of these to go; then it's time for an M & M candy." All children were given the same verbal encouragement (such as "You are working hard" or "You are a good worker") once during each task of the hierarchy.

For tasks 3, 4 and 5, half the subjects in each grade were administered parts A first, then parts B. The other half did parts B first, then parts A.

For task 5B, on the Optacon, the child was told: "I am going to show you a machine called an Optacon. This machine helps blind people to read print." The child was asked if he/she knew what print is. Print was described as something you write on paper with a pen, pencil or typewriter. The child was told that the Optacon is a delicate machine and must be handled gently. After being warned about the noise the Optacon makes, the child was told how to open the case and switch on the machine. He/she was then shown the camera as it was being taken out of the case and housed on the Automatic Page Scanner. The child was then directed to put an index finger on the array (the "plate") of the Optacon. The experimenter then demonstrated on the child's arm how the finger should rest without pressure or movement on the array and should cover as much of the array as possible. Before testing in task 5B began, the child was asked to tell the experimenter what he/she felt on the array. There was a solid line across the top of the page of Optacon items. By manipulating the fine control knob on the Automatic Page Scanner, this line could be moved from the bottom to the top of the array. The purpose of this activity was to allow the child to familiarize him/herself with the Optacon and to allow the experimenter to check finger placement on the array.

The experimenter was able to see what was on the array by using a Visual Display (Model VIA) linked to the Optacon.

Most children used their left index finger on the array, but a few preferred their right and were allowed to use whichever they preferred. If any child was startled or appeared frightened by the noise or vibrations of the array, he/she was shown the intensity adjustment knob and was allowed to vary its position. Once testing began, this control was set at approximately a two o'clock position.

The Automatic Page Scanner was set at 12.5 words per minute for all children, although when a child wanted the presentations slower, this was allowed for the first two items in this task. After each presentation of an item, the child was asked if he/she wanted to feel it again. The children were allowed as many presentations of an item as they wanted. On the average, children responded with sure (although not always correct) responses after three presentations of an item.

The maximum time for each child's assessment was one hour. Children in the second grade usually required only 40-45 minutes.

D. Data Analysis

A scalogram analysis (Guttman, 1950) was used in analyzing the data in reference to the hypothesis, which is concerned with the order of behavioral objectives. Two separate analyses were done, each using tasks 1 and 2, followed by 3A, 4A and 5A or 3B, 4B and 5B. The usefulness of scalogram analysis for the purpose of evaluating hypothesized hierarchical relationships among specified behavioral objectives has been demonstrated (Boozer and Lindvall, 1971).

Scalogram analysis provides a procedure for arranging the tasks such that achieving a passing score in a behavioral objective higher in the sequence reliably predicts passage of all objectives lower in the sequence. An example of a hypothetical set of perfectly scaled data is presented in Table 6. Subjects are listed down the side, objectives across the top. Each individual's performance on each objective are coded as "0" indicating a failing performance or "1" indicating a passing performance. It should be noted that in perfectly scaled data, once a subject fails an objective, he fails all subsequent objectives. Conversely, if he passes an objective, he has passed all earlier objectives. Perfect scales however are rarely found and Table 7 is an example of a hypothetical set of data with errors, indicating the passing of a higher level objective and failing of a lower level one. In scalogram analysis, the number of errors in a set of data is used to calculate the <u>coefficient of reproducibility</u>, which is a measure of the degree to which a set of data approximates a perfect scale.

Table 6

Hypothetical Data for a Perfect Scale

		Objectives:				
		1	2	3	4	5
Subjects:	A	1	1	1	1	1
	B	1	1	1	1	0
	C	1	1	1	0	0
	D	1	1	0	0	0
	E	1	0	0	0	0
	F	0	0	0	0	0

Table 7

Hypothetical Data for a Scale with Scaling "Errors"

		Objectives:				
		1	2	3	4	5
Subjects:	A	1	1	1	0	1
	B	1	1	1	1	0
	C	1	0	1	0	0
	D	1	1	0	0	0
	E	1	0	0	0	0
	F	0	0	0	0	0

Additional analyses of the collected data were also undertaken to reveal whether there were differences in the order of emergence of tactual discrimination skills between children in residential schools and children in public day facilities. Further scalogram analyses were also attempted by grade levels, to show the emergence of these skills as blind children progress through the school system. Analysis was also undertaken to show at what grade level(s) young blind children are capable of the simple tactual discriminations presented on the Optacon. One additional analysis of the total scores was attempted to determine the effect of administering the tasks in two orders, braille sequence first or Optacon sequence first, to the children.

III. RESULTS

The purpose of the study was to investigate empirically a sequence of tasks in tactual discrimination, hypothesized to be in hierarchical order from simple to complex and from those learned first to those acquired later. The findings in relation to the hypothesis are reported below.

A. The Hypothesis

The following hypothesis was tested: basic tactual discrimination skills as defined by the following numbered behavioral objectives are acquired in the order, 1, 2, 3A, 4A, 5A or 1, 2, 3B, 4B, 5B. (See diagram on p. 20.)

1. Given four solid objects (a ball, a cube, a rectangular block, a pyramid) in a row, three of which are identical, the child will correctly indicate discrimination by touching the object that is "not the same" as the others. The child will say "This one."
2. Given four flat (puzzle pieces) figures (a circle, a square, a rectangle, a triangle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the object that is "not the same" as the others. The child will say "This one."

3A. Given four embossed dot geometric figures (a circle, a square, a rectangle, a triangle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

3B. Given four raised line geometric figures (a circle, a square, a rectangle, a triangle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

4A. Given four embossed dot line figures (a vertical, a horizontal, a diagonal, an angular line) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

4B. Given four raised line segments (a vertical line, a horizontal line, an open circle, a closed circle) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

5A. Given four braille figures in a row (corresponding to the letters C and L and the contractions ST and OW) in a row, three of which are identical, the child will correctly indicate discrimination by touching the one that is "not the same" as the others. The child will say "This one."

5B. With the child's preferred index finger on the array of the Optacon, with the Automatic Page Scanner set a fixed, slow rate of presentation, given four line figures (a vertical line, a horizontal line, an open circle, a closed circle) in a row, three of which are identical, the child will correctly indicate discrimination by saying "This one," as the one figure that is "not the same" appears.

Since it is not the intention of this study to establish the equivalence of tasks 3A, 4A and 5A to tasks 3B, 4B and 5B, the data for each branch of the hierarchy were analyzed separately. They are reported below as for two separate hierarchies.

Scalogram analysis requires that the raw scores be converted into dichotomous (pass-fail) scores as designated by a criterion of mastery. It has been shown (LaPresta, 1975) that the alteration of the mastery criterion can have a significant effect on the scales produced.
For the sequence of skills in tasks 1, 2, 3A, 4A and 5A, the braille sequence, raw scores for all subjects are shown in Appendix D. When the raw scores are converted into dichotomous scores, five different scalograms are produced. Tables 8, 9, 10, 11 and 12 show the scalograms resulting by the use of mastery criteria of 4 or more, 5 or more, 6 or more, 7 or more, and 8 respectively.

The coefficient of reproducibility is a measure of the degree to which a set of data approximates a perfect scale and ranges from zero (0.0) to one (1.0). A minimum reproducibility coefficient of .80 was used throughout this study as the criteria for the existence of an acceptable scale (Boozer and Lindvall, 1971). The coefficient of reproducibility is computed according to the following formula:

TABLE 8

Scalogram of Results

for Tasks 1, 2, 3A, 4A, 5A;

Criterion of Mastery: 4 or more

Subjects Number	Tasks 1	2	3A	4A	5A	Total
15	1	1	1	1	1	5
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
21	1	1	1	1	1	5
22	1	1	1	1	1	5
24	1	1	1	1	1	5
25	1	1	1	1	1	5
26	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
39	1	1	1	1	1	5
40	1	1	1	1	1	5
41	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
49	1	1	1	1	1	5
50	1	1	1	1	1	5
51	1	1	1	1	1	5
53	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
2	1	1	1	1	0	4
14	1	1	1	0	1	4
4	1	1	1	0	0	3
9	1	1	1	0	0	3
13	1	1	0	0	1	3
16	1	1	1	0	0	3
1	1	1	0	0	0	2
3	1	1	0	0	0	2
6	1	1	0	0	0	2
8	1	1	0	0	0	2
37	1	1	0	0	0	2
52	1	1	0	0	0	2
5	1	0	0	0	0	1
7	1	0	0	0	0	1
11	1	0	0	0	0	1
12	0	0	0	1	0	1
18	0	1	0	0	0	1
23	1	0	0	0	0	1
10	0	0	0	0	0	0
33	0	0	0	0	0	0

TABLE 9

Scalogram of Results

for Tasks 1, 2, 3A, 4A, 5A;

Criterion of Mastery: 3 or more

Subjects Number	Tasks 1	2	3A	4A	5A	Total
15	1	1	1	1	1	5
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
21	1	1	1	1	1	5
24	1	1	1	1	1	5
25	1	1	1	1	1	5
26	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
33	1	1	1	1	1	1
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
39	1	1	1	1	1	5
40	1	1	1	1	1	5
41	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
49	1	1	1	1	1	5
50	1	1	1	1	1	5
51	1	1	1	1	1	5
52	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
14	1	1	0	0	1	1
1	1	1	0	0	0	1
2	1	1	0	0	0	1
6	1	1	0	0	0	1
8	1	1	0	0	0	1
9	1	1	0	0	0	1
22	0	0	1	0	1	1
32	1	1	0	0	0	1
53	1	1	0	0	0	1
3	1	0	0	0	0	1
5	1	0	0	0	0	1
7	1	0	0	0	0	1
11	1	0	0	0	0	1
13	0	0	0	0	1	1
18	0	1	0	0	0	1
4	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	0	0	0	0
16	0	0	0	0	0	0
23	0	0	0	0	0	0
33	0	0	0	0	0	0

TABLE 10

Scalogram of Results

for Tasks 1, 2, 3A, 4A, 5A;

Criterion of Mastery: 8 or more

Subjects Number	Tasks 1	2	3A	4A	5A	Total
15	1	1	1	1	1	5
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
11	1	1	1	1	1	5
24	1	1	1	1	1	5
25	1	1	1	1	1	5
26	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
11	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
40	1	1	1	1	1	5
41	1	1	1	1	1	5
41	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
50	1	1	1	1	1	5
51	1	1	1	1	1	5
52	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
39	1	1	1	0	1	4
49	1	1	1	0	1	4
14	1	1	0	0	1	3
2	1	1	0	0	0	2
3	1	1	0	0	0	2
6	1	1	0	0	0	1
9	1	1	0	0	0	1
37	1	1	0	0	0	2
53	1	1	0	0	0	2
1	1	0	0	0	0	1
5	1	0	0	0	0	1
7	1	0	0	0	0	1
13	0	0	0	0	1	1
12	0	0	1	0	0	1
4	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
11	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0
23	0	0	0	0	0	0
33	0	0	0	0	0	0

TABLE 11

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion of Mastery: 7 or more

Subjects Number	Tasks 1	2	3A	4A	5A	Total
15	1	1	1	1	1	5
17	1	1	1	1	1	5
19	1	1	1	1	1	5
11	1	1	1	1	1	5
24	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
41	1	1	1	1	1	5
42	1	1	1	1	1	5
44	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
51	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
20	1	1	0	1	1	4
13	1	1	1	0	1	4
26	1	1	1	0	1	4
19	1	1	1	0	1	4
43	1	1	1	0	1	4
49	1	1	1	0	1	4
50	1	0	1	1	1	4
52	0	1	1	1	1	4
14	1	1	0	0	1	3
40	1	1	1	0	0	3
49	1	1	0	0	1	3
5	1	1	0	0	0	2
9	1	1	0	0	0	2
2	0	1	0	0	0	1
5	1	0	0	0	0	1
6	1	0	0	0	0	1
13	0	0	0	0	1	1
37	0	1	0	0	0	1
1	0	0	0	0	0	0
4	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
21	0	0	0	0	0	0
12	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0
12	0	0	0	0	0	0
23	0	0	0	0	0	0
13	0	0	0	0	0	0
33	0	0	0	0	0	0

TABLE 12

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion of Mastery: 5

Subject Number	Tasks					
	1	2	3A	4A	5A	Total
17	1	1	1	1	1	5
24	1	1	1	1	1	5
27	1	1	1	1	1	5
29	1	1	1	1	1	5
32	1	1	1	1	1	5
33	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
42	1	1	1	1	1	5
46	1	1	1	1	1	5
51	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
23	1	1	1	0	1	4
28	1	1	1	0	1	4
30	1	1	1	0	1	4
34	1	1	1	0	1	4
41	1	1	1	0	1	4
44	1	1	1	0	1	4
45	1	1	2	0	1	4
47	1	1	2	0	1	4
48	1	1	0	1	1	4
49	1	1	2	0	1	4
52	0	1	1	1	1	4
56	1	1	1	1	0	4
15	1	1	1	0	0	3
19	1	1	1	0	0	3
20	1	1	0	0	1	3
21	0	1	1	0	1	3
26	1	1	0	0	1	3
31	1	1	0	0	1	3
40	1	1	1	0	0	3
43	1	1	0	0	1	3
14	1	0	0	0	1	2
39	1	1	0	0	0	2
50	0	0	1	0	1	2
2	0	1	0	0	0	1
3	1	0	0	0	0	1
1	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0
22	0	0	0	0	0	0
25	0	0	0	0	0	0
35	0	0	0	0	0	0
37	0	0	0	0	0	0
53	0	0	0	0	0	0

$$\text{Coefficient of reproducibility} = 1 - \frac{\text{Number of errors}}{\text{Total number of responses}}$$

There are several methods of counting the number of errors in a scalogram. By the first method (Method 1), all zeros that appear to the left of a one in a scalogram are counted. By the second method (Method 2), all ones that appear to the right of a zero are counted. By the third method (Method 3), which may produce the highest number of errors, all ones that should be zeros and all zeros that should be ones in order to produce a perfect scale are counted. Guttman (1950) refers to Method 3 as producing a measure of improvement, rather than a measure of reproducibility. All three methods have been referred to as producing measures of reproducibility by other investigators (Boozer & Lindvall, 1971; Wang, 1971; Wang, Resnick, and Boozer, 1971). The coefficients of reproducibility for the current data computed by all three methods are summarized in Table 13. The coefficients range from .86 to .99 indicating that the data approximate a perfect scale and therefore support the hypothesis.

The results for the sequence of skills in tasks 1, 2, 3B, 4B and 5B were analyzed in the same manner. The raw scores for all subjects in these five levels are also shown in Appendix D. The scalograms for this sequences are shown in Tables 14, 15, 16, 17 and 18 using mastery criteria of 4 or more, 5 or more, 6 or more, 7 or more and 8 respectively. Coefficients of reproducibility for these scalograms are summarized in

TABLE 13

Summary of Coefficients of Reproducibility

for the Braille Sequence Scalogram

Mastery Criteria	Error-counting Methods		
	1	2	3
8	.90	.91	.86
7+	.94	.93	.91
6+	.96	.98	.96
5+	.96	.98	.96
4+	.97	.99	.97

TABLE 14

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion for Mastery: 4 or more

Subject Number	Tasks 1	2	3B	4B	5B	Total
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
23	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
39	1	1	1	1	1	5
41	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
49	1	1	1	1	1	5
51	1	1	1	1	1	5
52	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	[illegible]	1	5
4	1	1	1	1	0	4
6	1	1	1	1	0	4
14	1	1	1	1	0	4
15	1	1	1	1	0	4
21	1	1	1	1	0	4
22	1	1	1	1	0	4
24	1	1	1	1	0	4
26	1	1	1	1	0	4
31	1	1	1	1	0	4
37	1	1	1	1	0	4
40	1	1	1	1	0	4
50	1	1	1	1	0	4
3	1	1	0	1	0	3
9	1	1	1	0	0	3
13	1	1	0	1	0	3
16	1	1	1	0	0	3
1	1	1	0	0	0	2
2	1	1	0	0	0	2
8	1	1	0	0	0	2
18	0	1	1	0	0	2
33	1	1	0	0	0	2
5	1	0	0	0	0	1
7	1	0	0	0	0	1
11	1	0	0	0	0	1
12	0	0	0	1	0	1
25	1	0	0	0	0	1
10	0	0	0	0	0	0
53	0	0	0	0	0	0

TABLE 15

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion for Mastery: 5 or more

Subject Number	Tasks 1	2	3B	4B	5B	Total
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
23	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
39	1	1	1	1	1	5
41	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
49	1	1	1	1	1	5
51	1	1	1	1	1	5
52	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
14	1	1	1	1	0	4
15	1	1	1	1	0	4
21	1	1	1	1	0	4
24	1	1	1	1	0	4
26	1	1	1	1	0	4
31	1	1	1	1	0	4
40	1	1	1	1	0	4
50	1	1	1	1	0	4
3	1	1	0	1	0	3
6	1	1	1	0	0	3
37	1	1	1	0	0	3
2	1	1	0	0	0	2
8	1	1	0	0	0	2
9	1	1	0	0	0	2
33	1	1	0	0	0	2
1	1	0	0	0	0	1
4	0	0	1	0	0	1
5	1	0	0	0	0	1
7	1	0	0	0	0	1
11	1	0	0	0	0	1
12	0	0	0	1	0	1
18	0	1	0	0	0	1
22	0	0	1	0	0	1
10	0	0	0	0	0	0
13	0	0	0	0	0	0
16	0	0	0	0	0	0
25	0	0	0	0	0	0
53	0	0	0	0	0	0

TABLE 16

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion of Mastery: 6 or more

Subject Number	Tasks 1	2	3B	4B	5B	Total
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
27	1	1	1	1	1	5
22	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
23	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
49	1	1	1	1	1	5
51	1	1	1	1	1	5
52	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
58	1	1	1	1	1	5
57	1	1	1	1	1	5
56	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
33	1	1	1	1	0	4
21	1	1	1	1	0	4
24	1	1	1	1	0	4
25	1	1	1	1	0	4
26	1	1	1	1	0	4
28	1	1	1	1	0	4
40	1	1	1	1	0	4
41	1	1	1	1	0	4
50	1	1	1	1	0	4
14	1	1	0	1	0	3
37	1	1	1	0	0	3
2	1	1	0	0	0	2
3	1	1	0	0	0	2
6	1	1	0	0	0	2
9	1	1	0	0	0	2
53	1	1	0	0	0	2
1	1	0	0	0	0	1
5	1	0	0	0	0	1
7	1	0	0	0	0	1
4	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0
15	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0

TABLE 17

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion of Mastery: 7 or more

Subject Number	Tasks 1	2	3B	4B	5B	Total
38	1	1	1	1	1	5
39	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
45	1	1	1	1	1	5
51	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
53	1	1	1	1	1	5
60	1	1	1	1	1	5
15	1	1	1	1	0	4
17	1	1	1	1	0	4
20	1	1	1	1	0	4
21	1	1	1	1	0	4
24	1	1	1	1	0	4
25	1	1	1	1	0	4
26	1	1	1	1	0	4
27	1	1	1	1	0	4
28	1	1	1	1	0	4
30	1	1	1	1	0	4
31	1	1	1	1	0	4
38	1	1	1	1	0	4
39	1	1	1	1	0	4
40	1	1	1	1	0	4
41	1	1	1	1	0	4
43	1	1	1	1	0	4
52	0	1	1	1	1	4
14	1	1	0	1	0	3
50	1	0	1	1	0	3
2	1	1	0	0	0	2
9	1	1	0	0	0	2
3	0	1	0	0	0	1
5	1	0	0	0	0	1
6	1	0	0	0	0	1
37	0	1	0	0	0	1
1	0	0	0	0	0	0
4	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
33	0	0	0	0	0	0
32	0	0	0	0	0	0

TABLE 10

Scalogram of Results

for Tasks 1, 2, 3B, 4B, 5B;

Criterion of Mastery: [illegible]

Subject Number	Tasks 1	2	3B	4B	5B	Total
19	1	1	1	1	1	5
29	1	1	1	1	1	5
34	1	1	1	1	1	5
42	1	1	1	1	1	5
46	1	1	1	1	1	5
51	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
15	1	1	1	1	0	4
17	1	1	1	1	0	4
20	1	1	1	1	0	4
24	1	1	1	1	0	4
25	1	1	1	1	0	4
26	1	1	1	1	0	4
27	1	1	1	1	0	4
28	1	1	1	1	0	4
30	1	1	1	1	0	4
31	1	1	1	1	0	4
32	1	1	0	1	1	4
33	1	1	1	1	0	4
36	1	1	1	1	0	4
38	1	1	1	1	0	4
39	1	1	1	1	0	4
41	1	1	1	1	0	4
43	1	1	1	1	0	4
44	1	1	1	1	0	4
45	1	1	1	1	0	4
47	1	1	1	1	0	4
48	1	1	1	1	0	4
52	0	1	1	1	1	4
21	0	1	1	1	0	3
40	1	1	1	0	0	3
49	1	1	1	0	0	3
56	1	1	0	1	0	3
14	1	0	0	1	0	2
50	0	0	1	1	0	2
2	0	1	0	0	0	1
3	1	0	0	0	0	1
1	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
35	0	0	0	0	0	0
37	0	0	0	0	0	0
53	0	0	0	0	0	0

Table 19. They range from .92 to .99, indicating that the data approximate a perfect scale and therefore, the hypothesis is supported.

TABLE 19

Summary of Coefficients of Reproducibility

for the Optacon Sequence Scalograms

Mastery Criteria	Error-counting Methods		
	1	2	3
8	.97	.95	.94
7+	.92	.97	.92
6+	.99	.99	.99
5+	.97	.98	.96
4+	.98	.98	.97

B. Additional Analyses

Each of the two sequences of tasks, the braille sequence and the Optacon sequence, was then subdivided to show the scalograms representing the scores of children in residential and day programs. Tables 20, 21, 22, 23 and 24 show the resulting scalograms for the braille sequence of tasks, using mastery criteria of 4 or more, 5 or more, 6 or more, 7 or more, and 8 respectively. The coefficients of reproducibility for these scalograms are summarized in Table 25. They range from .80 to 1.0 for residential students and from .92 to .98 for day students. Although all the coefficients of reproducibility are within the range for an acceptable scale, it is noted that residential students' scalograms show a wider range of coefficients.

For the Optacon sequence, the subdivisions by day and residential programs are represented by Tables 26, 27, 28, 29 and 30, using mastery criteria of 4 or more, 5 or more, 6 or more, 7 or more, and 8 respectively. The coefficients of reproducibility are summarized in Table 31. For residential students, coefficients of reproducibility range from .94 to 1.0; for day students, they range from .94 to .99. This does not suggest an important difference between residential and day students in their acquisition of skills in the Optacon sequence.

Each of the two sequences of tasks was then subdivided to show the scalograms representing the scores of children in each grade level. Tables 32, 33, 34, 35 and 36 show the resulting scalograms for the braille sequence of tasks, using mastery criteria of 4 or more,

TABLE 20

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A,

by Residential and Day Programs

Criterion of Mastery: 4 or more

(All Grade Levels)

	Residential 1	2	3A	4A	5A	Total		Day 1	2	3A	4A	5A	Total
21	1	1	1	1	1	5	15	1	1	1	1	1	5
22	1	1	1	1	1	5	17	1	1	1	1	1	5
24	1	1	1	1	1	5	19	1	1	1	1	1	5
25	1	1	1	1	1	5	20	1	1	1	1	1	5
26	1	1	1	1	1	5	31	1	1	1	1	1	5
27	1	1	1	1	1	5	32	1	1	1	1	1	5
28	1	1	1	1	1	5	34	1	1	1	1	1	5
29	1	1	1	1	1	5	35	1	1	1	1	1	5
30	1	1	1	1	1	5	36	1	1	1	1	1	5
41	1	1	1	1	1	5	38	1	1	1	1	1	5
42	1	1	1	1	1	5	39	1	1	1	1	1	5
43	1	1	1	1	1	5	40	1	1	1	1	1	5
44	1	1	1	1	1	5	51	1	1	1	1	1	5
45	1	1	1	1	1	5	52	1	1	1	1	1	5
46	1	1	1	1	1	5	54	1	1	1	1	1	5
47	1	1	1	1	1	5	55	1	1	1	1	1	5
48	1	1	1	1	1	5	56	1	1	1	1	1	5
49	1	1	1	1	1	5	57	1	1	1	1	1	5
50	1	1	1	1	1	5	58	1	1	1	1	1	5
2	1	1	1	1	0	4	59	1	1	1	1	1	5
4	1	1	1	0	0	3	60	1	1	1	1	1	5
9	1	1	1	0	0	3	14	1	1	1	0	1	4
1	1	1	0	0	0	2	13	1	1	0	0	1	3
3	1	1	0	0	0	2	16	1	1	1	0	0	3
6	1	1	0	0	0	2	37	1	1	0	0	0	2
8	1	1	0	0	0	2	53	1	1	0	0	0	1
5	1	0	0	0	0	1	11	1	0	0	0	0	1
7	1	0	0	0	0	1	12	0	0	0	1	0	1
23	1	0	0	0	0	1	18	0	1	0	0	0	1
10	0	0	0	0	0	0	33	0	0	0	0	0	0

TABLE 21

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Residential and Day Programs

Criterion of Mastery: 3 or more

(All Grade Levels)

	Residential 1	2	3A	4A	5A	Total		Day 1	2	3A	4A	5A	Total
21	1	1	1	1	1	5	15	1	1	1	1	1	5
24	1	1	1	1	1	5	17	1	1	1	1	1	5
25	1	1	1	1	1	5	19	1	1	1	1	1	5
26	1	1	1	1	1	5	20	1	1	1	1	1	5
27	1	1	1	1	1	5	31	1	1	1	1	1	5
28	1	1	1	1	1	5	32	1	1	1	1	1	5
29	1	1	1	1	1	5	34	1	1	1	1	1	5
30	1	1	1	1	1	5	35	1	1	1	1	1	5
41	1	1	1	1	1	5	36	1	1	1	1	1	5
42	1	1	1	1	1	5	38	1	1	1	1	1	5
43	1	1	1	1	1	5	39	1	1	1	1	1	5
44	1	1	1	1	1	5	40	1	1	1	1	1	5
45	1	1	1	1	1	5	51	1	1	1	1	1	5
46	1	1	1	1	1	5	52	1	1	1	1	1	5
47	1	1	1	1	1	5	54	1	1	1	1	1	5
48	1	1	1	1	1	5	55	1	1	1	1	1	5
49	1	1	1	1	1	5	56	1	1	1	1	1	5
50	1	1	1	1	1	5	57	1	1	1	1	1	5
2	1	1	0	0	0	2	58	1	1	1	1	1	5
3	1	1	0	0	0	2	59	1	1	1	1	1	5
4	1	1	0	0	0	2	60	1	1	1	1	1	5
8	1	1	0	0	0	2	14	1	1	0	0	1	3
9	1	1	0	0	0	2	37	1	1	0	0	0	2
22	0	0	1	0	1	2	53	1	1	0	0	0	2
1	1	0	0	0	0	1	11	1	0	0	0	0	1
5	1	0	0	0	0	1	13	0	0	0	0	1	1
7	1	0	0	0	0	1	18	0	1	0	0	0	1
6	0	0	0	0	0	0	12	0	0	0	0	0	0
10	0	0	0	0	0	0	16	0	0	0	0	0	0
23	0	0	0	0	0	0	33	0	0	0	0	0	0

TABLE 22

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Residential and Day Programs

Criterion of Mastery: 6 or more

(All Grade Levels)

	Residential 1	2	3A	4A	5A	Total		Day 1	2	3A	4A	5A	Total
21	1	1	1	1	1	5	15	1	1	1	1	1	5
24	1	1	1	1	1	5	17	1	1	1	1	1	5
25	1	1	1	1	1	5	19	1	1	1	1	1	5
26	1	1	1	1	1	5	20	1	1	1	1	1	5
27	1	1	1	1	1	5	31	1	1	1	1	1	5
28	1	1	1	1	1	5	32	1	1	1	1	1	5
29	1	1	1	1	1	5	34	1	1	1	1	1	5
30	1	1	1	1	1	5	35	1	1	1	1	1	5
41	1	1	1	1	1	5	36	1	1	1	1	1	5
42	1	1	1	1	1	5	38	1	1	1	1	1	5
43	1	1	1	1	1	5	40	1	1	1	1	1	5
44	1	1	1	1	1	5	51	1	1	1	1	1	5
45	1	1	1	1	1	5	52	1	1	1	1	1	5
46	1	1	1	1	1	5	54	1	1	1	1	1	5
47	1	1	1	1	1	5	55	1	1	1	1	1	5
48	1	1	1	1	1	5	56	1	1	1	1	1	5
50	1	1	1	1	1	5	57	1	1	1	1	1	5
49	1	1	1	0	1	4	58	1	1	1	1	1	5
2	1	1	0	0	0	2	59	1	1	1	1	1	5
3	1	1	0	0	0	2	60	1	1	1	1	1	5
6	1	1	0	0	0	2	39	1	1	1	0	1	4
9	1	1	0	0	0	2	16	1	1	0	0	1	3
1	1	0	0	0	0	1	37	1	1	0	0	0	2
5	1	0	0	0	0	1	53	1	1	0	0	0	2
7	1	0	0	0	0	1	13	0	0	0	0	1	1
22	0	0	1	0	0	1	11	0	0	0	0	0	0
4	0	0	0	0	0	0	12	0	0	0	0	0	0
8	0	0	0	0	0	0	14	0	0	0	0	0	0
10	0	0	0	0	0	0	18	0	0	0	0	0	0
23	0	0	0	0	0	0	33	0	0	0	0	0	0

TABLE 23

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Residential and Day Programs

Criterion of Mastery: 7 or more

(All Grade Levels)

	Residential 1	2	3A	4A	5A	Total		Day 1	2	3A	4A	5A	Total
21	1	1	1	1	1	5	15	1	1	1	1	1	5
24	1	1	1	1	1	5	17	1	1	1	1	1	5
27	1	1	1	1	1	5	19	1	1	1	1	1	5
28	1	1	1	1	1	5	31	1	1	1	1	1	5
29	1	1	1	1	1	5	32	1	1	1	1	1	5
30	1	1	1	1	1	5	34	1	1	1	1	1	5
41	1	1	1	1	1	5	35	1	1	1	1	1	5
42	1	1	1	1	1	5	36	1	1	1	1	1	5
44	1	1	1	1	1	5	38	1	1	1	1	1	5
46	1	1	1	1	1	5	51	1	1	1	1	1	5
47	1	1	1	1	1	5	54	1	1	1	1	1	5
48	1	1	1	1	1	5	55	1	1	1	1	1	5
25	1	1	1	0	1	4	56	1	1	1	1	1	5
26	1	1	1	0	1	4	57	1	1	1	1	1	5
43	1	1	1	0	1	4	58	1	1	1	1	1	5
45	1	1	1	0	1	4	59	1	1	1	1	1	5
50	1	0	1	1	1	4	60	1	1	1	1	1	5
49	1	1	0	0	1	3	20	1	1	0	1	1	4
9	1	1	0	0	0	2	33	1	1	1	0	1	4
5	1	1	0	0	0	2	52	0	1	1	1	1	4
2	0	1	0	0	0	1	16	1	1	0	0	1	3
3	1	0	0	0	0	1	40	1	1	1	0	0	3
6	1	0	0	0	0	1	13	0	0	0	0	1	1
1	0	0	0	0	0	0	37	0	1	0	0	0	1
4	0	0	0	0	0	0	11	0	0	0	0	0	0
7	0	0	0	0	0	0	12	0	0	0	0	0	0
8	0	0	0	0	0	0	14	0	0	0	0	0	0
10	0	0	0	0	0	0	18	0	0	0	0	0	0
22	0	0	0	0	0	0	39	0	0	0	0	0	0
23	0	0	0	0	0	0	53	0	0	0	0	0	0

TABLE 24

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Residential and Day Programs

Criterion of Mastery: 8

(All Grade Levels)

	Residential							Day					
	1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total
24	1	1	1	1	1	5	17	1	1	1	1	1	5
27	1	1	1	1	1	5	32	1	1	1	1	1	5
29	1	1	1	1	1	5	35	1	1	1	1	1	5
42	1	1	1	1	1	5	36	1	1	1	1	1	5
46	1	1	1	1	1	5	38	1	1	1	1	1	5
25	1	1	1	0	1	4	51	1	1	1	1	1	5
28	1	1	1	0	1	4	54	1	1	1	1	1	5
30	1	1	1	0	1	4	55	1	1	1	1	1	5
41	1	1	1	0	1	4	57	1	1	1	1	1	5
44	1	1	1	0	1	4	58	1	1	1	1	1	5
45	1	1	1	0	1	4	59	1	1	1	1	1	5
47	1	1	1	0	1	4	60	1	1	1	1	1	5
48	1	1	0	1	1	4	34	1	1	1	0	1	4
49	1	1	1	0	1	4	52	0	1	1	1	1	4
21	0	1	1	0	1	3	56	1	1	1	1	0	4
26	1	1	0	0	1	3	15	1	1	1	0	0	3
43	1	1	0	0	1	3	19	1	1	1	0	0	3
50	0	0	1	0	1	2	20	1	1	0	0	1	3
2	0	1	0	0	0	1	31	1	1	0	0	1	3
3	1	0	0	0	0	1	40	1	1	1	0	0	3
1	0	0	0	0	0	0	14	1	0	0	0	1	2
4	0	0	0	0	0	0	39	1	1	0	0	0	2
5	0	0	0	0	0	0	11	0	0	0	0	0	0
6	0	0	0	0	0	0	12	0	0	0	0	0	0
7	0	0	0	0	0	0	13	0	0	0	0	0	0
8	0	0	0	0	0	0	16	0	0	0	0	0	0
9	0	0	0	0	0	0	18	0	0	0	0	0	0
10	0	0	0	0	0	0	33	0	0	0	0	0	0
22	0	0	0	0	0	0	37	0	0	0	0	0	0
23	0	0	0	0	0	0	53	0	0	0	0	0	0

TABLE 25

Summary of Coefficients of Reproducibility

for the Braille Sequence Scalograms,

by Residential and Day Programs (All grade levels)

	Residential Programs			Day Programs		
Error-counting method:	1	2	3	1	2	3
Mastery Criteria:						
8	.87	.88	.80	.94	.94	.93
7+	.94	.94	.90	.93	.93	.92
6+	.98	.98	.96	.95	.98	.96
5+	.98	.99	.96	.95	.98	.96
4+	1.00	1.00	1.00	.95	.97	.94

TABLE 26

Scalograms of Results for Tasks 1, 2, 3B, 4B, 5B

by Residential and Day Programs

Criterion of Mastery: 4 or more

(All Grade Levels)

	Residential							Day					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
25	1	1	1	1	1	5	17	1	1	1	1	1	5
37	1	1	1	1	1	5	19	1	1	1	1	1	5
16	1	1	1	1	1	5	20	1	1	1	1	1	5
29	1	1	1	1	1	5	32	1	1	1	1	1	5
30	1	1	1	1	1	5	34	1	1	1	1	1	5
41	1	1	1	1	1	5	35	1	1	1	1	1	5
42	1	1	1	1	1	5	36	1	1	1	1	1	3
43	1	1	1	1	1	5	38	1	1	1	1	1	5
44	1	1	1	1	1	5	39	1	1	1	1	1	5
45	1	1	1	1	1	5	51	1	1	1	1	1	5
46	1	1	1	1	1	5	52	1	1	1	1	1	5
47	1	1	1	1	1	5	54	1	1	1	1	1	5
48	1	1	1	1	1	5	55	1	1	1	1	1	5
49	1	1	1	1	1	5	56	1	1	1	1	1	5
4	1	1	1	1	0	4	57	1	1	1	1	1	5
6	1	1	1	1	0	4	58	1	1	1	1	1	5
21	1	1	1	1	0	4	59	1	1	1	1	1	5
22	1	1	1	1	0	4	60	1	1	1	1	1	5
24	1	1	1	1	0	4	14	1	1	1	1	0	4
26	1	1	1	1	0	4	15	1	1	1	1	0	4
50	1	1	1	1	0	4	31	1	1	1	1	0	4
3	1	1	0	1	0	3	37	1	1	1	1	0	4
9	1	1	1	0	0	3	40	1	1	1	1	0	4
1	1	1	0	0	0	2	13	1	1	0	1	0	3
2	1	1	0	0	0	2	16	1	1	1	0	0	3
8	1	1	0	0	0	2	18	0	1	1	0	0	1
5	1	0	0	0	0	1	53	1	1	0	0	0	1
7	1	0	0	0	0	1	11	1	0	0	0	0	1
23	1	0	0	0	0	1	12	0	0	0	1	0	1
10	0	0	0	0	0	0	33	0	0	0	0	0	0

TABLE 27

Scalograms of Results for Tasks 1, 2, 3B, 4B, 5B

by Residential and Day Programs

Criterion of Mastery: 5 or more

(All Grade Levels)

	Residential							Day					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
35	1	1	1	1	1	5	17	1	1	1	1	1	5
37	1	1	1	1	1	5	19	1	1	1	1	1	5
28	1	1	1	1	1	5	20	1	1	1	1	1	5
29	1	1	1	1	1	5	31	1	1	1	1	1	5
30	1	1	1	1	1	5	34	1	1	1	1	1	5
41	1	1	1	1	1	5	35	1	1	1	1	1	5
42	1	1	1	1	1	5	36	1	1	1	1	1	5
43	1	1	1	1	1	5	38	1	1	1	1	1	5
44	1	1	1	1	1	5	39	1	1	1	1	1	5
45	1	1	1	1	1	5	51	1	1	1	1	1	5
46	1	1	1	1	1	5	52	1	1	1	1	1	5
47	1	1	1	1	1	5	54	1	1	1	1	1	5
48	1	1	1	1	1	5	55	1	1	1	1	1	5
49	1	1	1	1	1	5	56	1	1	1	1	1	5
21	1	1	1	1	0	4	57	1	1	1	1	1	5
24	1	1	1	1	0	4	58	1	1	1	1	1	5
26	1	1	1	1	0	4	59	1	1	1	1	1	5
50	1	1	1	1	0	4	60	1	1	1	1	1	5
3	1	1	0	1	0	3	14	1	1	1	1	0	4
6	1	1	1	0	0	3	15	1	1	1	1	0	4
2	1	1	0	0	0	1	31	1	1	1	1	0	4
8	1	1	0	0	0	2	40	1	1	1	1	0	4
9	1	1	0	0	0	1	37	1	1	1	0	0	3
1	1	0	0	0	0	2	53	1	1	0	0	0	2
4	0	0	1	0	0	1	11	1	0	0	0	0	1
5	1	0	0	0	0	1	12	0	0	0	1	0	1
7	1	0	0	0	0	1	18	0	1	0	0	0	1
22	0	0	1	0	0	1	23	0	0	0	0	0	0
10	0	0	0	0	0	0	16	0	0	0	0	0	0
23	0	0	0	0	0	0	33	0	0	0	0	0	0

TABLE 28

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Residential and Day Programs

Criterion of Mastery: 6 or more

(All Grade Levels)

	Residential							Day					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
27	1	1	1	1	1	5	17	1	1	1	1	1	5
28	1	1	1	1	1	5	19	1	1	1	1	1	5
29	1	1	1	1	1	5	20	1	1	1	1	1	5
30	1	1	1	1	1	5	51	1	1	1	1	1	5
42	1	1	1	1	1	5	52	1	1	1	1	1	5
43	1	1	1	1	1	5	34	1	1	1	1	1	5
44	1	1	1	1	1	5	55	1	1	1	1	1	5
45	1	1	1	1	1	5	56	1	1	1	1	1	5
46	1	2	1	1	1	5	59	1	1	1	1	1	5
47	1	1	1	1	1	5	52	1	1	1	1	1	5
48	1	1	1	1	1	5	52	1	1	1	1	1	5
49	1	1	1	1	1	5	54	1	1	1	1	1	5
21	1	1	1	1	0	4	55	1	1	1	1	1	5
24	1	1	1	1	0	4	56	1	1	1	1	1	5
25	1	1	1	1	0	4	57	1	1	1	1	1	5
26	1	1	1	1	0	4	58	1	1	1	1	1	5
41	1	1	1	1	0	4	59	1	1	1	1	1	5
50	1	1	1	1	0	4	40	1	1	1	1	1	5
1	1	2	0	0	0	1	15	1	1	1	1	0	4
3	1	1	0	0	0	2	38	1	1	1	1	0	4
6	1	1	0	0	0	1	40	1	1	1	1	0	4
9	1	1	0	0	0	1	14	1	1	0	1	0	5
1	1	0	0	0	0	1	57	1	1	1	0	0	5
5	1	0	0	0	0	1	53	1	1	0	0	0	1
7	1	0	0	0	0	1	11	0	0	0	0	0	0
4	0	0	0	0	0	0	22	0	0	0	0	0	0
8	0	0	0	0	0	0	23	0	0	0	0	0	0
10	0	0	0	0	0	0	16	0	0	0	0	0	0
22	0	0	0	0	0	0	28	0	0	0	0	0	0
23	0	0	0	0	0	0	35	0	0	0	0	0	0

TABLE 29

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Residential and Day Programs

Criterion of Mastery: 7 or more

(All Grade Levels)

	Residential							Day					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
29	1	1	1	1	1	5	19	1	1	1	1	1	5
42	1	1	1	1	1	5	31	1	1	1	1	1	5
43	1	1	1	1	1	5	34	1	1	1	2	1	5
44	1	1	1	1	1	5	55	1	1	1	1	1	5
46	1	1	1	1	1	5	56	1	1	1	1	1	5
47	1	1	1	1	1	5	51	1	1	1	1	1	5
48	1	1	1	1	1	5	54	1	1	1	1	1	5
49	1	1	1	1	1	5	55	1	1	1	1	1	5
21	1	1	1	1	0	4	56	1	1	1	1	1	5
24	1	1	1	1	0	4	57	1	1	1	1	1	5
25	1	1	1	1	0	4	58	1	1	1	1	1	5
26	1	1	1	1	0	4	59	1	1	1	1	1	5
27	1	1	1	1	0	4	60	1	1	1	1	1	5
28	1	1	1	1	0	4	15	1	1	1	1	0	4
30	1	1	1	1	0	4	17	1	2	1	1	0	4
41	1	1	1	1	0	4	20	1	1	1	1	0	4
45	1	1	1	1	0	4	51	1	1	1	1	0	4
50	1	0	1	1	0	5	58	1	1	1	1	0	4
3	1	1	0	0	0	1	59	1	1	1	1	0	4
9	1	1	0	0	0	1	40	1	1	1	1	0	4
1	0	1	0	0	0	1	52	0	1	1	1	1	4
5	1	0	0	0	0	1	14	1	1	0	1	0	5
6	1	0	0	0	0	1	27	0	1	0	0	0	1
1	0	0	0	0	0	0	11	0	0	0	0	0	0
4	0	0	0	0	0	0	22	0	0	0	0	0	0
7	0	0	0	0	0	0	23	0	0	0	0	0	0
8	0	0	0	0	0	0	16	0	0	0	0	0	0
10	0	0	0	0	0	0	18	0	0	0	0	0	0
22	0	0	0	0	0	0	55	0	0	0	0	0	0
23	0	0	0	0	0	0	52	0	0	0	0	0	0

TABLE 30

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Residential and Day Programs

Criterion of Mastery: 8

(All Grade Levels)

	Residential							Day					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
29	1	1	1	1	1	5	19	1	1	1	1	1	5
42	1	1	1	1	1	5	34	1	1	1	1	1	5
46	1	1	1	1	1	5	51	1	1	1	1	1	5
24	1	1	1	1	0	4	54	1	1	1	1	1	5
25	1	1	1	1	0	4	55	1	1	1	1	1	5
26	1	1	1	1	0	4	57	1	1	1	1	1	5
27	1	1	1	1	0	4	58	1	1	1	1	1	5
28	1	1	1	1	0	4	59	1	1	1	1	1	5
30	1	1	1	1	0	4	60	1	1	1	1	1	5
41	1	1	1	1	0	4	15	1	1	1	1	0	4
43	1	1	1	1	0	4	17	1	1	1	1	0	4
44	1	1	1	1	0	4	20	1	1	1	1	0	4
45	1	1	1	1	0	4	31	1	1	1	1	0	4
47	1	1	1	1	0	4	32	1	1	0	1	1	4
48	1	1	1	1	0	4	35	1	1	1	1	0	4
21	0	1	1	1	0	3	36	1	1	1	1	0	4
49	1	1	1	0	0	3	38	1	1	1	1	0	4
50	0	0	1	1	0	2	39	1	1	1	1	0	4
2	0	1	0	0	0	1	52	0	1	1	1	1	4
3	1	0	0	0	0	1	40	1	1	1	0	0	3
1	0	0	0	0	0	0	56	1	1	0	1	0	3
4	0	0	0	0	0	0	14	1	0	0	1	0	2
5	0	0	0	0	0	0	11	0	0	0	0	0	0
6	0	0	0	0	0	0	12	0	0	0	0	0	0
7	0	0	0	0	0	0	13	0	0	0	0	0	0
8	0	0	0	0	0	0	16	0	0	0	0	0	0
9	0	0	0	0	0	0	18	0	0	0	0	0	0
10	0	0	0	0	0	0	33	0	0	0	0	0	0
22	0	0	0	0	0	0	37	0	0	0	0	0	0
23	0	0	0	0	0	0	53	0	0	0	0	0	0

TABLE 31

Summary of Coefficients of Reproducibility

for the Optacon Sequence Scalograms

by Residential and Day Programs (All Grade Levels)

Error-counting method:	Residential Programs			Day Programs		
	1	2	3	1	2	3
Mastery Criteria:						
8	.97	.96	.94	.96	.94	.94
7+	.98	.98	.96	.98	.96	.96
6+	1.0	1.0	1.0	.99	.99	.98
5+	.96	.98	.96	.97	.98	.97
4+	.99	.99	.98	.96	.97	.96

TABLE 32

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Grade Levels

Criterion of Mastery: 4 or more

(Residential and Day Combined).

	Kindergarten							Grade One							Grade Two					
	1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total
15	1	1	1	1	1	5	21	1	1	1	1	1	5	41	1	1	1	1	1	5
17	1	1	1	1	1	5	22	1	1	1	1	1	5	42	1	1	1	1	1	5
19	1	1	1	1	1	5	24	1	1	1	1	1	5	43	1	1	1	1	1	5
20	1	1	1	1	1	5	25	1	1	1	1	1	5	44	1	1	1	1	1	5
2	1	1	1	1	0	4	26	1	1	1	1	1	5	45	1	1	1	1	1	5
14	1	1	1	0	1	4	27	1	1	1	1	1	5	46	1	1	1	1	1	5
4	1	1	1	0	0	3	28	1	1	1	1	1	5	47	1	1	1	1	1	5
9	1	1	1	0	0	3	29	1	1	1	1	1	5	48	1	1	1	1	1	5
13	1	1	0	0	1	3	30	1	1	1	1	1	5	49	1	1	1	1	1	5
16	1	1	1	0	0	3	31	1	1	1	1	1	5	50	1	1	1	1	1	5
1	1	1	0	0	0	2	32	1	1	1	1	1	5	51	1	1	1	1	1	5
3	1	1	0	0	0	2	34	1	1	1	1	1	5	52	1	1	1	1	1	5
6	1	1	0	0	0	2	35	1	1	1	1	1	5	54	1	1	1	1	1	5
8	1	1	0	0	0	2	36	1	1	1	1	1	5	55	1	1	1	1	1	5
5	1	0	0	0	0	1	38	1	1	1	1	1	5	56	1	1	1	1	1	5
7	1	0	0	0	0	1	39	1	1	1	1	1	5	57	1	1	1	1	1	5
11	1	0	0	0	0	1	40	1	1	1	1	1	5	58	1	1	1	1	1	5
12	0	0	0	1	0	1	37	1	1	0	0	0	2	59	1	1	1	1	1	5
18	0	1	0	0	0	1	23	1	0	0	0	0	1	60	1	1	1	1	1	5
10	0	0	0	0	0	0	33	0	0	0	0	0	0	53	1	1	0	0	0	2

TABLE 33

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Grade Levels

Criterion of Mastery: 5 or more

(Residential and Day Combined)

	Kindergarten							Grade One							Grade Two					
	1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total
15	1	1	1	1	1	5	21	1	1	1	1	1	5	41	1	1	1	1	1	5
17	1	1	1	1	1	5	24	1	1	1	1	1	5	42	1	1	1	1	1	5
19	1	1	1	1	1	5	25	1	1	1	1	1	5	43	1	1	1	1	1	5
20	1	1	1	1	1	5	26	1	1	1	1	1	5	44	1	1	1	1	1	5
14	1	1	0	0	1	3	27	1	1	1	1	1	5	45	1	1	1	1	1	5
2	1	1	0	0	0	2	28	1	1	1	1	1	5	46	1	1	1	1	1	5
3	1	1	0	0	0	2	29	1	1	1	1	1	5	47	1	1	1	1	1	5
6	1	1	0	0	0	2	30	1	1	1	1	1	5	48	1	1	1	1	1	5
8	1	1	0	0	0	2	31	1	1	1	1	1	5	49	1	1	1	1	1	5
9	1	1	0	0	0	2	32	1	1	1	1	1	5	50	1	1	1	1	1	5
1	1	0	0	0	0	1	34	1	1	1	1	1	5	51	1	1	1	1	1	5
5	1	0	0	0	0	1	35	1	1	1	1	1	5	52	1	1	1	1	1	5
7	1	0	0	0	0	1	36	1	1	1	1	1	5	54	1	1	1	1	1	5
11	1	0	0	0	0	1	38	1	1	1	1	1	5	55	1	1	1	1	1	5
13	0	0	0	0	1	1	39	1	1	1	1	1	5	56	1	1	1	1	1	5
18	0	1	0	0	0	1	40	1	1	1	1	1	5	57	1	1	1	1	1	5
4	0	0	0	0	0	0	22	0	0	1	0	1	2	58	1	1	1	1	1	5
10	0	0	0	0	0	0	37	1	1	0	0	0	2	59	1	1	1	1	1	5
12	0	0	0	0	0	0	23	0	0	0	0	0	0	60	1	1	1	1	1	5
16	0	0	0	0	0	0	35	0	0	0	0	0	0	53	1	1	0	0	0	2

TABLE 34

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Grade Levels

Criterion of Mastery: 6 or more

(Residential and Day Combined)

	Kindergarten					
	1	2	3A	4A	5A	Total
15	1	1	1	1	1	5
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	1	1	1	5
14	1	1	0	0	1	3
2	1	1	0	0	0	2
3	1	1	0	0	0	2
6	1	1	0	0	0	2
9	1	1	0	0	0	2
1	1	0	0	0	0	1
5	1	0	0	0	0	1
7	1	0	0	0	0	1
13	0	0	0	0	1	1
4	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0

	Grade One					
	1	2	3A	4A	5A	Total
21	1	1	1	1	1	5
24	1	1	1	1	1	5
25	1	1	1	1	1	5
26	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
40	1	1	1	1	1	5
39	1	1	1	0	1	4
37	1	1	0	0	0	2
22	0	0	1	0	0	1
23	0	0	0	0	0	0
33	0	0	0	0	0	0

	Grade Two					
	1	2	3A	4A	5A	Total
41	1	1	1	1	1	5
42	1	1	1	1	1	5
43	1	1	1	1	1	5
44	1	1	1	1	1	5
45	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
50	1	1	1	1	1	5
51	1	1	1	1	1	5
52	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
49	1	1	1	0	1	4
53	1	1	0	0	0	2

TABLE 35

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Grade Levels

Criterion of Mastery: 7 or more

(Residential and Day Combined)

	Kindergarten					
	1	2	3A	4A	5A	Total
15	1	1	1	1	1	5
17	1	1	1	1	1	5
19	1	1	1	1	1	5
20	1	1	0	1	1	4
14	1	1	0	0	1	3
3	1	1	0	0	0	2
9	1	1	0	0	0	2
2	0	1	0	0	0	1
5	1	0	0	0	0	1
6	1	0	0	0	0	1
13	0	0	0	0	1	1
1	0	0	0	0	0	0
4	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
16	0	0	0	0	0	0
18	0	0	0	0	0	0

	Grade One					
	1	2	3A	4A	5A	Total
21	1	1	1	1	1	5
24	1	1	1	1	1	5
27	1	1	1	1	1	5
28	1	1	1	1	1	5
29	1	1	1	1	1	5
30	1	1	1	1	1	5
31	1	1	1	1	1	5
32	1	1	1	1	1	5
34	1	1	1	1	1	5
35	1	1	1	1	1	5
36	1	1	1	1	1	5
38	1	1	1	1	1	5
25	1	1	1	0	1	4
26	1	1	1	0	1	4
39	1	1	1	0	1	4
40	1	1	1	0	0	3
37	0	1	0	0	0	1
22	0	0	0	0	0	0
23	0	0	0	0	0	0
33	0	0	0	0	0	0

	Grade Two					
	1	2	3A	4A	5A	Total
41	1	1	1	1	1	5
42	1	1	1	1	1	5
44	1	1	1	1	1	5
46	1	1	1	1	1	5
47	1	1	1	1	1	5
48	1	1	1	1	1	5
51	1	1	1	1	1	5
54	1	1	1	1	1	5
55	1	1	1	1	1	5
56	1	1	1	1	1	5
57	1	1	1	1	1	5
58	1	1	1	1	1	5
59	1	1	1	1	1	5
60	1	1	1	1	1	5
45	1	1	1	0	1	4
49	1	1	1	0	1	4
50	1	0	1	1	1	4
52	0	1	1	1	1	4
43	1	1	0	0	1	3
53	0	0	0	0	0	0

TABLE 36

Scalogram of Results for Tasks 1, 2, 3A, 4A, 5A

by Grade Levels

Criterion of Mastery: 8

(Residential and Day Combined)

	Kindergarten							Grade One							Grade Two					
	1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total		1	2	3A	4A	5A	Total
17	1	1	1	1	1	5	26	1	1	1	1	1	5	42	1	1	1	1	1	5
15	1	1	1	0	0	3	27	1	1	1	1	1	5	46	1	1	1	1	1	5
19	1	1	1	0	0	3	29	1	1	1	1	1	5	51	1	1	1	1	1	5
20	1	1	0	0	1	3	32	1	1	1	1	1	5	54	1	1	1	1	1	5
14	1	0	0	0	1	2	55	1	1	1	1	1	5	55	1	1	1	1	1	5
2	0	1	0	0	0	1	36	1	1	1	1	1	5	57	1	1	1	1	1	5
3	1	0	0	0	0	1	58	1	1	1	1	1	5	58	1	1	1	1	1	5
1	0	0	0	0	0	0	25	1	1	1	0	1	4	59	1	1	1	1	1	5
4	0	0	0	0	0	0	28	1	1	1	0	1	4	60	1	1	1	1	1	5
5	0	0	0	0	0	0	30	1	1	1	0	1	4	41	1	1	1	0	1	4
6	0	0	0	0	0	0	34	1	1	1	0	1	4	44	1	1	1	0	1	4
7	0	0	0	0	0	0	21	0	1	1	0	1	3	45	1	1	1	0	1	4
8	0	0	0	0	0	0	26	1	1	0	0	1	3	47	1	1	1	0	1	4
9	0	0	0	0	0	0	31	1	1	0	0	1	3	48	1	1	0	1	1	4
10	0	0	0	0	0	0	40	1	1	1	0	0	3	49	1	1	1	0	1	4
11	0	0	0	0	0	0	39	1	1	0	0	0	2	52	0	1	1	1	1	4
12	0	0	0	0	0	0	22	0	0	0	0	0	0	56	1	1	1	1	0	4
13	0	0	0	0	0	0	25	0	0	0	0	0	0	43	1	1	0	0	1	3
16	0	0	0	0	0	0	33	0	0	0	0	0	0	50	0	0	1	0	1	2
18	0	0	0	0	0	0	37	0	0	0	0	0	0	53	0	0	0	0	0	0

5 or more, 6 or more, 7 or more, and 8 respectively. The coefficients of reproducibility for these scalograms are summarized in Table 37. The range of coefficients for kindergarten children is from .92 to .98; for grade one children, the range is from .86 to 1.0; for grade two children the range is from .80 to 1.0. Inspection of these scalograms reveals that with each of the criteria of mastery, increasing numbers of children in successive grade levels were able to achieve mastery of the tasks.

The subdivisions by grade level for the Optacon sequence of tasks are represented by scalograms in Tables 38, 39, 40, 41 and 42, using mastery criteria of 4 or more, 5 or more, 6 or more, 7 or more, and 8 respectively. The coefficients of reproducibility for these scalograms are summarized in Table 43. The range of coefficients for kindergarten children is from .92 to .99; for grade one children the range is from .95 to 1.0; for grade two, the range is from .92 to 1.0. Inspection of these scalograms reveals that with each of the criteria of mastery, increasing numbers of children in the successive grade levels were able to achieve mastery of the tasks.

When performance on the Optacon alone is inspected the scalograms reveal different percentages of children in each grade level showing passing performances with the various different criteria of mastery.

TABLE 37

Summary of Coefficients of Reproducibility

for the Braille Sequence Scalograms,

by Grade Levels, (Residential and Day Combined)

	Error-counting methods	Kindergarten			Grade One			Grade Two		
		1	2	3	1	2	3	1	2	3
Mastery Criteria:	8	.94	.97	.94	.90	.91	.86	.88	.86	.80
	7+	.92	.95	.92	.96	.96	.92	.94	.90	.90
	6+	.94	.98	.96	.97	.98	.96	.99	.99	.90
	5+	.93	.97	.94	.97	.98	.96	1.0	1.0	1.0
	4+	.93	.96	.92	1.0	1.0	1.0	1.0	1.0	1.0

TABLE 38

Scalograms of Results for Tasks 1, 2, 3B, 4B, 5B

by Grade Levels

Criterion of Mastery: 4 or more

(Residential and Day Combined)

	Kindergarten							Grade One							Grade Two					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
17	1	1	1	1	1	5	25	1	1	1	1	1	5	41	1	1	1	1	1	5
19	1	1	1	1	1	5	27	1	1	1	1	1	5	42	1	1	1	1	1	5
20	1	1	1	1	1	5	28	1	1	1	1	1	5	43	1	1	1	1	1	5
4	1	1	1	1	0	4	29	1	1	1	1	1	5	44	1	1	1	1	1	5
6	1	1	1	1	0	4	30	1	1	1	1	1	5	45	1	1	1	1	1	5
14	1	1	1	1	0	4	32	1	1	1	1	1	5	46	1	1	1	1	1	5
15	1	1	1	1	0	4	34	1	1	1	1	1	5	47	1	1	1	1	1	5
3	1	1	0	1	0	3	35	1	1	1	1	1	5	48	1	1	1	1	1	5
9	1	1	1	0	0	3	36	1	1	1	1	1	5	49	1	1	1	1	1	5
13	1	1	0	1	0	3	38	1	1	1	1	1	5	51	1	1	1	1	1	5
16	1	1	1	0	0	3	39	1	1	1	1	1	5	52	1	1	1	1	1	5
1	1	1	0	0	0	2	21	1	1	1	1	0	4	54	1	1	1	1	1	5
2	1	1	0	0	0	2	22	1	1	1	1	0	4	55	1	1	1	1	1	5
8	1	1	0	0	0	2	24	1	1	1	1	0	4	56	1	1	1	1	1	5
18	0	1	1	0	0	2	26	1	1	1	1	0	4	57	1	1	1	1	1	5
5	1	0	0	0	0	1	31	1	1	1	1	0	4	58	1	1	1	1	1	5
7	1	0	0	0	0	1	37	1	1	1	1	0	4	59	1	1	1	1	1	5
11	1	0	0	0	0	1	40	1	1	1	1	0	4	60	1	1	1	1	1	5
12	0	0	0	1	0	1	25	1	0	0	0	0	1	50	1	1	1	1	0	4
10	0	0	0	0	0	0	33	0	0	0	0	0	0	53	1	1	0	0	0	2

TABLE 39

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Grade Levels

Criterion of Mastery: 5 or more

(Residential and Day Combined)

	Kindergarten							Grade One							Grade Two					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
17	1	1	1	1	1	5	25	1	1	1	1	1	5	41	1	1	1	1	1	5
19	1	1	1	1	1	5	27	1	1	1	1	1	5	42	1	1	1	1	1	5
20	1	1	1	1	1	5	[illegible]	1	1	1	1	1	5	43	1	1	1	1	1	5
14	1	1	1	1	0	4	29	1	1	1	1	2	5	44	1	1	1	1	1	5
15	1	1	1	1	0	4	30	1	1	1	1	1	5	45	1	1	1	1	1	5
3	1	1	0	1	0	3	32	1	1	1	1	1	5	46	1	1	1	1	1	5
6	1	1	1	0	0	3	34	1	1	1	1	1	5	47	1	1	1	1	[illegible]	5
2	1	1	0	0	0	2	35	1	1	1	1	1	5	48	1	1	1	1	1	5
8	1	1	0	0	0	2	36	1	1	1	1	1	5	49	1	1	1	1	1	5
9	1	1	0	0	0	2	38	1	1	1	1	1	5	51	1	1	1	1	1	5
1	1	0	0	0	0	1	39	1	1	1	1	1	5	52	1	1	1	1	1	5
4	0	0	1	0	0	1	21	1	1	1	1	0	4	54	1	1	1	1	1	5
5	1	0	0	0	0	1	24	1	1	1	1	0	4	55	1	1	1	1	1	5
7	1	0	0	0	0	1	26	1	1	1	1	0	4	56	1	1	1	1	1	5
11	1	0	0	0	0	1	31	1	1	1	1	0	4	57	1	1	1	1	1	5
12	0	0	0	1	0	1	40	1	1	1	1	0	4	58	1	1	1	1	1	5
18	0	1	0	0	0	1	37	1	1	1	0	0	3	59	1	1	1	1	1	5
10	0	0	0	0	0	0	22	0	0	1	0	0	1	60	1	1	1	[illegible]	1	5
13	0	0	0	0	0	0	25	0	0	0	0	0	0	50	1	1	1	1	0	4
16	0	0	0	0	0	0	33	0	0	0	0	0	0	53	1	[illegible]	0	0	0	[illegible]

TABLE 40

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Grade Levels

Criterion of Mastery: 6 or more

(Residential and Day Combined)

Kindergarten	1	2	3B	4B	5B	Total	Grade One	1	2	3B	4B	5B	Total	Grade Two	1	2	3	4	5	Total
17	1	1	1	1	1	5	27	1	1	1	1	1	5	42	1	1	1	1	1	5
19	1	1	1	1	1	5	28	1	1	1	1	1	5	43	1	1	1	1	1	5
20	1	1	1	1	1	5	29	1	1	1	1	1	5	44	1	1	1	1	1	5
15	1	1	1	1	0	4	30	1	1	1	1	1	5	45	1	1	1	1	1	5
14	1	1	0	1	0	3	31	1	1	1	1	1	5	46	1	1	1	1	1	5
2	1	1	0	0	0	2	32	1	1	1	1	1	5	47	1	1	1	1	1	5
3	1	1	0	0	0	2	34	1	1	1	1	1	5	48	1	1	1	1	1	5
6	1	1	0	0	0	2	35	1	1	1	1	1	5	49	1	1	1	1	1	5
9	1	1	0	0	0	2	36	1	1	1	1	1	5	51	1	1	1	1	1	5
1	1	0	0	0	0	1	39	1	1	1	1	1	5	52	1	1	1	1	1	5
5	1	0	0	0	0	1	21	1	1	1	1	0	4	54	1	1	1	1	1	5
7	1	0	0	0	0	1	24	1	1	1	1	0	4	55	1	1	1	1	1	5
4	0	0	0	0	0	0	25	1	1	1	1	0	4	56	1	1	1	1	1	5
8	0	0	0	0	0	0	26	1	1	1	1	0	4	57	1	1	1	1	1	5
10	0	0	0	0	0	0	38	1	1	1	1	0	4	58	1	1	1	1	1	5
11	0	0	0	0	0	0	40	1	1	1	1	0	4	59	1	1	1	1	1	5
12	0	0	0	0	0	0	37	1	1	1	0	0	3	60	1	1	1	1	1	5
13	0	0	0	0	0	0	22	0	0	0	0	0	0	41	1	1	1	1	0	4
16	0	0	0	0	0	0	23	0	0	0	0	0	0	50	1	1	1	1	0	4
18	0	0	0	0	0	0	33	0	0	0	0	0	0	53	1	1	0	0	0	2

TABLE 41

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Grade Levels

Criterion of Mastery: 7 or more

(Residential and Day Combined)

Kindergarten	1	2	3B	4B	5B	Total	Grade One	1	2	3B	4B	5B	Total	Grade Two	1	2	3B	4B	5B	Total
19	1	1	1	1	1	5	29	1	1	1	1	1	5	42	1	1	1	1	1	5
15	1	1	1	1	0	4	32	1	1	1	1	1	5	43	1	1	1	1	1	5
17	1	1	1	1	0	4	34	1	1	1	1	1	5	44	1	1	1	1	1	5
20	1	1	1	1	0	4	35	1	1	1	1	1	5	46	1	1	1	1	1	5
14	1	1	0	1	0	3	36	1	1	1	1	1	5	47	1	1	1	1	1	5
3	1	1	0	0	0	2	21	1	1	1	1	0	4	48	1	1	1	1	1	5
9	1	1	0	0	0	2	24	1	1	1	1	0	4	49	1	1	1	1	1	5
2	0	1	0	0	0	1	25	1	1	1	1	0	4	51	1	1	1	1	1	5
5	1	0	0	0	0	1	26	1	1	1	1	0	4	54	1	1	1	1	1	5
6	1	0	0	0	0	1	27	1	[illegible]	1	1	0	4	55	1	1	1	1	1	5
1	0	0	0	0	0	0	28	1	1	1	1	0	4	56	1	1	1	1	1	5
4	0	0	0	0	0	0	30	1	1	1	1	0	4	57	1	1	1	1	1	5
7	0	0	0	0	0	0	31	1	1	1	1	0	4	58	1	1	1	1	1	5
8	0	0	0	0	0	0	38	1	1	1	1	0	4	59	1	1	1	1	1	5
10	0	0	0	0	0	0	39	1	1	1	1	0	4	60	1	1	1	1	1	5
11	0	0	0	0	0	0	40	1	1	1	1	0	4	41	1	1	1	1	0	4
12	0	0	0	0	0	0	37	0	1	0	0	0	1	45	1	1	1	1	0	4
13	0	0	0	0	0	0	22	0	0	0	0	0	0	52	0	1	1	1	1	4
16	0	0	0	0	0	0	23	0	0	0	0	0	0	50	1	0	1	1	0	3
18	0	0	0	0	0	0	33	0	0	0	0	0	0	53	0	0	0	0	0	0

TABLE 42

Scalogram of Results for Tasks 1, 2, 3B, 4B, 5B

by Grade Levels

Criterion of Mastery: B

(Residential and Day Combined)

	Kindergarten							Grade One							Grade Two					
	1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total		1	2	3B	4B	5B	Total
19	1	1	1	1	1	5	29	1	1	1	1	1	5	42	1	1	1	1	1	5
15	1	1	1	1	0	4	34	1	1	1	1	1	5	46	1	1	1	1	1	5
17	1	1	1	1	0	4	24	1	1	1	1	0	4	51	1	1	1	1	1	5
20	1	1	1	1	0	4	25	1	1	1	1	0	4	54	1	1	1	1	1	5
14	1	0	0	1	0	2	26	1	1	1	1	0	4	55	1	1	1	1	1	5
2	0	1	0	0	0	1	27	1	1	1	1	0	4	57	1	1	1	1	1	5
3	1	0	0	0	0	1	28	1	1	1	1	0	4	58	1	1	1	1	1	5
1	0	0	0	0	0	0	30	1	1	1	1	0	4	59	1	1	1	1	1	5
4	0	0	0	0	0	0	31	1	1	1	1	0	4	60	1	1	1	1	1	5
5	0	0	0	0	0	0	32	1	1	0	1	1	4	41	1	1	1	1	0	4
6	0	0	0	0	0	0	35	1	1	1	1	0	4	43	1	1	1	1	0	4
7	0	0	0	0	0	0	36	1	1	1	1	0	4	44	1	1	1	1	0	4
8	0	0	0	0	0	0	38	1	1	1	1	0	4	45	1	1	1	1	0	4
9	0	0	0	0	0	0	39	1	1	1	1	0	4	47	1	1	1	1	0	4
10	0	0	0	0	0	0	21	0	1	1	1	0	3	48	1	1	1	1	0	4
11	0	0	0	0	0	0	40	1	1	1	0	0	3	52	0	1	1	1	1	4
12	0	0	0	0	0	0	22	0	0	0	0	0	0	49	1	1	1	0	0	3
13	0	0	0	0	0	0	23	0	0	0	0	0	0	56	1	1	0	1	0	3
16	0	0	0	0	0	0	33	0	0	0	0	0	0	50	0	0	1	1	0	2
18	0	0	0	0	0	0	37	0	0	0	0	0	0	53	0	0	0	0	0	0

TABLE 43

Summary of Coefficients of Reproducibility

for the Optacon Sequence Scalograms

By Grade Level (Residential and Day Combined)

	Error-counting methods	Kindergarten			Grade One			Grade Two		
		1	2	3	1	2	3	1	2	3
Mastery Criteria:	8	.97	.98	.96	.99	.95	.96	.96	.93	.92
	7+	.98	.98	.96	.99	.99	.98	.98	.94	.96
	6+	.99	.99	.98	1.0	1.0	1.0	1.0	1.0	1.0
	5+	.93	.96	.92	.98	.99	.98	1.0	1.0	1.0
	4+	.94	.95	.92	1.0	1.0	1.0	1.0	1.0	1.0

Table 44 summarizes these results. Using the lower mastery criteria (50%, 62.5% and 75%), half or more of the children in grade one were able to achieve passing scores on the Optacon. For all of the criteria of mastery, half or more of the children in grade two achieved passing scores on the Optacon. This suggests that the simple tactual discriminations given on the Optacon were not beyond the capabilities of the first grade children and were within the capabilities of the second grade children tested in this study.

For half of the subjects in each grade level, the braille sequence tasks (3A, 4A, 5A) were administered first; the other half of the subjects performed the Optacon sequence (3B, 4B, 5B) first. To determine whether the order of presentation of the tasks effected student performance, total scores on all tasks in the hierarchy were computed. Mean total scores for those who were administered the braille sequence first were compared with mean total scores for those who performed the Optacon sequence first, using a Student t-test. The results, reported in Table 45, indicate that the order of presenstation had no effect on performance.

TABLE 44

Summary of Children in Each Grade Level

Passing Optacon Performance

Mastery Criteria:	Kindergarten		Grade One		Grade Two	
	Number	Percent	Number	Percent	Number	Percent
8	1	5	3	15	10	50
7+	1	5	5	25	15	75
6+	3	15	10	50	17	85
5+	3	15	11	55	18	90
4+	3	15	11	55	18	90

TABLE 45

Comparison of Total Scores for Two Orders

of Administration of Tasks

	Total Scores			
	Mean	S.D.	t	*p
Braille Sequence First	44.63	19.94		
			-1.207	n.s.
Optacon Sequence First	50.67	18.21		

t = 1.673 required for significance at .05 level,

58 df.

IV. DISCUSSION

This study was concerned with the development of tactual discrimination skills in young blind children. A part of this investigation was an attempt to validate a sequence of tasks in tactual discrimination culminating with the discrimination of tactile reading symbols used in the instruction of these children. It was hypothesized that basic tactual discrimination skills as defined by the following numbered tasks are acquired in the order of 1, 2, 3A, 4A, 5A or 1, 2, 3B, 4B, 5B: (see diagram on p. 20).

1. Given four solid geometric shapes in a row, three of which are identical, discriminate the one that is not the same as the others.

2. Given four flat (puzzle pieces) figures in a row, three of which are identical, discriminate the one that is not the same as the others.

3A. Given four embossed dot geometric figures in a row, three of which are identical, discriminate the one that is not the same as the others.

3B. Given four raised line geometric figures in a row, three of which are identical, discriminate the one that is not the same as the others.

4A. Given four embossed dot line figures in a row, three of which are identical, discriminate the one that is not the same as the others.

4B. Given four raised line segments in a row, three of which are identical, discriminate the one that is not the same as the others.

5A. Given four braille figures in a row, three of which are identical, discriminate the one that is not the same as the others.

5B. Using the Optacon, given four inkprint line figures in a row, three of which are identical, discriminate the one that is not the same as the others.

Scalogram analysis was used to analyze the results of the study and these analyses validated the hypothesizes sequence of tasks.

Additional scalogram analyses of the braille sequence of tasks by day and residential programs showed a wider range of coefficients of reproducibility in the scores of residential than in those of day program students (Table 25). It is also noted that in the scalogram analyses of the braille sequence of tasks by grade level, a similar wide range of coefficients is found in those of the second grade students (Table 37). Inspection of these coefficients and scalograms suggest that overlapping in both of these cases of wide ranges of coefficients (.80 to 1.0) are the scores of the same second grade residential students. It was also noted earlier that second grade residential students were significantly older than their day program counterparts. In other words, although the relationship between tasks in the braille sequence is hierarchical, there is some variability in the extent to which performance can be predicted from higher to lower tasks in the sequence. This variability seems related to the criterion of mastery expected of the child, his grade placement and perhaps, his age. Generalizations of this kind however are limited by the small sample size of the children tested.

Scalogram analyses of the Optacon sequence of tasks did not show differences between students in day and residential programs in the order of emergence of skills.

Additional scalogram analyses by grade level of both the braille and the Optacon sequences of tasks showed that increasing numbers of children in the successive grade levels were able to achieve mastery of the tasks.

The significance of the application of a variety of mastery of criteria lies in its translation for instructional purposes. It indicates variability in the rate at which a child is moved from one learning task to another.

Scalogram analyses of the tasks in the Optacon sequence of the hierarchy validated the hypothesized order. The data also showed that even with a minimal period of familiarization with the Optacon, many of the children in first grade and most of the children in second grade were capable of at least half of the simple tactual discriminations given on the Optacon. A second purpose of the validation of this sequence was to provide direction for the development of readiness materials culminating with Optacon use. Since the inception of this study, both the American Institutes for Research (1974) and the San Diego City Schools (1974) have broadly disseminated their previously developed materials for teaching young blind children to use the Optacon. These manuals, like the ones available from Telesensory Systems, Inc. (1973) encourage the use of thermoform or plastic letters prior to and during the use of the Optacon for familiarization with the printed letter. The data from this study implicitly support the progression discussed earlier, from the use of active touch to the use of passive touch. Explicitly, the data from this study support the suggested use of raised line forms in Optacon readiness materials.

A. Suggested Further Research

Several avenues for further research are indicated by the present study. It is suggested that future research be conducted to expand and explore other components of the task of reading tactile materials in addition to tactual discrimination.

In the hierarchy of the present study, the tasks may be said to have varied primarily in one respect, the materials. The validation of this sequence of materials suggests that it may be used as part of a comprehensive battery of materials for braille and/or Optacon reading readiness. On the other hand, the question form remained the same throughout all tasks, as did the response which was linked to actually touching the object while responding. Variations in both the question form and the method of responding were suggested by the spontaneous behaviors of several children during testing. For example, during the course of testing, it was observed that many children "translated" the given question, "Find the one that is not the same," into "Find the one that is different." This suggests that for these particular children, the use of the word "different" was easier. Also during the course of testing, it was observed that many children reported their response with the number or position of the correct response, in addition to saying "This one." This naming response requires that the child remember not only the correct figure which he touched, but also its position in relation to other figures.

This reporting is therefore considered to require greater skill in tactual and spatial memory than any tasks in the present study. Research using variations in the question form as well as in the form of reporting responses could be incorporated into an expanded version of the present hierarchy in an effort to delineate early development of tactual and spatial memory as well as early cognitive-linguistic development. A third and related possibility for investigation is the sequencing of format variations associated with specific questions, such as matching to a stimulus figure or finding two figures that are the same in an array of other different figures. The optimal order for introduction of these exercise formats has not been reported in relation to blind children.

Within the present hierarchy, it is also possible to explore variations in the shapes and sizes of the objects and figures that were used. This is true for each task of the hierarchy including braille, where a validated sequence for the introduction of specific braille code characters would add valuable information to the development of reading readiness materials.

Building on the present hierarchy, which involves only tactual discrimination, further research in the recognition and identification of braille figures and lettershapes presented on the Optacon would further the development of a curriculum guide for the instruction of young blind children (Moore and Bliss, 1975).

The same sequence of tasks shown to be hierarchical for blind children may be applied to other populations. The application of this sequence to a sighted population of the same age, for example would have implications for the "compensation" theory of sensory deprivation. The comparison of scores for blind and sighted children would yield information not only about the early tactual discriminations of the blind compared to the sighted; it could also show the transfer effect in the present tasks when they are encountered without previous experience in discriminations that are tactual but not visual. The application of the present hierarchy to a multiply handicapped population would also yield valuable information. Specifically, it might help to determine whether the sequence of acquisition of skills is the same for this group as for others.

Groups of other tactual learners, such as mentally retarded or learning disabled children, might also benefit from the application of the present hierarchy. The process of learning through the use of tactile materials is not unique to the blind.

In summary, this study has validated a sequence of tasks in tactual discrimination for young blind children, culminating with the tactual discrimination of tactile reading symbols. Suggestions for further research included the exploration of other components of the task of reading tactile materials, the variation of materials within the present hierarchy and the application of the present hierarchy to different populations.

APPENDICES

Appendix A

Review of Related Literature

The literature related to the development of tactual perception skills comes from a variety of fields, including experimental and developmental psychology, and special education, including braille, tactile map, and Optacon research. The largest portion of this literature in psychology and education consists of studies comparing the tactile skills of blind and sighted subjects in an effort to prove or disprove the "compensation" theory of sensory deprivation. This theory has important implications for what is known or hypothesized about the development of tactual perception skills in blind children. If the skills of the blind are superior to those of the sighted, one might theorize that the blind have a more well-developed or well differentiated sense of touch because they have given it more use. As is pointed out by Rice (1970), it is not clear in the available literature ". . . whether this hypothesized sensory enhancement would be manifested in inversely proportional amounts to the degree of visual impairment or only when there is total blindness. If differences in sensory ability do exist as a function of loss of sight, however, then testing totally blind subjects should reveal them" (p. 2). In addition to the degree of vision, the age of onset of blindness and the duration of blindness are also important subject variables which many of the early studies fail to specify.

A second recurring theme in the available literature on sensory deprivation is the concept of the "critical period," defined by Rice (1970) as: "a hypothetical time interval early in infancy during which stimulation of the sensory modalities is necessary to normal physiological, perceptual, emotional and social development" (p. 16). On the basis of animal studies (Nissen, Chow and Semmes, 1951), it has been suggested that restrictions in early tactual experience result in failure to develop normal haptic perception. On the human level, several studies (Hunter, 1954; Casler, 1965) support this theory.

For the present purposes, the underlying issues may be summarized as follows: (1) Is there a difference in the tactual perception skills of the sighted and the blind and, (2) Can tactual perception skill levels be altered by training? The review of the literature attempts to deal with these questions.

The components directly related to tactile tasks, that is tactile sensitivity, tactile resolution and tactile image perception were used as a means of grouping the literature on the development of tactual perception.

1. <u>Development of Tactual Perception Skills</u>

<u>Tactile Sensitivity</u>. Tactile sensitivity is defined by TSI authors (1973) as tactile pressure threshold. For skillful Optacon reading,

pressure threshold must be 'within the normal range. If conditions exist which effect tactile sensitivity, such as diabetes, the status and future status of these conditions need to be carcfully considered with respect to possible limitations they might impose on Optacon performance" (p. 14).

According to Silver (1972), at birth, "the newborn infant has mature sensory receptors for pressure, pain and temperature from his entire body surface" (p. 23). This does not suggest, however, that the perceptual or interpretive capabilities of the newborn are equivalent to those of the growing child or mature adult. The effects of experience and maturation on sensitivity to tactile stimuli have yet to be fully clarified.

In the literature comparing the pressure thresholds of sighted and blind subjects, several variables are suggestive of developmental information. For example, Axelrod (1959) reported that early-blind subjects exerted more pressure and were more successful in making the same discriminations as late-blind subjects, but this was true for boys only. Axelrod also noted that his study showed an "absence in adequate samples of enough representatives of both sexes (Axelrod, 1961, p. 53).

In a more clearly developmental study with sighted subjects, Ghent (1961) tested 108 children between the ages of 5 and 11 years. He found that pressure thresholds in the dominant and non-dominant hands did change with age, and also that the pattern of changes (on the thumbs) was very different in boys and girls. These findings lend support to Axelrod's (1959) and illustrate the need to consider not only the sex of the subjects, but their handedness or hand-dominance as well.

Several authors (Bürklen, 1932; Weiner, 1963) have separated good and poor braille readers in an attempt to describe the habits of each. The implicit assumption of such an approach is that poor braille readers resemble the untaught, unskilled or immature. Although it is not clear that the poor braille reader resembles the immature braille reader enough to generalize from one to the other, such is the underlying suggestion of these studies.

Bürklen's study (1932) was the earliest to deal with tactile pressure among a number of other variables. Bürklen reported that good readers exerted slight and uniform pressure, while poor readers employed strong and variable pressure. Weiner (1963) found the performances of good and poor braille readers were significantly different on complex (though not on simpler) tactual perception tasks. He theorized that within the blind population, differences in neural sensitivity in the fingertips may account for superior performances in tactual perception skills by good braille readers.

Studying speed and pressure factors in braille reading, Holland (1934) reported that fast readers tended to use less pressure than slow readers. Good readers (not always the same as fast readers) tended to increase the amount of pressure exerted at the end of a given paragraph. Holland concluded: "On account of the small number of subjects used in this study, each of the foregoing conclusions is offered as an hypothesis rather than an absolute truth" (p. 17).

The most recent addition to the group of studies on tactile pressure and sensitivity was made by Kusajima (1974). Braille readers at the Tokyo School for the Blind were instructed to read in their usual manner and their tactile pressure, hand movements, use of different fingers, and other factors were observed. In general, Kusajima suggested that the greater the pressure exerted by the braille reader, the more likely that he is finding the material difficult, the more letter-by-letter reading he is doing, and the more likely that he is a poor reader. Expert readers "move their fingers with almost uniform pressure over all the cells of the braille line" (p. 20).

This finding agrees nicely with observations made by TSI authors (1973) on problems in finger positioning on the Optacon. Experimental research suggests that the vibrating pins of the Optacon array ". . . produce a stronger sensation if they actually make and break contact with the skin as they vibrate. . . Heavy finger pressure on the array will tend to dampen out the vibration of the pins, reducing sensation and should, therefore, be avoided" (TSI, 1973, p. 62).

In braille reading as well as in Optacon use, the student is advised to exert only moderate pressure, as evenly as possible along a given line.

Austin and Sleight (1952a, 1952b) identified a range from zero to three ounces as the numerical value of the pressure exerted in 99% of the discriminations made by adult subjects. In their study (1952b), there were no significant differences between sexes, handedness, or fingers employed in making tactile discriminations. The numerical value of the pressure that children would need to exert in order to perform the same tasks has not been suggested in the literature reviewed.

In summary, many variables, such as subjects' sex and handedness or hand-dominance have been suggested as influencing tactile sensitivity, but to date, there appears to be no conclusive evidence reported concerning differences between the blind and sighted, or the effects of training on tactile sensitivity.

Tactile Resolution. Tactile resolution has been defined as the minimum spatial separation at which two points can be distinguished from one. For Optacon use, the tactile two-point threshold "needs to be within normal ranges. As with tactile sensitivity, conditions such as diabetes are reason for careful assessment in this area" (TSI, 1973, p. 14).

Measures of two-point threshold are normally a part of the neurological examination of the child. Unlike those for tactile sensitivity, measures of tactile resolution in normal children do suggest a pattern of growth and development. Paine and Oppé (1966) reported:

> Testing is begun with the points separated at the distance of the normal threshold, which is two millimeters or less on the fingertips or lips. . . Threshold distances are larger in the case of young children or of the mentally retarded or inattentive. Elevations of threshold of less than 100 percent of the normal value are probably to be ignored, but consistently asymmetrical thresholds warrant thought even if of lesser degree (p. 204)

Variations up to 100 percent seem to occur frequently in the young normal population. This suggests that differences in tactile resolution measures between the sighted and the blind populations should, therefore, be large and consistent differences, especially in children, if they are to be taken as proof of "compensatory" development of the sense of touch.

In discussing the possible interpretations of various imperceptions of stimuli, Paine and Oppé (1966) warn that certain phenomena in older children may imply abnormality; but the same phenomena in younger children "are probably normal up to the age of 6 or 7 years" (p. 206). Two questions are raised by the fact that the two-point threshold is normally inconsistent in the young child: (1) is a consistent two-point threshold a necessary criterion for Optacon use? If so, (2) could early training on two-point discriminations enhance the development of consistent two-point thresholds in children younger than 6 or 7 years? These questions remain unanswered in the literature reviewed.

In 1918, Seashore and Ling found no differences between sighted and blind adult subjects in two-point thresholds. On the other hand, Brown and Stratton (1925) investigated the "spatial threshold" of blind and sighted children. Subjects in this study used active touch. Each of the 35 children (ranging from fourth through ninth grade) ran their fingers over many raised points, as over a page of braille. Points were arranged in rows with irregular alternations of single points and of pairs of points, the two points set at varying but accurately measured distances. In all cases, the blind had lower thresholds (more sensitivity) than the sighted. The totally blind group also had lower thresholds than the partially sighted, again suggesting a compensatory advantage to the blind by degrees of visual impairment. The thresholds did not however vary with grade levels or ages of the children. The 35 children in the study ranged in grade levels from grades four to nine, and in ages from 12 to 18 years.

Axelrod (1959) reported significantly lower thresholds in the early-blind on the right index finger only, compared with sighted subjects. For the left index finger, the girls (blind and sighted) had significantly better acuity than boys. The range in age of Axelrod's subjects was 108 to 248 months or 9 to 20.6 years.

Other factors which have been suggested as influencing two-point threshold perceptions are the parameters of the stimuli and the manner of their application. Gilmer (1966) reported that two-point thresholds for vibrations are greater than the static threshold for any given region. For electro-vibratory stimuli, the frequency, intensity and duration of stimulation have been shown to influence perception, (Bliss, 1974; Bliss and Crane, 1969; Gescheider, 1970). If two electrical stimuli do not have exactly simultaneous onset times, an illusion of movement is created (Gibson, 1965). Research on temporal numerosity has determined that the perceptual rates for hearing, vision, and touch are approximately the same, about 80 milli-seconds per perceived unit (White and Cheatham, 1959); this research has supported the hypothesis that "there is some temporal process in the central nervous system that limits and orders the perceptual events in the major sense modalities" (White and Cheatham, 1959, p. 444).

Gibson (1962), among others, has differentiated between active and passive touch and suggested that "stimuli which have one excitatory capacity for a receptive sub-system in passive touch will have a different excitatory capacity in active touch - a different specificity" (p. 484). This suggestion has been verified by research showing that the two-point threshold is reduced (greater sensitivity), if active touch is employed, allowing "micro-dot" braille to be legible (Gill and James, 1973).

Optacon research has shown that there is a limitation on the amount of surface tissue that can be "trained" (Baer and Hill, 1972). TSI authors summarized this research in saying: ". . . experiments with experienced Optacon readers indicate that good pattern recognition ability has only been developed over an area corresponding to the upper two-thirds of the array. The resolution on the area of the finger corresponding to the bottom one-third of the array is still too poor to tell much more than if something is there or not" (TSI, 1973, p. 61).

In summary, research related to tactile resolution has shown only inconclusive evidence of differences between the blind and sighted populations. It has been demonstrated that the two-point threshold may be lowered and sensitivity increased by the use of active touch, and with practice. In summarizing issues in cutaneous communication, information processing and the two-point threshold, Gilmer wrote: "We have a storehouse of information about rate of reception of auditory and visual signals and how we interpret a particular code, but we know little about cutaneous codings beyond the long history of the use of braille" (Gilmer, 1966, p. 18). Research on braille will be reported separately. It suffices for present purposes to say that the current inter-dot (.090 inches or 2.3 mm) and inter-cell (.160 inches or 4.06 mm) standard spacings are within the two-point perceptual capabilities (that is, above threshold level) of the normal six-year old child. If training can in fact enhance those capabilities, all the more reason to train the young blind child.

Tactile Image Perception. Of the three components of Optacon use given by TSI authors (1973), this one seems least well defined: "The student needs to be able to perceive images as complex as lettershapes" (TSI, 1973, p. 14). Among the numerous perceptions and sensations that can be carried by stimulations of the skin are itch, tickle, vibrations, contact, pressure, shape, mass, texture, wetness, dryness, warmth, cold, electric shock and pain. Since the terminal objective involves the perception of images such as lettershapes, the review of literature was confined to studies dealing with the perception and discrimination of shapes. Complexity has been defined as dependent on the number of different stimuli and responses possible in a given block of time and space (DeCecco, 1968). With this definition in mind, research studies on complex tactual perception tasks were grouped according to the different kinds of stimuli they utilized.

<u>Maze learning</u>. The skills involved in finger-maze learning bear resemblance to the skills involved in tactual perception on the Optacon if one considers maze learning to be based on the ability to perceive and utilize incoming, moving tactile information. A series of studies (Berg and Worchel, 1956; Bottrill, 1968; Knotts and Miles, 1929; Koch and Ufkess, 1926; Rivenes and Cordellos, 1970) have investigated the comparative skills of blind and sighted subjects on a variety of maze-learning tasks.

Berg and Worchel (1956) compared the performance of matched blind, deaf and normal subjects. For the U-maze employed, the normal and blind subjects surpassed the deaf, by which the authors inferred that "verbalization plays a significant role in determining these differential performances" (Berg and Worchel, 1956, p. 92). Knotts and Miles (1929) had also suggested that an advantage is given to those who use verbalization in learning the pathway through a maze.

These studies add weight to the suggestion by TSI authors that in teaching Optacon skills, the student's learning is facilitated when the teacher verbally describes each letter and points out critical features of each letter (TSI, 1973).

Both Berg and Worchel (1956) and Knotts and Miles (1929) also reported superior performance by the late-blind, compared to the early-blind. On the other hand, Koch and Ufkess (1926) reported that the performance of the blind as a group was inferior to that of the sighted; neither Bottrill (1968), nor Riveness and Cordellos (1970) found any differences on the performance on a finger-maze, or a walking test between blind and sighted subjects.

Gomulicki's maze-learning experiments (1961) are of particular interest. Gomulicki used two types of mazes: a walking maze and a stylus maze 1/30th the size of the large one of the identical shape. A cross-section of congenitally blind subjects and sighted subjects ranging in age from 5 to 16 years were each divided into two sub-groups. In both cases, one sub-group performed the large maze first, while the other performed the small maze first. Both blind and sighted groups were found to need more trials to learn the smaller maze than the larger maze, suggesting that tasks involving large motor movements are easier than those involving fine motor movements. On both mazes, for younger subjects, the sighted were superior to the blind, but the learning curves continued to approach each other. For the stylus-maze, the learning curves of the blind caught up with the sighted by the age of fourteen and thereafter the blind were superior to the sighted. Learning curves for the walking maze met at the age of sixteen. An important finding was that the transfer effect was significantly stronger in shifting from the large to the small maze. The correlation between the two mazes was significantly higher for the blind than for the sighted.

In summary, research evidence suggests all of the three possibilities: the blind as a group are (1) better than, (2) not different from, and (3) worse than the sighted in maze-learning. Gomulicki's (1961) study gives evidence of the transfer of learning from large motor movements to fine motor movements.

Solid forms. The recognition of 30 common household objects by blind children in two levels of nursery, kindergarten and first grade was investigated by Nolan and Morris (1960). Objects ranged from those commonly contacted on a daily basis to those that would require considerable exploration in order to obtain contact. Variability within grades decreased gradually and a small, though regular increase in mean scores was seen with grade progression. Results strongly supported the feasibility of using object recognition "as an estimate of concept development and experience level for young blind children" (Nolan and Morris, 1960, p. 25). The goal of anticipated further research was reportedly to organize items into an age scale.

In 1963, Ewart and Carp published the results of a comparison of the tactile recognition of solid wooden forms by sighted and blind subjects. In all, eight stimulus forms were used including a ball (of 1-in. radius), a crescent (2 in. between tips), a quarter-circle (2-in. radius), a square (2 x 2 in.), a rectangular block (1.5 x 2.5

in.), a pyramid (2-in. sides) and a parallelogram (2-in. sides). The task involved matching the stimulus object to its identical mate in a choice of four objects. Blind subjects were residents of the Texas School for the Blind and the sighted children were residents of a children's home "to control for institutionalization" (Ewart and Carp, 1963, p. 488). The two groups had similar ranges in ages (8-16 years). The IQ scores of the sighted subjects were measured by the Stanford-Binet Scale, Form M; those of the blind were measured by the Interim Hayes-Binet or the WISC (Verbal) Scale. In the absence of any instrument for equating the IQs of the blind and the sighted, intelligence was controlled only to the extent that the lower levels (below 80) were eliminated. The results showed no differences between blind and sighted subjects' performances. There was however a significant interaction between vision and the IQ variable. Blind subjects with high IQs (above the median for the group) were superior not only to blind subjects with low IQs, but also to both high and low IQ sighted subjects. For both blind and sighted subjects, the least errors were made in recognition of the ball and the crescent, while the most errors were made in recognition of the semicircle, quarter-circle and triangle.

Eaves and Klonoff (1970) compared blind and sighted subjects on a tactual and a performance test. Each of the 40 blind and 40 sighted subjects (age 6 to 26 years) was given three opportunities (one with the dominant hand, one with the non-dominant hand, and one with both hands) to complete a Tactual Performance Test (TPT), which is a modification of the Seguin Formboard. After three trials, subjects were asked to draw a picture of the form-board. The authors found no significant differences between the performances of blind and sighted subjects. However, subjects with no vision or light perception only were superior to the sighted in the use of the dominant hand. They were also superior to those with guiding vision in the total time to complete the task, using the dominant hand. The IQ score of the totally blind group was found to correlate significantly with their TPT score. The authors suggested that the superior performance of the totally blind in comparison to the partially sighted and the sighted groups is related to their presumed increased experience in tactual tasks.

Research on the recognition and identification of geometric forms has recently been completed at the American Printing House for the Blind. The set of objects, called Mitchell Wire Forms consists of raised line figures of a circle, a square and a triangle on thermoformed plastic, a tangible plane figure of each shape and three-dimensional solids of a sphere (which pulls apart from two equal halves), a cube and a pyramid. In a recent pilot study (American Printing House for the Blind, 1974), ten students from grades one to three were able to identify the shapes of these forms when represented in the three versions (raised line, tangible plane figures and three-dimensional solids). Since the purpose of the research was the field-testing of materials, no further evaluation was considered necessary.

In summary, although research supported the feasibility of using recognition of common household objects as an estimate of concept development and experience level for young blind children, the tactile recognition (and identification) of solid forms has had relatively little investigation. The studies reviewed gave limited evidence of superiority of blind over sighted subjects. The relevance of the degree of vision, hand dominance and IQ scores of subjects were suggested. The order of difficulty of tactual recognition of various objects by both blind and sighted subjects was suggested by Ewart and Carp's (1963) study.

Raised-line figures. The earliest research reviewed by this author in the discriminability of raised line figures by the blind was done by F. K. Merry (1932, 1933) and R. V. Merry (1930). These studies were designed to determine the usefulness and meaningfulness to blind children of two forms of raised line figures: simple embossed geometric shapes (a circle, a square, a triangle, a cross and a star), and embossed representations involving perspective in objects such as a house, a table, a wheel, etc. Of the geometric shapes, the order of difficulty from easiest to hardest is as listed above. A separate experiment tested the blind children's improvement in recognition of both geometric designs and pictures involving perspective after a period of systematic instruction. Younger children showed more improvement than older children, but both made significant improvement in the recognition of geometric shapes. In the recognition of pictures involving perspective, so little gain was made after instruction, that Merry and Merry (1933) concluded: "it seems unwise to expend any considerable amount of time teaching blind children how to recognize tactually pictures of three dimensional objects" (p. 163).

In 1971, Nolan compared the efficiency of reading raised and incised lines by 96 braille readers in grades 4 through 12. Differences between grade levels were statistically significant. A significant difference was also found favoring the raised line. However, "of more critical importance is the 38 percent increase in reading time required" for the incised line (Nolan, 1971, p. 63). Nolan concluded that the use of incised lines and symbols for the blind should be avoided.

Research on line symbols for the standardized tactile symbology of maps for the blind has been reported by Nolan and Morris (1962). Using a paired-comparison technique with blind children ranging in grade levels from 4 through 12, seven highly discriminable line symbols were identified. Ease of learning and relearning of verbal stimuli associated with each symbol was also investigated. Since tactile symbols for area and points on a tactile map were researched at the same time, Nolan and Morris concluded that "the primary symbolic material necessary for the design of tactual graphics is now available" (Nolan and Morris, 1962, p. 18).

In the studies cited above, the following criteria were used for acceptance of a symbol as discriminable: (1) that average confusion with other acceptable symbols should be 5% or less; (2) that confusion with itself or any other single symbol accepted by the above criterion should be 10% or less; and (3) that for any set of symbols acceptable by criteria one and two, there should be no significant differences in discriminability of acceptable symbols among children in grades ranging from 4 through 12 (Nolan and Morris, 1962). Since the criteria for acceptance of these symbols precluded differences in discriminability by grade levels, little is known about the early development of these discriminations.

A second problem open to question in these studies is their use of the paired-comparison technique, also used by Gliner (1967). It has been suggested (Schiff, 1967) that this technique yields results of only limited value to the diagrammatic presentation of information. Schiff argued that as the amount of information to be discriminated is increased, lines and symbols lose discriminability. Conversely, symbols which may be highly discriminable in the context of a tactile map, may not be in a paired-comparison experiment. Gill and James (1973) also noted that another disadvantage of the paired-comparison technique is that the number of tests is N (N + 1) / 2 where N is the number of different symbols to be tested. The large number of tests required for a relatively small number of items may be a source of monotony to subjects, which in turn may cause an increase in the number of errors.

Of particular interest in the studies on tactile line discriminations are the findings of Pick and Pick (1966). In an earlier study (Gibson, Gibson, Pick and Osser, 1962), normative data for the visual discrimination of letter-like forms and five transformations were established for four through eight-year olds. There was a decrease in errors for all transformations as age increased but some transformations were harder to discriminate from the standard than others. The closed-open distinction for curves was discriminated very early. Other types of transformations had varying rates of improvement. These results were interpreted to mean that certain distinctive features or dimensions of difference, critical for differentiating among forms, are learned. It was suggested that previous experience with solid objects could transfer to this new discrimination task. In 1966, Pick and Pick produced the same forms in raised metal lines on a smooth metal background and compared the tactual perceptions of normal, partially sighted, and blind subjects ranging in age from 6 to 17 years. For sighted children, the same-different judgements proved much more difficult tactually than they had been visually. They did show a statistically significant decrease in errors with age. For the visually handicapped subjects as a whole group, there was a surprising lack of improvement with age, which suggests that this type of discrimination skill is "teachable," but does not emerge spontaneously with tactual experience. For the totally blind group only, the interaction between age and type of form was statistically significant. Generally, the number of errors made in the task depended on the age of the subject, the amount of vision present and nature of the differences between members of the paired-comparison.

In summary, it has been shown that the perception of raised line figures by blind children may be improved by systematic instruction. The use of incised lines does not compare favorably with the use of raised lines. Several highly discriminable line symbols have been identified for use in maps for the blind. The totally blind show improved discrimination of letter-like forms and their transformations with increasing age.

Embossed dot figures. In 1968, Crandell, et al., developed an instrument, the Tactile-Kinesthetic Form-Discrimination Test (TKT) to measure tactile-kinesthetic discriminations of embossed, geometric forms including, circles, squares, ellipsoids, rectangles, and other polygons of a variety of sizes. The task utilized two question forms: select one item which is different from four others, and match one of four figures which is similar to a stimulus figure. Subjects were residential students at Overbrook School for the Blind in the elementary and high school departments and ranged in age from 10 to 21 years. Verbal WISC and WAIS intelligence quotients were available and all subjects were totally blind or retained no use-able vision beyond gross object perception since the age of four years. The test was analyzed for item difficulty, item discrimination, item uniqueness, the reliability and validity measures were determined. Statistically significant correlations were found with verbal IQ scores and grade level placement, suggesting that this ability may be related to other educationally relevant factors.

Hammill and Crandell (1969) used the Tactile-Kinesthetic Form Discrimination Test in a second study of blind and partially sighted children, ranging in age from 6.25 to 10.6 years. The authors attempted to extend reliability and validity measures of the test to younger children and discussed relationships between the test and chronological age, mental age, IQ, abstracting ability, sound discrimination ability, visual acuity, father's occupation, and braille reading ability. Reliability coefficients indicated acceptable temporal stability and internal consistency. Statistically significant correlations were obtained between the test and IQ scores, mental ages, and scores on the abstraction test, although not with chronological age, visual acuity, or father's occupational levels. No meaningful correlations was established between the TKT and the sound discrimination test, although both related significantly to mental age, suggesting that these two perceptual skills develop independently. On finding a statistically significant difference between the means of scores on the TKT of braille and print readers, the authors concluded that "either Braille reading improves tactual-form discrimination ability. . . or children are selected for reading with their eyes as the result of inability to read Braille" (Hammill and Crandell, 1969, p. 68).

The materials of the Tactual Discrimination Worksheets available from the American Printing House for the Blind include among other activities, exercises in the discrimination of geometric forms in solid dot (filled in) and dotted outline patterns. The shapes represented are: circles, squares; triangles; rectangles; and diamonds in two different sizes. Field-testing of these materials was carried out with 89 children in kindergarten through third grade in eight residential schools for the visually handicapped. Results showed that there was no significant difference by grade levels in the ability to perform the discriminations in the geometric forms (American Printing House for the Blind, 1974). Nor was there any significant difference between solid dot and dotted outline forms. It was suggested that differences between schools and the fact that students in kindergarten and the first grade often receive training in these discriminations may account for this finding (Caton, 1974). It should also be noted that on the exercises requiring the child to find the one item which is different from others in an array of four, the difference between items for many of the presentations was a size difference as well as, or instead of, a difference in form. Discriminations based on shape were found to be significantly less difficult than those based on size. Analyses of these exercises may also have been confounded by the fact that for many presentations, there were two correct answers.

In summary, tactual discriminations of embossed dotted geometric forms have been investigated. It has been suggested that the mode of reading of the child (visual or tactual) may influence the ability to make these discriminations. In view of contradictory evidence for the relationship between these discriminations and grade level placement, further research seems warranted.

Braille research. Reviews of the early historical development of tactile materials for the blind are available elsewhere (French, 1932; Rodenberg, 1955). It is interesting to note however that historically, raised line figures of the Roman alphabet predated the popular acceptance of the embossed dot form, the braille cell. According to Bürklen (1932) "experience with dotted and pearl types demonstrated the superior tangibility of punctographic embossing over that of the raised line type . . . Hence it was necessary that a script for the blind should be made up of dots" (p. 4). Between the years 1850 and 1870, after a long and bitter struggle against line type, braille type was adopted as the universal system.

Several research studies using the braille code have already been cited (Bürklen, 1932; Holland, 1934; Kusajima, 1974; Weiner, 1963). These studies suggest that there are distinct differences in the reading habits of good and poor braille readers.

The standard spacing of the dots of the braille code has been determined by research (Bürklen, 1932; Maxfield, 1928; Meyers, Ethington and Ashcroft, 1958; Uniform Type Committee, 1908, 1910, 1913). It has been suggested that readability of the braille code is improved for children when braille is printed using smaller (.123") between-cell spacing than current (.160") standard between-cell spacing (Zickel and Hooper, 1957). This may be due to the smaller finger sizes of young children. The smaller (.123") spacing made braille readability poorer for adults (Zickel and Hooper, 1957).

Studies of the frequency of appearance of braille characters and contractions (Kederis, Siems and Haynes, 1965; Rex, 1970) have relevance to braille readers because of the space which is saved by the use of contractions and because greater frequency of occurrence of various characters of the code facilitates the reading of braille. It was reported by Umsted (1970, p. 58) that the use of Grade 2 braille required almost 12 per cent less space. Kederis et al. (1965) showed that dots on the left of the cell occurred 7 per cent more often than dots on the right. Upper dots were 8 per cent more prevalent than lower dots. The occurrence of dots in their various positions was in direct inverse relationship with the frequency of missed dots by cell position. Implications of these findings bear directly on the teaching of the braille code to beginners.

Rex (1970) analyzed the braille transcriptions of four basal reader series used in teaching reading to blind children, preprimer level through second semester, third grade level. In all four series, most of the braille contractions had been introduced by the end of the third grade with no particular attention given to the order of difficulty of braille contractions. She concluded that the basal readers analyzed did not provide adequate instructional material for the teaching or learning of the unique aspects of the braille code.

Studies I - IV of perceptual factors in braille word recognition by Nolan and Kederis (1969) showed that while the number of dots within a cell did appear to be a significant variable in favor of fewer dots, no systematic pattern for this effect could be established except that braille characters and words with most of the dots on the left and in the upper part of the cell were more easily recognized than those with many dots, dots on the right, and on the bottom half of the cell. Generally, characters with dots more widely dispersed were more easily recognized, and 86 per cent of the errors were due to missed dots. The number of dots, position of the dots, and the presence or absence of braille contractions and their orthography within words were all significantly related. No clear-cut patterns of relationships were pinpointed, but these various factors did interact in their effects on recognition and readability.

Maxfield (1928) found left-hand readers to be the most efficient in contrast to the findings of Bürklen (1932). After surveying the present procedures used for teaching braille reading in the United States, Lowenfeld, et al. (1969) recommended that allowances be made for individual differences in reading behavior. Because no statistically significant differences in comprehension and reading rate were found between students using their left hand, right hand, or both hands, individual hand-preferences was encouraged for teaching braille reading.

As extensive analysis of errors in braille reading was conducted by Ashcroft (1960). Using oral reading performance of elementary grade children, 728 subjects in grades two through six read preselected paragraphs which were graded for reading difficulty. The material contained 185 signs, abbreviations, and contractions considered essential to reading the braille code. Each subject read until he made 10 or more errors. Eight error-type groups were analyzed under the headings of problems in perception, problems in orientation, and problems of memory. Of these, problems in perception of missed dots, added dots, and ending problems were the largest percentage of errors. Ashcroft summarized recommendations for each of the eight error types as well as for teaching methods and materials. Recommendations for revisions in the braille code were also made.

Of particular relevance are the studies providing evidence of improved braille reading speed and accuracy after training. Flanagan (1966) trained 15 junior high subjects for a total of 2100 hours on an automated self-instruction device while 15 control subjects spent the same amount of time in traditional reading. Braille was introduced on a tape which moved from right to left across an exposed presentation window. Significant differences favored the experimental group in the rate of braille reading on the post-treatment measure. Experimental gains remained constant with only minor exceptions after a three-month non-instructional interval. Motivation was an uncontrolled intervening variable.

Kederis, Nolan and Morris (1967) did not obtain significant effects either with a controlled rapid exposure device or with a variable-speed pacing device. Both studies had an experimental and control group of 15 matched subjects with the experimental group practicing reading with their instruments for one-half hour daily for 20 consecutive school days. "The most important finding of the present studies was that stimulation of motivation to read faster resulted in remarkable reductions in reading times by all subjects" (p. 104). The average reduction in reading time (24 per cent) showed that effects from motivation have important implications for education.

A recent report on the use of programmed machine-paced instructional devices (Flanagan and Joslin, 1969) involved 13 subjects from third through ninth grade. Nine 15-minute periods were used to remediate the 17 characters of the alphabet which had presented the most difficulty in earlier phases of the study. Thirteen control subjects received an equal amount of training with braille on thermoplastic film. The increase in speed of perception of the braille characters after training was statistically significant.

Henderson (1967) reported by Umsted (1970) showed that training in character recognition produced significant increases for elementary grade students in comprehension of silent reading, in oral reading speed, and in accuracy of oral reading. In contrast, Kederis, et al. (1967) found no significant effects on the reading speed of subjects who were trained in whole-word recognition. According to Nolan and Kederis, (1969), "as the complexities of Grade 2 braille are encountered, constant monitoring of character recognition skills and knowledge of code meanings seem critical" (pp. 50-51).

Umsted (1970, 1971) demonstrated that the influence of training for accuracy and greater speed in code recognition did not have any appreciable effect on the comprehension scores in silent reading. However, Umsted (1970) did find a 60 percent reduction in the mean number of errors and a 30 per cent gain in silent reading speed by the experimental group. Each of the low, medium, and high level reading groups showed increases in reading speeds.

In summary, several investigators on the braille code itself have led to the establishment of current standard spacings. Studies in the frequency of occurrence of braille characters and of dots within the braille cell as well as studies of errors in braille reading have identified the most common problems in the perception of the braille code. On these bases, further revisions of the braille code have been suggested in the literature. There is also evidence reported that braille reading speed and accuracy may be improved by a variety of remedial techniques.

Optacon-related research. An important distinction between braille and the use of the Optacon lies not only in the stimuli, but in the active-passive dimension. Karp (1962) presented sighted adult subjects with a variety of stimuli in three different conditions. In the "place" method, subjects were given stimuli (the size of braille) directly on their fingers. In the "movement" condition, stimuli were moved across the subjects' fingertips at a speed controlled by the experimenter. In the "free movement" condition, individuals were allowed to move their fingers freely over the stimuli. Karp found that free motion by the subject over raised dot patterns yielded much better recognition than if the pattern was presented in one place or moved over the skin. Similarly, Bauer (1952) had shown that one-second long contacts with textures were not as efficient as one second long explorations permitting movement. These studies suggest facilitation of learning when active touch is employed.

A transfer of learning from active to passive forms of perception has been suggested by Piaget (1960) and has been shown in animal research. Zimmerman (1964) showed that object-discrimination learning facilitates the discrimination of pictures. With children (Kohnstamm, 1963) the use of blocks in a training period appeared to simplify a classification task tested with pictures. Gibson (1969) interpreted these studies to mean that "distinctive feature differences are more easily picked up with a solid, three-dimensional object and their surrogates in the drawings are thereby rendered more perceptible" (p. 278). This provides reason to expect that object discrimination practice will facilitate transfer to the passive perception of forms on the Optacon.

A second important element of perception on the Optacon is the vibration of the reeds of the array. Gilmer (1966) noted that the two-point threshold for vibration is greater than the static threshold for any given region. Yet for vibrating stimuli, it has also been shown that if a computer is programmed to move a letter under the finger, perception is stronger and clearer than for a stationary presentation (Bliss and Crane, 1969). In this particular form of passive touch, there is an interaction between the gains made by movement of the stimuli and the loss of sensitivity in the vibrating two-point threshold.

Foulke (1971) discussed studies of improved reading rates by the use of a machine which allowed braille characters to pass beneath the fingertips of the reader. Under these conditions, a "kind of dynamic patterning" (p. 26) emerges. The pattern is a consequence of the motion of the braille stimuli. It is Foulke's contention that the movement of the braille characters across the passive receptors of the skin is analogous to the perception of signals in Morse code. "When code characters are sent at a fast enough rate and with proper timing, the experienced operator hears not a succession of dots and dashes, but a rhythmic pattern that identifies whole words and phrases for him" (Foulke, 1971, p. 26). That this sort of dynamic patterning constitutes a higher level of perception than the use of active touch (as in the normal perception of braille) is presumed. The question that seems worthy of further investigation is whether there is a relationship of dependence between the two forms of perception.

In summarizing Optacon-related research in tactile perception, Bliss and Crane (1969) wrote:

> Our experiments have thus far been conducted with what we might call tactually naive adult subjects. One naturally wonders to what extent the tactile mode could be developed with training starting in early childhood. Are our tactually-naive subjects in somewhat the same position as those who experience vision for the first time late in life? The strong difference between our one early-blind subject and all the others at least suggests that there are great possibilities. It makes sense to consider a tactile training program begun in parallel with the normal visual reading programs for children. (p. 228)

To date, although a small number of young blind children are learning to use the Optacon, systematic research of Optacon-readiness has not been found to be reported.

Studies of tactile image perception have been reviewed and grouped according to the different kinds of stimuli utilized: mazes; solid forms; raised line figures; embossed dot figures; braille; and Optacon. Within these studies, there is no conclusive evidence of differences in the development of tactual discriminations between blind and sighted populations. Factors such as the degree of visual impairment and the use of the preferred hand have been noted as important considerations in tactual discrimination skills. Evidence of gradual improvement in tactual discrimination skills in blind children has been found generally in relation to grade level placements but not chronological age. This relationship and studies in the improvement of speed and accuracy in braille recognition suggest that tactual discrimination skills may be improved through instruction.

In conclusion, the literature on the development of tactual perception was reviewed according to three components of tactual perception as suggested by TSI authors (1973): tactile sensitivity; tactile resolution; and tactile image perception. The review of the literature supported the following conclusions:

(1) There is no conclusive evidence of differences in the development of tactual discrimination skills in the blind and sighted populations.

(2) Research suggests that although a consistent two-point threshold should not be a serious consideration in tactual readiness for the young blind child, there is evidence that this threshold may be lowered by the use of active touch and after training.

(3) The speed and accuracy of braille code recognition may also be improved by instruction and training. Conclusions (2) and (3) were taken to support the contention that training and practice can enhance the blind child's performance in tactual discrimination.

(4) There is evidence that the transfer of learning from large to fine motor movement facilitates the learning of tactual discrimination skills.

(5) There is also evidence that the use of active touch facilitates learning.

(6) The factors which have been suggested as important considerations in the learning of tactual discrimination skills are hand preference, degree of visual impairment, IQ scores, grade level placements, and on a theoretical base, the detection of distinctive features.

While the review of the literature does support the above conclusions, there is hardly enough information available on which to base a program of tactual readiness for reading tactile materials. As has already been mentioned, numerous suggestions for developing tactual readiness are in the literature. Currently available materials for teaching tactual readiness include the Touch and Tell volumes and the Tactual Discrimination Worksheets. Yet little has been found about the sequence of development, or ordering of the tasks within these materials, nor whether training with these materials might facilitate learning braille or the use of the Optacon.

2. Sequences of Development in Tactual Discrimination

The review of the literature has thus far dealt individually with tactile materials such as mazes, solid forms, raised lines and embossed dot figures, braille as well as Optacon. The problem of ordering tactual discrimination tasks for a tactual readiness program for blind children requires that comparisions be made across categories of stimulus forms. Although no studies comparing the perceptions of young blind children on all these stimuli could be found in the literature, a series of generalizations do emerge from results previously cited.

The first of these generalizations is that the child's development in tactual discrimination skills follows a progression from large to fine hand movements, as in the manipulatory exploration of materials using the whole hand followed by the use of the fingertips only. This progression from large to fine movements is suggested by Gomulicki's (1961) study. Further substantiation for this progression is given by Zaporozhets (1965) in his elaborate description of the developmental nature of children's tactile explorations:

> A comparison of the actions of children in different age groups permitted us to characterize the stages of development in the tactile movements of the child's hand. The movements of the three-year old child were more like catching than like touching. Often small children played with the figure instead of examining it. For example, the child placed his palm on the edges of the figure and pushed it with his fingers. . .

> The movements of the four- to five-year-old children considerably reminded us of those of the three year olds, but you could see more elements here. The same catching of the edge of the object with four fingers and the palm was observed, but the hands did not stay in this position for long. Rather quickly, the four-year-old children started to acquaint themselves with the object more actively by using the palms and the surfaces of the fingers. Fingertips were almost absolutely passive in the tactile process. Usually, the palping was done with one hand only.
>
> In children five to six years of age, you could see the simultaneous touching of the figure, the two hands moving toward each other or in opposite directions. But the systematic tracing of the outline of the whole figure was not yet observed. Usually, children confined themselves to careful examination of some specific feature of the figure, for example, of some hollow part or some projection, without correlating them or locating their position on the whole figure. . . And it was with six-year-old children that you could observe the systematic tracing of the whole outline of the figure with the fingertips, as if the children were reproducing the form of the figure with their tactile movements by modeling its form (p. 85)

In terms of the sequence of materials for tasks in tactual discrimination, this progression has traditionally been translated into the use of large manipulable objects before the use of smaller and/or less concrete ones. Kohnstamm (1963) tested sighted five-year-olds on the classification of pictures. His study showed that by the use of manipulable blocks in the training period, the learning problem was simplified for the children, suggesting transfer of learning. Gottesman (1971) compared blind and sighted children in their performance on a Piaget-type task of visual and haptic perception using geometric plane figures. Children were observed in three age groups: 2-4; 4-6; and 6-8-year-olds. His study revealed a "similarity in performance of both sighted and blind children on a developmental scale" (p. 579). Further, in field-testing materials of the Tactual Discrimination Worksheets, item difficulty indices showed that the geometric forms, which were larger than the size of braille were more easily discriminated than the braille code characters (Caton, 1974). These studies provide suggestive evidence of transfer of learning as the materials are changed from more to less concrete and from large to small.

The suggestion that this progression should be used in tactual readiness materials has been made by Nolan and Kederis (1969). They advised that a program of tactual readiness should include manipulations of three-dimensional objects. It should then

> proceed from gross perception of previously learned two-dimensional forms expressed in terms of diminishing numbers of points (for example, a square produced initially large by dotted lines reduced to a square represented by four points) to actual discrimination of the forms of the braille characters. (p. 50)

In addition to the progression from large to fine hand movements, a second generalization is that the child's development in tactual discrimination skills follows a progression from the early use of active touch to the later use of passive touch. That the use of active touch makes tactual discriminations easier is suggested by evidence that the two-point threshold is reduced, hence sensitivity increased, if active touch is employed (Gill & James, 1973). Karp (1962) found that free motion by the sighted subjects over raised-dot patterns yielded much better recognition than if the pattern was presented in one place or moved over the skin. For the rapid discrimination of textures (Bauer, 1952), explorations permitting movement were more efficient than mere physical contacts of the same length of time. Zaporozhets (1965) reported that in three- and four-year-old children "when an adequate perceptive image. . . cannot be created by means of visual and tactile acquaintance with an object, such image can be formed in the course of practical manipulations with the object" (p. 89). Piaget's observations and theory of perceptual development lend further support for the progression from the use of active to passive touch. Perception for Piaget involves assimilation of sensory input to a schema and often, ensuing upon this, accommodation of the schema to the specific object. Throughout his discussion, Piaget emphasizes the role of activity and motor processes as distinguished from passive perception, especially in the early sensory-motor and concrete-operational stages (Honstead, 1968).

The active-to-passive progression may be translated into the use of materials for active touch prior to the introduction of materials on the Optacon. Research (Resnick, Siegel and Kresh, 1971) has shown that subjects who learned tasks in optimal order, that is, the simpler task first, then the more complex, learned the complex task in fewer trials than subjects who began with the complex task. In addition, those who succeeded in learning the complex task first showed evidence of having acquired the simpler task.

The third generalization about the development of tactual discrimination skills is inherent in several of the studies cited earlier (Gomulicki, 1961; Kohnstamm, 1963; Resnick et al., 1971). In general it can be said that the child benefits from the transfer of learning from simple to more complex tasks. In instructional psychology, this generalization provides the rationale for the building of curricula and sequences in hierarchial order. For Gagné (1965),

> establishing the conditions for transferability of what is learned can be seen to be an educational function of considerable importance. It involves procedures that will have an effect not only on the acquisition of further knowledge, as in vertical transfer, but also on the broad application of learned capabilities to novel and practial situations. (p. 338)

The generalizations discussed above were not limited in their applicability to blind children only. If they are to be used as guidelines for the ordering of tasks for blind children, the question of the similarities and differences in the over-all development of blind and sighted children becomes particularly relevant. The review of the literature provided inconclusive evidence of differences in the development of tactual discrimination skills between blind and sighted children. Yet differences in the ages of attainment of developmental milestones for blind and sighted children do exist.

In describing the blind child's cephalocaudal sequences of development, it was noted (Scholl, 1973) that the physical development of the blind infant proceeds through the same sequential pattern but his rate is usually retarded. The reason usually cited is that the blind child lacks the visual stimulation which motivates the normal child, particularly in early life. As early as 16 weeks of age (the age at which the normal child may track an object with his eyes and may attempt to reach for it) the blind child is at a great disadvantage.

> For the blind child, knowledge of the object world comes primarily through tactile and only secondarily through auditory channels. Consequently, the blind infant must first know and recognize a sound toy by touch before that toy can be used for auditory tracking/and or motivation for reaching and grasping. (Scholl, 1973, p. 66).

In a more detailed analysis of the motor development of blind and sighted infants, Fraiberg (1968) showed that blind children may follow a maturational pattern and timetable that closely parallels those of the sighted child during the early months. Then, in the last quarter of the first year, the delay of the blind babies in locomotion is ". . . linked to a problem in prehension and to the circuitous route that leads a blind baby to locate an object on sound cue alone and to reach for and attain an object" (p. 285).

In addition to problems in prehension and locomotion, other atypical behaviors have been observed in the blind child's spatial orientation, exploratory hand movements and object relations (Gesell, Ilg and Bullis, 1949). Retardation in learning to control fingers and in the efficient use of hands is often observed by teachers of young blind children (Scholl, 1973). It is Gesell's (1949) conclusion however that blindness in itself does not produce a serious degree of retardation. That these developmental problems occur frequently in blind children underscores the need already shown for a program of tactual readiness. However, despite the differences in attainment and the prevalence of developmental problems, the sequence of milestones in the development of the organism remains the same for both blind and sighted children.

Appendix B

The Optacon

One of the most recent advances in systems of reading of the blind has been the development and production of the Optacon. The Optacon is an optical-to-tactile converter designed to enable blind persons to read print materials. Its size and shape resemble a portable cassette-type tape recorder. Like the microphone which can be extended from the tape recorder, the camera is an extension of the Optacon. As the reader moves the camera across a line of print, photosensors in the camera relay the image of each letter to the Optacon. Each letter is transformed electronically into a tactile image which is felt on one finger placed on an array of 144 vibrating pins. The magnification adjustment on the camera allows the blind person to read by touch a variety of sizes and types.

The Optacon has been commercially available since 1971, from Telesensory Systems, Inc. (TSI) of California. There are two main advantages reported by adult Optacon users (Goldish and Taylor, 1974). First, the blind person has independent access to printed materials; he no longer needs to be dependent on external sources, such as a sighted reader, braille transcriptions or recorded materials. Second, he also has immediate access; he can read soup can labels, the telephone book, personal letters and other printed materials when and wherever he desires.

Appendix C

Distribution of Subjects, by Agency

The following lists the number of subjects and the agency through which they were located. Thanks are due to the following agencies for their cooperation:

Subjects	Residential Programs
5	Western Pennsylvania School for Blind Children
4	Overbrook School (Pennsylvania)
8	West Virginia School for the Blind
3	Virginia School at Hampton
2	Ohio State School for the Blind
1	New York Institute for the Education of the Blind
2	Maryland School for the Blind
1	Kentucky School for the Blind
4	New York State School for the Blind
30	

Subjects	Day Programs
2	Logan School (Pennsylvania)
3	Upsal Day School (Pennsylvania)
4	Pennsylvania Intermediate Units 15, 22 & 25
7	New Jersey Commission for the Blind
1	A southern Ohio public school district
4	Toledo Public Schools (Ohio)
1	Erlanger Public Schools (Kentucky)
1	Livonia Public Schools (Michigan)
1	Sterling Heights Public Schools (Michigan)
2	Lincoln Park Public Schools (Michigan)
2	Greater Detroit Society for the Blind (Michigan)
1	Kalamazoo Intermediate School District (Michigan)
1	Allegan Intermediate School District (Michigan)
30	

Appendix D: Subjects' Ages, Grades, Sex and Raw Scores

Subject Number	C.A.*	Grade	Sex	Tasks 1	2	3A	4A	5A	3B	4B	5B	Totals Braille Sequence	Totals Optacon Sequence	All Tasks
1	5-1	K	M	6	4	1	1	1	1	1	1	13	13	16
2	4-7	K	M	6	8	4	4	0	2	3	1	22	20	28
3	5-1	K	M	8	7	1	2	2	2	5	1	20	23	28
4	8-11	K	M	4	4	4	2	2	5	4	1	16	18	26
5	7-9	K	M	7	2	1	2	1	1	1	1	13	12	16
6	6-4	K	F	7	6	2	2	3	5	4	1	20	23	30
7	7-9	K	M	6	2	1	1	1	1	1	1	11	11	14
8	5-11	K	F	5	5	2	0	1	2	1	2	13	15	18
9	7-11	K	F	7	7	4	2	1	4	3	2	21	23	30
10	10-3	K	M	1	2	1	1	1	2	2	1	6	8	11
11	4-1	K	M	5	3	1	2	3	0	0	2	14	10	16
12	5-10	K	M	2	3	3	4	2	3	5	1	14	14	24
13	6-7	K	F	4	4	1	3	7	3	4	2	19	17	28
14	6-4	K	F	8	7	4	3	8	5	8	1	30	29	44
15	6-5	K	F	8	8	8	7	7	8	8	3	38	35	57
16	4-1	K	M	4	4	4	1	1	4	2	2	14	16	22
17	5-11	K	M	8	8	8	8	8	8	8	6	40	38	62
18	5-11	K	M	2	5	2	3	0	4	1	1	12	13	18
19	5-6	K	F	8	8	8	7	7	8	8	8	38	40	62
20	7-9	K	M	8	8	6	7	8	8	8	6	37	38	59
21	7-0	1	M	7	8	8	7	8	8	8	3	38	34	57
22	8-10	1	M	4	4	6	4	5	5	4	2	23	19	34
23	7-7	1	M	4	3	1	1	1	1	1	2	10	11	14
24	8-2	1	M	8	8	8	8	8	8	8	4	40	36	60
25	7-1	1	F	8	8	8	6	8	8	8	5	38	37	59
26	7-2	1	M	8	8	7	6	8	8	8	3	37	35	56
27	8-4	1	M	8	8	8	8	8	8	8	6	40	38	62
28	8-2	1	F	8	8	8	7	8	8	8	6	39	38	63

*Chronological age in years - months

Subject Number	C.A.	Grade	Sex	Tasks 1	2	3A	4A	5A	3B	4B	5B	Total Braille Sequence	Total Optacon Sequence	All Tasks
29	7-4	1	F	8	8	8	8	8	8	8	8	40	40	64
30	8-1	1	F	8	8	8	7	8	8	8	6	39	38	61
31	5-9	1	F	8	8	7	7	8	8	8	0	38	32	54
32	7-6	1	F	8	8	8	8	8	7	8	8	40	39	63
33	7-1	1	M	3	2	1	1	1	1	1	1	8	8	11
34	8-1	1	M	8	8	8	7	8	8	8	8	39	40	63
35	6-9	1	F	8	8	8	8	8	8	8	7	40	39	63
36	7-5	1	F	8	8	8	8	8	8	8	7	40	39	63
37	8-10	1	M	6	7	3	2	3	6	4	2	21	25	33
38	6-10	1	M	8	8	8	8	8	8	8	5	40	37	61
39	8-5	1	F	8	8	7	5	7	8	8	6	35	38	57
40	7-0	1	F	8	8	8	6	6	8	7	3	36	34	54
41	7-11	2	F	8	8	8	7	8	8	8	5	39	37	60
42	7-4	2	F	8	8	8	8	8	8	8	8	40	40	64
43	9-3	2	F	8	8	6	6	8	8	8	7	36	39	59
44	7-5	2	F	8	8	8	7	8	8	8	7	39	39	62
45	8-10	2	F	8	8	8	6	8	8	8	6	38	38	60
46	9-8	2	M	8	8	8	8	8	8	8	8	40	40	64
47	8-5	2	F	8	8	8	7	8	8	8	7	39	39	62
48	10-1	2	F	8	8	7	8	8	8	8	7	39	39	62
49	11-8	2	F	8	8	8	5	8	8	7	7	37	38	59
50	9-11	2	M	7	6	8	7	8	8	8	3	36	32	56
51	7-10	2	F	8	8	8	8	8	8	8	8	40	40	64
52	7-2	2	M	6	8	8	8	8	8	8	8	38	38	62
53	8-11	2	F	6	6	1	1	1	1	2	1	15	16	19
54	9-6	2	F	8	8	8	8	8	8	8	8	40	40	64
55	7-10	2	F	8	8	8	8	8	8	8	8	40	40	64
56	8-0	2	F	8	8	8	8	7	7	8	7	39	38	61
57	7-7	2	M	8	8	8	8	8	8	8	8	40	40	64
58	6-0	2	F	8	8	8	8	8	8	8	8	40	40	64
59	7-0	2	M	8	8	8	8	8	8	8	8	40	40	64
60	7-9	2	M	8	8	8	8	8	8	8	8	40	40	64

REFERENCES

American Institutes for Research. Education evaluation of the Optacon (Optical-to-Tactual Converter) as a reading aid to blind elementary and secondary students. Final report on Contract No. OEC-0-72-5180 under grant from the Bureau of Education for the Handicapped, September, 1974.

American Printing House for the Blind. Educational Research, Development and the Reference Group Report on Research and Development Activities-Fiscal 1974.

Aschroft, S. C. Errors in oral reading of braille at elementary grade levels. Doctoral dissertation, University of Illinois, 1960.

Aukerman, R. C. Approaches to Beginning Reading. New York: John Wiley & Sons, Inc., 1971.

Austin, T. R., & Sleight, R. B. Accuracy of tactual discrimination of letters, numerals and geometric forms. Journal of Experimental Psychology, 1952, 43, 239-247 (a).

Austin, T. R., & Sleight, R. B. Factors related to speed and accuracy of tactual perception. Journal of Experimental Psychology, 1952, 44, 283-287 (b).

Axelrod, S. Effects of early blindness: Performance of blind and sighted children on tactile and auditory tasks. (Research Series, No. 7). New York: American Foundation for the Blind, 1959.

Axelrod, S. Report on the effects of early blindness on the performance of blind and sighted children. In American Foundation for the Blind. Report of proceedings of conference on research needs in braille, New York: Author, 1961, p. 52-54.

Baer, J., & Hill, J. W. Optical-to-tactile image conversion for the blind. Stanford Research Institute: Final Report on Project 8647 and 1417 under Grant 14-P-55296/9-02 with the Social and Rehabilitation Service of the Department of Health, Education, and Welfare, June, 1972. Cited by Telesensory Systems, Inc. Optacon training: Teaching guidelines. Stanford, California: Author, 1973.

Bauer, H. J. Discrimination of tactual stimuli. Journal of Experimental Psychology, 1952, 44, 455-459.

Benton, C., & Ellis, A. Teaching reading to beginning students. International Journal for the Education of the Blind, May, 1956, 5: 88-90.

Berg, J., & Worchel, P. Sensory contribution to human maze learning: A comparison of matched blind, deaf and normals. Journal of General Psychology, 1956, 54, 81-93.

Birch, H. G., & Lefford, A. Intersensory development in children. Monographs of the Society for Research in Child Development. 1963, 28, p. 63-67 (2, serial no. 86).

Bliss, J. C. Summary of three Optacon-related cutaneous experiments. In F. A. Geldard (Ed.) Conference on Vibrotactile Communication, Austin, Texas: The Psychonomic Society, 1974.

Bliss, J. C., & Crane, H. D. Tactile perception. Research Bulletin, 1969, 19, 205-231.

Boozer, R. F., & Lindvall, C. M. An investigation of selected procedures for the development and evaluation of hierarchical curriculum structures, 1971/23, Learning Research and Development Center, University of Pittsburgh, 1971.

Bottrill, J. H. Locomotor learning by the blind and sighted. Perceptual and Motor Skills, 1968, 26, 282.

Brown, M. S., & Stratton, G. M. The spatial threshold of touch in blind and seeing children. Journal of Experimental Psychology, 1925, 8, 434-442.

Bürklen, K. Touch Reading of the Blind (Translated by F. K. Merry). New York: American Foundation for the Blind, 1932.

Cardinale, J. F. Methods and procedures of braille reading. Research Bulletin, June, 1973, No. 26, 171-183.

Carrow, M. A. The development of auditory comprehension of language structure in children. Journal of Speech and Hearing Disorders, May, 1968, 33, 105-108.

Casler, L. The effects of extra tactile stimulation on a group of institutionalized infants. Genetic Psychology Monograph, 1965, 71, 137-75.

Caton, H. R. Tactual Discrimination Worksheets. Peronal communication, December, 1974.

Chall, J. S. Learning to Read: The Great Debate. New York: McGraw-Hill Book Co., 1967.

Crandell, J., Hammill, D., Witkowski, C., & Barkowich, F. Measuring form discrimination in blind individuals. International Journal for the Education of the Blind, 1968, 18(3), 65-68.

DeCecco, John P. The Psychology ot Learning and Instruction: Educational Psychology. New Jersey: Prentice-Hall, Inc., 1968.

Duncan, B. Suggestions for using Touch and Tell, a readiness book for future braille readers. Louisville, Ky.: American Printing House for the Blind, 1974.

Eaves, L., & Klonoff, H. A comparison of blind and sighted children on a tactual and performance test. Exceptional Children, 1970, 37, 269-273.

Elms, H. Shortcuts in learning braille. International Journal of Education of the Blind, Oct., 1959, 9, No. 1, 4-9.

Ewart, A. G., & Carp, M. Recognition of tactual forms by sighted and blind subjects. American Journal of Psychology, 1963, 76, 488-491.

Flanigan, P. J. Automated training and braille reading. New Outlook for the Blind, May, 1966, 60, No. 5, 141-146.

Flanigan, P. J., & Joslin, E. S. Patterns of response in the perception of braille configurations. The New Outlook for the Blind. Oct., 1969, 63, No. 8, pp. 232-244.

Foulke, E. Non-Visual Communications, X Reading by touch, Education of the Visually Handicapped, March, 1971, 25-28.

Fraiberg, Selma. Parallel and divergent patterns in blind and sighted infants. Psychoanalytic Studies of the Child, 1968, 23, 272-286.

French, R. S. From Homer to Helen Keller, New York: American Foundation for the Blind, 1932.

Gagné, R. M. The Conditions of Learning. New York: Holt, Rinehart and Winston, 1965.

Gescheider, G. A. Some comparisons between touching and hearing. Institute of Electrical and Electronics Engineers, Inc. Transactions on Man-Machine Systems, March, 1970, Vol. MMS-11, No. 1, p. 28-35.

Gesell, A. and Amatruda, C. S. Developmental Diagnosis: Normal and Abnormal Child Development. New York: Harper & Row, Publishers, 1947.

Gesell, A., Ilg, F. L., & Bullis, G. E. Vision: Its Development in Infant and Child, New York: Hafner Press, 1949.

Ghent, L. Developmental changes in tactile thresholds on dominant and non-dominant sides. Journal of Comparative Physiological Psychology, 1961, 54, 670-673.

Gibson, E. J. Principles of Perceptual Learning and Development. New York: Appleton-Century-Crofts, 1969.

Gibson, E. J., Gibson, J. J., Pick, A. D., & Osser, H. A. A developmental study of the discrimination of letter-like forms. Journal of Comparative and Physiological Psychology, 1962, 55, 897-906.

Gibson, J. J. Observations on active touch. Psychological Review. Nov., 1962, 69(6), 477-491.

Gibson, R. H. Perception of apparent movement from cutaneous electrical stimulation. Research Bulletin, April, 1965, 9, 13-21.

Gill, J. M., & James, G. A. A study on the discriminability of tactual point symbols. Research Bulletin, June, 1973, 26, 19-34.

Gilmer, B. Von Haller. Problems in Cutaneous Communication from Psychophysics to Information Processing. New York: American Foundation for the Blind, 1966.

Glaser, R., & Resnick, L. B. Instructional Psychology, 1972/6 Learning Research and Development Center, University of Pittsburgh, 1972.

Gliner, C. R. Tactual discrimination thresholds for shape and texture in young children. Journal of Experimental Child Psychology. 1967, 5, 536-547.

Goldish, L. H., & Taylor, H. E. The Optacon: A valuable device for blind persons. New Outlook for the Blind, 1974, 68(2), 49-56.

Gomulicki, B. R. The Development of Perception and Learning in the Blind. The Psychological Laboratory, London: Cambridge University Press, 1961.

Gottesman, M. A comparison study of Piaget's development schema of sighted children with that of a group of blind children, Child Development, 1971, 42(2), 573-580.

Guttman, L. The basis for scalogram analysis. In S. A. Stauffer, et al. (Eds.) Measurement and Prediction. Vol. IV. Studies in Social Psychology in World War II. Princeton: Princeton University Press, 1950.

Hammill, D., & Crandell, J. M., Jr. Implications of tactile-kinesthetic ability in visually handicapped children' Education of the Visually Handicapped, 1969, 1(3), 65-69.

Henderson, F. The effect of character recognition training on braille reading. Unpublished Specialist in Education Thesis. George Peabody College for Teachers, 1967. Cited in R. G. Umsted, Improvement of braille reading through code recognition training. Unpublished doctoral dissertation, George Peabody College for Teachers, 1970.

Holland, B. F. Speed and pressure factors in braille reading. Teachers Forum, 1934, 7, 13-17.

Honstead, C. The developmental theory of Jean Piaget. In J. L. Frost (Ed.) Early Childhood Education Rediscovered. New York: Holt, Rinehart and Winston, Inc., 1968, pp. 132-45.

Hunter, I. M. L. Tactile-kinesthetic perception of straightness in blind and sighted humans. Quarterly Journal of Experimental Psychology, 1954, 6, 149-154.

Karp, S. Experiments in tactual perception. Research Bulletin, Dec., 1962, No. 2, 14-21.

Kederis, C. J., Nolan, C. Y., & Morris, J. E. The use of controlled exposure devices to increase braille reading rates. International Journal of Education of the Blind, 1967, 15, 38-46.

Kederis, C. J., Siems, J. R., & Haynes, R. L. A frequency count of the symbology of English braille grade 2, American usage. International Journal of Education of the Blind, 1965, 15, 38-46.

Kenmore, J. R. Enrichment of the primary reading program. New Outlook for the Blind. Feb., 1957, 56-64.

Knotts, J. R., & Miles, W. R. The maze learning ability of blind compared with sighted children. Journal of Genetic Psychology, 1929, 36, 21-50.

Koch, H. L., & Ufkess, J. A comparative study of the stylus maze learning by blind and seeing subjects. Journal of Experimental Psychology, 1926, 9, 118-131.

Kohnstamm, G. A. An evaluation of part of Piaget's theory. Acta Psychologica, 1963, 21, 313-56.

Kurzhals, I. W. Reading made meaningful through a readiness for learning program. International Journal for the Education of the Blind, 1966, 15(4), 107-111.

Kurzhals, I. W., & Caton, H. R. A tactual road to reading. Unpublished. Louisville, Ky.: American Printing House for the Blind, 1974.

Kusajima, T. Visual Reading and Braille Reading: An Experimental Investigation of the Physiology and Psychology of Visual and Tactual Reading. New York: American Foundation for the Blind, 1974.

LaPresta, J. J. The effects of alteration of the mastery criterion on the scales produced by a multiple scalogram analysis of a learning program. Masters thesis, University of Pittsburgh, 1975.

Liguori, Sr. M. Building reading readiness in blind children. New Outlook for the Blind, 1956, 50, 295-302.

Lowenfeld, Berthold (Ed.). The Visually Handicapped Child in School. New York: The John Day Company, 1973.

Lowenfeld, B., Abel, G. L., & Hatlen, P. H. Blind Children Learn to Read. Springfield, Illinois: Charles C. Thomas, 1969.

Maxfield, K. E. The Blind Child and His Reading. New York: American Foundation for the Blind, 1928.

Merry, F. K. A further investigation to determine the value of embossed pictures for blind children. Teachers Forum, 1932, 4, 96-99.

Merry, F. K. An experiment in teaching blind children to recognize simple embossed pictures. Teachers Forum, 1933, 5, 73-76, 78.

Merry, R. V. To what extent can blind children recognize tactually simple embossed pictures? Teachers Forum, 1930, 3, 2-5.

Merry, R., & Merry, F. The tactual recognition of embossed pictures by blind children. Journal of Applied Psychology. 1933, 17, 148-163.

Meyers, E., Ethington, D., & Ashcroft, S. Readability of braille as a function of three spacing variables. Journal of Applied Psychology, 1958, 42, 163-165.

Moore, M. W., & Bliss, J. C. The Optacon reading system. Education of the Visually Handicapped, May, 1975, 7, no. 2, p. 33-39.

Nissen, H. W., Chow, K. L., & Semmes, J. Effects of restricted opportunity for tactual kinesthetic and manipulative experience on the behavior of a chimpanzee. American Journal of Psychology, 1951, 64, 485-507.

Nolan, C. Y. Relative legibility of raised and incised tactual figures. Education of the Visually Handicapped, 1971, 3(2), 33-36.

Nolan, C. Y., & Kederis, C. J. Perceptual Factors in Braille Word Recognition, Research Series, No. 20. New York: American Foundation for the Blind, 1969.

Nolan, C. Y., & Morris, J. E. Variability among young children in object recognition. International Journal for the Education of the Blind, Oct., 1960, 23-25.

Nolan, C. Y., & Morris, J. E. Tactual symbols for the blind. Final Report: OVR-RD-587. Louisville, Ky.: American Printing House for the Blind, 1962.

Nolan, C. Y., & Morris, J. E. Development and validation of the Roughness Discrimination Test. International Journal for the Blind, Oct., 1965, 1-6.

Paine, R. S., & Oppé, T. E. Neurological Examination of Children, London: Spastics Society Medical Education and Information Unit & Wm. Heinmann Medical Books Ltd., 1966.

Piaget, J. Psychology of Intelligence. Patterson, NY: Little-field, Adams & Co., 1960.

Pick, A. D. Improvement of visual and tactual form discrimination. Journal of Experimental Psychology, 1965, 69, 331-339.

Pick, A. D., & Pick, H. L. Jr. A developmental study of tactual discrimination in blind and sighted children and adults. Psychonomic Science, 1966, 6, 367-8.

Pittam, V. G. Reading readiness. New Outlook for the Blind, 1965. 59, 322-324.

Resnick, L. B., Siegel, A. W., & Kresh, E. Transfer and sequence in learning double classification skills. Journal of Experimental Child Psychology, 1971, 11, 139-49.

Resnick, L. B., & Wang, M. C. Approaches to the validation of learning hierarchies. Preprint 50, Learning Research and Development Center, University of Pittsburgh, 1969.

Resnick, L. B., Wang, M. C., & Kaplan, J. Behavior analysis in curriculum design: A hierarchically sequenced introductory mathematics curriculum. Monograph 2, Learning Research and Development Center, University of Pittsburgh, 1970.

Rex, E. J. A study of basal readers and experimental supplementary instructional materials for teaching primary reading in braille. (Part I: An analysis of braille features in basal readers). Education for the Visually Handicapped, 1970, 2, 97-107.

Rice, C. E. Early blindness, early experience, and perceptual enhancement. Research Bulletin, 1970, 22, 1-22 (AFB).

Rivenes, R. S., & Cordellos, H. C. Kinesthetic performance by blind and sighted. Perceptual and Motor Skills, 1970, 30, 76.

Rodenberg, L. W. The Story of Embossed Books for the Blind. Educational Series, No. 2. New York: American Foundation for the Blind, 1955.

San Diego Unified School District. EHA Title VI-B: Optacon Readiness and Elementary Reading Materials. San Diego, California: Author, 1974.

Schecter, N. L. Tactile vs. Tactual. New Outlook for the Blind, (Sept.) 1973, 67(7), 321-2.

Schiff, W. Using raised line drawings as tactual supplements to recorded books for the blind. Final Report, RD-1571-S, Recordings for the Blind. New York: June, 1967. Cited in J. M. Gill and G. A. James. A study on the discriminability of tactual point symbols. Research Bulletin. 1973, 26, 19-34.

Scholl, G. T. Understanding and meeting developmental needs. In B. Lowenfeld (Ed). The Visually Handicapped Child in the School. New York: The John Day Company, 1973.

Seashore, C. L., & Ling, T. L. The comparative sensitiveness of blind and seeing persons. Psychological Monographs, 1918, 25(108), 148-158.

Silver, H. K. Growth and development. In C. H. Kempe, H. K. Silver & D. O'Brien. Current Pediatric Diagnosis and Treatment. Los Altos, California: Lange Medical Publications, 1972.

Telesensory Systems, Inc. (TSI) Optacon training: Teaching guidelines. Stanford, California: Author, 1973.

Tinker, M. A. Preparing Your Child for Reading. New York: Holt, Rhinehart and Winston, 1974.

Umsted, R. G. Improvement of braille reading through code recognition training: Review of the literature and bibliography. Research Bulletin, June, 1971, 23, 50-62.

Umsted, R. G. Improvement of braille reading through code recognition training. Unpublished. Doctoral dissertation, George Peabody College for Teachers, 1970.

Uniform Type Committee. Report of the uniform type committee. Outlook for the Blind, 1908, 1, 154-162.

Uniform Type Committee. Report of the uniform type committee. Outlook for the Blind, 1910, 4, 73-81.

Uniform Type Committee of the American Association of Workers for the Blind: Fourth Biennial Report. Outlook for the Blind, 1913, 7, 1-48.

Wang, M. C. Psycho metric studies in the validation of an early learning curriculum. In L. B. Resnick (Ed.) Hierarchies in children's learning. Learning Research and Development Center, University of Pittsburgh, 1971.

Wang, M. C., Resnick, L. B.,& Boozer, R. The sequence of development of some early mathematics behavior. Child Development, 1971, 42, 1767-1778.

Wegehoft, J. My Fingers Do Good Work, A story-related approach to preprimer braille drills. Louisville, Ky.: American Printing House for the Blind, in press.

Weiner, L. H. The performance of good and poor braille readers on certain tests involving tactual perception. International Journal for the Education of the Blind, 1963 12(3), 72-77.

White, C. T., & Cheatham, P. G. Temporal numerosity: IV. A comparison of the major senses. Journal of Exceptional Psychology, 1959, 6, 441-444.

Zaporozhets, A. V. The development of perception in the preschool child. In Monographs of the Society for Research in Child Development. 1965, 30(4, Serial No. 112).

Zickel, V. W.,& Hooper, M. S. The program of braille research: A progress report. International Journal of Education of the Blind, 1957 (May), 6, 79-86.

Zimmerman, R. The facilitation of picture discrimination after object discrimination learning in the neonatal monkey and probably vice versa. Paper read at the meeting of the Psychonomics Society, Niagara Falls, 1964. Cited in E. J. Gibson, Principles of Perceptual Learning and Development. New York: Appleton-Century-Crofts, 1969.