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UNIVERSITY OF ALBERTA

THE ADAPTATION OF THE COGNITIVE ASSESSMENT SYSTEM (CAS) FOR USE WITH BLIND PERSONS

BY

MARION ELISABETH DE MAN

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY

IN

SCHOOL PSYCHOLOGY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

SPRING, 1993

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled The adaptation of the Cognitive Assessment System (CAS) for use with blind persons, submitted by Marion E. de Man in partial fulfillment of the requirements for the degree of Doctor of Philosophy in School Psychology.

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DEDICATED

TO

DR. MARGARET WILKINSON

for her support and encouragement

in every possible way

AND

My father PIETER

My mother CORRIE

for sharing my dream

ABSTRACT

The primary purpose of this research was to adapt the Cognitive Assessment System (CAS) for use with blind persons and to examine the efficacy of changing the visual test materials into a tactual format. The second purpose was to gather evidence that each CAS test adapted for the blind was a measure of the construct it was designed to assess. The third purpose was to examine if congenitally blind persons engage in simultaneous processing to code information they receive through successive tactual inputs. The final purpose was to compare the performance of congenitally blind and blindfolded persons on tests that use a tactual format.

In Study 1, test materials were adapted and administered to 30 congenitally blind persons ranging in age from 19 to 43 years. Findings showed that the seemingly simple translation of letters or numbers into braille may have changed the task-demands of some tests, but did not affect others. The dynamic processes that underlie the constructs of Planning, Attention, and Simultaneous and Successive processing were examined by questioning all subjects and analyzing the video tapes of the assessment sessions. Findings were supportive of the four constructs. Congenitally blind subjects were able to process tactual/spatial information simultaneously, but there were differences in their ability to do so. The capacity of their working memory, and their facility of attaching verbal labels to the tactually perceived information, appeared to influence how well they were able to process information in a simultaneous manner.

In Study 2 the performance of the same 30 congenitally blind subjects, as well as 15 tactually experienced and 15 tactually inexperienced, blindfolded-sighted subjects, of similar ages, were compared on tests utilizing a tactual format. The sighted were able to evoke visual images for some of the test materials, demonstrating more facility than the blind in attaching verbal labels to the tactually perceived forms. The blind had more facility in using a tactual frame of reference and representational system. Implications for further research are discussed.

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CHAPTER I

INTRODUCTION

Assessment of cognitive abilities is an important element in the development of individualized educational programmes for blind students and in the formulation of rehabilitative and vocational services for blind adults. Effective programming, rehabilitation, and informed vocational choice are only possible when there is a clear understanding of the ability level, interests, and personal qualities of a given individual. Assessment is a multifaceted process of gathering information (Ysseldyke, 1979). The administration and interpretation of tests represent only one aspect of this process, but its importance cannot be underestimated. Intelligence tests, in particular, are used frequently by school systems, post secondary institutions, and clinics in the classification, labelling, educational and vocational placement, and remediation of many students and clients. This is the case, even though the nature of intelligence and its relationship to quantifiable scores has not been adequately established in the literature.

In the United States, Public Law 94-142 required that students be assessed with instruments validated for the particular purpose for which they were being used (DHEW, 1977). Public Law 94-142 stimulated considerable controversy in Canada and the United States about how intelligence tests were being used and interpreted with handicapped students (Scholl, 1984). Since many of the published tests for the blind had gone out of print and efforts at developing new tests had been abandoned psychologists were faced with the choice of either a very limited range of instruments designed specifically for blind individuals, or the option of modifying tests developed for the sighted population (Newland, 1979). In addition, psychologists had to deal with the fact that the normative tests currently in print that were originally designed for the blind, fail to meet minimum standards for technically adequate measures (Bradley-Johnson, 1986).

The lack of appropriate tests for the blind population is a serious matter. Information is needed on the cognitive processes of the blind and improvements are also required in the relevant areas of psychometry. Consequently, information reported on the cognitive functioning of blind persons has had to be interpreted with caution, as conclusions reached were likely to be based on either the use of technically inadequate measures, or adaptations of measures which were normed on the sighted population. Assessments based on inadequate test instruments may lead to misdiagnoses and faulty categorization. Additionally, decisions in the areas of educational programming, counselling, and vocational training may be adversely affected.

A definition of intelligence needs to be included in the test manual of all cognitive assessment instruments in order for results to be interpreted with integrity. The construct of intelligence has been defined in various ways by different theorists (Cattell, 1963; Galton, 1883; Guilford, 1956; Spearman, 1904; Wechsler, 1974). Intelligence, generally has been conceived of as including abilities that are both verbal and non-verbal. Numerous measures of intelligence have been devised and extensively utilized, reflecting different theoretical viewpoints on what is meant by intelligence.

Substantive theoretical shifts regarding the nature of intelligence have gone unheeded in the test publishing industry (Kaufman, 1979). During the last decade the need for theory-driven assessment instruments has become a priority for a number of test developers (Das, Kirby, & Jarman, 1979; Kaufman, 1979). These developers advocate that tests need to have solid theoretical underpinnings demonstrating an obvious alignment with a particular theory, which is reflected in the rationale used in item selection.

A model of intelligence based on the writings and research of Luria (1966a, 1966b, 1970, 1973) was developed by Das and Naglieri (1990). This model is known by its acronym PASS, which refers to planning, attention, and simultaneous and successive cognitive processing. Many experimental tests, that purport to measure the PASS constructs, have been developed by Das and his associates. Most notably, Das and Naglieri (1987, 1989) have created the Das-Naglieri Cognitive Assessment System (CAS), which has been available on a tryout basis. This battery holds promise for the assessment of cognitive functioning not only in the general population but also in the sensory impaired and the mentally handicapped populations. The subtests in this battery are most efficiently solved by predominantly using one of the four PASS constructs. This allows for interpretation of assessment results within the context of the PASS theory.

With respect to the present study, the major purpose was to adapt the CAS for use with blind persons. Adaptations made to the CAS included: (a) the selection of test items with the potential to measure the constructs of planning, attention, and simultaneous and successive processing; (b) the collection of data for initial test norms; and (c) the making of test refinements by reducing the length of the battery and by establishing time limits for testing.

The second purpose of this study was to evaluate whether the adapted version holds promise for the assessment of the constructs of planning, attention, and simultaneous and successive processing among blind persons.

The third purpose of this study was to examine whether or not information is processed independent of sensory reception. The question specifically addressed was whether information received successively can be processed simultaneously. Congenitally blind persons, who have no visual memory, were considered to be the best population for the investigation of this question, since they receive information through the tactual and auditory modalities, which depend on successive inputs.

The final purpose of this study was to gain an understanding of the ability of blind and sighted individuals to perceive and evaluate information received through the tactual sense, as well as to obtain preliminary data on the strategies used by the blind and their blindfolded-sighted counterparts while completing the tests that have a tactual format. An attempt to accomplish this was made by comparing the performance of congenitally blind adults with that of blindfolded-sighted potters and non-potters. The potters were experienced in using their tactual sense to gain information, while the non-potters were not experienced in using the tactual modality. All subjects were questioned on the strategies they used while completing the tests. The subjects were also videotaped to allow for observational analysis.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Cognitive Assessment Practices of Blind Persons

Terminology and Incidence of Blindness

It is difficult to obtain an accurate estimate of the number of blind persons in North America, as there are no central registries in Canada or the United States. In addition, there is a lack of consensus on the definition of blindness. By means of illustration, although statistics on the number of blind Canadians are kept within a registry of the Canadian National Institute for the Blind (CNIB), registration with the CNIB is on a voluntary basis and the registry includes legally blind persons, as well as individuals with poor or failing vision. According to this registry (CNIB, 1991) there were about 70,420 blind and visually impaired persons in Canada in 1991, of which 4,201 were under the age of eighteen years. CNIB officials estimate that approximately 90 per cent of these persons had some residual vision. These numbers are underestimates, because many blind Canadians choose not to register with the CNIB.

The generally accepted legal definition of blindness in North America, includes all persons whose visual acuity is equal to, or less than, 20/200 in the better eye, after the best possible correction, or those who have a field of vision equal to, or less than, 20 degrees (Heward & Orlansky, 1980). Of those who qualify as legally blind by this definition, 80 percent may have some usable vision (Robinson, 1985). Legal blindness includes individuals who are absolutely blind, in addition to those who have some light perception, motion perception, or form perception (Jordan, 1978). Light perception allows the individual to tell whether it is light or dark. Light perception often does not extend to a localized perception of light but is more of a generalized nature (Faye, 1984).

The impairment of eye structures and tissue can be due to many conditions. Some originate during the prenatal period or the birth process, while others may develop during the lifespan. Congenital blindness usually means that the condition is present at birth, while adventitious blindness means that conditions are acquired by, or caused by, accident after birth. However, for the purpose of this study, the term congenitally blind will refer to those individuals who have light perception or less, who lost their sight during their first two years of life, and who do not have visual memory. The term adventitiously blind will refer to persons who became blind after age two, and who have retained some visual memory. These definitions are in agreement with the terminology used in most research studies.

Issues in Test Development for the Blind

Ideally, assessments should provide information about both the product and process of learning (Spungin & Swallow, 1975). The product of learning is often measured by norm referenced measures. Items thought to sample the domain of behaviors believed to reflect intelligence are also norm referenced, but vary because of differing conceptualizations of intelligent behaviors. The norm-referenced intelligence tests compare a single scoring profile with the measures obtained from testing a larger group. Individual performances can be compared with the performance of others of the same age. The information obtained can be used to identify general areas of strength and weakness as compared to those of the normative group. The measurement of the process of learning is in its infancy and is being developed by the systematic and direct observation of the strategies adults and children use while engaged in problem solving.

The performance of blind adults and children on standardized, norm-referenced intelligence tests may not be valid as an indicator of skills and abilities, and as a predictor of school success. The value of results from a standardized test depends in large measure on the characteristics of the normative group. The same test items may create different demands for adults and children with different backgrounds, experiences, and learning opportunities (Salvia & Ysseldyke, 1981). The environments of blind and sighted persons are different. Congenitally blind persons, who have no memory of visual experiences, still have a wealth of information about the visual world. Their knowledge is primarily received through the tactual and auditory modalities, which allow them to gain an understanding of such complex relations as perspective, depth, and occlusion (Kennedy, 1980). That blind individuals do not necessarily have equal opportunities for tactual learning is a continuing concern for those charged with any assessment of this population. Opportunities are varied, since they depend on the family environment and the educational history of each individual. Some of the information that cannot be obtained through tactual exploration can be acquired through verbal instruction. Representation of information is therefore different between individuals who are congenitally blind and those who are sighted. Sighted persons can use visual imagery to mentally represent tangible objects, whereas congenitally blind persons must rely on semantic representations or other figurative modalities. It is difficult for people who have their sight, to avoid projecting some of their own visual meanings onto the tactual perceptions of blind persons and not to assume that what is felt is the same as what is seen; for example, a sea lion made out of pottery is not going to give the blind person a realistic concept of a sea lion, as the size, slipperiness of the skin, temperature, sound, and smell are left out. The model might look like a sea lion, but does not feel like one (Cutsforth, 1951). Révész (1933) noted that "there is no visual experience which from a phenomenologic point of view has anything in common with an acoustic or haptic experience" (p.29). Blind persons experience difficulty in gaining complete representations of very large objects. The story, for example, of the blind men feeling different parts of an elephant, and each coming up with a different concept of what they were perceiving, is an accurate reflection of reality for the blind. It is difficult to comprehend the differences that exist between the experiences and reality of blind persons and sighted individuals. A lot of information is gained only through visual experience, including color, brightness, form, movement and spatial distance. Blind adults and blind children gain an awareness of these concepts through language. Their experience of words, such as brown or dim, is different from that of their sighted counterparts. This raises the issue of "verbalism", the use of words by individuals to which they can attach insufficient experiential relations (Harley, 1963). The blind, for example, may be able to give a verbal description or definition of a concept without possessing a true understanding of that concept. French (1932) noted that "the word is never an adequate symbol for the entity, process or idea that it symbolizes" (p. 185). When words without accompanying concrete experiences are accepted by a blind person, there is a danger that the understanding is vague and inaccurate. Blind individuals, because of their lack of visual input, have a relatively restricted range of experience. Therefore, their verbal abilities may not adequately reflect their overall abilities (Warren, 1984). There has been little research comparing tactual and auditory experiences to visual experiences and their subsequent influence on developmental sequences. The influence of vision, or the lack thereof, on learning styles is not well understood. A common test, without appropriate adaptations for differing perceptual modalities, is therefore unable to do justice to both the blind and sighted populations (Warren, 1984).

Blind persons have special needs in the assessment process, which to date have not been adequately met. There are only a small number of formal assessment instruments that have separate norming for blind populations and all have problems with different aspects of their technical adequacy. It is difficult to find a large enough representative sample for norming purposes. The population base is small, scattered, and often difficult to locate. A representative sample should include a breakdown of norms according to level of vision (Vander Kolk, 1981). It is also essential to account for the age at which vision was lost. Congenitally blind persons, as compared to adventitiously blind individuals, should be expected to respond differently to test items because it is generally accepted that previous vision influences conceptual development. Placement in a residential school as compared to placement in a regular school may also influence test performance (Jordan, 1978).

Bauman and Kropf (1979) recommended that norms should be established for the following blind and visually impaired groups:

> (a) those blind from birth vs those who lost vision after establishing visual concepts; (b) those who are totally blind vs those with several levels of useful vision; (c) those who have years of experience as blind persons vs. those recently blinded; and, (d) those in whom blindness is the only significant handicap vs those who are multiply handicapped. (p. 259)

They acknowledged that establishing norms for these different groups would be a time-consuming and expensive process. Regardless of the stringency of criteria imposed on sample selection, it is difficult to control for all the variables because of the heterogeneity of the blind population. It is also difficult to find sufficient numbers of subjects when high standards are maintained, because of the low incidence of blindness in North America.

The Need for Intelligence Tests for the Blind

Questionnaires were sent by Bauman and Kropf (1979) during 1978-79 to agencies and schools in North America, soliciting information about the type of tests being administered to the blind and visually impaired. They received replies from 104 psychologists in 32 states and five provinces. Their data showed that the Wechsler tests were by far the most frequently used. The respondents rated them from good to adequate, but noted that the Performance subtests could only be used by some of the visually impaired. The Haptic Intelligence Scale for the Adult Blind (Shurrager & Shurrager, 1964) was also reported to be widely used, but was rated from good to questionable. The Stanford-Ohwaki-Kohs Block Design Intelligence Test for the Blind (Suinn & Dauterman, 1966) was considered somewhat popular and received scattered ratings from high to low. It was apparent that there was no unanimity among the psychologists regarding the types of tests they used and their evaluation of these tests. Psychologists voiced their greatest dissatisfaction with the tests that purported to assess non-verbal intelligence. Bauman and Kropf reported that, with the possible exception of the Verbal tests of the Wechsler Scales, no test was fully accepted for use with the blind or visually impaired and that research was needed. They recommended that a more thorough study of tests be conducted, including a laboratory evaluation, a description of the population for whom the test is deemed to be effective, as well as instructions for adaptation of the test materials, procedures, and interpretation. The survey showed that psychologists tend to use assessment instruments with the blind and visually impaired that have not been normed on these populations. The rationale for this practice is often twofold: (a) the blind live in a sighted world and should be measured against that standard, and (b) the goal of the assessment is to discover the individual's ability to function in the environment of the sighted (Bateman, 1965). Although the rationale is understandable, it is based on the faulty assumption that a test is valid for the blind mainly because it is valid for the sighted. Any score comparisons between blind persons and sighted individuals are of unknown validity, since test norms for the sighted reflect sensory intactness, coordination, and experiential factors, in addition to intellectual or developmental status (Swallow, 1981).

Modifications to individual intelligence tests that are often made to adapt them for use with blind persons include: (a) changing the stimulus item by substituting concrete pictures for symbolic pictures or words, using objects instead of pictures, enlarging pictures or print, transcribing print into braille, or reading items out loud; (b) omitting items; or (c) changing the response mode by allowing gesturing or pointing, presenting items in a multiple choice or yes/no manner, using braille answer sheets, typing or brailling answers, having oral responses recorded by the examiner, or by lengthening the time permitted. The general rule for allowing time extensions is to allot one and a half times the regular period for large print and twice the usual time for readers of braille. The practice of reading aloud multiple-choice answers should be avoided as it places a heavy load on memory and puts the individual tested at a disadvantage (Bauman and Kropf, 1979; Swallow, 1981; Turner and Erchul, 1987). Such adaptations may affect the validity of the norms and decrease the reliability, when only portions of the test are administered. Adaptations also increase the chance that the item content is inappropriate (Goldman & Duda, 1980). Tests that were designed for a sighted population often contain items that require visualization and knowledge that is usually obtained visually. Blind individuals would not be aware of such information, unless someone had informed them. Swallow (1981) noted that the advantages of modifying a test are examiner familiarity with the test and lowered costs because new materials are not required. When using normative data, based on a sighted population, for blind persons, it should be kept in mind that such data cannot adequately predict their success in school or vocational training, although results obtained in this manner may provide diagnostic information about individual strengths and weaknesses, which might be helpful in designing an education plan. Reports of such findings need to indicate that a nonstandardized assessment was performed and that interpretation was based on behavioral observations of the individual's interaction with the test items. Formal comparison to the sighted normative group should not be made when the purpose of the assessment is to predict future success in school or vocational training. This was emphasized by Warren (1984), who stated that "a test should not be used for prediction in situations where it has not been demonstrated to have good predictive validity" (p.180).

The specially designed tests for the blind frequently suffer from low validity and reliability. Some of the problems include: (a) inadequate sampling and outdated norms; (b) inadequate psychometric properties; (c) poorly standardized test instructions; (d) lengthy administration time; (e) unavailability of manuals or kits and outdated materials; and (f) difficulty with interpretation of scores because of lack of supporting documentation (Bauman, 1975; Bauman & Kropf, 1979; Gutterman, Ward & Genshaft, 1985; Turner & Erchul, 1987). Another concern is that most of these tests are verbal tests. This places an individual who is not verbally oriented at a disadvantage (Coveny, 1976; Hatwell, 1978). Blind persons, however, who perform well on verbal tests often demonstrate a less than average ability to cope with vocational activities and daily life experiences (Dauterman, Shapiro & Suinn, 1967).

Given the problems that are associated with administering only verbal tests to the blind, it is interesting that the Verbal subtests of the Wechsler Intelligence Scales are widely accepted as assessment instruments of choice with the blind population (Bauman & Kropf, 1979). This is mainly because they are easy to administer, appear to require only minimal modification for use with blind adults and children, and are extensively used with the sighted population. The Verbal subtests of the Wechsler Intelligence Scale for Children-Revised (WISC-R) and the Wechsler Adult Intelligence Scale-Revised (WAIS-R) are often solely used to establish the cognitive functioning level of the blind. This is the case despite the fact that Wechsler (1974) conceived of intelligence as a global entity in which all abilities are equally important. The Performance subtests of the Wechsler Intelligence Scales are ignored with the blind because they rely on intact visual functioning. The comparison of the blind and sighted on the Verbal subtests is unsatisfactory because of a lack of norms for the blind and because verbal intelligence is normally considered only one facet of intelligence (Warren, 1984).

Research comparing the performance of blind and sighted children on the Verbal subtests of the Wechsler Intelligence Scale for Children (WISC) and WISC-R determined that: (a) they obtain equivalent Verbal IQ's; (b) their profiles differ substantially in that the blind demonstrate better auditory attention and selective exposure to different content areas; (c) blind children do better on the immediate auditory recall of numbers, (d) they do equally well on the more concrete and functional reasoning aspects of abstract reasoning; and (e) blind children experience more difficulty with the higher levels of conceptual thinking (Hopkins & McGuire, 1966; Smits & Mommers, 1976; Tillman, 1967a; Tillman, 1967b; Vander Kolk, 1977, 1981; Warren, 1984). Tillman (1967b) noted that the blind child tends to approach abstract conceptualization problems from a concrete and functional level. Vander Kolk (1977) reviewed a number of studies in which the WISC was administered to blind students. He concluded that there is a fairly consistent higher Digit Span score for the blind, and he suggested that reliance on verbalization may produce a highly developed attention-concentration factor in the blind. Hopkins and McGuire (1966) found greater scatter within the blind group and cautioned against subtest analysis. Smits and Mommers (1976) indicated that only broad information is obtained by studying the differences between blind and sighted children on the WISC. They felt that more differentiated measures are needed to gain a better understanding.

Although a number of efforts have been made to assess the non-verbal cognitive functioning of blind adults and children, none have been very successful. Some of the reasons are that: (a) tactual discrimination varies between individuals because it depends on the level of experience with this modality and physical health and functioning; (b) not enough is known about the cognition of the blind; and (c) non-verbal tests are time consuming to prepare and expensive to distribute.

The Role of Tactual Perception in Test Development

The role of tactual perception in learning is important and should be given priority in measuring learning and cognitive ability among blind persons (Kainthola & Singh, 1992). Assessment batteries that include tests employing a tactual mode of presentation, or response, need to have paid particular attention to the selection of normative samples, time allowances for completion of tasks, and observation measures of tactual scanning strategies.

Selection of normative samples is important because the extent to which visual experience facilitates tactual perception is by no means clear. Whether non-visual tactual information is recoded into a visual image by those with previous visual experience or is coded in a form that is tactual in nature needs further investigation. Tactual perception may be more accurate in blind than in sighted adults. This could be because blind persons may develop and refine abilities which the sighted have little reason to practice (Jones, 1975). Blindfolded-sighted adults and blind adults were compared by Cronin, McLaren and Campbell (1983) on the tactual recognition of ten shapes. They found that the blind performed significantly better on tactual recognition of the shapes than the blindfolded-sighted and that there was no significant difference in their mean time of exploration. Foulke and Warm (1967) found that among adult blind and adult sighted skilled braille readers the blind made fewer errors than the sighted in comparing forms made up of braille-like raised dots. The congenitally blind, however, were found to be poorer than the adventitiously blind or blindfolded-sighted in recognizing raised designs and pictures (Heller, 1989; Kennedy

& Fox, 1977; Lederman, Klatzky, Chataway & Summers, 1990). The difficulty the congenitally blind experience in interpreting raised designs might indicate that some previous visual experience facilitates tactual perception. In fact, Cairns and Coll (1977) found that the performance of good visual imagers was better than poor visual imagers on tactual recognition tasks. Lederman, et al. (1990) suggested that those with previous visual experience might use visual imagery to mediate tactual recognition of the raised designs. However, in a study conducted by Locher (1982), during which sighted undergraduates assembled six-piece jigsaw puzzles under four conditions of visual-tactual perception, subjects reported that during the tactual condition they relied on tactual information and found it difficult to translate this information into a visual image unless they could identify the shape quickly. Marmor and Zaback (1976) explored whether mentally rotated forms must be coded as visual images. They used congenitally blind, adventitiously blind, and blindfolded-sighted adults. Their results suggested that for tactual stimuli, visual imagery is not necessary for mental rotation. The congenitally blind appeared to mentally organize the attributes of tactual forms in such a manner that they were able to entertain them simultaneously, which made mirror image discrimination possible. The blindfolded-sighted and adventitiously blind, however, both surpassed the congenitally blind in speed of mental rotation. They reported that mental rotation might be easier to perform upon visual rather than tactual representations. Different strategies used by blind and blindfolded-sighted groups during tactual form recognition were reported by Bailes and Lambert (1986). The congenitally and adventitiously blind reported using imagery strategies predominantly, while the blindfolded-sighted used mostly a mixture of verbal and imagery codes. Other researchers have found that congenitally blind children could successfully encode pictures using some form of representational system (Kennedy, 1980; Pring, 1987; Pring & Rusted, 1985). Review of the pertinent literature shows that the assumption cannot be made that tactual information is coded in a form that is tactual or verbal in nature, unless the individuals in the sample have no visual memory and are unable to perceive forms visually. If a normative sample were to include both individuals with and without visual memory, the results would be difficult to interpret because visual imagery might be a variable.

Additionally, it cannot be assumed that tactual problem-solving takes approximately twice the time that visual problem-solving takes. The tactual perceptual field is smaller than the visual field. It is usually possible to take in considerable visual information with a single glance. In contrast, the tactual area that can be explored in one glance is limited to the width of the fingertips. Findings from a study conducted by Loomis, Klatzky, and Lederman (1991) suggested that the effective tactual field of view is limited to one finger pad. Exploration by two fingers did not improve accuracy of recognition. In order to take in the same amount of information, tactual perception has to rely more on sequential exploration than vision, because of the restricted field of perception. O'Connor and Hermelin (1978) found that when input was received tactually or auditorially, information was processed serially, while visual input tended to be processed more simultaneously. Although vision also involves a sequential process, depending on a succession of eye fixations, it is much quicker than tactual perception. Sequential exploration imposes a memory load which could make it more difficult to integrate the information and to obtain a holistic appreciation of the design or object. A person examining a design tactually has only the input available that has been intentionally explored, while an individual using vision takes in a large number of cues simultaneously in one single visual fixation. Tactual exploration requires more time than visual exploration. Reasonable time allowances for completion of tests that utilize either a tactual mode of presentation or response need to be established during test development for the different normative groups. It is therefore of interest to note that the revised Standards for Educational and Psychological Testing (American Psychological Association, 1985) suggest that time limits for assessments be established empirically.

Tactual scanning strategies may affect the performance on tests that use a tactual mode of presentation or response. To gain information from a diagram or a map a blind individual needs to conduct a systematic search of the entire display to get the general configuration of parts of the display and to develop a frame of reference. Using a simple tactual map, Berla (1972) found that more target symbols were located with vertical scanning than horizontal scanning. In a subsequent study, Berla and Murr (1974) found that a two-handed vertical scanning technique, in which the hands moved from the top of the display to the bottom and from the bottom to the top, was superior to: (a) a horizontal scan, in which one hand searched the map from left to right and right to left and the other served as a reference or place holder along the map; and (b) a horizontal asymmetrical scan, in which the right hand was on the right side of the map and the left hand on the left side and both moved horizontally towards each other and after meeting away from each other until the entire display was searched. Berla and Murr recommended that further research be conducted to determine how tactual scanning strategies affect the ability of the blind to organize information in terms of spatial relationships and to localize symbols. Hand movements during tactual exploration were examined by Lederman and Klatzky (1987). They found that the hand can serve as an efficient perceptual device and that typical movements used to examine a surface area were "lateral motion", in which the fingers quickly rub back and forth across a small area, and "pressure", in which force is evident in the fingers. They found that these movements were essential for tactual recognition and apprehension. Tactual reading of maps was also examined by Berla, Butterfield and Murr (1976). They tested the map reading ability of 36 blind, braille reading students from grade 4 to 12. They found that the best readers primarily used the fingertip of the index finger, while poor readers tended to use their index, middle, and ring fingers, collectively, to locate distinctive features or to trace shapes. Tactual scanning strategies need to be observed to gain information on the ability of individuals to process information. A list of observational strategies needs to be included for each test that requires tactual problem solving in order for the findings to be meaningful.

Summary

Only a small number of formal assessment instruments that measure cognitive functioning have been specifically designed for the blind. These tests suffer from technical inadequacies, such as inadequate sampling, nonstandardized administration, and heavy reliance on the verbal modality of presentation and response. The validity of these tests is therefore questionable. Psychologists often attempt to modify other published and available IQ measures in order to use them with the blind population. In such cases, instructions are adapted, time limits are lengthened, items are omitted or changed, and scoring is liberalized. Such practices affect the validity and reliability and negate the purpose of doing an assessment. An intelligence measure must demonstrate adequate validity if the results are going to be useful for educational and vocational planning.

Assessment batteries that include tests employing a tactual mode of presentation or response need to be used with normative samples that reflect the heterogeneity of the blind population, establish reasonable time allowances for completion of tasks, and develop observational measures of tactual scanning strategies.

Blind persons, who rely on the tactual modality to receive information, have to deal with multiple stimuli in order to make sense of what they perceive. The blind as a group might be more accurate in perceiving tactual stimuli than the sighted. There also appears to be a difference between congenitally blind and adventitiously blind individuals in their ability to recognize raised designs and pictures. Research findings have not been able to establish the extent to which visual experience facilitates tactual perception.

Information that is obtained tactually and auditorially is serial in nature, in contrast with input received visually, which is more simultaneous since a large number of cues can be visualised in one glance. Strategies for effective and efficient tactual exploration and recognition have been identified by a number of researchers. Tactual strategies need further investigation because they affect the type of information the blind individual is able to gain from diagrams and maps, which in turn influences learning and cognition.

When interpreting the test results of the blind, the psychologist has to decide whether incorrect responses are due to an inability to perform the task because of cognitive factors or result from reduced visual functioning. This is a complicated decision, given the few tests available to the psychologist and their questionable validity.

Psychologists, who have limited experience working with the blind and visually impaired, may be tempted to attribute findings to the presence of decreased visual functioning (Kastenbaum, 1981). Psychologists also need to take into account: (a) the role of vision with regard to cognitive growth; (b) the interaction of such cognitive abilities as spatial understanding and tactual skills, and (c) the abilities that underlie test performance are inadequately understood. Newland (1965) suggested that "until we know that the primary mental ability pictures for all kinds of handicapped are the same as those for the nonhandicapped, we must accept only provisionally the majority of our current testing approaches" (p.91).

Present practices in the assessment of blind adults and children do not have an adequate rationale. If useful assessment of the blind is to take place, then tests that have a theoretical foundation need to be developed.

Planning, Attention, and Simultaneous and Successive Processing

The PASS Theory

The PASS theory is a cognitive theory of mental abilities which was initially described as a model of information integration (Das, 1972; Das, et al., 1979). The theory offers a "plausible description of cognition and of the cognitive processes involved in the achievement of tasks" (Kirby & Das, 1990, p. 329). The theory is based on a purported physiological basis for human cognitive abilities. The roots of the theory lie in Luria's adoption of Sechenov's (1878) syntheses, which infer that the cortex engages in two types of integrative activity, simultaneous and successive, and the social theory of mental processes (Vygotsky, 1962), as well as Anokhin's (Luria, 1973) concept of "functional organization." Basic to Luria's (1966a, 1973, 1974) model of higher cortical functioning is the conception of the brain as a dynamic functional system. Naglieri and Das (1990a) conceptualized a functional system as a "system of cognitive processing (which) provides a particular type of intellectual activity that the individual can use according to the demands of the environment" (p. 306). Luria posited the existence of three basic, functional units that form the basis of cognitive activity. These units are necessary for the integration and ultimate production of human behaviour.

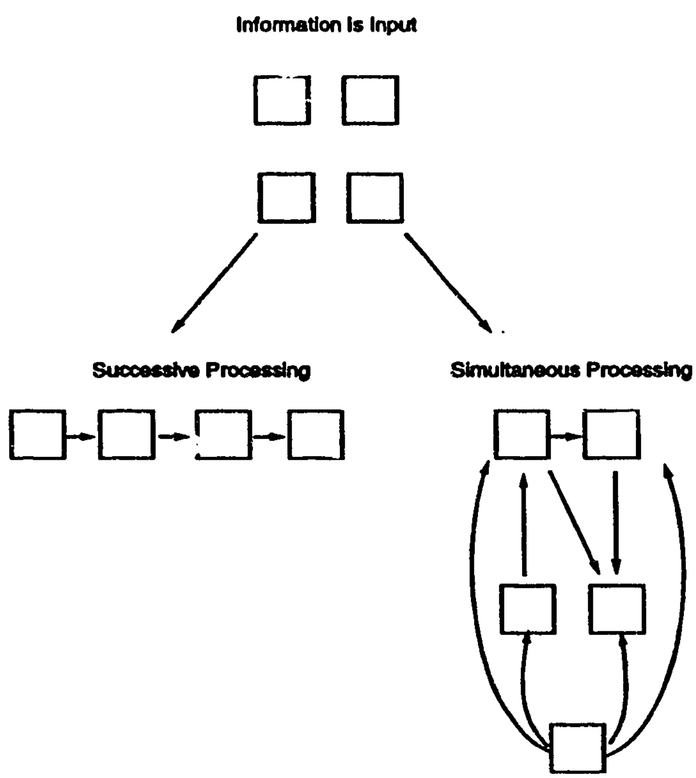
The first functional unit is an arousal unit which maintains attention and wakefulness, regulates cortical tone, and provides a general state of readiness and focus of attention. The second functional unit receives, sorts, and records sensory information, and integrates and stores this information using successive and simultaneous processing. The third functional unit organizes, plans, regulates, and verifies behaviour. These three functional units, although separate, work in conjunction with each other. Each provides its own specific cognitive processes that can be used by an individual to respond to task-demands in the environment. Conscious mental activity requires the interaction of all three functional units. Each functional unit is arranged hierarchically in at least three cortical zones that are assumed to control the functions of the unit and to have differing responsibilities. The primary zone is modal specific for sensory reception and, consequently, information is received in an auditory, visual, or tactual kinaesthetic form. The secondary zone is responsible for the analysis and integration of information received from the primary zone; thus, information is coded and compared with codes in long-term memory. The tertiary zone is one of overlap, where cross modal integration occurs and information from all senses is integrated into meaningful associations.

The first functional unit regulates attention and arousal through the metabolic process, stimulus arrival, and the individual's intent or planning. Attention and arousal are associated with the hippocampus, the brain stem, and the reticular formation. Attention and arousal are important in that they direct and in turn are affected by such complex activities as the formation of intentions and plans. Arousal could be described as the mechanism of this system, while attention could be viewed as the observable behaviors. Attention and arousal are considered to be determinants of task performance. They influence the ability to code information and to plan.

The second functional unit is responsible for the storage and transformation of information. Luria (1966b) observed the effects of lesions on the subsequent behaviour of adults who had suffered brain injuries. He noted that brain trauma to specific cortical locations resulted in characteristic processing deficits that were manifested in two types of integrative activity, successive series or simultaneous groups. Simultaneous processing is linked to the broad functions of the occipitoparietal area of the brain. Lesions within the occipitoparietal area have been observed to result in disturbances of simultaneous processing. Simultaneous processing refers to the synthesis of separate elements into groups, with the result being immediately at once surveyable without dependence upon its position in the whole. Simultaneous processing is symmetric and accessible at all points; consequently, the code that is formed is multi-dimensional in nature. Components of systems need to be represented simultaneously in order for an individual to explore and determine the relationships among them. Simultaneous processing has some connection to a spatial-visual factor and a nonverbal factor, although it is by no means specific to these factors. Auditory events may need simultaneous processing; the categorization of an orally presented list of words would be one example (Das, 1988; Das & Jarman, 1981; Das, et al., 1975, 1979; Das & Molloy, 1975). Simultaneous processing can be considered as "the measure of the size of the units that can be constructed in working memory" (Kirby & Das, 1990, p.322). Successive processing is associated with the broad functions of the frontotemporal area. Lesions within the frontotemporal region of the brain have been observed to result in disturbances of successive processing, which refers to processing of information in a serial order. The components of systems are represented one after the other so that a system of cues consecutively activates the components, creating a form of serial interdependence. In successive processing the system is not totally surveyable at any point in time and it is asymmetric or accessible in one direction only; thus the code that is formed is one-dimensional. Successive processing is concerned with integrating information in a temporal sequence and relates to both verbal and non-verbal material. Tachistoscopically presented digit sets are an example of successive processing (Das, 1984; Das, et al.,1975, 1979; Das & Molloy, 1975). Successive processing is considered to be "the measure of the size of the working memory" (Kirby & Das, 1990, p.322). Thus processing, whether it be simultaneous or successive, is related to the functioning of the working memory. Both simultaneous and successive processing can occur at memory, perceptual, and conceptual levels. Simultaneous and successive processing are essentially independent and are posited to normally operate collaboratively when evoked in problem-solving activity (Kirby & Das, 1990). Individuals might, however, be more efficient in one processing type over the other. Kirby and Williams (1991) emphasized that "a difficulty in using either type of processing can be due to a lack of ability or to the inappropriate use of abilities" (p. 67). The functions of the processing system cut across a series of dichotomies, for instance, verbal and non-verbal, and visual and auditory. A case in point is that tests involving auditory or visual modalities were shown by Das, et al. (1979) to load on the successive factor. The two types of processing are often inextricably blended in intellectual activity and there is no hierarchy implied between them (Das, 1984). Tasks can generally be solved by using either one of the two processes, although, depending on the task or the activity, one is usually more efficient than the other. Most tasks involve elements of both types and no task is considered as "pure" simultaneous or successive. Luria (1970) found that a lesion of the frontotemporal region leaves simultaneous processing ability intact but impairs successive processing, while in the occipitoparietal region this is reversed. A diagram of simultaneous and successive processing is shown in Figure 1.

Figure 1

Schematic Illustration of Simultaneous and Successive Processing



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The third functional unit is identified with the frontal lobes, particularly the prefrontal region. This unit is responsible for planning processes and it regulates, controls, and integrates all conscious activity. The complex processes involved in the third unit distinguish humans from primates (Naglieri & Das, 1990a), and are considered to be the essence of intelligence. Planning refers to goal setting, strategy selection, and monitoring of performance and depends on attention and arousal, simultaneous and successive processing, as well as the existence of prior knowledge.

The three units or systems are interdependent and are involved in virtually all tasks (Kirby & Das, 1990). This complex interaction determines which information is transmitted by the sensory register to the processing system. A weakness in one system may therefore be compensated for in another system or may be found to be disrupting other systems. For example, Kirby and Williams (1991) observed that a deficiency in memory could be due to problems in the processing system, the attention or arousal system, or the planning system. It is important to note that the processing system is purported to be unaffected by the mode of input. Consequently, information that is received by the sensory receptor in a successive manner can be processed simultaneously and vice versa. The type of processing that occurs depends upon three factors: (a) the preferred mode of processing of the individual, (b) the task-demands, and (c) the interaction between the demands of the task and the preferred mode of processing. The mode of output is also posited to be independent of the input mode. The PASS theory, in addition to incorporating the neuropsychological principles described by Luria (1966), is also based on delineates the cognitive processes it has inferred. The theory describes how cognition operates and how the brain regulates intelligent behaviour, with the caution that the biological mechanisms underlying these processes need further investigation. It explains individual differences in cognitive functions by three neuropsychological processes: attention, coding, and planning. A diagram of the theory is shown in Figure 2.

Intelligence, according to this theory, consists of structure (the brain), processes (attention, coding and planning) and knowledge base (the accumulated experiences of the individual) (Das, 1984). Knowledge base is defined as "all the information an individual has available at the time of processing, including temporary information received to solve the particular task at hand" (Naglieri & Das, 1990a, p.316).

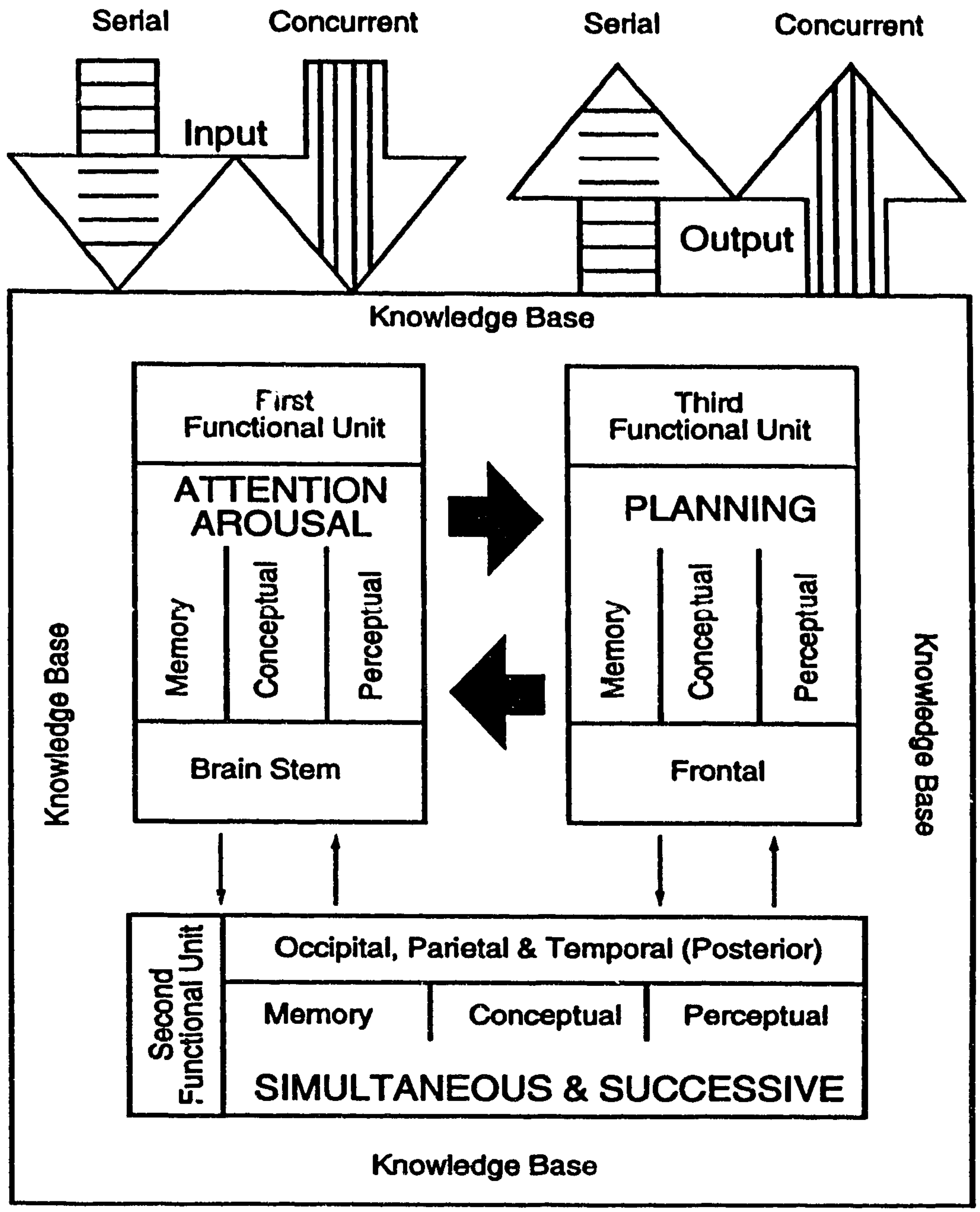
The Das-Naglieri Cognitive Assessment System

Tests have been developed to investigate planning, attention, and simultaneous and successive processing. The underlying assumption in developing these tests was that the attributes of tasks affect the nature of cognitive processes displayed by the individual. The CAS battery consists of tests that are most efficiently solved by the predominant use of one of the processing strategies, the use of planning strategies, and attentiveness to the task.

Tests that are sensitive to the processing requirements of the first functional unit demand cortical arousal and a state of alertness as a requirement to solve a task.

Figure 2

PASS Theory of Information Integration



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Attentional processes are inferred to be functioning when an individual is able to respond selectively to an array of stimuli based on the demands of the task. Activities that purport to test the processes of the second functional unit require the individual to either interrelate the component parts of a task to solve it correctly, or to understand that in order to solve the task, the specific ordering of the stimuli needs to be processed. For simultaneous processing multiple relationships need to be interrelated, while for successive processing the linearity of the relationships is the focus. The planning processes of the third functional unit are assumed to be engaged when an individual is presented with a problem and has to solve it. The "how" of the problem-solving process dominates. This involves the decisions that the individual needs to make about what method to use; for example, whether the individual should apply a previously learned or novel solution, or whether the individual should set in motion attentional, simultaneous and successive processes, to review the solution's effectiveness and to modify it if needed (Das, et al., 1979; Naglieri & Das, 1990a).

The tests that were developed allow for quantification of an individual's facility or efficiency in planning, attention, simultaneous and successive cognitive processes, as defined by the theory. The tests provide an opportunity for assessment of intellectual functions, as defined by the PASS theory, in a normative context. The tests delineate the intellectual processes which underlie individual differences in intelligence. Along with these tests, Das and his colleagues have developed guidelines for constructing activities and tasks that are expected to improve deficient processes. They are also in the process of developing remediation activities and programmes.

Research is ongoing and new findings are incorporated into the tests and activities. These tests will help to identify the different type of learners, which will assist with the effective matching of learners with instructional practices.

Validity of the PASS Theory

The purpose of the PASS theory is to advance our understanding of cognition. Its validity is based on the extent to which the tests are able to measure the constructs of planning, attention, and simultaneous and successive processing. Research that has attempted to demonstrate the construct validity of the theory has been ongoing and has used factor analysis to clarifv the relationships between the different tasks and the processes they are purported to measure. Earlier studies (Das, et al., 1975, 1979) were exploratory in nature and used principal components analysis although critics claim that this method of analysis does not yield accurate estimates of loadings (Snook & Gorsuch, 1989). Later studies (Das & Jarman, 1988; Naglieri, Das, Stevens & Ledbetter, 1991) used confirmatory factor analysis and the data obtained were suggestive of a good fit to the PASS theory of cognitive processes. Das and Varnhagen (1986) and Das and Naglieri (1989) also reviewed the earlier research and found that the overall data supported simultaneous and successive processing as separate factors.

Evidence has been presented to suggest that simultaneous and successive processing are identifiable across IQ groups, populations of retarded children, and different age groups, although this is in question with the elderly

(Cowart & McCallum, 1984; Das, et al., 1979; Das & Molloy, 1975; Jarman, 1978; McCallum & Merritt, 1983; Molloy, 1973). Research on the validity of the PASS theory is ongoing with handicapped populations and normal populations, which will continue to extend the theory in new areas.

A multi-trait-multi-method (MTMM) investigation of planning and simultaneous and successive processing was conducted by Cowart and McCallum (1988). Their purpose was to examine the extent to which planning and simultaneous and successive processing occur independently of the method that assesses these constructs. They selected six tests, two for each construct, that utilized two different methods of presentation, verbal (auditory) and non-verbal (visual-spatial). The Raven Progressive Matrices (non-verbal) and the Orientation to Direction (verbal), from the Stanford-Binet Scale, Form L-M, were selected as tests of simultaneous processing. Naglieri and Das (1990b) have found that the Raven Progressive Matrices is a measure of simultaneous processing, but question the use of Orientation to Direction as a test of simultaneous processing. Digit Span Forward (verbal), from the WAIS-R and Hand Movements (non-verbal), from the Kaufman Assessment Battery for Children (K-ABC), were selected as tests of successive processing. The inclusion of Hand Movements was questioned by Naglieri and Das (1990b) as this is a test from the K-ABC battery found by Kaufman and Kaufman (1983) to load heavily on simultaneous processing for older children. Trail Making and Verbal Fluency were selected as tests of planning. Trail Making (non-verbal) was originally presented by Armitage (1946) and Verbal Fluency (verbal) was shown by Milner (1964) to be useful in the diagnosis of frontal lobe patients. The use of Verbal Fluency was also questioned by Naglieri and Das (1990b). It was found to load on simultaneous, successive, and planning factors (Ashman and Das, 1980). The six tests were administered to 120 undergraduates attending a university in the United States. The subjects were tested in groups of about 25, which is a departure from the one-to-one administration of the CAS. Cowart and McCallum reported that the MTMM matrix failed to produce evidence of validity of the constructs. They concluded that the method of presentation, verbal and non-verbal, could account for the variance within the data, rather than the constructs themselves. This study also failed to include tests of attention and arousal, thus excluding the first functional unit.

Naglieri and Das (1990b) recommend that validity studies of the PASS theory should include all three functional units. The findings of Cowart and McCallum underscore the need for further studies that aim to identify the extent to which the variance can be explained by the method of presentation or the constructs. Naglieri and Das (1990b) caution that information about validity of the PASS theory can only be obtained through the use of appropriate tests of planning, attention, and simultaneous and successive processing.

The inclusion of the Trail Making test and the Matching Numbers test in the CAS was questioned by Kaufman (1990), who does not agree with Das and Naglieri that the factor upon which these tests load can be interpreted as indicative of planning. In Kaufman's opinion, the low level skills required for these tests contradict the characteristics of the third functional unit of the brain. Research findings, however, have shown that simple planning tasks correlate with more complex planning tasks (Ashman & Das, 1980; Das & Heemsbergen, 1983; Garofalo, 1986). Naglieri and Das (1990a) have indicated that a planning task should require an individual to develop an approach of solving a simple task. Individual differences are observed between the approaches and the effectiveness of each approach.

The PASS theory has been likened to the theory of cognitive/information processing proposed by Kaufman and Kaufman (1983). The theory put forth by Kaufman and Kaufman has a purported physiological basis for human cognitive abilities and stems from Kaufman and Kaufman's (1983) interpretation of theories and research in clinical neuropsychology. The work of Luria and Das influenced Kaufman and Kaufman. The K-ABC test battery they constructed, was not based solely on the work of Luria and Das, but was developed to reflect their own theory.

The Kaufman Assessment Battery for Children

The K-ABC is the first major published battery to be based upon a theory of cognitive/information processing that attempts to specify styles of information processing (Kaufman & Kaufman, 1983; Sternberg, 1984) for children two and a half to twelve and a half years of age. The K-ABC is based on a convergence of findings from research in neuropsychology and cognitive psychology. Commonalities between the theories reflect the intersection of several theoretical approaches (Kaufman, 1984; Kaufman, O'Neal, Avant & Long, 1987). Kaufman and Kaufman (1983) extracted from cognitive, split-brain, and cerebral specialization research (Bogen, 1975; Das, et al., 1975; Levy-Agresti & Sperry, 1968; Nebes, 1974; Neisser, 1967; Sperry, 1968) their own unique theory of sequential and simultaneous processing. It is their interpretation of these theories, their interrelationships and juxtapositions, that form the basis of the K-ABC. The K-ABC is an individually administered test of intelligence and achievement. It attempts to put into practice a theoretical concept of sequential and simultaneous processing, and to measure ability (intelligence) on the basis of the processing style required to solve the tasks. Consistent with the belief that the style of problem-solving of children and their ability to process information is different from their acquisition of knowledge, a separate measure of achievement is included in the K-ABC.

Kaufman and Kaufman (1983) emphasize that placement of the tasks on the Sequential and Simultaneous Scales of the K-ABC are solely dictated by their mental processing demands. Thus, neither the modality of presentation nor the modality of response determine the scale placement of the task. The tasks are primarily, but not exclusively, sequential or simultaneous in nature. However, they are not pure measures, as they generally have elements of each processing style.

Sternberg (1984) indicates that the K-ABC is not a measurement of cognitive style; rather it is a measure of information processing that equates styles of information processing with tasks. These tasks purport to measure either simultaneous or sequential processing, with scores on the two kinds of tasks combining to yield subscale scores. Das (1984) made a similar observation. He noted that "the battery does not provide a procedure for scoring the performance on a task according to the strategies used by the child, the tasks are scored as defined" (p.233).

The factor analyses reported by Kaufman and Kaufman (1983) are factor analyses of tests. Strommen (1988) tested the assumption that the three factors (sequential processing, simultaneous processing, and achievement), which form the foundation of the K-ABC's three scales, are uncorrelated or only moderately correlated with one another. However, he obtained interfactor correlations ranging from moderate values of .56 and .58 to substantial values of .91 and 1.0. Five of the 11 correlations between the sequential and simultaneous factors were in excess of .70 and 17 of the 22 correlations between the sequential factor and simultaneous factor and the achievement factor were also in excess of .70.

Strommen suggested two possible explanations for these results. The first explanation agrees with the observations of Das (1984) and Sternberg (1984) that sequential and simultaneous processing are independent abilities which are not measured by the tasks in the K-ABC, and points to the K-ABC's inability to discriminate between the constructs it claims to measure. The second explanation is that the constructs are not independent of each other. Jensen (1984) found substantial general factor, or "g" loadings on the two processing scales. His data suggested that "g" accounted for four to six times as much of the total variance of the processing scales as the combined sequential and simultaneous processing factors. Keith and Dunbar (1984) also suggested that the Simultaneous and Sequential Processing Scales might more correctly be labelled nonverbal reasoning and verbal reasoning, respectively.

The factor structure of the K-ABC and the WISC-R was investigated by Kaufman and McLean (1987). The results indicated that the WISC-R and the K-ABC factors generally converge in three major abilities, and suggest that the underlying constructs in the two batteries are quite similar. K-ABC Achievement corresponded closely to WISC-R Verbal Comprehension; K-ABC Simultaneous Processing resembled WISC-R Perceptual Organization; and K-ABC Sequential Processing was similar to WISC-R Freedom from Distractibility. These results support an alternate interpretation of the K-ABC.

The interpretation of the sequential and simultaneous processing styles was found by Willis (1985) to be obscured by confounding influences of response modalities. He examined the response modalities of the K-ABC and noted they are not evenly distributed across the Sequential and Simultaneous Scales. The Sequential Scale does not have a visual-oral modality, while the Simultaneous Scale omits auditory-oral and auditory-motor modalities. The response modalities of the processing scales of the K-ABC were also criticized by Das (1984). He observed that none of the sequential tasks are outside the domain of memory, and that a verbal-nonverbal dichotomy appears to correspond with the sequential-simultaneous distinction. It was noted by Bracken (1985) that the processing scales are weighted between 57% and 63%, at the different age levels, in favour of the Simultaneous Scale. He maintained that the sequential-simultaneous model is not hierarchical, and that the higher emphasis placed on the Simultaneous Scale confounds interpretation of the results. He also indicated that most of the subtests of the Mental Processing Composite (MPC) are insufficient measures of complex abilities; for example, the Sequential Scale reflects simple sequential visual and auditory short-term memory and excludes the measurement of complex intellectual abilities that are part of school learning.

The K-ABC only attempts to assess the processing abilities defined by Kaufman and Kaufman as sequential and simultaneous processing. These abilities are similar to Luria's second functional unit, which is one of the three basic functional units identified by Luria (1966a, 1966b, 1973, 1974) that are purported to form the basis of cognitive activity. They exclude attention and planning, which, according to Luria, are necessary for the integration and production of human behaviour. The tests that form the K-ABC were not selected for adaptation for the blind as they are based on a narrow theory of cognitive ability and their validity has been seriously challenged in the literature.

Summary

The PASS theory is a broad conceptualization and framework for cognitive processing. The roots of the theory lie in neurophysiology, neuropsychology, and cognitive-psychological principles. Its proposed model of cognitive assessment is an example of a new approach to the assessment of cognitive processes. While it allows for the formal assessment of cognitive functioning, it also delineates the processes that theoretically underlie individual differences in cognitive functioning, and provides guidelines for teaching and remediation. The model provides a theoretical perspective, from which to evaluate test results, and instructional methods for both adults and children.

The test battery developed by Das and Naglieri (1987, 1989), in comparison to the K-ABC, attempts to provide more comprehensive and representative measures of the two coding factors. Simultaneous and successive processing tests are evenly weighted, while the K-ABC is heavily weighted in favour of the Simultaneous Scale. The Das and Naglieri battery also includes planning factor measures as well as attentional and arousal factor measures. The planning tests attempt to provide information on how individuals select ways to organize their responses, an aspect which is omitted in traditional psychometric assessment (Kirby & Das, 1990).

The CAS battery was selected for adaptation for the blind, since it measures a broad range of cognitive functions and was constructed to represent a theoretical model of cognitive functioning. Review of the literature shows that the CAS tests have sufficient validity to be accepted as an alternative to traditional psychometric assessment. Adaptation of these tests might provide insight into the cognitive functioning of the blind that has previously been impossible.

Issues Arising from the Review of the Literature

The major purpose of this study was to adapt the CAS for use with blind persons. The review of the related literature presented a survey of research in the following areas: (a) the cognitive assessment practices used with blind persons; (b) the need for valid and reliable intelligence tests for use with blind persons; (c) the role of tactual perception in test development; and (d) the PASS theory, the CAS, and the K-ABC.

Four major issues have arisen from the review of the literature. Firstly, there is a lack of cognitive assessment instruments that are able to provide a reliable and valid estimate of a blind person's cognitive functioning level. In order for the results of an assessment to be useful, interpretation needs to be in the context of the theory upon which the instrument was based. Interpretation of test results without this link between theory and instrument is meaningless, as the particular conceptualization of cognitive ability is unknown. The PASS theory and the CAS tests that were developed to assess an individual's facility or efficiency in planning, attention, and simultaneous and successive cognitive processing hold promise for use with blind persons. Evidence to support the theoretical basis of the CAS has been documented in the literature (Naglieri & Das, 1990a; Naglieri, Das, & Jarman, 1990). These tests were designed to identify the different learners, in terms of their planning ability, attending behaviors, and preferred processing mode, in order that instructional practices can be effectively matched.

A second issue is whether test materials can be adapted for use by blind persons without changing the task-demands. There is a dearth of research documenting the efficacy of changing visual materials into a tactual format.

A third issue is whether blind persons are able to efficiently process tactual/spatial information simultaneously. The blind appear to receive most of their information successively, either through the tactual or auditory modalities, although information may arrive through any of the senses in a simultaneous manner. The PASS theory advances that processing is independent of mode of input; accordingly, information that is received successively can be processed simultaneously. Information is processed according to the requirements of the task, not the mode of input. Vision, however, has been viewed by others to be the primary modality for organizing and relating spatial information. In this view, the absence of sight implies a lack of gestalt and an inability to process tactual information holistically (Casey, 1978; Révész, 1933; Von Senden, 1932).

A fourth issue is whether blind and blindfolded-sighted persons use different strategies in tactual problem solving. The review of the literature has shown that vision, or a memory of vision, may influence the way an individual apprehends tactual information.

These issues will form the basis for Study 1 and Study 2. The major purpose of Study One is to adapt tests of the CAS for use with blind persons and to examine whether the integrity of the adapted materials will be maintained. This study will also investigate how blind persons explore and determine the relationships among different pieces of information that are presented simultaneously. Study Two will compare the performance and the strategies of blind persons and blindfolded-sighted persons on tests that require tactual problem solving. Study 1 and Study 2 are exploratory and are conducted to determine whether the development of the CAS for use with blind persons holds promise.

CHAPTER III

STUDY 1: ADAPTATION OF THE CAS FOR USE WITH BLIND PERSONS

Selection of Tests

The experimental test battery comprised 12 tests, of which 11 were selected from the CAS, designed to assess the planning, attention, and simultaneous and successive processing abilities of 5 to 17 year old children. The CAS, which was available as a tryout edition, consisted of 16 tests, two of which were repeated. The 11 tests selected were: Receptive Attention, Auditory Selective Attention, Number Finding, Word Series, Sentence Repetition and Questions, Color Ordering, Design Construction, Matrices, Simultaneous Verbal, Visual Search, and Matching Numbers. The Syllogisms Test was adapted from a test developed by Heemsbergen (1980).

The selection of tests for inclusion in the battery was based on the following criteria:

No adaptation for the blind was required, or

(a) only test items suitable for adaptation were selected;

(b) meaningful adaptation in a tactual format was possible;

(c) integrity of the CAS tests was maintained;

(d) test items were tactually legible;

(e) size of tactual shapes and figures was kept to the same size as that of the print version whenever possible; and

(f) the adaptation process did not interfere with the level of difficulty of test items.

A variation in presentation and response modality of the tests that are purported to measure each construct was desired.

The adaptation of test materials involved the creation of a master copy for each test item that had printed, pictorial, or diagrammatic information. The CAS test materials were created from a visual perspective, as a result the adapted version may not have emphasized features that are crucial to tactual apprehension. Adaptation of visual materials into a tactual format may present considerable interpretation difficulties for blind persons and the assumption should not be made that what is visually simple is also easy to apprehend tactually. In fact, the reverse of this assumption is often the case, with the tactual version being more complex. During the adaptation process care was taken to exclude test items that appeared to be tactually more complex than their visual counterpart. Two blind proofreaders examined the materials for ease of tactual apprehension. The use of texture was considered to be an effective way of presenting tactual graphics. Textures were chosen from a number of materials that were commercially available. Only textures with a pattern variation that followed highly discriminating dimensions were included (Heath, 1958; Nolan & Morris, 1971; Schiff, 1966). Among the dimensions of texture discrimination used in the patterns were: kind of element, spacing between elements, size of elements; as well as regular and irregular, density, height, and sharpness. Raised line figures, that were sufficiently large in area for details to be tactually discriminable, were also used. The size constraint of the braille code had to be accepted as an uncontrolled variable. Braille takes more space than print, because the size of the braille cell is constant and cannot be reduced. Reduction would make the braille cell tactually indiscriminable.

Adaptation of the test materials was possible with the assistance of two braille transcribers, two blind and one sighted braille proofreaders, and a consultant for the visually impaired. Advice and assistance throughout the adaptation of the CAS and reviews of the master copies, to ensure maintenance of the integrity of the CAS tests, were provided by the authors of the CAS.

Reproduction of Tests

The Thermoform process of producing multiple copies from a single master was chosen. This process allowed for low cost copies that are durable and contain no variation in design characteristics. At present, no means of mass production are available to create master copies. The masters for the tests requiring tactual discrimination of forms were produced by pasting textured materials on braille paper. Shapes were made from different materials and with various levels of thickness. Materials used to produce lines had to be durable enough to withstand heat, to remain raised under pressure, and to show variation in thickness. Coarse sandpaper and corrugated cardboard produce textures in Thermoform that feel different. Velvet, on the other hand, reproduces a texture almost identical to that of fine sandpaper. To make copies, a sheet of Thermoform plastic was placed over the master, and as heat was applied in a partial vacuum, the plastic molded itself around the surfaces of the master.

The disadvantages of Thermoform are copy size limitations (11" x 11 1/2") and the "glossy feel" of the final copy.

Adaptation of Tests

Measures of Attention

Attention is conceptualized in two categories: focused and divided (Naglieri, et al., 1990). In focused attention, the individual is required to attend to one piece of information while excluding other information. In divided attention, the individual is required to share time between two competing dimensions or two sources of information. The individual needs to be able to detect the two dimensions of the stimulus and to select the dimension that is provided in the instructions, while ignoring the competing dimension. The competing dimension always consists of a stimulus that is as pronounced, or even more pronounced, than the target stimulus (Naglieri & Das, 1990a).

Receptive Attention.

The Receptive Attention test is based on the work of Posner and Boies (1971). The individual is required to attend to one kind of information and exclude all other information. This task was selected by Das (1993) because it comprises selectivity, resistance to distraction and shifting or switching strategies. Davies, Jones and Taylor

(1984) considered these three characteristics to be essential features of selective attention. The individual's task is to find and point to pairs of letters that are the same, on the basis of a physical or a category/name match. The test, I . ages 8 and above, consists of two parts. The first part consists of a physical match task, which involves the detection and underlining of upper case or lower case pairs of letters that are identical, such as TT or ee. The second part consists of a name match task, which involves the detection and underlining of pairs of letters with the same name presented in upper and lower cases, such as Tt or eE.

The test materials were transcribed into braille. Braille letters consist of an arrangement of dots in various spatial positions and relationships. The requirement to underline the identical and same name pairs of letters was changed. The subjects were required to point to each identical and same name pair of letters and say, "This one". The time limit of 2 minutes for each part was disregarded and the braille version had no time limit.

Scoring involves the tabulation of a score out of 50 (items correct) for each of the physical match task and the name match task, and the number of false alarms (identification of incorrect pairs of letters) was noted. The presentation modality of this test is braille (reading recognition) while the response modality is oral and motor.

Number Finding.

This test, for ages 8 and above, consists of two parts. The test requires selective responding. The subject's task is to find and underline specific numbers that contain both targets and distracters. The numbers are printed in two styles of type. In the first part the subject has to identify and underline the numbers 1, 2, and 3 in one style of type and ignore them when they are printed in the competing style. The subject also has to ignore the numbers 4, 5, and 6 in any of the two styles of type. In the second part the subject has to identify and underline the numbers 1, 2, and 3 in one style of type and 4, 5, and 6 in the other style. These numbers have to be ignored when they are printed in the competing style. The aspect of selective responding lies at the point of determining whether the stimulus is one style of type or the other (Naglieri & Das, 1990a).

Scoring involves the tabulation of a score out of 44 (items correct) for each part and the recording of the number of false alarms. There is a time limit of 1 1/2 minutes each part.

Adaptation involved using upper cell literary numbers and lower cell Nemeth code numbers, in place of style of type, as competing dimensions. In literary braille, the first 10 letters of the alphabet indicate a letter, but with the addition of a particular symbol a numeral is indicated. Nemeth code is a complete set of codified meanings used for mathematics. The subjects were required to point to each identified number and to say "This one". The braille version did not have a time limit. The presentation modality of this test is braille (reading recognition) while the response modality is oral and motor.

Auditory Selective Attention.

This test, for ages 8 and above, requires the subject to listen to a 5 minute tape recording that was prepared for the CAS. The subject has to share time between two sources of information and the test measures the extent to which this is done without a loss of efficiency. The requirement is to listen for specific words when said by a man or a woman and to respond by tapping on the table. The test consists of five 1 minute segments.

The administration procedure, scoring criteria, and directions were unchanged. Scoring involves the tabulation of a score out of 15 (words correct) for each of the five segments and the recording of the number of false alarms. The presentation modality of this test is auditory while the response modality is motor.

Measures of Successive Processing

Successive processing tasks require the individual to appreciate the serial nature of stimuli that have a range in level of difficulty. The individual either needs to reproduce a particular sequence of events or answer questions that require the specific ordering of events to be correctly interpreted. The stimuli are ordered without surveyability (Naglieri & Das, 1990a; Naglieri et al., 1990).

Word Series.

The recall of a series of words has been shown to load on the successive factor (Das, et al.,1979; Naglieri & Das, 1988). This test requires the subject to repeat a series of words in the same order in which they are verbally presented. The examiner says the words at the exact rate of one per second, without grouping. Series range in length from 2 to 9 words. Testing is discontinued after four consecutive failures. Scoring involves the tabulation of a score out of 141 (words correct) and of a wordspan (two items correct in a series) out of nine.

This test was adapted to keep the stimulus response modality of the measures of the successive processing construct varied. Adaptation involved transcribing the word series into braille and placing each series on a separate page. Subjects were required to read each word series in one continuous motion, without stopping, or backtracking. Each series could only be read once and subjects had to lift their hands from the page as soon as they were finished reading. Subjects were required to say the series aloud in the order read, after their hands were lifted from the page. The presentation modality of this test is braille (reading recognition) while the response modality is oral.

Color Ordering.

This test, for ages 5 and above, requires the subject to turn plastic chips of blue, white, olive, yellow, black, gray, and orange color in the specific orders demonstrated. The chips are placed in front of the subject and are arranged in the sequence indicated on the presentation card. Sequences range in length from 2 to 9 chips. Testing is discontinued after four consecutive failures.

Adaptation involved replacing each color with a shape cut out of velour paper. Replacements were as follows: circle - blue, triangle - white, rectangle - olive, cross - yellow, half moon - black, diamond - gray, and star - orange. An extra shape was added in the form of an irregular pentagon. The card was replaced with two wooden trays that were made for this test, each with eight circles cut out to insert chips. The plastic chips were replaced by wooden chips, each with two protruding handles for ease of turning. The wooden trays and chips were painted to obtain a smooth surface. Each shape was glued on one side of each of the chips (see Appendix A). Sequences varied in length from 2 to 8, and the ninth sequence was omitted.

The chips remained placed on the two trays in the same order throughout the test. While spatial position of the chips remained the same, the exposure of the chips was different in each series. The task required the subject to turn chips, in the specific order demonstrated by the examiner. The order of the sequences is indicated on the Record Form. The chips, with their smooth side up, were placed in front of the subject on two trays. One tray was used by the examiner for demonstration and the other tray was used by the subject for responding. The examiner turned over one chip at a time on the demonstration tray. The subject was required to locate the turned chip. Only after the chips had been turned in the desired sequence could the subject turn the chips in the same order on the response tray.

Scoring involves the tabulation of a score out of 137 (shapes correct) and of a wordspan (two items correct in a series) out of eight. The test was renamed

Successive Ordering. The presentation modality of this test is tactual and the response modality is motor.

Sentence Repetition and Questions.

This test consists of two parts. Sentence Repetition requires the subject to repeat up to 17 sentences exactly as presented. The correct order of the sentence must be retained. To reduce meaning, the items contain color words in place of content words. Sentence Questions uses the same sentences as presented in Sentence Repetition. The task is to answer a question about the sentence which requires comprehension of the syntax of the sentence.

Scoring involves a score out of 17 for each part. The sentences, questions, administration, scoring procedures, and directions were not adapted. The presentation modality of this test is auditory while the response modality is oral.

Measures of Simultaneous Processing

Simultaneous processing tasks require the individual to survey and recognize the relationships among all elements of an item in order to arrive at a correct answer. The individual has to incorporate all the stimuli in a complete pattern. The complexity of a task is a function of the number of interrelationships among the elements (Naglieri & Das, 1990).

Design Construction.

This test, for ages 5 and above, was developed by Das and Naglieri (1987). The task is to construct an abstract design, from blue and white plastic square chips, that matches a standard. There are six solid chips, blue on one side and white on the other and six half-chips, half blue and white on one side and diagonally half blue and half white on the other. The time limit for items 1 to 5 is 1 minute, for items 6 and 7 it is 1 1/2 minutes, and for items 8 to 16 it is 2 minutes. Testing is discontinued after four consecutive failures. Scoring involves the tabulation of items correct.

The test was adapted by changing the plastic chips to wooden square blocks. The colour blue was changed to a texture made from velour paper and the white colour was changed to a smooth painted surface. The stimulus cards were changed from a visual presentation of each design to a stimulus card presenting the design in a tactual format. Velour paper was substituted for the blue colour and smooth cardboard paper was used for the white colour (see Appendix A). The time limit for each item was increased to 5 minutes. More than 5 minutes was felt to inhibit motivation. Testing was discontinued after two consecutive failures. The presentation and response modality of this test are both tactual.

Simultaneous Verbal.

This test, for ages 5 and above, presents the subject with questions that require the evaluation of logical grammatical relationships and require the ability to interrelate all the parts. The task is to choose from among six options, depicted on each stimulus page, the one option that correctly answers the question read by the examiner. Each question is also printed on each stimulus page. Subjects are not required to give a verbal explanation of their answer, but must indicate their choice by pointing. There is a 1 1/2 minute time limit for each item. Testing is discontinued after four consecutive failures.

Adaptation involved rejection of the sample item and items 1 to 7, 9, 10, and 13. These items had pictures that could not be reproduced tactually in a meaningful manner. The remaining items used geometric shapes, which were adapted to a tactual format. Item 8 became the sample and items 11, 12, and 14 to 26 made up the test. The layout of each stimulus page was kept the same. The questions were transcribed into braille. The six options were separated by raised lines. The geometric shapes were cut out of smooth cardboard and were glued onto the master copies. A layering process was used that involved placing the shape that was visually inside another shape on top of that shape. By means of clarification, when there was a square inside a triangle visually, the tactual version had a square glued on top of the triangle. After reproduction in Thermoform the square could be tactually perceived as being inside the triangle (see Appendix A). The time limit for each item was increased to 5 minutes. More than 5 minutes was felt to inhibit motivation. The subject was required to read the question aloud, so that the examiner could ascertain that the question was read accurately.

Scoring involves the tabulation of items correct. The presentation modality of this test is tactual and braille (reading) while the response modality is oral and motor.

Matrices.

This test requires the subject to complete figural analogies presented in a progressive matrix format. The task is to select one of the six options placed below the matrix that best completes the abstract analogy. There is a 2 minute time limit for each item. Testing is discontinued after four consecutive failures.

Adaptation involved rejection of items 7, 12, 13, 19, 20, 30, and 31. These items were considered to be too tactually complex. The remaining sample and 24 items were included in the adapted version. When color was an element of the test, texture was substituted. The textures used included velour paper, graphite paper, smooth cardboard, rubberized material, raised lines, and string. The shapes were cut out and glued onto the master copies and the raised lines were made on the master copy. A layering process, similar to the one described for the Simultaneous Verbal test, was used. The layout of each stimulus page was kept the same (see Appendix A).

This test requires the subject to determine which options to choose by deduction from the permutation of variables, such as texture, shape, number, size, or by extrapolation of such trends in shape and size.

The time limit for each item was increased to 5 minutes. More than 5 minutes was felt to inhibit motivation. Scoring involves the tabulation of items correct. The presentation modality of this test is tactual while the response modality is oral and motor.

Measures of Planning

Planning tests require the individual to develop an approach to solving a simple task. Das and Naglieri (1987) have maintained minimal task requirements, since the purpose is for the individual to develop some effective means of solving the task. Individual differences in the ability to develop problem-solving strategies become evident.

Visual Search.

This test, for ages 5 and above, requires the subject to develop an efficient approach to finding a stimulus on a page. The task is to point to an object, number, or letter in the visual field that matches the target stimulus. The target stimulus is in a center box and the match is in the area around the center box. Each target has only one match on a page. The test consists of four subtests. Subtest A, Automatic Search, requires the subject to find the match of a target object. The match is placed among distracter numbers. Subtest B, Number among Numbers, requires the subject to find the match of a target number. The match is placed among distracter numbers. Subtest C, Object among Objects, requires the subject to find the match of a target object. The match is placed among distracter objects. Subtest D, Letter among Letters, requires the subject to find the match of a target letter. The match is placed among distracter letters. There are two searches on each page and there is a 1 1/2 minute time limit for each page.

Adaptation involved placing only one search on a page, because a larger area was needed. The space between the distracters was increased to accommodate braille. The relative position of the distracters was kept the same. In Automatic Search, the stimulus object was replaced by shapes made out of braille paper, velour paper, felt, and aluminum paper. Each shape was cut out individually and glued on the braille paper. Numbers were used as distracters and they were transcribed into literary braille numbers (see Appendix A). In Number among Numbers, the numbers were transcribed into literary braille numbers. In Shape among Shapes, the objects were replaced by shapes. The shapes were made out of the same materials as were used for Automatic Search subtest (see Appendix A). In Letter among Letters, the letters were transcribed into braille. Each subtest consisted of two demonstration items and eight test items. The eight test items contained four low density items (with 19 to 25 distracters) and four high density items (with 43 to 50 distracters).

Scoring involves recording the time for each subtest. The time limit was extended to 2 minutes for each search. The test was renamed Tactual Search. The presentation modality of this test is tactual while the response modality is oral and motor.

Matching Numbers.

This test, for ages 8 and above, requires the individual to find and underline two numbers that are the same on each row. The test consists of three parts. Each part has eight rows and each row is made up of six numbers. There is a 3 minute time limit for each part. The numbers increase in length from one to seven digits over the three parts.

Adaptation involved transcribing the numbers into literary braille numbers. Rows had to be split, because of the space requirement of braille. The carry-over technique was used to indicate to the reader that the row was continuing. This is an accepted practice in braille. Underlining numbers was changed to pointing and by acknowledging the choice verbally. The braille version did not have a time limit.

Scoring involves the recording of time taken for each part. The presentation modality of this test is braille (reading recognition), while the response modality is oral and motor.

Syllogisms.

A planning task, requiring the solving of more cognitively complex problems, was added to the experimental test battery, in order to potentially engage the subject in executive or planning strategies. Syllogistic reasoning tasks were selected as an example of a cognitively complex problem involving formal logic (Cohen, 1987; Lane, Fletcher & Fletcher, 1983). Heemsbergen (1980) developed thirty-two categorical syllogisms based on two premises and a conclusion. For an individual to correctly indicate whether the conclusion follows logically from the premises, the reordering or conversion of the premises might be required. Series A, items 1 - 8, are in a forward chain and require no conversions or reordering. For example:

Mary is taller than Sue

Sue is taller than Joan

Mary is taller than Joan - True or False?

Series B, items 9 - 16, require the reordering of one premise. For example:

Susan is taller than Ann

Jane is taller than Susan

Ann is taller than Jane - True or False?

Series C, 17 - 24, require the conversion of one premise. For example:

Ann is taller than Alice

Susan is shorter than Alice

Susan is taller than Ann - True or False?

Series D, items 25 - 32, require the reordering and conversion of the premises.

Heemsbergen (1980, ' und that the time taken by his subjects to complete the Syllogisms Test correlated significantly with such planning tests as: Planned Composition, Trail Making and Visual Search. The test scores, however, did not correlate with these planning tests.

Adaptation of this test involved the transcription of the syllogisms into braille. Scoring involves the tabulation of items correct for each series and the recording of time taken for each series. The presentation modality of this test is braille (reading) while the response modality is oral.

Field Testing

The experimental battery was administered to two blind volunteers. The purpose was to locate and remediate any potential problems in test administration and scoring, as well as to gain information about the amount of time that would be required to administer the battery. As a result, directions were altered slightly for clarity. Actual administration time was approximately 4 hours.

CHAPTER IV

STUDY 1: RESEARCH QUESTIONS AND HYPOTHESES

Purpose of the Study

The primary purpose of Study 1 was to collect data for initial test norms and to inspect the pattern of responses on the tests of the experimental battery, to determine whether the adaptations appeared to have changed the task-demands of the tests. The second purpose of Study 1 was to identify behaviors by means of self-report and observation to begin the process of gathering evidence that each test is a measure of the construct it was designed to measure. The long-term goal of development of the CAS for use with blind persons is to obtain detailed information about the relationship between the construct and a number of behaviors. The third purpose of Study 1 was to examine the performance of congenitally blind persons on tests that were designed to measure simultaneous processing and that use a tactual/spatial format. The final purpose of Study 1 was to suggest test refinements by examining the time limits for testing and the length of tests.

Research Questions

The following is a list of questions generated from the review of the related literature:

1 Does the transcription of printed materials into braille and the transformation of pictorial or diagrammatic materials into a tactual format retain the integrity of the tests?

2 Are congenitally blind persons able to successfully complete the tests that use a tactual presentation?

3 How do congenitally blind persons approach tasks that demand simultaneous processing?

4 What are the reported perceptions of the congenitally blind subjects on the demands of each test?

5 What are the observable behaviors that congenitally blind persons exhibit while they are engaged in tactual problem solving?

6 What are reasonable time limits for the timed tests?

7 Could some tests that have a large number of items be shortened?

Arising from the preceding questions, the following is a list of specific hypotheses relating to the use of the adaptation of the CAS with congenitally blind persons.

Hypotheses and Rationale

Hypothesis 1: Performance of congenitally blind persons on the Physical Match Task (PMT) of the Receptive Attention Test will be significantly better than their performance on Name Match Task (NMT) of the Receptive Attention Test.

Hypothesis 1a: The mean time on PMT will be significantly less than the mean time on NMT.

Hypothesis 1b: The mean score on PMT will be significantly higher than the mean score on NMT.

Hypothesis 1c: The mean number of false alarms on PMT will be significantly less than the mean number of false alarms on NMT.

Rationale: The PMT involves the identification of upper and lower case pairs of letters that are identical. The NMT involves the identification of pairs of letters with the same name presented in upper and lower cases. The PMT was designed to be easier to complete than the NMT. In the literature it has been demonstrated that with the sighted population, the PMT is completed faster than the NMT, and that higher scores are obtained on the PMT (Das, Mensink & Mishra, 1990; Ojile, 1992; Proctor, 1981).

Hypothesis 2: There will be no significant difference in the performance of congenitally blind persons on the five segments of the Auditory Selective Attention Test (ASA1 to ASA5).

Rationale: The Auditory Selective Attention test consists of five 1 minute taped segments and involves identifying specific words said by a man or a woman. These segments are designed to be of similar difficulty since they measure the extent to which individuals are able to identify the words without loss of efficiency over a 5 minute period.

Hypothesis 3: Performance of congenitally blind persons on the first part (NF1) of the Number Finding Test will be better than their performance on the second part (NF2).

Hypothesis 3a: The mean time on NF1 will be significantly less than the mean time on NF2.

Hypothesis 3b: The mean score on NF1 will be significantly higher than the mean score on NF2.

Hypothesis 3c: The mean number of false alarms on NF1 will be significantly less than the mean number of false alarms on NF2.

Rationale: The NF1 involves the identification of the lower cell Nemeth code numbers 1, 2, and 3 and the ignoring of these numbers when they are upper cell literary numbers. The NF2 was designed to be more difficult since it involves two target dimensions. It requires the identification of the upper cell literary numbers 1, 2, and 3 and the lower cell Nemeth code numbers 4, 5, and 6, as well as the ignoring of these numbers when they are in the competing dimension.

Hypothesis 4: Congenitally blind persons will take less time to complete the low density test items than the high density test items on the following subtests of the Tactual Search Test: Automatic Search (TSA), Number among Numbers (TSN), Shape among Shapes (TSS), and Letter among Letters (TSL).

Rationale: The low density items of each of the four subtests consist of a stimulus with 19 to 25 distractors on each page, compared to the high density items that have a stimulus with 43 to 50 distractors on each page. It is expected that it is more time consuming to find the stimulus among 43 to 50 distractors than among 19 to 25 distractors.

Hypothesis 5: There will be a significant difference in time taken by congenitally blind persons to complete the four subtests of the Tactual Search Test: TSA, TSN, TSS, and TSL.

Rationale: The four subtests were designed to be different. In TSA the stimulus is a shape and the distractors are literary braille numbers; in TSN the stimulus and the distractors are literary braille numbers; in TSS the stimulus and distractors are all shapes; while in TSL the stimulus and distractors are all braille letters. A difference in time taken is predicted. A finding of no difference would suggest that the task-demands of the four subtests might be more similar than different.

Hypothesis 6: There will be a significant difference in time taken by congenitally blind persons to complete each of the four series of the Syllogisms test.

Rationale: The four series of the Syllogisms test were designed by Heemsbergen (1980) to have different task-demands. The first series (SYLT1) of categorical syllogisms is in a forward chain; the second series (SYLT2) requires the reordering of one premise; the third series (SYLT3) requires the conversion of one premise; and, the fourth series (SYLT4) entails the reordering and conversion of the premises. A finding of no difference would suggest that the task-demands of these four series might be more similar than different.

Hypothesis 7: There will be a significant difference in the number of test items completed correctly on each of the four series of the Syllogisms test (SYLS1 to SYLS4) by congenitally blind persons.

Rationale: A difference in scores among the four series is expected as they were created to vary in difficulty. A finding of no difference would suggest that the task-demands of the series might be more alike than different.

Hypothesis 8: There will be a significant difference in time taken by congenitally blind persons to complete the three parts of the Matching Numbers Test.

Rationale: The Matching Numbers test involves the identification of two numbers that are the same in a row of six numbers. In the first part (MN1) numbers increase in length from 2 to 3 digits, in the second part (MN2) from 4 to 5 digits, and in the third part (MN3) from 6 to 7 digits. It is expected that time taken to match the numbers would increase over the three parts as longer numbers would take more time to read.

CHAPTER V

STUDY 1: METHOD

Subjects

Thirty subjects (20 females and 10 males) ranging in age from 19 to 43 years took part in the study. The mean age of the subjects was 31.8 years (SD = 8.97). The sample consisted of 13 totally blind subjects and 17 subjects with light perception. One subject had a mild hearing impairment and was aided in one ear. Another subject was epileptic and on Tegretol medication which controlled seizure activity. Causes of blindness are summarized in Table 1.

Retinopathy of Prematurity involves the proliferation of retinal blood vessel development in premature infants. This may lead to scarring, bleeding, or retinal detachment. Retinoblastoma is a malignancy of the retina that usually requires the surgical removal of the anterior chamber or entire globe of the eye. Macular Degeneration involves progressive damage to the central part of the retinal cones. Anophthalmia entails the absence of one or both eyeballs. Optic Nerve Atrophy is a dysfunction of the optic nerve, which results in the inability to conduct electrical impulses to the brain and in the paling of the optic disc. Rubella Syndrome is the result of the transmission of the German measles virus by the mother to the fetus. This virus can cause damage to the eyes, ears , heart, and brain. Congenital Amaurosis involves the degeneration of the macula at or shortly after birth. Cortical

Blindness is the result of damage to the visual cortex or the posterior visual pathways. Some etiologies of blindness are unknown.

Subjects covered the spectrum of socioeconomic backgrounds and a range of educational attainment. Table 2 presents the level of education and Table 3 shows the employment status of the subjects. The WAIS-R Verbal IQ's of the subjects ranged from 83 to 150, with a mean IQ of 115.47 and SD of 17.92. Half the subjects indicated that they preferred reading books, memos or letters in braille, while 13 subjects favored audio tapes or personal readers. The remaining two subjects were partial to the use of the computer or opticon.

Table 1

Causes of Blindness, Frequency Distribution

Cause	Frequency
Retinopathy of Prematurity	17
Retinoblastoma	3
Macular Degeneration	3
Anophthalmia	2
Optic Nerve Atrophy	1
Rubella Syndrome	1
Congenital Amaurosis	1
Cortical Blindness	1
Undetermined	1

N=30

Table 2

Level of Education, Frequency Distribution

Education	Frequency
Grade 11	3
Grade 12	8
College	2
College Diploma	5
University	3
Undergraduate Degree	6
Graduate Degree	3

N=30

Table 3

Employment Status, Frequency Distribution

Status	Frequency
Employed	15
Unemployed	3
Student	12

N=30

Subjects were obtained with the assistance of teachers of the blind and consultants in the area of visual impairment and blindness. Former students were contacted by the teachers and consultants and asked whether they would be interested in participating in the study. Only those individuals who expressed a genuine interest were enlisted. Selected subjects did not receive remuneration for their participation. It was necessary to recruit subjects from two provinces besides Alberta (British Columbia, and Ontario), because of the stringency of criteria imposed on sample selection and the low incidence of congenital blindness.

Every attempt was made to obtain a homogeneous sample. Only congenitally blind individuals were considered for inclusion in the study. A questionnaire was designed to obtain information about personal, educational, and occupational history (see Appendix B). This questionnaire was administered to potential subjects. Subjects were asked about the extent of blindness, age of onset, cause of blindness, visual memory, medical history, educational level, and employment status. Selection criteria for congenital blindness were: (a) onset of total blindness before the age of 2 years; and (b) subjects were considered totally blind if they had minimal visual residual for light perception and lacked enough visual experience to have a visual representation of objects or internalized visual images. Subjects were screened to meet criterion (b) by ensuring that they could not identify three fingers presented at a distance of 75 cm.

It was explained to subjects that: (a) they were being asked to take part in intellectual testing and experimental test activities designed to assess their processing ability and their ability to attend to tasks and to plan, (b) the experimental tests would be presented in the tactual and auditory modalities, (c) the longterm goal of the study was to produce a test for the blind, (d) test results would be used to establish normative data and provide indices of preferred strategies, and (e) assessment sessions would be video taped, to allow for strategy analysis and for demonstration purposes. Subjects were given a consent form in braille (see Appendix C). Confidentiality was assured.

It was then established that potential subjects, who met the criteria of congenital blindness, were able to recognize numerals, letters, and words. This was important since braille is an essential element of some of the tests of the experimental battery. Subjects were required to read aloud, without difficulty, the numerals 0 to 9 in both literary braille and Nemeth code. A reading passage at the grade 4 level was selected from the Diagnostic Reading Program developed by Alberta Education (1989). The requirement was that subjects were able to read this passage fluently aloud with no more than two errors (see Appendix D).

It was also established that the subjects selected for the study were not mentally handicapped. Congenitally blind individuals, in addition to their loss of vision, may have neurological impairments that are not specifically documented and that may have an impact on cognitive functioning. The Verbal Scale of the WAIS-R (Wechsler, 1981) was administered as a screening measure. Subjects with a Verbal IQ of 83 or higher were included in the study.

Procedure

Subjects were tested individually in a quiet room in their home or at an office. The Canadian National Institute for the Blind in Ontario and British Columbia made office space available. In Alberta, office space was provided by the Edmonton Public School District and the Calgary We Care Home Services Ltd..

The author received the assistance of a graduate student, who had been a consultant in the area o[illegible]d visual impairment, to administer the questionnaire, braille s[illegible]ire, and the WAIS-R, and to assist with the analysis of the video tapes. The author administered the experimental test battery.

Administration time of the screening measure was approximately 1 to 1 1/2 hours. The experimental battery took from 3 to 4 1/2 hours to administer, depending on the speed and ability of each subject. Assessments were conducted in two sessions of approximately 2 to 3 hours each. Typically, the sessions were completed within one day. However, there were a few subjects where the time interval between the two sessions was five days. Subjects were questioned on the strategies they used, after completion of each experimental test, and were also asked to provide feedback on what they thought about the test. The question asked was: "Could you tell me how you tackled this task and what ran through your mind while you were doing it?" "Please tell me whatever you can, your observations will help with the development of this test." The information was noted and analyzed for commonalities and trends. Assessments took place from August, 1991 to January, 1992.

The experimental test battery was administered in the following order:

1. Receptive Attention
2. Auditory Selective Attention
3. Number Finding
4. Word Series
5. Sentence Repetition and Questions
6. Successive Ordering
7. Design Construction
8. Simultaneous Verbal
9. Matrices
10. Tactual Search
11. Syllogisms
12. Matching Numbers

CHAPTER VI

STUDY I: RESULTS AND DISCUSSION

In this section the results obtained on each test of the experimental battery are presented and discussed. Tests are discussed in the order they were administered. Five areas, when applicable, are examined: (a) descriptive statistics, (b) a restatement of the hypotheses presented in Chapter IV, together with a presentation of the related findings and conclusions, (c) reported test taking strategies and observations, (d) video tape analyses of test taking behaviors; and (e) possible test revisions for the following tests: Design Construction, Simultaneous Verbal, Matrices, and Tactual Search.

Tests

Receptive Attention

The mean and SD for the following dependent variables of time (in seconds), score (items correct), and the number of false alarms were computed for the Physical Match task, the Name Match task, and the Receptive Attention total scale. These are presented in Tables 4 and 5.

> Hypothesis 1: Performance of congenitally blind persons on the Physical Match Task (PMT) of the Receptive Attention Test will be significantly better than their performance on the Name Match Task (NMT) of the Receptive Attention Test.

Hypothesis 1a: The mean time on PMT will be significantly less than the mean time on NMT.

Hypothesis 1b: The mean score on PMT will be significantly higher than the mean score on NMT.

Hypothesis 1c: The mean number of false alarms on the PMT will be significantly less than the mean number of false alarms on NMT.

To test Hypothesis 1, t-tests were performed. The results of the two-tail t tests (see Table 4) showed a significant difference between the PMT (Mean=242.400) and the NMT (Mean=229.233) on only the time variable. Subjects took longer to complete the PMT than the NMT. This finding was opposite to that predicted in hypothesis 1a. In the literature it has been demonstrated that with the sighted population, the PMT is completed faster than the NMT (Das, Mensink & Mishra, 1990; Ojile, 1992; Proctor, 1981). Millar (1977) found with congenitally blind school-aged children that successive physical matching of the braille letters SS and EE was significantly faster than name matching of the letters [illegible] and SE. Millar suggested that braille letter like visual letter matching involves memory for physical (tactual) characteristics. Das (1993) suggested that the physical code arrives at the output faster than the name code. The PMT accesses both perceptual and memory systems which require relatively low-level perceptual analyses that leave no enduring trace. The NMT, on the other hand, accesses a cognitive code. The cognitive load is attributed to the distracting pairs of letters. NMT requires the selective encoding of the target pairs, the adoption of a strategy for shifting their attention from pair to pair and resistance to the effect of distracters. Results suggest that the disparity between the tactual code and the name code might be different from the visual code and the name code.

Of the 23 subjects who completed the NMT faster, 16 indicated they found the task-demands of the PMT and the NMT similar. They pointed out they were able to do the NMT more quickly as they had warmed up to the task and were more practised. Four of the 7 subjects who took longer to complete the NMT than the PMT indicated they had to "untrain" themselves from doing the NMT according to the requirements of the PMT and lost time during this process. The remaining 10 subjects did not make any comments, except to indicate that they found this test repetitive. All subjects indicated they had to keep their attention focused on the test and that they could not let their mind wander. Contrary to what was predicted in Hypothesis 1b and 1c, no significant difference was found between the PMT (Mean=48.20) and the NMT (Mean=47.80), on the score variable, nor on the number of false alarms variable, the PMT (Mean=0.067) and the NMT (Mean=0.167). These findings were opposite to those of Ojile (1992), who found a significant difference between scores on the PMT and the NMT. In his study, both hearing and deaf school-aged children obtained higher scores on the PMT than the NMT.

An explanation for the findings of the current study may be that in the braille code the upper case and lower case letters are the same, except for a single dot. To distinguish between upper and lower case in braille, a dot 6 is added before the letter to show capitalization. In the PMT subjects were required to point out identical pairs of letters (EE ss), while in the NMT the requirement was to point out letters with the same name (Ee sS) (see Figure 3). In braille, EE and Ee are physically more similar than in print. In braille, the NMT may be more of a physical match task than a name match task, and if that were the case, then a difference in scores would not be expected. Another explanation of the findings of the current study may be that the majority of subjects responded to the PMT and the NMT by not only pointing to identify the letters but also by naming them. The PMT may have been more of a name match task than a physical match task for these subjects. This illustrates that assumptions about task demands based on printed materials should not be made when these materials are transcribed into braille. Feedback from the subjects was supportive of the supposition that the PMT and the NMT are more similar than different. Responses also lent support to the underlying construct of the test in that subjects used such words as attention, concentration, and focus in describing what they considered to be the requirement for completing the tasks.

The usefulness of keeping both the PMT and the NMT in the battery will require further investigation with another sample.

Table 4

Mean, SD, and t-tests for the Receptive Attention Test

Variable: Time in Seconds

Task	Mean	SD	DF	t	P
PMT	242.400	77.459	29	2.64	0.013
NMT	229.233	68.596			

Variable: Score

Task	Mean	SD	DF	t	P
PMT	48.200	2.455	29	1.11	0.277
NMT	47.800	2.041			

Variable: False Alarms

Task	Mean	SD	DF	t	P
PMT	0.067	0.254	29	1.00	0.326
NMT	0.167	0.461			

Table 5

Mean and SD for the Receptive Attention Test

Variable	Mean	SD
Total Time (in seconds)	459.133	166.866
Total Score	96.000	4.060
Total False Alarms	0.267	0.521

Figure 3

Braille Letters

braille cell

1 ○○ 4
2 ○○ 5
3 ○○ 6

EE

○○ ●○ ○○ ●○
○○ ○● ○○ ○●
○● ○○ ○● ○○

Ee

○○ ●○ ●○
○○ ○● ○●
○● ○○ ○○

ss

○● ○●
●○ ●○
●○ ●○

sS

○● ○○ ○●
●○ ○○ ●○
●○ ○● ●○

Auditory Selective Attention Test

The mean and SD for the following dependent variables were computed for each of the five 1 minute segments of the Auditory Selective Attention Test as well as for the full scale, score, and number of false alarms. These are presented in Table 6.

Hypothesis 2: There will be no significant difference in the performance of congenitally blind persons on the five segments of the Auditory Selective Attention Test (ASA1 to ASA5).

To test Hypothesis 2, a one-way analysis of variance (ANOVA) with repeated measures was performed on ASA1 to ASA5 (see Table 7). The F ratio ($p > .05$) was not significant. The findings were in support of hypothesis 2, since these segments were designed to be of a similar level of difficulty. A variable response pattern on ASA1 to ASA5 would have been indicative of a loss in attentional efficiency, which would suggest that the segments were of different difficulty levels, or that the sample contained individuals with attentional difficulty, or, that fatigue was a factor influencing the score.

Subject feedback lent support to the underlying construct of the test to measure divided attention. Subjects reported the following observations and strategies:

1. Twenty-one subjects found it difficult to switch between the two voices (those of the man and the woman). Their initial inclination was to concentrate on one voice and not the other. They had to make a concerted effort to concentrate on both voices.

2. Four subjects mainly concentrated on one voice and ignored the other. They found that this was the only way they could focus on the task.

3. Six subjects used one hand to tap on the table for the woman's voice and the other hand for the man's voice. They found that this strategy worked well for them as it eliminated confusion.

4. Eighteen subjects did not allow themselves to think about their response, as they felt there was not enough time. They described their responding as a "reflex" action. They had to keep up with the pace of the tape and ignore whether they were right or wrong.

5. Twenty-seven subjects found this test taxing, because they had to concentrate throughout the duration of the test.

Table 6

Mean and SD of the Auditory Selective Attention Test

Variable: Score

Task	Mean	SD
ASA (Total)	47.933	12.437
ASA1	9.700	3.385
ASA2	9.633	3.200
ASA3	9.000	2.877
ASA4	9.600	3.169
ASA5	10.000	2.533

Variable: False Alarms

Task	Mean	SD
ASA (Total)	15.667	25.416
ASA1	3.867	5.457
ASA2	3.100	4.780
ASA3	2.933	5.388
ASA4	2.700	6.249
ASA5	3.000	5.896

Table 7

One-Way Analysis of Variance with Repeated Measures of The Auditory Selective Attention Test

Source	SS	DF	MS	F	P
Test	15.91	4	3.98	1.03	0.397
Error	449.29	116	3.87		

Number Finding Test

The mean and SD for the dependent variables of time, score (items correct), and the number of false alarms were computed for NF1 and NF2 and the full scale of the Number Finding Test. These are presented in Tables 8 and 9.

Hypothesis 3: Performance of congenitally blind persons on the first part (NF1) of the Number Finding Test will be better than their performance on the second part (NF2).

Hypothesis 3a: The mean time on NF1 will be significantly less than the mean time on NF2.

Hypothesis 3b: The mean score on NF1 will be significantly higher than the mean score on NF2.

Hypothesis 3c: The mean number of false alarms on NF1 will be significantly less than the mean number of false alarms on NF2.

To test Hypothesis 3, t-tests were performed. The results of the two-tail t tests (see Table 8) showed significant differences for all three dependent variables. The NF1 took less time to complete than NF2 (NF1 mean=153; NF2 mean=294), there was a higher mean score on NF1 than NF2 (NF1=42; NF2=38); and, NF1 had less false alarms than NF2 (NF1=0.97; NF2=2.7). These findings were in support of hypothesis 3.

These results are encouraging and suggest that transcription into braille did not change the task-demands. The NF2 was designed to be more difficult than NF1. In the NF2 the subject is required to attend to two different target dimensions, while in the NF1 there is only one target dimension.

Comments from the subjects were consistent with the findings. All 30 subjects took less time to complete NF1 than NF2, while 24 subjects obtained a higher score on NF1 than NF2, and 17 subjects had less false alarms on NF1 than NF2. All subjects indicated that NF2 required more concentration than NF1. They observed that NF2 was more difficult, because they had to pay attention to two things at the same time. Six subjects found this test very challenging and three of them indicated that they came close to not completing NF2.

Table 8

Mean, SD, and t-tests for the Number Finding Test

Variable: Time in Seconds

Task	Mean	SD	DF	t	P
NF1	153.033	47.213	29	7.83	<0.001
NF2	294.400	106.196			

Variable: Score

Task	Mean	SD	DF	t	P
NF1	42.133	2.193	29	4.63	<0.001
NF2	38.933	3.532			

Variable: False Alarms

Task	Mean	SD	DF	t	P
NF1	0.967	0.490	29	2.88	0.007
NF2	2.700	3.354			

Table 9

Mean and SD for the Number Finding Test

Variable	Mean	SD
Total Time (in seconds)	447.433	131.270
Total Score	81.067	4.502
Total False Alarms	3.667	3.477

Word Series Test

Since there is no hypothesis concerning the Word Series Test (WS), only descriptive information is presented. The mean and SD for the dependent variables of score (items correct) and wordspan were computed. These are presented in Table 10. This test was changed from the original version in that the word series were presented in braille instead of auditorially. It appears from feedback provided by the subjects that the original requirement of the test was not changed. Subjects indicated that they perceived that the intent of the task was to keep as many words as possible in memory, in the right order. The majority likened it to remembering a telephone number.

The three strategies that subjects reported using were: (a) 21 subjects tried to hold as many words as possible in working memory, (b) three subjects attached some meaning to the words in the series by means of mnemonic devices; and (c) six subjects combined the longer series into groups of two to three words (chunking), which meant they engaged in simultaneous processing. Subjects who found this task difficult indicated that they would draw a blank right after reading the series or would become confused on the order of the words.

Table 10

Mean and SD for the Word Series Test

Variable	Mean	SD
Score	74.467	22.682
Word Span	5.433	1.104

Sentence Repetition and Questions Tests

Since no hypothesis was formulated, the only information presented for Sentence Repetition (SR) on and Sentence Questions (SQ) is descriptive. The mean and SD for the dependent variable of score (items correct) was computed for both SR and SQ. These are presented in Table 11.

This test was administered in the same manner as the original version. The observations made by the subjects reflected the underlying construct of the test. Feedback from the subjects indicated that two strategies were used for SR. Eighteen subjects indicated that their initial strategy was to attempt to make sense out of the sentence, so it would be easier to retain in memory. They found that this strategy only worked with the first couple of sentences and became a hindrance when the sentences became longer. They soon had to abandon this strategy in favour of remaining [illegible] listening, in order to remember the sentence in the right order. This latter strategy was also used by the [illegible] subjects.

Nine subjects indicated that they found SQ easier than SR. They could apply their knowledge of the way in which words are put together to form their responses. They also pointed out that the order of the words within the sentence was important. The other 21 subjects were not able to put into words any of their thoughts.

Table 11

Mean and SD for the Sentence Repetition and the Sentence Questions Tests

Variable	Mean	SD
SR	10.567	1.695
SQ	13.167	2.805

Successive Ordering Test

Since there is no hypothesis concerning the Successive Ordering Test (SO), only descriptive information is presented. The mean and SD for the dependent variables of score (items correct) and shape span (longest series correct) were computed for the SO. These are presented in Table 12.

Analysis of subject feedback would suggest that the task-demands of the test were changed during the adaptation process. The CAS version was designed so that individuals would integrate the test stimuli in a specific series in a chain-like progression. In the adapted version it became apparent that although this happened for the majority of subjects, some subjects interrelated the stimuli into a spatial pattern. Subjects reported using the following strategies:

1. Fifteen subjects identified the textured shape on each chip and attached a numeral to it. The rectangle would be named three, as it was in the third position from the subject's left, while the pentagon would be named nine, as it was in the ninth position from the subject's left. Number sequences were rehearsed by all, and chunked by some, in groups of three or four.

2. Two subjects identified the texture on each chip by shape name. They used the spatial position of each chip as a cue to temporal order. To illustrate, the chips were always arranged on the tray in the following order with the textured shape turned down: circle, triangle, rectangle, cross, moon, diamond, star, and pentagon. In the presentation of the series cross, circle, rectangle, triangle, and moon, the subject would remember it as follows: middle position, three to the left, two to the right, one to the left, and three to the right. Subjects expressed some frustration with this strategy, as they could be out one position at the start of the sequence, but have the sequence correct after that and still receive no credit.

3. Two subjects used a variation of strategy 2, but did not attach a name to the shape; instead they remembered it by how it felt. One of the two commented that he placed the chips on a mental grid pattern.

4. Two subjects used another variation of strategy 2. They gained a sense of the spatial layout of the tray (eight chips in a row) and focused on the pattern in which the chips were turned and the spatial distances between the turned chips. They ignored shape and texture completely.

5. Three subjects created the same spatial array from left to right and ignored the order in which the chips were presented. When it was pointed out to them that they needed to pay attention to the order in which the chips were turned, they became confused and were only able to complete a few sequences.

Six subjects reported using a combination of strategies. Five started off using either strategies 2 to 4 and switched to strategy 1 when the strategy resulted in incorrect reproduction of the sequence, while one started with strategy 1 and switched to strategy 4.

These strategies are interesting in light of the findings reported by O'Connor and Hermelin (1978). They found that sensory-intact subjects tended to recall spatially presented items in their temporal presentation order when they were able to draw on a verbal code. With material they were not able to verbalize, subjects displayed a tendency to recall material spatially. One of the latter experiments they conducted in this series is especially relevant with respect to the strategies reported for SO. O'Connor and Hermelin presented series of groups of three Roman or Arabic letters to school-aged children. They operated under the assumption that the Arabic letters would be perceived as shapes that could not be verbalized. Each letter either occurred in a spatially different position, with the implication that the spatial position of the items could be used as a cue for temporal order, or was presented in the same position, successively. They kept the spatial and temporal order incongruent, so that the letters never appeared in a left-to-right succession. They provided the following example, if the letters "k" "m" "g" occurred in a temporally successive order, the spatial order might be "g" on the left side, "k" in the middle, and "m" on the right side. Results showed that Roman letters were recognized most often as a temporally ordered sequence, while Arabic letters were frequently perceived in a spatially ordered form from left to right. Subjects tended to encode the visually presented verbal material in an articulatory-acoustic form.

It appears, from the strategies reported by the subjects in the present study, that when the visual modality was changed to the tactual modality, a similar pattern occurred, but that this pattern was not as conclusive. The majority of the subjects reported that they encoded the tactually presented material in a verbal code, while the remaining subjects processed the same material in terms of a tactual/spatial code. Without exception, subjects who did not draw on a verbal code recalled the order of presentation spatially.

The video tapes were analyzed in order to determine whether observable behaviors would provide some insight into the strategies that were used. The following behaviors were evident from the tapes:

(a) one hand was moved from the beginning of the demonstration tray from left to right until encountering the first chip that was turned;

(b) verbal rehearsal took place, with the subject verbalizing the order during demonstration by openly verbalizing, mouthing, or whispering;

(c) tactual rehearsal was exhibited by the subject using the demonstration tray, with the subject subsequently touching the chips previously turned in the demonstration sequence;

(d) the first chip to be turned during a response was located, without using the rest of the tray as a cue;

(e) at the beginning of a response, the chips were counted from left to right, until the first chip to be turned was located (counting was considered to be observed, if the subject verbalized numbers, moved lips or tapped on each chip in order);

(f) the subject counted the chips in the same manner as described in (c), but more than once during the reproduction of a sequence; and,

(g) one hand was used as a place holder along the tray.

The behaviors described in (b), (c), (e), and (f) tended to signify that the subject was using strategy 1, while behaviors (a) and (g) were either indicative of strategy 1 or strategies 2, 3, and 4. The behavior described in (d) tended to indicate that strategies 2, 3, or 4 were used. A clear picture of strategy use could not be obtained by mere observation, as some of the behaviors were utilized in a number of strategies. Behaviors would, however, provide a clinician with some initial insight into the strategy being used. This would be especially helpful with individuals who would have difficulty verbalizing the strategies they used during the test.

Table 12

Mean and SD for the Successive Ordering Test

Variable	Mean	SD
Score	94.900	41.435
Shape Span	6.533	1.756

Design Construction Test

The only information presented for the Design Construction Test (DC) is descriptive, as no hypothesis was formulated. The mean and SD for the dependent variable of time (calculated on items correct) was computed for the DC scale and the 16 items. These are presented in Tables 13 and 14. Only [illegible] that were scored correctly were considered in the calculation of mean time. The amount of time an individual took to complete an item correctly was useful information. Two subjects, for example, could have answered an item correctly, but differed in the length of time it took them to reach their answer. Mean time for correct items could, therefore, potentially be meaningful as a discriminating variable between subjects.

Subject feedback showed that the majority of subjects experienced difficulty replicating the designs. Subjects reported the following observations:

1. Eighteen subjects indicated that the replication of designs required a concept of the whole design. It is of interest to note that subjects had

difficulty describing how, and in what form, they gained this overall concept. It was evident they were attempting to describe a tactual image, but that language became a barrier. There did not appear to be language to describe the representational format of tactual images.

2. The same 18 subjects pointed out that after they gained an overall concept of the design, they examined its different parts in order to assemble the blocks in a replication of the design.

3. Six subjects indicated that they tried to gain a concept of the size of the smooth and textured areas in order to replicate a design.

4. Thirteen subjects expressed frustration when faced with the fifth item of block design, which was the first design to include both solid and half blocks. They were unable to gain a representational image and, without this image, they could not replicate the design. It became evident, upon questioning, that these subjects had limited experience with this type of a task.

An explanation for the difficulties experienced with this test by a majority of the subjects may be that fewer stimuli could be simultaneously managed in the tactual mode than in the visual mode. Expressed differently, it may be a question of capacity limitations of tactual/spatial working memory. Simultaneous processing is considered to be a measure of the number of units that can be constructed in working memory (Kirby & Das, 1990). The capacity of tactual/spatial working memory may be a differentiating factor among persons. Individual differences in the capacity limitations of visuospatial and tactual/spatial working memory were found by Cornoldi, Cortesi and Preti (1991). Their findings suggested that congenitally blind persons were disadvantaged in processing tactual features and content, as well as spatial configurations. They found that even those blind persons who show the presence of imagery processes still demonstrated such limitations when compared to sighted people. It was noted that blind persons who were subjects in their experiments had limited practice and experience with three-dimensional shapes and that their performance improved throughout the experimental tasks, suggesting a practice effect. This coincides with the reports of subjects in this study, who claimed no, or limited, exposure to tactual/spatial tasks.

The video tapes were analyzed to gain an understanding of the tactual manipulation that subjects employed while working on the task. The following behaviors were observed:

1. The blocks were sorted by texture, before the design on the demonstration card was examined.
2. The two hands were engaged in separate activities, one hand examined the design on the card, while the other hand was placing the blocks together to form the design. This strategy allowed subjects to maintain a direct image of the design instead of having to rely on a trace image.
3. The blocks were manipulated by both hands, but the design on the card was frequently reexamined by one or both hands.

4. The design on the card was examined before the blocks were manipulated.
5. The scale of the design was measured using a finger as a measuring device.
6. The design was constructed horizontally, vertically, or by working on sections of the design, such as the middle part or one or other of the sides.
7. Attention was paid to replicating the textured areas of the design while ignoring the smooth areas.

An analysis of the pattern of responses was undertaken in order to shorten DC, both in terms of establishing a time limit for items and by reducing the number of items. Assumptions about how much time blind persons would reasonably need to complete test items were not made at the onset of this study. One of the purposes of this study was to establish time limits after examination of the data. To this end, a liberal time limit of 300 seconds was provided to prevent time from becoming a confounding variable. During field testing, lack of motivation was generally evident after approximately 300 seconds. Sometimes the 300 second limit was extended for subjects who appeared motivated to continue or who requested to continue. If motivation seemed low, the 300 second time limit was put into effect.

It is clear from Table 14 that if the time limit was set at 180 seconds few subjects would be lost. To illustrate, item 7 at 180 seconds has 11 subjects who passed it correctly, compared to 14 subjects at 300 seconds. A 180 second time limit was, therefore, considered to be reasonable.

For the purpose of eliminating test items, a graph was constructed based on the total (revised) number of subjects who correctly passed each item (see Figure 4). Inspection of the graph revealed that items 9 to 16 were too difficult for most subjects in the study. Items 9 to 16 could, therefore, be omitted from future administrations of the test.

Table 13

Mean and SD of the Design Construction Test

Variable	Mean	SD
Time (in seconds) (based on correct items)	44.774	24.467
Score (items correct)	5.933	3.107

Table 14

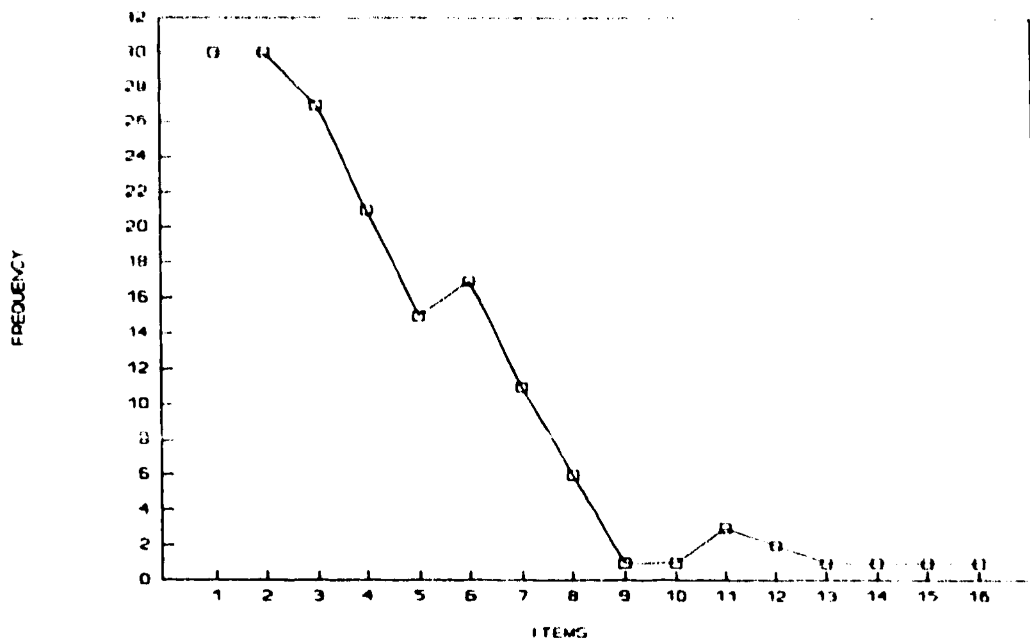
Mean, SD, and, numbers correct based on time intervals for the Design Construction Test

Variable: Time in Seconds (calculated on items correct)

				No. Correct by Time Interval				
Item	No.of Ss correct	Mean (time)	SD (time)	0-60	61-120	121-180	181-240	241-300+
1	30	12.567	11.822	29	1			
2	30	13.433	14.771	29	1			
3	27	29.037	18.251	26	1			
4	21	50.714	37.710	13	7	1		
5	15	50.067	38.356	10	5			
6	19	62.684	58.918	13	2	2	2	
7	14	112.643	99.527	6	3	2	2	1
8	6	118.833	36.019	1	1	4		
9	4	190.500	37.820			1	3	
10	1	93.000	n/a		1			
11	3	84.000	3.606		3			
12	2	130.000	18.385		1	1		
13	2	198.500	140.714		1			1
14	2	153.500	96.874		1		1	
15	1	160.000	n/a			1		
16	1	170.000	n/a			1		

Figure 4

Revised Frequency of No. Correct for the Design Construction Test



Simultaneous Verbal Test

Only descriptive information is available for the Simultaneous Verbal Test (SV), since a hypothesis was not formulated. The mean and SD for the dependent variable of time (calculated on items correct) was computed for the SV scale and the 15 items. These are presented in Table 15. Only items that were scored correctly were considered in the calculation of mean time.

The SV test required the subject to evaluate logical grammatical relationships. The subject was presented with a question to be answered by interrelating all the parts, such as: "Which picture shows a circle above a square that is to the right of a triangle and to the left of a cross?" The subject needed to deduce the relationships among the circle, square, triangle, and cross based on the logical grammatical structure of the statement.

Feedback and observations from the subjects reflected the intent of the test. Subjects reported the following strategies and observations:

1. Twenty-six subjects first searched the six options on the page for the first direction in the question (a circle above a square) followed by the next direction, and the next one, until the question was answered. Thus, these subjects were able to eliminate some of the options, because they did not fit the initial direction.
2. Four subjects were unable to devise a workable strategy. They randomly searched the options and experienced difficulty interrelating the different directions in a question.
3. Twelve subjects observed that all the directions in each question were interrelated and that they had to keep these relationships stored in memory.

4. Six subjects said that, as the questions included more directions, they became more difficult and taxing on memory. The subjects indicated that their mistakes were due to an inability to keep all the directions straight.

The observation by some of the subjects that the test placed a considerable load on working memory capacity is interesting. When functioning in the visual modality a person can quickly glance back and forth across the page, but in the tactual modality going back and forth across the page takes much longer. Scanning in the tactual modality is more difficult than surveying in the visual modality. In the tactual modality the subject needs to apprehend all of the salient features to create a representational image, and then store this image in working memory, before all the different relationships among the different elements can be surveyed and manipulated. Given the reality of individual differences in capacity of tactual/spatial working memory, or in the ability to create a representational image, it is not surprising that a number of subjects found this test taxing.

The video tapes were analyzed to gain insight into the behaviors that were exhibited. The behaviors observed were:

1. One hand was used as a place holder, while the other hand was actively exploring the page.

2. The subject first searched for the first direction in the question; upon locating this direction, the subject reread the instructions then continued to search for the next direction. In the subsequent searches only the options containing the previously found directions were searched and all the other options were ignored.
3. The options were explored horizontally or vertically on the page.
4. The question or parts of the question were reread.
5. The subject rehearsed, verbally.

These observable behaviors mirrored the subjects' self-reports.

An analysis of the pattern of responses was completed to establish a time limit for the 15 items. Similarly to the Design Construction Test, a generous time limit of 300 seconds was used during test administration. It is clear from Table 16 that, with a 300 second time limit, the test items did not provide enough differentiation among subjects. A time limit of 60 seconds, however, would yield a range of item difficulty.

Table 15

Mean and SD for the Simultaneous Verbal Test

Variable	Mean	SD
Time (in seconds) (based on items correct)	50.986	26.235
Score (items correct)	11.233	3.059

Table 16

Descriptive Data for the Simultaneous Verbal Test: Mean, SD, numbers correct based on time intervals

Variable: Time in Seconds (calculated on items correct)

				No. Correct by Time Interval				
Item	No.of Ss correct	Mean (time)	SD (time)	0-60	61-120	121-180	181-240	241-300+
1	27	28.741	[illegible].615	25	2			
2	21	47.905	38.014	17	2	2		
3	26	39.192	21.585	21	5			
4	26	62.385	47.997	20	3	2	1	
5	27	33.148	30.000	22	5			
6	27	26.111	22.565	25	2			
7	28	35.607	26.790	21	7			
8	22	45.227	25.746	17	5			
9	22	61.227	34.068	13	8	1		
10	18	78.722	71.810	10	3	4		1
11	15	42.533	27.594	13	1	1		
12	14	63.357	56.757	8	5			1
13	23	54.739	4[illegible]	15	6	2		
14	22	82.864	[illegible]	6	13	2	1	
15	19	115.895	66.037	3	9	3	3	1

Matrices Test

The mean and SD for the dependent variable of time (calculated on items correct) was computed for the whole scale and individually for the 24 items of the Matrices Test (MAT). These are presented in Tables 17 and 18. Only items that were scored correctly were considered in the calculation of mean time.

The MAT test consists of Naglieri's (1985) figural matrices that require conceptual reasoning about a design in matrix format. The matrices are designed in such a way that each component of the matrix is interrelated to the other components.

Feedback and observations of about half the subjects mainly focused on their accurate perception of the test requirement to piece together a mental image of successive inputs (bits of information), and the difficulty many of them experienced in gaining such a representational image. One subject likened it to constructing a mental image of "tiny slices of experience." In order for subjects to mentally manipulate the different parts of each test item, they had to gain a sense of the comprising variables, such as those of texture, shape, number, and size. Only after gaining this perspective could they create an accurate representational image of the complete pattern. At this point the options could be considered and a deduction could be made about which option completed the pattern. Given the above, the results are encouraging, since they suggest that about half the subjects were able to accomplish this. It is of interest to note that subjects did not appear to attach verbal labels to the shapes in the pattern and options. When providing feedback about a certain test item they would use such words as "it did not seem to be the same" to describe two different shapes. They would not spontaneously name the shapes as, for example, a triangle or a square.

About a quarter of the subjects were unable to grasp the nature of the task and selected an option by ch ce, just to get the task finished. The other quarter had some understanding, but were unable to create representational images effectively or were unable to store the different variables into working memory.

Analysis of the video tapes revealed the following observable behaviors:

1. One hand was used as a place holder while the other hand actively explored the page.
2. All the parts of the pattern were explored by going back and forth to different parts. At this point, it is interesting to note that tactual organization often looks visually disorganized, because it accesses a different retrieval system.
3. The entire pattern was examined before the options were explored.
4. The pattern and the options were frequently examined until an option was chosen.

The pattern of responses was analyzed in order to shorten the MAT, both in terms of establishing a time limit for test items and by reducing the number of items. In this initial study, a time limit of 300 seconds for each item was provided. It is clear from an inspection of Table 20 that few subjects would be eliminated if the time limit was set at 180 seconds for each item.

A graph was constructed based on the total number of subjects (revised) who correctly passed each item (see Figure 5). The graph shows that items 17 to 24 did not provide enough differentiation among subjects to warrant inclusion in the test. These items were generally too difficult for subjects and only a few were able to complete them.

In summary, it is recommended that the adapted MAT test will have a time limit of 180 seconds for each item and will consist of items 1 to 16.

Table 17

Mean and SD of the Matrices Test

Variable	Mean	SD
Time (in seconds) (based on items correct)	51.417	25.804
Score (items correct)	8.300	4.699

Table 18

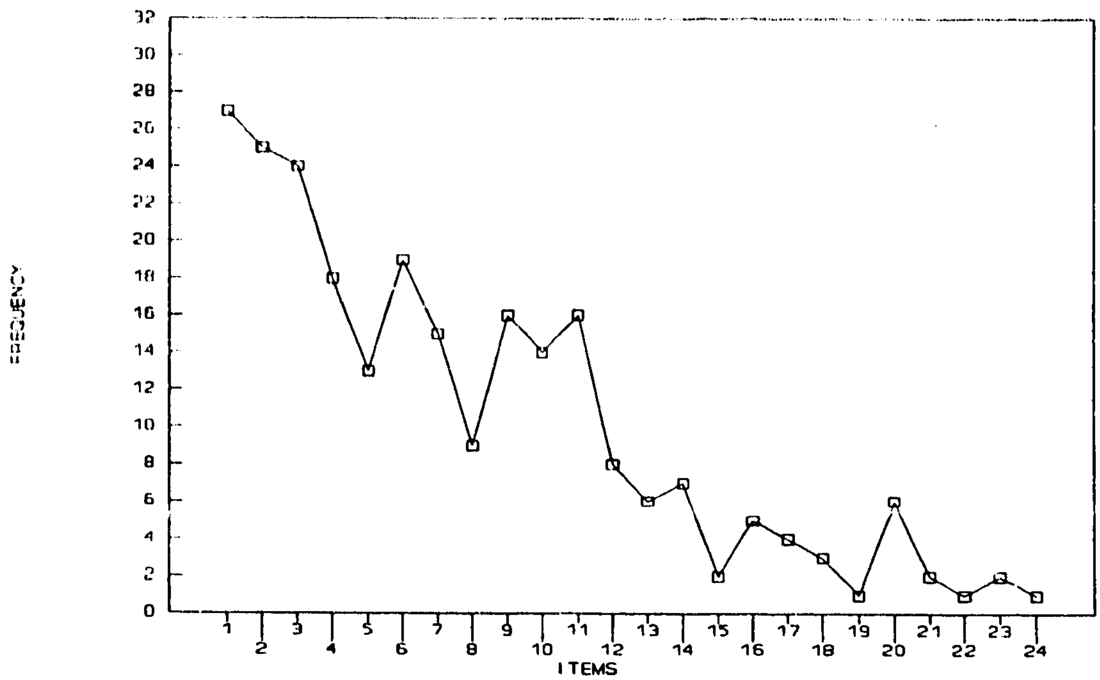
<u>Descriptive Data for the Matrices Test: mean, SD, numbers passed based on time intervals</u>

Variable: Time in Seconds (calculated on items passed)

Item	No.of Ss correct	Mean (time)	SD (time)	No. Passed by Time Interval 0-60	61-120	121-180	181-240	241-300+
1	27	32.444	20.857	25	2			
2	25	20.800	13.611	25				
3	25	38.560	39.148	20	4		1	
4	19	45.842	39.846	13	5		1	
5	13	74.923	47.799	7	3	3		
6	19	52.684	31.378	13	5	1		
7	15	45.867	20.996	13	2			
8	9	65.111	36.244	5	3	1		
9	16	43.125	23.670	12	4			
10	14	34.929	23.597	13	1			
11	16	34.063	12.969	16				
12	9	100.667	67.672	3	4	1	1	
13	6	104.500	54.254	2	1	3		
14	7	66.286	50.799	4	2	1		
15	2	107.000	35.355		1	1		
16	7	150.286	82.845	1	2	2	1	1
17	4	101.500	58.392	1	2	1		
18	3	99.000	61.000	1	1	1		
19	1	205.000	n/a			1		
20	6	98.667	45.143	2	3	1		
21	2	61.500	20.506	1	1			
22	1	197.000	n/a			1		
23	2	104.500	27.577		1	1		
24	1	147.000	n/a		1			

Figure 5

Revised Frequency of No. Correct for the Matrices Test



Tactual Search Test

The mean and SD for the dependent variable of time was computed for the following subtests of the Tactual Search Test: (a) the Automatic Search subtest (TSA), low and high density (TSAa and TSAb); (b) the Shape among Shapes subtest, low and high density (TSSa and TSSb); (c) the Number among Numbers subtest, low and high density (TSNa and TSNb); and (d) Letter among Letters subtest, low and high density (TSLa and TSLb). These statistics are presented in Table 19.

Hypothesis 4: Congenitally blind persons will take less time to complete the low density test items than the high density test items on the following subtests of the Tactual Search Test: Automatic Search (TSA), Number among Numbers (TSN), Shape among Shapes (TSS), and Letter among Letters (TSL).

To test Hypothesis 4, t-tests were performed. The results of the two-tail t tests (see Table 19) showed that for all subtests, a significant difference ($P < .05$) was found. Subjects took significantly less time to search the low density items as compared to the high density items. These findings were supportive of Hypothesis 4. Subjects had to identify the critical features of each distractor and compare it to the stimulus. Time required was found to be approximately in direct proportion to the number of distractors for the following three subtests TSA, TSS, and TSN.

Hypothesis 5: There will be a significant difference in time taken by congenitally blind persons to complete the four subtests of the Tactual Search Test: TSA, TSN, TSS, and TSL.

To test Hypothesis 5, a one-way analysis of variance (ANOVA) with repeated measures was performed on TSA, TSS, TSN, and TSL (see Table 20). The F ratio ($p < .05$) was found to be significant. A post-hoc comparison using Scheffé tests ($p < .05$) was used to delineate subtest differences. The TSA was found to be significantly different from TSS (mean dif=29.44), TSN (mean dif=10.59), and TSL (mean dif=17.16). The TSS was significantly different from TSN (mean dif=18.85) and TSL (mean dif=12.28). There was no significant difference found between TSN and TSL (required dif=8.05). It is interesting to note that subject mean times on TSL and TSN were not significantly different.

Subjects indicated that they found TSN and TSL to be similar. Transcription into the braille code of the numbers and letters might have minimized the differences between them. Visually, numbers and letters look different, while in the braille code the differences are physically less pronounced. The numbers 1 to 9 are the same as the first nine letters of the alphabet, and zero is the same as the letter "j". To transform these letters into numbers, a number sign is placed in front of the letter. The task-demands of these two subtests may be similar as the only difference between them is the number sign for TSN and the letters k to z for TSL. Subjects provided little feedback about this test. About half indicated that the test required a systematic approach to scanning or searching, while the remainder focused their comments more on the length of the tests and the time required to complete them. A number of subjects suggested that the test be cut down in size, as they had to struggle to maintain a high level of motivation.

The video tapes were analyzed to determine the type of tactual scanning strategies employed by the subjects. Scanning strategies are important as they provide insight into how the person develops a frame of reference and gains information. The Tactual Search test affords a great opportunity for analysis of these strategies. Berla (1972) investigated the scanning techniques employed by adult blind subjects. In subsequent studies it was determined that to locate target symbols, scanning in a vertical pattern was superior to scanning in a horizontal pattern (Berla, 1973; Berla &

Murr, 1974). Three scanning strategies were evaluated by Berla and Murr (1974) for their thoroughness and effectiveness, including a vertical scan, a one-hand horizontal scan, and an asymmetrical horizontal scan (descriptors of these scans are in the review of the related literature). They found that the vertical scan was most efficient.

The following scanning strategies were identified from the video analysis:

1. A vertical scan (VS), in which both hands were used to search the map from top to bottom and bottom to top until the page had been covered.
2. A variation of the vertical scan (VVS), in which one index finger of one hand was kept on the target stimulus, while the hand of the finger that maintained stimulus contact and the hand that scanned the page interchanged.
3. A one hand horizontal scan (HS), in which one hand searched the page horizontally while the other hand maintained stimulus contact. A problem with this technique was that the area under the forearm of the hand that maintained stimulus contact would frequently be missed.
4. A variation of the horizontal scan (HS1), in which the hands interchanged, thus avoiding the "blind spot" under the forearm.
5. Another variation of the horizontal scan (HS2), in which one hand scanned, while the other hand was completely off the page.
6. A horizontal asymmetrical scan (HAS), where both hands moved from the outside of the page to the centre and back to the outside until the page had been covered.

7. A reading mode scan (RMS), where the horizontal movement was left to right, (either one handed or two handed), in a braille reading motion, instead of a sweeping motion.

8. A random scan (RS), in which no discernable pattern was evident.

From inspection of Table 21 it is clear that the majority of the subjects used the same scanning technique for each of the four subtests. A number of subjects, however, used several scanning techniques on one page or during one subtest; their data was not included in Table 21. It is interesting to note that vertical scanning techniques were predominantly used, since vertical scanning was found to be by Berla (Berla 1973; Berla & Murr, 1974) the most efficient and thorough. Only a few subjects attached a verbal label to the shapes, in contrast to the majority who attached verbal labels to the numbers and letters. Stimulus contact was maintained more often when scanning shapes than letters or numbers, which might be because it would be more difficult to keep a tactual image in working memory than a verbal label.

The scanning techniques used for TSN and TSL were similar, and the mean time difference was not found to be significant. If this test were to be shortened for future use, one of these subtests could potentially be eliminated.

Table 19

Mean, SD, and t-tests for the Tactual Search Test

Variable: Time in Seconds

Task	Mean	SD	DF	t	P
TSAa	7.883	4.996	29	4.05	<0.001
TSAb	15.625	10.715			
TSSa	31.658	21.278	29	6.13	<0.001
TSSb	50.733	27.243			
TSNa	16.167	8.447	29	4.93	<0.001
TSNb	28.525	13.774			
TSLa	23.292	12.285	29	3.92	0.001
TSLb	34.533	16.280			

Table 20

One-Way Analysis of Variance with Repeated Measures of TSA, TSS, TSN, and TSL

Source	SS	DF	MS	F	P
Test	13670.46	3	4556.82	38.11	<0.001
Error	10402.26	87	119.57		

Table 21

Scanning Techniques of the Tactual Search Test

Subtest	VS	VVS	HS	HS1	HS2	HAS	RMS	RS
Automatic Search	8	7	2			1	5	
Number among Numbers	8	3	5		1	1	7	1
Shape among Shapes	8	5	4	1		2	4	
Letter among Letters	10					2	10	

Syllogisms Test

The mean and SD for the dependent variable of time was computed for the four series of the syllogism test (SYLT1 to SYLT4) and the full scale (SYLT). The mean and SD for the dependent variable scores were also computed for the four series (SYLS1 to (SYLS4) and the full scale (SYLS). These are presented in Table 22.

Hypothesis 6: There will be a significant difference in time taken by congenitally blind persons to complete each of the four series of the Syllogisms test.

To test Hypothesis 6, a one-way analysis of variance (ANOVA) with repeated measures was performed on the variable time for the SYLT1 to the SYLT4 (see Table 23). The F ratio ($p < .05$) was found to be significant. A post-hoc comparison using

Scheffé tests ($p < .05$) was used to delineate differences among the four series. Overall, the SYLT1 took longer to complete than the other three parts of the test. The SYLT1 was found to be significantly different in terms of completion time from the SYLT2 (mean dif=40.87), the SYLT3 (mean dif=50.93), and the SYLT4 (mean dif=41.07). All the other mean comparisons were not significant (required dif=40.00).

Hypothesis 6 was only partially supported. The time taken to complete SYLT1 was significantly longer than the time taken to complete the SYLT2 to the SYLT4. A possible explanation for this finding might be that subjects had to get used to this task. By the time they completed the eight syllogisms of the SYLT1 they had developed a workable strategy and were able to complete the other three series faster.

Hypothesis 7: There will be a significant difference in the number of test items completed correctly on each of the four series of the Syllogisms test (SYLS1 to SYLS4) by congenitally blind persons.

To test Hypothesis 7, a one-way analysis of variance (ANOVA) with repeated measures was performed on the variable scores for the SYLS1 to the SYLS4 (see Table 23). The F ratio ($p > .05$) was not found to be significant.

The findings did not support Hypothesis 7, since no significant difference was observed between the scores of the four series. It is of interest to note that Heemsbergen (1980) found that the scores did not discriminate between subjects and that relatively high scores were obtained by all the subjects in his study. Scores were also relatively high in the present study.

Feedback and observations from the subjects suggested that two strategies were used to solve the syllogisms. They were:

1. Eight subjects assigned numbers to the descriptors of older, younger, shorter, and taller. Older and taller received the higher numerical values.

2. Fifteen subjects mentally used lines to represent the individuals in the syllogisms and used the longest line to represent the descriptors of older or taller. One subject used a flight of stairs instead of lines.

Three subjects used a combination of the above two strategies, while three other subjects were unable to explain what strategy they used.

Given the findings, it seems reasonable to shorten this test. The following is proposed. The revised version should consist of only 16 items including the SYL1, in which the syllogisms are in their natural order and require no reordering or conversion of the premises, and the SYL4, which requires the reordering and conversion of the premises. It is recommended that the SYL2, which requires the reordering of one premise and the SYL3, which requires one premise to be converted, be omitted.

Table 22

Mean and SD for the Syllogisms Test

Variable: Time in Seconds

Task	Mean	SD
SYLT1	242.700	93.423
SYLT2	201.833	67.479
SYLT3	191.767	65.217
SYLT4	201.633	80.692
SYLT	837.933	246.478

Variable: Score (items correct)

Task	Mean	SD
SYLS1	5.933	1.760
SYLS2	6.333	1.561
SYLS3	6.433	1.832
SYLS4	5.800	5.955
SYLS	24.500	5.794

Table 23

<u>One-Way Analysis of Variance with Repeated Measures of the SYLT1 to the SYLT4</u>

(Time in Seconds)

Source	SS	DF	MS	F	P
Test	46121.17	3	15373.72	5.21	0.002
Error	256876.33	87	2952.60		

(Score based on items correct)

Source	SS	DF	MS	F	P
Test	8.42	3	2.81	1.95	0.128
Error	125.32	87	1.44		

<u>Matching Numbers Test</u>

The mean and the SD for the dependent variable of time was computed for the Matching Numbers Test (MN) and its three parts, MN1 to MN3. These are presented in Table 24.

<u>Hypothesis 8</u>: There will be a significant difference in time taken by congenitally blind persons to complete the three parts of the Matching Numbers Test.

To test Hypothesis 8, a one-way analysis of variance (ANOVA) with repeated measures was performed on MN1 to MN3 (see Table 25). The F ratio ($p < .05$) was found to be significant. A post-hoc comparison using Scheffé tests ($p < .05$) was used to delineate subtest differences. All three parts were significantly different from each other. The MN1 was found to be significantly different from the MN2 (mean dif=105.63), and the MN3 (mean dif=229.00). The MN2 was also found to be significantly different from the MN3 (mean dif=123.37). These findings were in support of Hypothesis 8. It would appear reasonable that it would take longer to compare larger numbers than smaller numbers.

Feedback and observations from the subjects indicated that they used two main strategies. They were:

1. Eight subjects compared whole numbers throughout the entire test.
2. Fourteen subjects narrowed down their search by comparing groups of digits and by quickly eliminating the numbers that did not contain the digits for which they were looking.

A number of subjects modified their approach during the test. The first strategy was initially used by an additional eight subjects, who switched to using the second strategy when the numbers became larger and they felt that the process became too cumbersome.

A number of subjects mentioned that they found this test interesting, as it made them think about what they were doing. They felt challenged to find a quick and efficient way of comparing the numbers and wanted to improve upon their performance.

Table 24

Mean and SD for the Matching Numbers Test

Variable: Time in Seconds

Task	Mean	SD
MN1	98.533	54.649
MN2	204.167	89.041
MN3	327.533	136.569
MN	630.233	264.080

Table 25

One-Way Analysis of Variance with Repeated Measures of the MN1 to the MN3

(Time in Seconds)

Source	SS	DF	MS	F	P
Test	788187.36	2	394093.68	124.72	<0.001
Error	183277.31	58	3159.95		

Summary

Data from 30 congenitally blind persons, ranging in age from 19 to 43 years, were collected for the 12 tests of the experimental assessment battery and presented for normative purposes. The pattern of responses of the subjects on the 10 tests adapted from the CAS, including scores, time taken, and subject feedback, were examined to determine whether the adaptations appeared to have changed the task-demands of the tests. The tests were adapted, since the assumption should not be made that the underlying abilities required by tests that are derived from studies with the sighted population are the same when they have been transcribed into braille or into a tactual format. This reasoning also applies to tests that do not require adaptation as their results depend in large measure on the characteristics of the normative group. The same test may well create different demands, since test norms for the sighted reflect sensory intactness, coordination, and experiential factors, in addition to intellectual or developmental status. The primary mental abilities that underlie test performance need to be understood, before conclusions about cognitive functioning are made. The following considerations are exemplified in the interpretation of the task-demands of the Receptive Attention Test, the Successive Ordering Test, and the Tactual Search Test may have been changed, because of the translation into braille or a tactual format.

The Receptive Attention Test consists of two subtests, a Physical Match task and a Name Match task. Results showed that subjects took longer to complete the Physical Match task than the Name Match task. The subjects did not obtain significantly different scores, or number of false alarms, between these two tasks. These findings were contrary to expectations. In the literature it had been demonstrated that with the sighted population, the Physical Match task was completed faster than the Name Match task and that higher scores were obtained on the Physical Match task. Two plausible explanations were offered. It was found that, in braille, the Name Match task may be more of a Physical Match task than a Name Match task, because in the braille code the upper and lower case letters are the same, except for a single dot signifying capitalization. Alternatively, the findings could also be explained by the fact that the majority of the subjects responded to both tasks by not only pointing to identify the letters, but also by naming them. It is, therefore, possible that the Physical Match task may have been more of a Name Match task.

The CAS version of the Successive Ordering Test was designed so that individuals would integrate the test stimuli in a temporal sequence. Although this also appeared to have occurred with the adapted version of the Successive Ordering Test in the majority of the congenitally blind subjects, a number of subjects reported that they interrelated the chips into a spatial pattern.

Subject performance on the four subtests of the Tactual Search Test was varied, as expected, except that there was no significant difference in performance found between the Number among Numbers and Letter among Letters subtests. Subjects indicated that they found these two subtests to be quite similar. Transcription into the braille code of the digits and letters might have minimized the differences between them. Visually, numbers and letters are different, while in the braille code the differences are physically less pronounced. The digits "1" to "9" and "0" are the same as the first ten letters of the alphabet. To transform these letters into digits, a number sign is placed in front of each letter.

The findings with the Receptive Attention Test, the Successive Ordering Test, and the Tactual Search Test underscore that assumptions about task-demands should not be made when transcription into braille or a tactual format is made.

Subject responses on the Number Finding Test and the Matching Numbers Test were according to expectations, which suggest that with the current sample of congenitally blind persons transcription into braille may not have affected the task-demands of these tests.

The results of the remaining adapted five tests are speculative, as not enough information is available. In Study 1 descriptive statistics were collected to provide a foundation for possible future studies. It is of interest to note that performance on the Syllogisms Test indicated that Series A took longer to complete than the other three series and that there were no significant differences in scores among any of the four series. This finding does not necessarily suggest that transcription into braille changed the demands of this test, as it has not been demonstrated in the literature that the four series of this particular test are measuring different abilities with the sighted population. Subject feedback did not provide any insight into whether or not they perceived the series to be of varying levels of difficulty.

The Word Series Test was adapted by changing the auditory presentation of the series into a braille format. Subject feedback suggested that the integrity of this test was maintained, as they accurately perceived the intent of this task to be that of keeping as many of the words as possible in working memory in the order of presentation. Some subjects reported using a "chunking" strategy for the longer series, which would suggest that they switched from successive processing to simultaneous processing.

The Design Construction Test, the Simultaneous Verbal Test, and the Matrices Test were adapted from a visual/spatial format to a tactual/spatial format. When visual/spatial patterns, designs, shapes, or forms are translated into a tactual format, one has to question whether the shape dimensions are equally meaningful to vision and touch. When using the tactual modality to receive information, it is possible that features are attended to that are not informative for the visual system and features highly critical for the tactual system may be lacking. It is therefore encouraging to note that subject feedback was supportive of the underlying construct of these tests. Subjects indicated that they had to apprehend all the different elements of a design or pattern and be able to mentally manipulate them at the same time, in order that they could form a whole pattern and deduct relationships between patterns. Subjects were also the most challenged and frustrated by these three tests. They were described as "brain teasers" and "brain stretchers." A number of subjects asked whether they could purchase the materials of the Design Construction Test and the Matrices Test. They explained that their sighted counterparts had numerous puzzles available to them, but that their choices were limited. They believed that these materials would afford them an opportunity to engage in a personal challenge.

The assessment sessions were video taped and the tapes were analyzed to identify observable test behaviors and strategies. Subjects were also questioned, after the administration of each test, on their perceptions of the task-demands and the strategies they used to complete the tests. Behaviors and strategies were identified for two reasons: (a) to assist with the long-term goal of delineating the different strategies used by individuals for each test, as the long-term goal is to develop an instrument that scores individual performance according to the strategies used; and (b) to examine the dynamic processes that underlie the four PASS constructs.

Specification of the mental operations involved in test performance leads to a description of each construct in terms of concrete, observable behaviors. When such behaviors are delineated, an attempt can be made to provide a description of the relationship between the construct and a number of different behaviors. The data from subject feedback and the video tapes are encouraging in that they are supportive of the four constructs. This study did not have enough subjects to obtain confirmative evidence of the constructs by using factor analysis to determine whether the expected pattern of relationships does indeed appear to exist.

Test refinements and revisions were proposed for the Design Construction Test, the Simultaneous Verbal Test, and the Matrices Test. It was established, that with the current sample of congenitally blind persons, a time limit of 180 seconds for the Design Construction Test and the Matrices Test would be reasonable, since few subjects required more than 180 seconds to complete test items. A time limit of 60 seconds was considered acceptable for the Simultaneous Verbal Test, since a time limit longer than 60 seconds did not provide enough differentiation among subjects. Items 9 to 16 of the Design Construction Test and items 17 to 24 of the Matrices Test did not provide enough differentiation among subjects to warrant inclusion in these tests.

CHAPTER VII

STUDY 2

PERFORMANCE OF BLIND AND BLINDFOLDED PERSONS - A COMPARISON

Purpose of the Study

The major purpose of Study 2 was to gain an understanding of the ability of congenitally blind and blindfolded-sighted persons to perceive and evaluate information received through their tactual sense. Level of experience in utilizing the tactual sense was postulated to be a variable. This variable was controlled by dividing the sighted into two groups: (a) those with experience using their tactual sense; and (b) those who were comparatively inexperienced. The second purpose of Study 2 was to compare the performance of blindfolded-sighted persons and congenitally blind persons on tests, using a tactual format, that were designed to measure the constructs of planning, and simultaneous and successive processing. The third purpose of Study 2 was to identify behaviors, by means of self-report and observation, that the blindfolded-sighted engage in during tactual problem solving. The final purpose of Study 2 was to compare the behaviors of blindfolded-sighted persons with those of congenitally blind persons when engaged in tactual problem solving.

Research Questions

The following is a list of questions generated from the review of the related literature:

1. Is there a difference in performance between congenitally blind persons and blindfolded-sighted persons on tests that purport to measure planning, simultaneous processing and successive processing?
2. Does the level of tactual experience of blindfolded-sighted persons influence their performance on tests that use a tactual format?
3. What are the reported perceptions of blindfolded-sighted persons on the demands of each test?
4. What are the observable behaviors that blindfolded-sighted persons exhibit while they are engaged in tactual problem solving?
5. Do congenitally blind persons and blindfolded-sighted persons report different perceptions on the demands of each test?
6. Do congenitally blind persons and blindfolded-sighted persons exhibit different behaviors while they are engaged in tactual problem solving?

Arising from the preceding questions, the following is a list of specific hypotheses relating to the use of the adaptation of the CAS with congenitally blind persons and blindfolded-sighted persons.

Hypotheses and Rationale

Hypothesis 1: There will be no differences between congenitally blind persons and tactually experienced and inexperienced blindfolded-sighted persons on the variable scores on the Successive Ordering Test (SO).

Rationale: The SO was designed to be a measure of successive processing. In the literature, blindness has not been linked to a deficiency in the ability to integrate information in a temporal sequence. Rather, the literature is replete with examples of blind persons demonstrating at least equal ability to that of the sighted on measures that require successive processing, such as the immediate auditory recall of numbers (Hopkins & McGuire, 1966; Smits & Mommers, 1976; Tillman, 1967a; Tillman, 1967b; Vander Kolk, 1977, 1981; Warren, 1984).

Hypothesis 2: The performance of tactually experienced and inexperienced blindfolded-sighted persons will be better than the performance of congenitally blind persons on the variable scores on the Design Construction Test (DC) and the Matrices Test (MAT).

Rationale: The DC and MAT were designed to be measures of simultaneous processing. These tests have been shown to measure the ability to synthesize separate elements into groups and the capacity to determine the relationships among these groups. Research in the area of blindness has demonstrated that the absence of sight tends to result in a lack of gestalt or a deficiency in holistic processing (Casey, 1978; Millar, 1975, 1976). Sight is considered essential for the synthesis of elements into an integrated form (Piaget, 1952). Blind persons, who function without the information and integration provided by vision, were able to unite simple forms or elements of form into an integrated whole, but were less efficient when they were required to unite more complex forms into a whole, or to mentally manipulate separate forms in order to establish the relationships among them (Révész, 1933; Worchel, 1951).

Hypothesis 3: Congenitally blind persons will perform better than tactually experienced and inexperienced blindfolded-sighted persons on the variable of time on the following subtests of the Tactual Search Test: Automatic Search (TSA) and Shape among Shapes (TSS).

Rationale: The Automatic Search subtest and the Shape among Shapes subtest were designed to be measures of planning, which refers to goal setting, strategy selection, and monitoring of performance. These subtests require the subject to select an efficient tactual scanning strategy. Efficiency of tactual exploration has been found to improve with experience and to be more accurate in blind persons than in blindfolded-sighted persons. Blind persons have more opportunities to develop and refine tactual exploration techniques, than sighted persons, who have little reason to develop tactual exploration techniques (Davidson, 1985; Foulke and Warm, 1967; Jones, 1975).

CHAPTER VIII

METHOD

Subjects

Three different groups of subjects were recruited for this study. Group 1 involved the 30 congenitally blind subjects that were used in Study 1. Group 2 was composed of 15 potters who were tactually experienced sighted subjects, while Group 3 was made up of 15 ordinary sighted subjects that were tactually inexperienced. Tactual experience was defined as the use of the tactual sense on a regular basis for a sustained period of time. Potters were selected because, in addition to vision, they tend to rely on their sense of touch for the recognition or differentiation of clay textures and for the creation of form. Tactual inexperience was defined as the lack of the conscious use of the tactual sense on a regular basis for a sustained length of time. None of the tactually inexperienced subjects engaged in activities, such as arts and crafts, which might have facilitated the efficient acquisition of tactual information.

Group 2 subjects were enlisted with the assistance of the Alberta Craft Council, the Arts Branch of Alberta Culture, and the Edmonton Potters' Guild. Group 3 subjects were recruited from the community at large.

Every attempt was made to obtain homogeneous groupings. A questionnaire was designed to obtain information about personal, educational, and occupational history (see Appendix E). Potential subjects were asked whether they worked with textured materials on a regular basis, and only those individuals who qualified as tactually experienced or inexperienced were included in the study. Additional selection criteria for Groups 2 and 3 were: (a) normal vision or corrected vision (wearing glasses or contact lenses); (b) a normal field of vision; and (c) an unfamiliarity with braille and other tactual materials prepared for the blind. Subjects were screened to meet criterion (b) by administering the Gross Confrontation Test to map the visual fields (see Appendix F).

It was explained to subjects that: (a) they were being asked to take part in intellectual testing and experimental test activities designed to assess their processing ability and their ability to plan, (b) the experimental tests would be presented in the tactual modality, (c) the longterm goal of the study was to produce a test for the blind, and (e) assessment sessions would be video taped, to allow for strategy analysis and for demonstration purposes. Subjects signed a consent form (see Appendix C). Confidentiality was assured.

Group 2 comprised 15 potters (10 females and 5 males) ranging in age from 27 to 46 years with a mean age of 37.4 years and SD of 5.79. Years of experience as a potter ranged from 1 to 22 years with a mean of 9.87 years and SD of 5.79, while hours devoted to the creation of pottery ranged from 4 to 40 hours per week with a mean of 18.87 hours and SD of 12.78.

Group 3 (non-potters) consisted of 15 adults (10 females and 5 males) from the general population ranging in age from 23 to 46 years with a mean age of 36.4 years and SD of 7.18.

Potters and non-potters covered the spectrum of socioeconomic backgrounds and a range of educational attainment. Table 26 presents the level of education for both groups and Table 27 shows their employment status.

Table 26

Level of Education of potters and non-potters. Frequency Distribution

Education	potters	non-potters
Grade 11		1
Grade 12	1	
College Diploma	7	3
University	1	3
Undergraduate Degree	4	5
Graduate Degree	2	3

N=15

Table 27

Employment Status of potters and non-potters, Frequency Distribution

Status	potters	non-potters
Employed	15	14
Student		1

N=15

Procedure

The sighted subjects (potters and non-potters) were tested individually in a quiet room in their home or at an office. In Edmonton, office space was provided by the Fdmonton Public School District. Administration of the battery of tests took from 1 1/2 to 2 1/2 hours, depending on the speed and ability of each subject. Subjects were blindfolded for each test, but were able to remove the blindfold between tests. The sighted subjects were questioned on the strategies they used, after completion of each experimental test, and were also asked to provide feedback about what they thought about the test. The questions asked were: "Could you tell me how you tackled this task and what ran through your mind while you were doing it?" and, "Please tell me whatever you can, your observations will help with the development of this test." The information was noted and analyzed for commonalities and trends. Assessments took place from February, 1992 to April, 1992.

The experimental test battery was administered in the following order:

1. Successive Ordering
2. Design Construction
3. Matrices
4. Automatic Search
5. Shape among Shapes

CHAPTER IX

RESULTS AND DISCUSSION

In this section the results obtained on each test administered are presented and discussed. Two areas are examined: (a) a restatement of the hypotheses presented in Chapter VII, together with a presentation of the related findings and conclusions, and (b) reported and observed test taking strategies of the blindfolded potters, the blindfolded non-potters, and the congenitally blind. This section concludes with a summary of the results.

Tests

Successive Ordering

Hypothesis 1: There will be no differences between congenitally blind persons and tactually experienced and inexperienced blindfolded-sighted persons on the variable scores on the Successive Ordering Test (SO).

To test Hypothesis 1, a one-way analysis of variance (ANOVA) was performed on the dependent variable scores on the SO for the congenitally blind, the potters, and the non-potters (see Table 28). The F ratio ($p > .05$) was not found to be significant. This finding was expected, as blind persons have demonstrated at least equal ability to that of the sighted on measures that require successive processing.

The CAS version of the SO was designed so that the test would be most efficiently completed by integrating the test stimuli in a specific series in a chain-like progression. Analysis of subject feedback would suggest that although successive integration of test stimuli occurred for the potters and non-potters, it occurred only with half of the congenitally blind subjects. The potters and non-potters reported that they assigned a numeral to each chip. The majority ignored the textured shape on each chip completely and assigned a numeral to each chip from left to right. A few did report paying attention to the textured shapes. Their strategy was to name the shape and to assign a numeral to each shape name. Five potters and three non-potters reported the chunking of numerals in the longer series; the remaining potters and non-potters used single numerals. Half the congenitally blind subjects reported using a number strategy, while the remainder used a strategy that interrelated the chips into a spatial pattern.

Results indicated that the spatially presented items were recalled in temporal order, when subjects drew on the verbal code by labelling the chips or the shapes on the chips. When the verbal code was not used, the order of the chips was processed in terms of a tactual/spatial code.

The video analysis revealed that the potters and the non-potters engaged in the same behaviors as the congenitally blind which were described in Study 1, with one exception, the potters and non-potters did not appear to be locating the first chip to be turned during a response, without using some part of the response tray as a cue. This behavior might therefore provide a clinician with some indication that a spatial strategy is being utilized.

Table 28

One-way Analysis of Variance of Group Differences

Variable: Successive Ordering (score based on items correct)

Source	SS	DF	MS	F	P
Group	943.359	2	471.675	0.351	0.706
Error	76650.833	57	1344.752		

Variable: Matrices (score based on items correct)

Source	SS	DF	MS	F	P
Group	15.883	2	7.942	0.446	0.642
Error	1015.767	57	17.821		

Variable: Design Construction (score based on items correct)

Source	SS	DF	MS	F	P
Group	82.450	2	41.225	5.037	0.0097
Error	466.533	57	8.185		

Variable: Automatic Search (time in seconds)

Source	SS	DF	MS	F	P
Group	460064.550	2	230032.275	28.683	<0.001
Error	457127.633	57	8019.783		

Variable: Shape among Shapes (time in seconds)

Source	SS	DF	MS	F	P
Group	684012.950	2	342006.475	12.595	<0.001
Error	1547838.700	57	27155.065		

Design Construction

Hypothesis 2: The performance of tactually experienced and inexperienced blindfolded-sighted persons will be better than the performance of congenitally blind persons on the variable scores on the Design Construction Test (DC) and the Matrices Test (MAT).

To test Hypothesis 2, a one-way analysis of variance (ANOVA) was performed on the dependent variable scores on DC for the congenitally blind, the potters, and the non-potters (see Table 28). The F ratio was significant ($p < .05$). A post-hoc comparison using Scheffé tests ($p < .05$) was used to delineate differences of performance among the three groups. The potters scored significantly higher (mean=8.733) than the blind (mean=5.933). All the other mean comparisons were non-significant. These results only partially support Hypothesis 2, since it had been expected that the non-potters would also score significantly higher than the congenitally blind.

Analysis of subject feedback provided some insight into these results. The subjects in the three groups all reported that they needed to have a concept of the whole design in order to replicate it. The difference between the groups was that the potters and non-potters used visual imagery, whenever possible, to mediate tactual recognition of the designs. This was a strategy not available to the congenitally blind. They had to rely on a different representational system to gain an overall concept. None of the congenitally blind subjects was able to explain the essence of this representational system and they could not compare it to anything they were able to describe in words. Millar (1975,1976) suggested that the only option open to congenitally blind persons is to encode the spatial arrays in terms of successive inputs, while blindfolded-sighted persons are able to access the use of visualization as a global organizer. It does not follow that congenitally blind persons are, therefore, unable to process spatial/tactual information simultaneously, but it does suggest that this is more difficult for them. Successive tactual inputs may quickly overload the size of the working memory system. This would impede active synthesis of all the elements of the design, as multiple units have to be created in working memory for mental manipulation of all the elements or forms to take place. The blindfolded potters and non-potters also struggled with the encoding of the designs when they were unable to access visualization and had to rely on a tactual frame of reference.

It is important to note that some of the congenitally blind subjects were able to complete a number of the tactually complex designs, which suggests that some blind persons are able to form gestalts from information perceived successively and that they have the ability to integrate all the parts of each design into an integrated whole.

The advantage of the potters on this test may be explained in terms of their practice in translating tactual information into a visual image. During the creation of a clay form, the potter has to create the form with the hands, but shapes the form according to a visual representation of what it will look like upon completion.

The video tapes were analyzed and the same behaviors that were evident for the congenitally blind subjects were also observed among the potters and the non-potters. All subjects, regardless of visual status, re-examined each design frequently during replication, suggesting that the tactual image is fleeting.

Matrices

Hypothesis 2: The performance of tactually experienced and inexperienced blindfolded-sighted persons will be better than the performance of congenitally blind persons on the variable scores on the Design Construction Test (DC) and the Matrices Test (MAT).

To test Hypothesis 2, a one-way analysis of variance (ANOVA) was performed on the dependent variable scores on the MAT for the congenitally blind, the potters, and the non-potters (see Table 28). The F ratio ($p > .05$) was non-significant. This finding was contrary to expectation.

Analysis of feedback received from the potters and the non-potters indicated that they accurately perceived that the requirement of the MAT was to synthesize the information they apprehended tactually and then to integrate it into different elements that were interrelated. They expressed frustration with their inability to gain a mental representation of the information on the more complex matrices, because they were unable to remember the tactual impressions long enough to be able to integrate them into a form. Their strategy of choice was to gain a visual representation of the forms in a matrix and to attach a verbal label to them. They were then able to manipulate the verbal labels and could explore and determine the relationships among them. Three subjects reported that, after looking at the test materials, the terms they used to describe the apprehended lines to themselves, such as "wavy" or "bumpy" bore no relationship to the actual visual form. Their visual representations of some of the more complex matrices did not resemble the actual visual form.

The congenitally blind experienced the same difficulties as the potters and non-potters, but the difference between them was in the representational system used. The congenitally blind appeared to use a tactual frame of reference, which they were unable to describe in understandable terms. They also did not appear to be attaching verbal labels to the shapes they apprehended.

The video tapes were analyzed and the same behaviors that were evident for the congenitally blind subjects were observed among the potters and the non-potters.

Tactual Search

Hypothesis 3: Congenitally blind persons will perform better than tactually experienced and inexperienced blindfolded-sighted persons on the variable of time on the following subtests of the Tactual Search Test: Automatic Search (TSA) and Shape among Shapes (TSS).

To test Hypothesis 3, a one-way analysis of variance (ANOVA) was performed on the dependent variable of time on TSA and TSS for the congenitally blind, the potters, and the non-potters (see Table 28). The F ratio ($p < .05$) was significant. A post-hoc comparison using Scheffé tests ($p < .05$) was used to delineate differences in time among the three groups. The congenitally blind took significantly less time in seconds to complete TSA (mean=94.033) than the potters (mean=283.533) and the non-potters (mean=251.933). There was no significant difference found between the potters and the non-potters. The congenitally blind took also significantly less time on TSS (mean=329.567) than the potters (mean=563.200) and the non-potters (mean=518.267). Time taken to complete TSS was not significantly different between the potters and the non-potters. Hypothesis 3 was supported, in that the congenitally blind took less time to complete TSA and TSS than the potters and non-potters.

Feedback provided by the potters and non-potters indicated that eight potters and 10 non-potters relied for the most part on their tactual sense to complete the individual searches. They would attach a verbal label to the stimulus shape, whenever possible, since that was easier to remember than the tactual image, but they would not try to identify all the different shapes on each page. They relied on the discriminable features of each shape, such as size or texture. Taking the time to identify each shape and to name it, was reported by these subjects to be inefficient. Reliance on the tactual impression was much quicker. The remaining potters and non-potters initially tried to visualize the shapes on the page, but switched to relying on their tactual sense when visualization became inefficient. It is interesting to note that four potters reported that they mainly used a visually mediated strategy, while none of the non-potters indicated a heavy reliance on this strategy. The congenitally blind provided little feedback, except to indicate that a systematic approach to searching the page increased time efficiency.

Analysis of the video tapes revealed that the majority of potters and non-potters used a vertical or a horizontal scanning technique while they maintained stimulus contact with one hand. The scanning techniques are presented in Table 29 and Table 30 and refer to the same behaviors that were listed in Study 1 as part of that study's discussion on the Tactual Search Test. The results are similar to those obtained with the congenitally blind subjects (see Table 21).

Table 29

Scanning Techniques of the Tactual Search Test for Potters

Subtest	VS	VVS	HS	HS1	HS2	HAS	RMS	RS
Automatic Search		8	5		1	1		
Shape among Shapes	1	8	4		1	1		

Table 30

Scanning Techniques of the Tactual Search Test for Non-Potters

Subtest	VS	VVS	HS	HS1	HS2	HAS	RMS	RS
Automatic Search		7	6	1		1		
Shape among Shapes		8	5	1		1		

Summary

Four tests from the experimental assessment battery were administered to a sample of congenitally blind adults and blindfolded-sighted adults. The purpose was to discover whether there was a difference in performance between these groups on tests that purport to measure planning, and simultaneous and successive processes. For the sighted adults the level of tactual experience was considered as a possible variable and was controlled by using potters, who rely greatly on touch in their work, and non-potters, comprising individuals with relatively little tactual experience.

The Successive Ordering Test was selected as a measure of successive processing. No significant difference was found between congenitally blind persons and the potters and non-potters on this instrument. This finding was expected, as blind and sighted persons have demonstrated equal abilities on other measures that require successive processing. One finding of note was that all the potters and non-potters reported using a number strategy to remember the temporal order of the chips. Only half of the congenitally blind reported using this strategy. The remainder used a strategy that related the chips to a spatial pattern. Blind persons who used a spatial strategy did not label or name the shapes on the chips.

The Design Construction Test and the Matrices Test were selected as measures of simultaneous processing. Results showed that the potters scored significantly higher on the Design Construction Test than the non-potters and the congenitally blind. All other mean comparisons for the Design Construction Test as well as the Matrices Test were not significant. Analysis of subject feedback provided some insight into these results. After completing the Design Construction Test, all subjects reported that they needed to have an idea of the whole design, in order to replicate it. The reported difference between the groups was that the potters and non-potters used mediating strategies, such as visual imagery and verbal labelling, while the congenitally blind did not appear to be attaching verbal labels to the forms and shapes in the designs and patterns and did not use visual imaging. The congenitally blind who demonstrated skill in completing the designs and solving the matrices, indicated that they used a representational system based on a tactual frame of reference. When asked to describe their representations, they experienced difficulty. The difficulty seemed to lie in the paucity of words in the English language to describe tactual experiences. Most of the descriptive words commonly used are based on visual representation. The potters, who obtained the highest mean score on the Design Construction Test, appeared to be the strongest visualizers. The majority of them indicated that they were able to translate the successive inputs into a visual image for many of the designs and matrices. It is of interest to note that both the potters and non-potters struggled with the encoding of the designs and patterns when they were unable to access visualization and had to rely on a tactual frame of reference.

The Tactual Search Test was selected as a measure of planning. Results showed that the congenitally blind took significantly less time to complete the Automatic Search subtest and the Shape among Shapes subtest than the potters and non-potters. The congenitally blind are more practised than the sighted at relying on their tactual sense for searching or scanning materials presented in this format, which is similar to braille. It is noteworthy that the potters and non-potters reported that they abandoned their strategy of visualizing the target stimuli. They stated that relying only on their tactual sense, or the feel of the target stimulus, proved to be more efficient. The analysis of the behaviors, using the video taped testing sessions, showed that the congenitally blind, the potters and the non-potters all used common strategies when engaged in tactual problem-solving.

CHAPTER X

GENERAL DISCUSSION AND IMPLICATIONS

The primary objective of this research was: (a) to adapt the CAS for use with blind persons, (b) to examine the efficacy of changing the visual test materials into a tactual format, and (c) to begin the process of gathering evidence to show that each test of the experimental battery is a measure of the construct it was designed to assess. A secondary objective of this research was to examine if congenitally blind persons engage in the simultaneous processing of information that they receive successively and to compare the performance of congenitally blind persons and blindfolded-sighted persons on tests that use a tactual mode of presentation. In Chapter X, the results are discussed both in relation to the objectives of this research and in terms of some of the theoretical and practical issues in the area of assessment of blind persons. Following the discussion, a number of implications for further research are outlined.

Discussion

The adaptation of the CAS has illustrated that redesigning a test for the blind population is not as simple as translating tests that were created for the sighted into a tactual format. For adaptation to be effective, there is the need to be cognizant of the limitations of the tactual representations of visually-based materials and of the ability of individuals to apprehend details sufficiently to comprehend them. This does not mean that tests used for the sighted cannot be adapted, but it does mean that one must ensure that the demands and the integrity of the tests remain the same. Adaptation of the CAS was based on the guiding principle that a change of format may affect the task-demands of a test, and that the significance of the changes requires further investigation. The tests in the experimental battery that exemplified this principle were the Receptive Attention Test, the Successive Ordering Test, and the Tactual Search Test.

The seemingly simple translation of letters or numbers into braille may have changed the task-demands of the Receptive Attention Test and the Tactual Search Test. The change from a visual presentation of colored chips to a tactual presentation of textured chips in the Successive Ordering Test may also have influenced task-demands, because a number of the congenitally blind subjects reported interrelating the sequence of chips in a spatial pattern, instead of a temporal sequence. In contrast, examination of the pattern of responses on the Number Finding Test and the Matching Numbers Test would suggest that transcription into braille did not affect the task-demands of these tests. The present study was not able to evaluate the effectiveness of adaptation of the remaining tests, except for subject feedback. However, an analysis of the feedback from subjects suggested that the integrity of the tests remained intact.

The dynamic processes that underlie the constructs of planning, attention, and simultaneous and successive processing were examined by questioning subjects, after administration of each test, on their perceptions of the task-demands of the test and the strategies they used to complete the test. Video tapes of the assessment sessions were also analyzed to delineate observable behaviors for each test. It is premature to conclude that the measures conform to the definitions of their respective constructs, but the findings of this study are encouraging and supportive of the constructs. Much work still needs to be done, but it can be safely concluded that the experimental battery holds promise as a battery of Planning, Attention, and Simultaneous and Successive Processing for use with blind persons.

The four constructs are considered to be interdependent and are involved in virtually all tasks. Simultaneous and successive processing, for example, operate collaboratively and are involved to some degree in all tasks. Both processes, however, can be measured independently, depending on the aspects of a task which are most difficult for the individual. A case in point is the Word Series Test. The difficulty for most of the congenitally blind subjects was associated with remembering the words in their temporal order, which involves successive processing. Results of Study 1 showed that this appeared to be true for the majority of the subjects. However, a few congenitally blind subjects changed the nature of the task to one of combining and relating words in chunks, which involves simultaneous processing. The Word Series Test illustrates that both processing styles can be involved. The tests designed to measure the four constructs are primarily, but not exclusively, a measure of the constructs. Thus, none of them are considered "pure" measures.

The foregoing discussion demonstrates why it is important that each test provides a procedure for scoring performance according to the strategies used. To accomplish this, each construct needs to be defined operationally, by including a list of the strategies and observable behaviors.

Results of the three tests that were designed to measure simultaneous processing, the Design Construction Test, the Simultaneous Verbal Test, and the Matrices Test, were examined to gain insight into whether congenitally blind persons process information, that is received through successive tactual inputs, in a simultaneous manner. These tests have been shown in the sighted population to measure the ability to synthesize separate elements into groups and the ability to determine the relationships among these groups. Research in the area of blindness has demonstrated that the absence of sight tends to result in a lack of gestalt, as sight has been considered essential for the synthesis of elements into an integrated form. Congenitally blind persons, when faced with information presented tactually, need to combine small parts perceived through successive inputs as a function of tactual exploration without any memory of a visual overview.

An analysis of the feedback provided by the congenitally blind subjects, after the administration of these three tests, would suggest that these subjects used a different organizational process than the visually based system. This was also noted by Jones ([illegible]) who believed that the organizational process in the blind takes longer to develop than a visually based system, but that the end result is not qualitatively different.

Subjects who were able to complete items of the Design Construction Test and the Matrices Test reported that they created a "whole" through some form of a representational system that appeared to be based on a tactual frame of reference. It is of note that none of these subjects was able to describe this representational system. We need a terminology related to tactual perception and experiences, as none of the present terminology appears to fit. In teaching and interacting with blind adults and children, communication by the sighted is currently built on a paradigm of a language based on visual experiences. The English language is rich in words that describe visual experiences, but impoverished when it comes to the description of information received through the sense of touch. The influence of the language of the sighted has also been studied by Santin and Nesker Simmons (1977). They noted that blind children experience difficulty in creating reality, because they experience the world through touch, hearing, smell, and taste, while the world is explained to them in a visually-oriented language that may not match the children's experiences. Without language, it is difficult to validate the tactual experience. Teachers will need to examine the terminology they use with blind adults and children. For effective communication to take place, there needs to be a terminology that is based on a tactual frame of reference instead of one that solely relies on a visual frame of reference.

Subjects also reported that they experienced difficulty with the more complex designs and matrices, because they were not able to store all the different parts in memory and, consequently, could not form an integrated "whole" or mentally manipulate the different elements. This is not surprising as simultaneous processing interacts with the limits of working memory to produce performance on a task. These subjects appeared to organize the attributes of the tactual forms into a spatial representation, to allow all attributes to be entertained simultaneously, and the capacity of their working memory influenced how well they were able to do this.

The Simultaneous Verbal Test provides language to label the different shapes. Subjects were instructed, for example, to identify "a cross under a triangle that is in a circle." Most subjects, during the beginning items, would quickly check with the examiner whether the shape they felt was indeed a cross or a triangle. When they had connected the verbal label to the shape they were able to solve this test relatively quickly, which suggests that tactual memory may be enhanced by attaching verbal labels to the tactual images. It also appears, from the results of this test. that verbally encoded information is longer lasting than tactually encoded information that is more readily retrievable.

These findings indicate that the congenitally blind are able to process tactual/spatial information simultaneously. It is remarkable that the congenitally blind performed equally well as the blindfolded non-potters on the two major simultaneous tests. Considerable individual differences among the congenitally blind in their ability to process tactual/spatial information simultaneously were observed. It is suggested that performance may be lower than that of the individual's potential, because of a difficulty in using language as a mediating strategy due to a lack of terminology for tactual experiences.

The performance of congenitally blind and blindfolded-sighted persons was compared on tests that utilized a tactual presentation. Feedback from these groups provided insight into the differences and similarities between them. The blindfolded-sighted reported using the following strategies: (a) a verbal strategy, in which they applied a name to the information they received tactually, (b) a visualization strategy that involved associating the tactual perception to a visual image, (c) a tactual strategy that involved relying on a tactual image for tasks that only required recognition of forms and not the mental manipulation of forms, and (d) a mixed strategy where imagery and verbal strategies were used in combination. The blindfolded-sighted reported that when they were unable to make a match between the form they perceived tactually and its visual counterpart, they found that verbally labelling their tactual experiences in words such as "bumpy", or "wavy" was not helpful, as they could not relate it to anything in their experiences. The words they had available to them and the actual sensory experience were not adequately matched.

Between the groups, a difference in performance was found on the Design Construction Test in favour of the blindfolded-sighted, and on the Tactual Search Test in favour of the congenitally blind. The only reported difference between the blindfolded-sighted and the congenitally blind appears to be that the sighted can evoke visual images and have more facility in using verbal labels. The congenitally blind appear to have more facility in using a tactual frame of reference and representational system. Some of the blind performed better on the tests than the sighted and some of the sighted performed better than some of the blind. Even though vision is often referred to as the integrating sense, some congenitally blind persons were able to integrate tactually perceived elements into a concept of the whole form. This was accomplished notwithstanding the fact that blind individuals receive incomplete information in a successive order.

Implications for Future Research

A number of implications for further research are suggested by the preceding discussion.

1. It would be useful to investigate the differences within the blind population, by administering the experimental battery to adventitiously blinded persons who lost their sight at varying ages. This would provide an indication of the similarities and differences between these groups and would also assist with the gathering of normative data.
2. To adapt the test materials for school-aged children and to gather normative data for children of varying ages. This will provide needed information on the cognitive functioning of this population.
3. There is a need to continue the process of examining the efficacy of changing the visual test materials into a tactual format.
4. Also apparent is a need to continue with the identification of behaviors, by means of self-report and observation, in order to proceed with the process of gathering evidence that each test is a measure of the construct it was designed to assess.

5. Additionally, there is a need to perform factor analytic studies in the later stages of research on the experimental battery in order to determine whether the expected pattern of relationships between the test scores and the factors exist.

6. Further insight may be gained by conducting research on those blind persons who are able to perform the tests expertly, as compared to those who experience difficulty. The differences between them may increase awareness of the type of abilities, strategies, or skills that are required for the cognitive processes. This is important information in the context of the PASS theory, as it would examine the constructs in a learning and training environment and provide information on remediation.

7. Further research needs to be conducted in the area of the language we use to communicate with blind adults and children pertaining to the information they receive from their sense of touch. Our present language does not allow for clear communication, which hampers validation of the tactual experience of blind persons.

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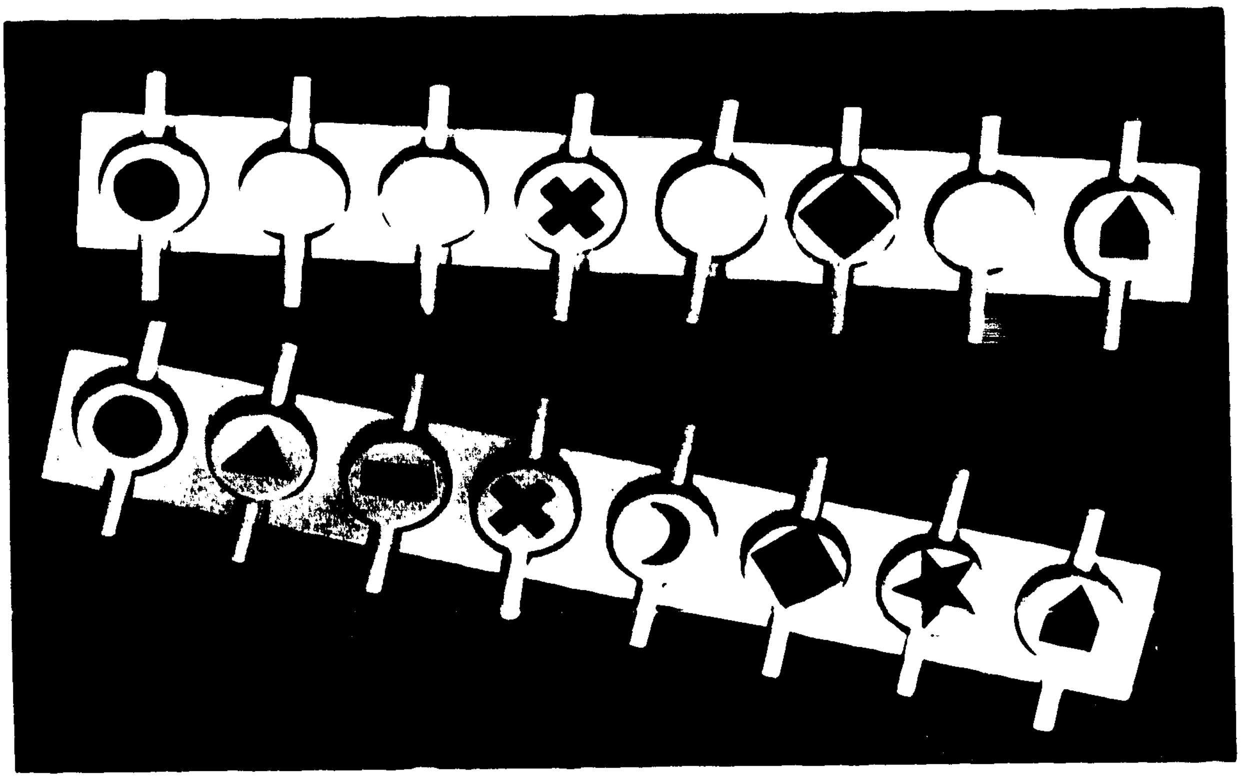
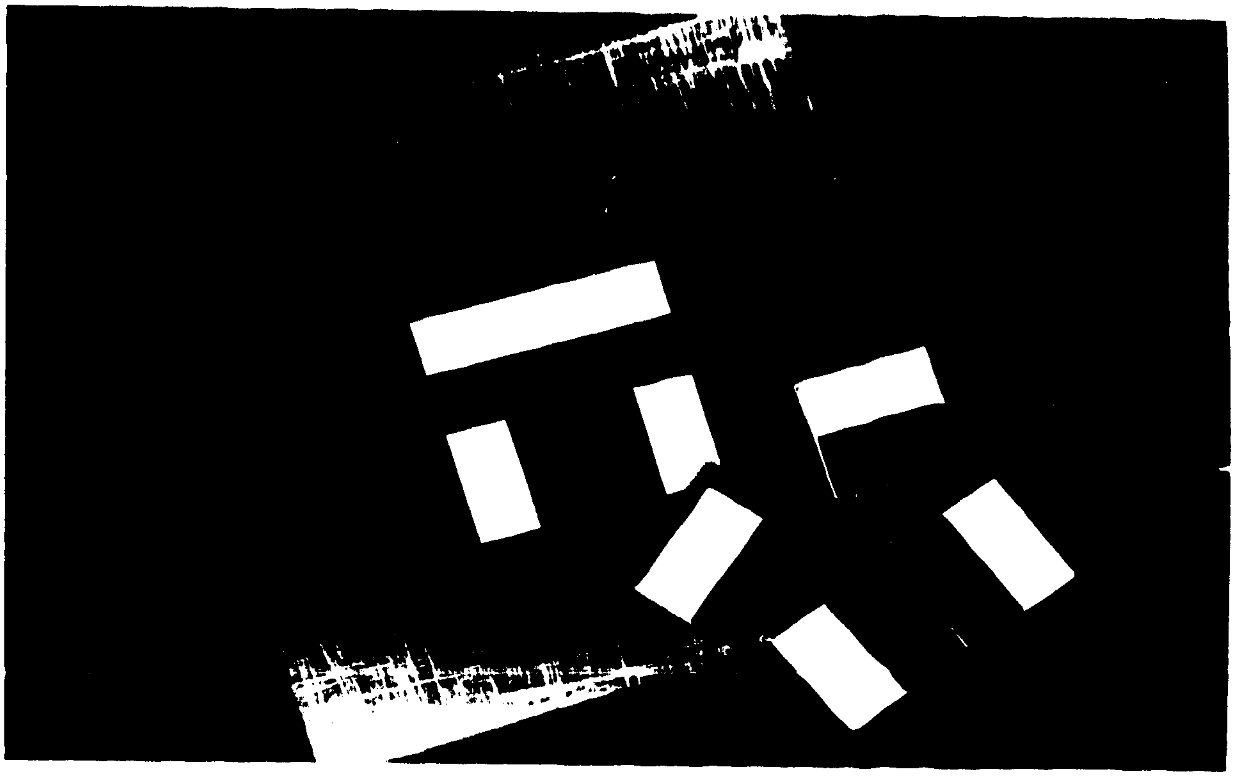
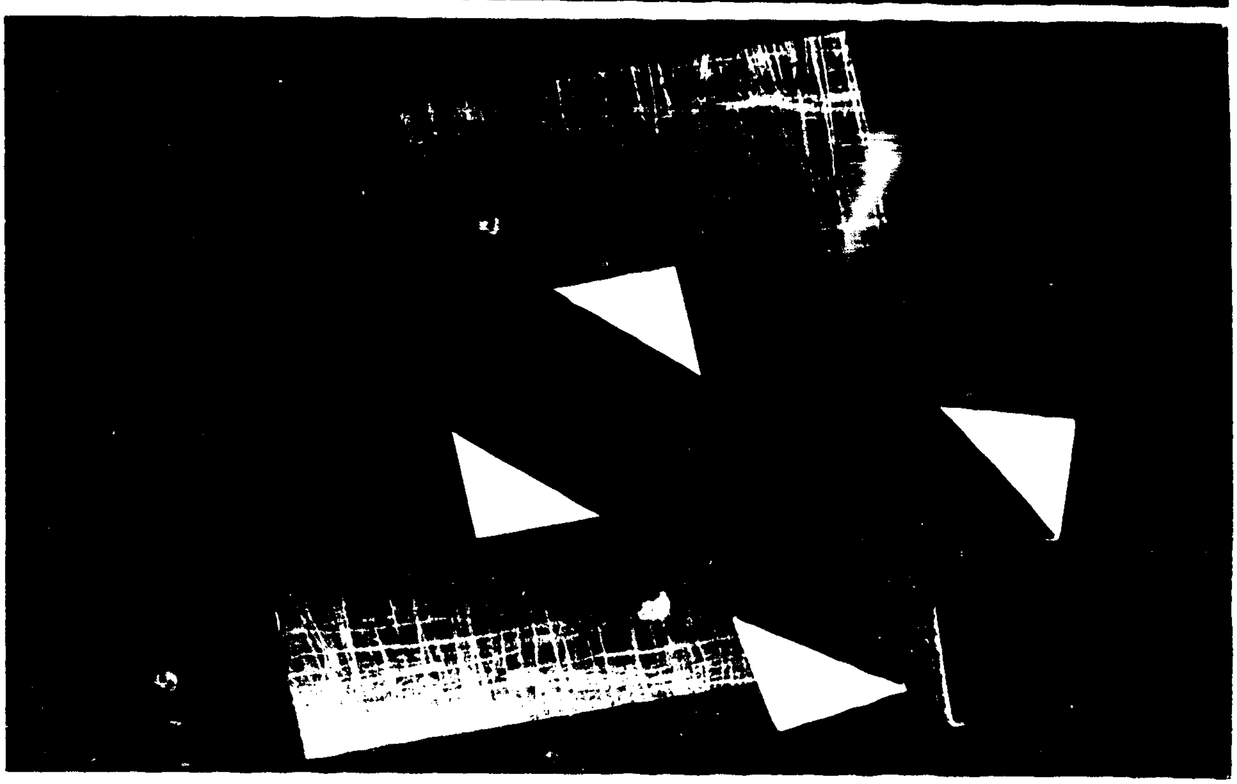
APPENDIX A: Test Samples

Successive Ordering Test

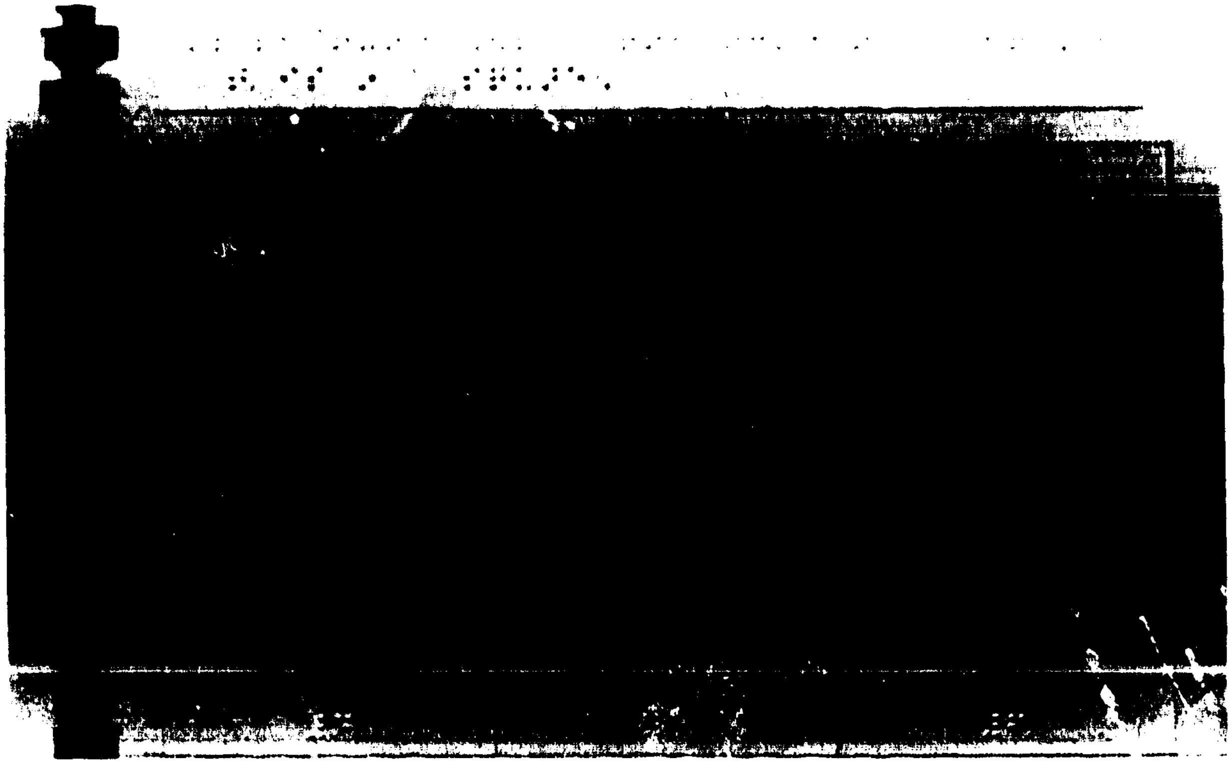


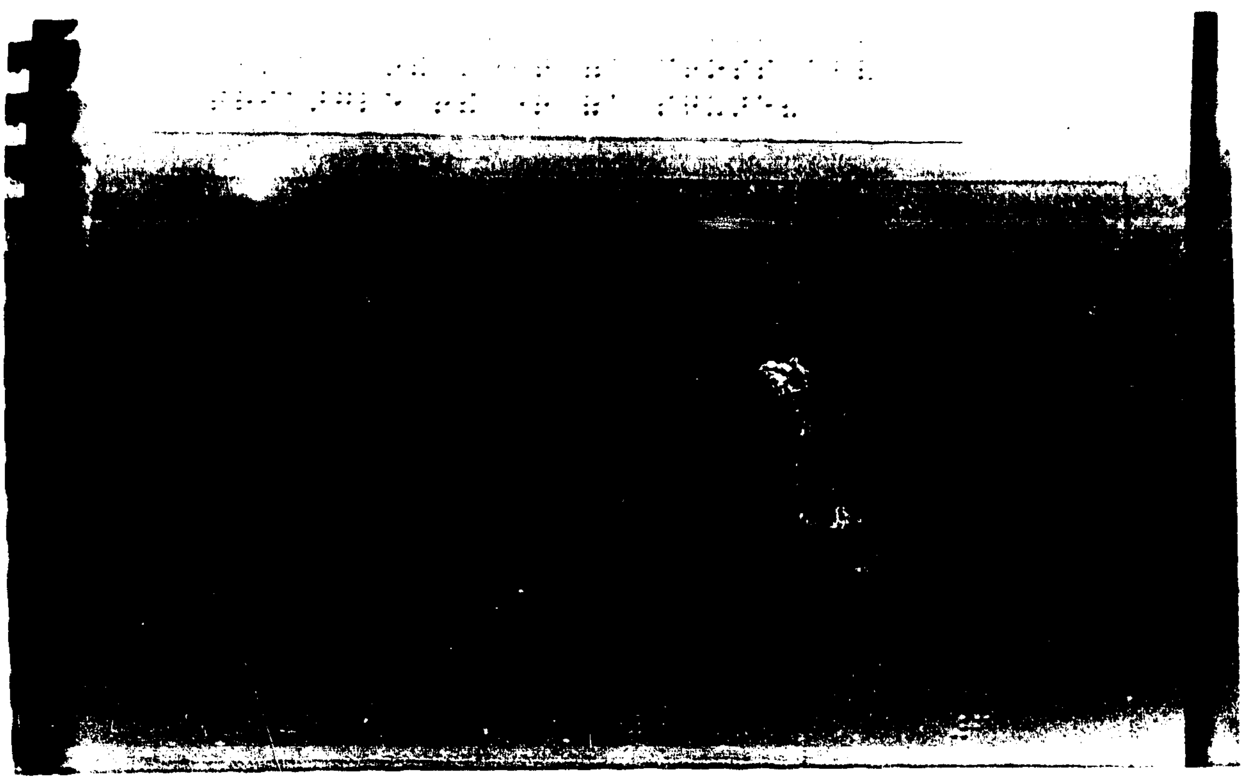
Design Construction Test



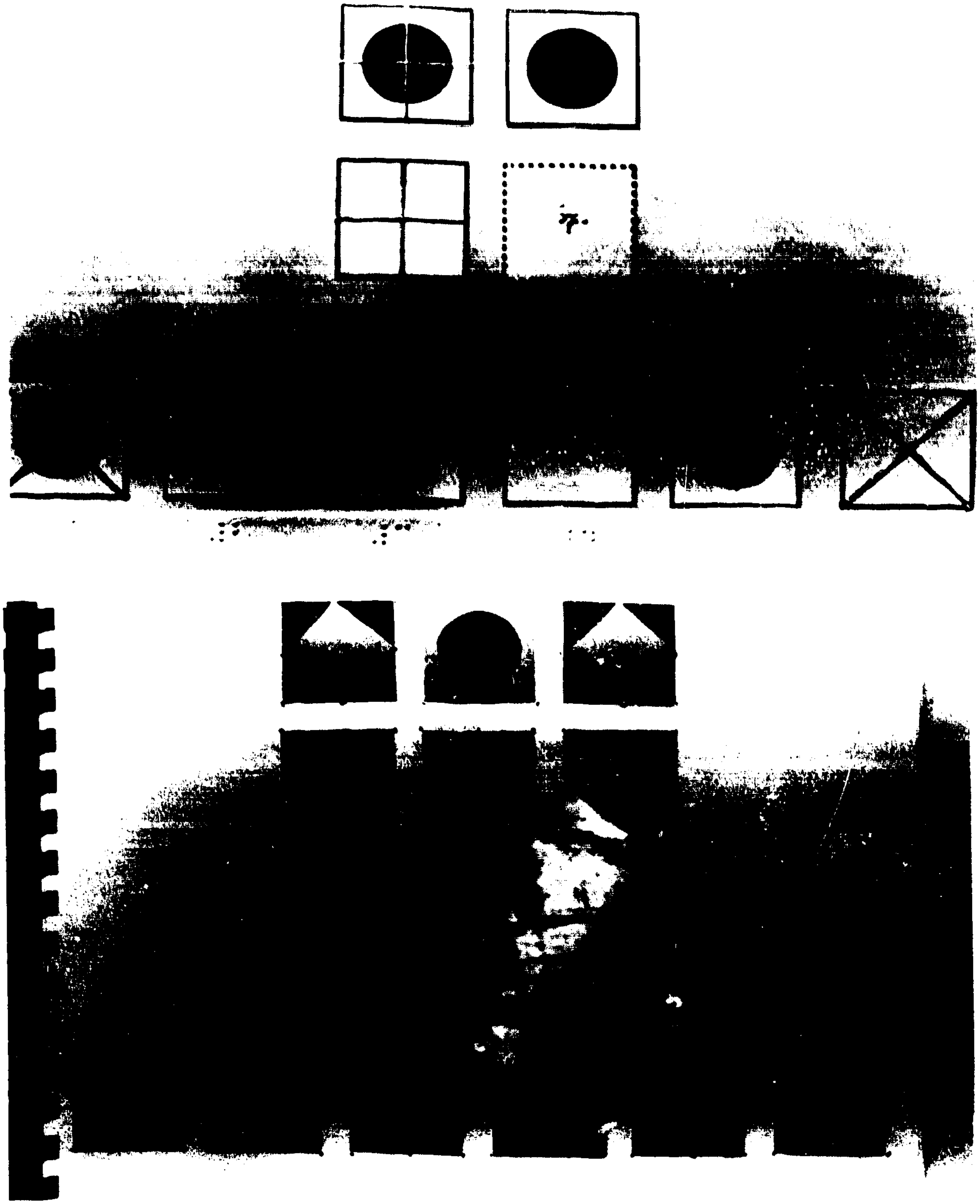


Simultaneous Verbal Test



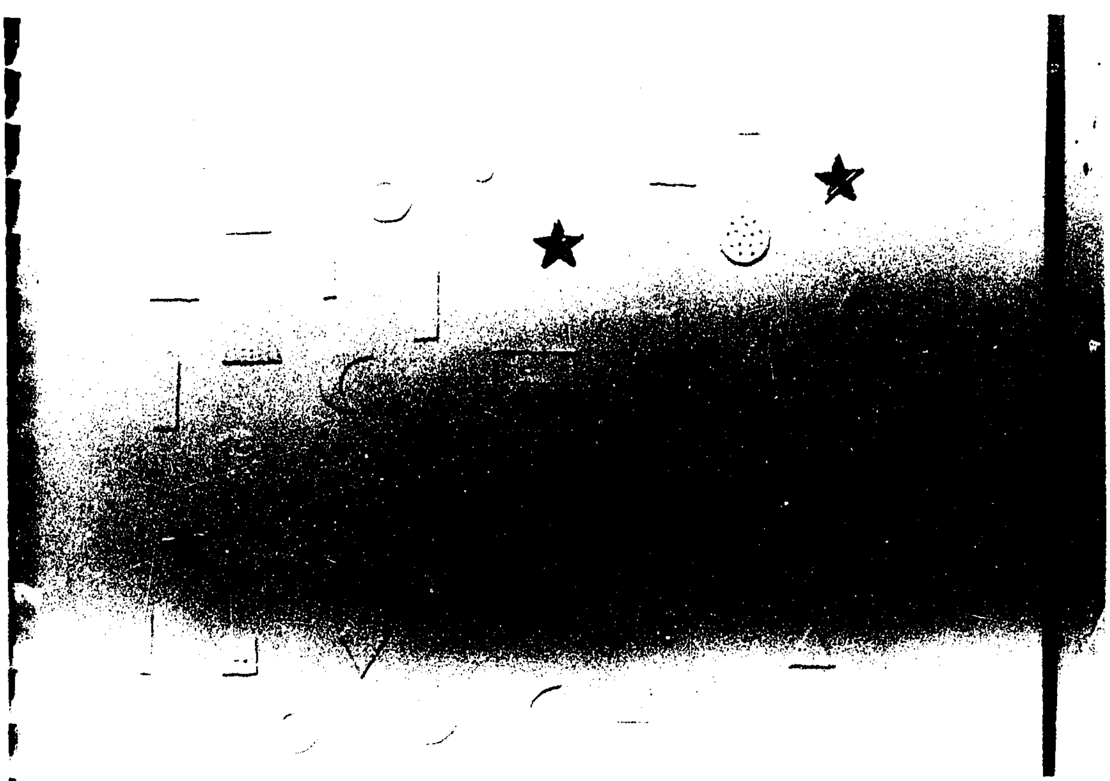


Matrices Test



Tactual Search Test - Automatic Search subtest

Tactual Search Test - Shape among Shapes subtest



APPENDIX B: Questionnaire for Blind Subjects

Subject No. ___________ M____ F____
Date of Assessment: ____ ____ ____
Date of birth: ____ ____ ____
Age: ____ ____ ____
Place of assessment:________________
Referral Agency:___________________
WAIS_______ READING_______

Name: ________________________________

Address:_______________________________
____

Postal Code: _________ Telephone:________

Educational History:

Elementary	Public School Integrated	Public School Special Class	Residential School for Blind	Resided at Home	In Residence	Other
8						

Junior High

Senior High

Indicate years itinerant (I) services or consultant (C) were available

Community College(s)	Program of Study	No. of Years Completed	Certificate or Diploma

University(s)

OTHER:

EMPLOYMENT HISTORY:

Present Occupation(s):	No. of Years	Adaptations for Employment

Previous Occupation(s)

VISION HISTORY:

Medical diagnosis:____

Age of onset or initial diagnosis: ____

Memory of vision or ever seeing: ____

Birth history if known:

Full Term: Y ___ N___ Premature: Y___ N___ Unremarkable Pregnancy: Y___ N___

Relatives with Vision Impairments:

mother	father	brother(s)	sister(s)
maternal grandmother	maternal grandfather	paternal grandmother	paternal grandfather
uncle(s)	aunt(s)	niece	nephew
son	daughter		

Visual Functioning:	Yes	No	Comments
light perception			
movement			
count fingers			
print size			

Visual Aides and Accommodations

	Yes	No	Hours per Week
optical aides			
braille			
personal reader			
magnifier			
auditory tapes			
monocular			
computer speech			
CCTV			
Kurzweill reader			
guide dog			
electronic travel aide			
long cane			

The last book I read for pleasure was:

____

____

It was in Braille, Audio Tape, Kurzweill, Computer, Personal Reader

____

The last book (material) I read for work or school was:

____

It was in Braille, Audio Tape, Kurzweill, Computer, Personal Reader

Preferred reading mode:

Braille, Audio Tape, Kurzweill, Computer, Personal Reader

If the above reading materials were not in braille, when was the last time you used braille, and for what?

____

Commute to Work:

Mode: bus, taxi, car pool, train Miles each way: __________

Do you feel that your education prepared you adequately for adult life?

____

What would you change if you could?

____

____

Do you think that visually impaired children are better served in residential or special programs, or in the mainstream?

____

____

APPENDIX C: Consent Form

I, ____ hereby give permission to Marion de Man and Bonnie Fyfe of the University of Alberta to administer a battery of psychological tests and to have the testing session(s) videotaped for research purposes.

I understand that the data and videotapes will be used for research purposes and conference presentations. I am voluntarily participating in this research and I am aware that I may discontinue the assessment session at any time.

______________________________ ______________________________

Subject Date

______________________________ ______________________________

Marion de Man Date

______________________________ ______________________________

Bonnie Fyfe Date

APPENDIX D: Screening Assessment

Name:____

Date of Birth:______________________________________

Date Tested:_______________________________________

Place Tested:_______________________________________

Braille

Literary #'s (Upper Cell)

0 1 2 3 4 5 6 7 8 9

Nemeth #'s (Lower Cell)

0 1 2 3 4 5 6 7 8 9

Pass ______ Fail ______

Reading

SUPERSTITIONS

Are you superstitious? Many people are. Some people show that they are superstitious by wearing certain objects. They believe these objects will keep them healthy or bring them good luck.

A long time ago, superstitious people believed that some objects could prevent sickness. They thought a fever could be prevented if they wore a dead spider. A mother would often hang garlic around her child's neck. The garlic didn't have any magic, but the smell kept people away. This included those people who might have been sick.

To protect themselves from evil, people also wore charms. Fortune-tellers chose special stones as charms for each month of the year. They told people to wear these stones for good luck. Today we refer to such stones as birthstones and still wear them for luck. Other charms still worn today are the rabbit's foot, the mustard seed and the four-leaf clover.

People's lives are still affected by superstitions. As long as some people have fears and do not feel certain about the future, they may continue to be superstitious. These people will wear favourite charms for health or good luck, even though charms do not have any proven powers.

Pass ______ Fail ______

APPENDIX E: Questionnaire for Sighted Subjects

Subject No. ____________ M____ F____

Date of assessment: ____________

Date of birth: ____________

Age: ____________

Place of assessment: ____________

Referral Agency: ____________

Name: ______________________________

Address: ______________________________

____

Postal Code: __________ Telephone: __________

Educational History:

Years High School(s)	Program of Study	No. of Completed	Certificate or Diploma

Community College(s)

University(s)

EMPLOYMENT HISTORY:

Present Occupation(s)	No. of Years	Comments

Previous Occupation(s)

VISION HISTORY

Visual acuity: ______________ **Glasses Y** __ **N** __ **Contact lenses Y** __ **No** __

Visual field: ____

Relatives with Vision Impairments:

mother	father	brother(s)	sister(s)
maternal grandmother	maternal grandfather	paternal grandmother	paternal grandfather
uncle(s)	aunt(s)	niece	nephew
son	daughter		

Are you familiar with braille?____

Do you work with textured materials on a regular basis? _________________

APPENDIX F: Gross Confrontation Test of the Visual Fields

Instructions for Examiners:

Seat yourself in front of the subject, almost knee to knee, so that the distance between your face and the subject's face is about three (3) feet. Have the subject remove his/her glasses if he/she wears them. Contact lenses may be worn, however, and if the acuity problem is severe enough, the test may be attempted with glasses on. **I'm going to sit in front of you and I want you to look directly at my nose.** Extend your arms to the sides about three (3) feet on each side and midway between you and the subject in the upper visual field. Use your own fields as the outer limits of the subject's fields. **I'm going to move either the hand to your left (move fingers of your right hand slightly) or to your right (move fingers of your left hand slightly). Tell me which side you see it move on by saying "right" if it is over to your right side or "left" if it is over to your left side. Be sure to look right at my nose all the time — don't look at my hands.** It is very difficult for some subjects to fixate vision on one point. You must be both patient and alert in order to give the stimulus only when the subject's vision is properly fixated.

First, give right or left stimuli in random sequence approximately four times each in order to determine the minimum amount of movement necessary to elicit consistent responses to unilateral stimulation.

Then give right, left, or both stimuli simultaneously in random sequence until "both" have been tried at least four times. Do this for the edge of the upper, middle, and lower visual fields. Record all misses.