HAPTITION: INTRA-MODAL AND CROSS-MODAL COMPARISONS BETWEEN NORMAL AND BRAIN-INJURED CHILDREN

by

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ABSTRACT

The purpose of this study was to explore the possibility of discriminating between three groups of children ("normal," "mildly brain-damaged," and "severely brain-damaged") by evaluating their respective abilities to compare the size, shape, and texture of certain objects by means of tactile perception. To this end seven subtasks were devised to measure the haptic perception of these qualities separately and in combination. Two of the subtasks included visual perception as well in a cross modal situation.

Twenty-one subjects were used in a pilot study which resulted in minor changes being made to the subtasks. In the experimental study twelve subjects of both sexes between the ages of seven and ten years formed each of the three groups.

Analysis of the results of the study showed significant differences (at the .05 level) between normal and severely brain-damaged subjects for two subtasks. No differences between minimally brain-damaged and severely brain-damaged subjects were shown for any of the subtasks at the .05 level of significance, and no difference was shown between normal and minimally brain-damaged subjects at this level of significance.

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HAPTITION: INTRA-MODAL AND CROSS-MODAL COMPARISONS

BETWEEN NORMAL AND BRAIN-INJURED CHILDREN

CHAPTER I

THE PROBLEM

Introduction

....

i
think it shall be roses and
spring will bring her
worms rushing through loam.

(afterward i'll
climb
by tall careful muscles

into nervous and accurate silence . . . . But first

you)

press easily
at first, it will be leaves
and a little harder
for roses
only a little harder

last   we
on the groaning flame of neat huge
trudging kiss moistly climbing hideously with
large minute
hips, O

.press

worms rushing slowly through loam[1]

Most poems of e. e. cummings attempt to produce visual images, but a few also employ the sense of touch to create impressions of tactile

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[1]e. e. cummings, *Poems 1923-1954* (New York: Harcourt, Brace, and World, Inc., 1954), p. 55.

sensations. The first use of the word "roses" in the above poem may produce a visual image in the mind of the reader because there is no contextual clue to accompany it. An individual's environmental sensations and memories are mostly visual perhaps because vision is the most efficient perceptual tool that we possess. By using it, we can perceive spatial information such as the dimensions of a room or the shape of a flower within a few seconds. The perception of information tactually requires much more time.

With long vowels and "s" sounds, cummings slows down the reader on the fourth line and introduces a memory of tactile sensation: the reader remembers that while he can perceive loam visually, he can also walk on it, dig in it, and feel it running through his fingers; loam is a rich, soft, yielding substance. Two more words, "climb" and "muscles," urge the reader to become aware of his own body, proprioceptively, so that he can easily become involved in sensual, tactile, kinesthetic experience in the next stanza where the word "roses" evokes more than a visual image.

In the last stanza the tactile kinesthetic experience is fractionated; the reader may perceive separately the sensations of orgasm, much as he perceives, via touch, each part of a geometric figure before he comprehends the whole figure.

Cummings is not concerned with the mechanics of perception; he is concerned with its representation. A great part of contemporary educational research, however, is concerned with the explanation of the perceptual processes to which cummings appeals. One outcome of this research has been the postulation of educational modalities to trace the perception of information.

The two modalities which have received most attention from researchers are vision and audition; the fact that children exist who do not learn through these modalities has been partially responsible for the relatively recent upsurge of research interest in the modality of touching and feeling ("haptition").[1] Additional interest in this (haptic) modality has been encouraged by the construction of several learning models which purport to describe the perceptual and motor development of people from birth to adulthood; haptic perception is of fundamental importance to these designs.

> The haptic system provides two major kinds of information. The first category includes information about the environment such as: (a) geometric information concerning surface area or size, shapes, lines and angles; (b) surface texture; (c) qualities of consistency such as hard, sorf, resilient, or viscous; (d) pain; (e) temperature; and (f) pressure.
>
> In the second category, bodily movement provides information about the body itself such as: (a) dynamic movement patterns of the trunk, arms, legs, mandible, and tongue; (b) static limb positions or posture; and (c) sensitivity to the direction of linear and rotary movement of the skull, limbs, and entire body. (O'Donnell 1969, p. 41)

These two forms of information, cutaneous and proprioceptive, allow us to perceive space and the objects within that space without the use of vision. Perceptual-motor theorists assert that this information must be received if such a phenomenon as visual-motor coordination is to be established in the individual's repertoire of behaviors: a child's

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[1]Use of the term "haptition" to describe touching and feeling seems as reasonable as use of "vision" and "audition" to describe seeing and hearing.

ability to perceive develops from the use of proprioceptive tools to the use of distal-perceptual tools, if the child has learned the basic skills necessary for the haptic perception of his body and spatial movement.

"It is logical to assume that all behavior is basically motor, that the prerequisites of any kind of behavior are muscular and motor responses. Behavior develops out of muscular activity, and so-called higher forms of behavior are dependent upon lower forms of behavior . . ." (Kephart 1971, p. 79). In the development of eye-hand coordination, for example, the hand initially is the exploring part; the eye follows it. As experience grows, as the eye learns what the hand feels, it begins to lead the hand because it is a quicker and more efficient receptor of information. The hand may continue to monitor the eye, to check it and supply additional information, but the eye becomes the director. In a normal child percepts from the eye can even be translated to the hand for tactual duplication, or a tactually perceived object can be translated into a visual image. A "perceptual-motor match" is established. The same percept can be obtained from either visual or haptic sensations.[1]

One application of this learning design is the suggestion that children who have difficulty learning to read through one modality may benefit from the use of multi-sensory stimulation which simultaneously "bombards" them with the same information through visual, auditory and haptic modalities. The intent is to produce a perceptual-motor match

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[1]More recent literature suggests definite limitations on this exchangeability of modality. While the same percept *can* be obtained from either modality, the exchangeability is limited by stimulus complexity. See Appendix B, p. 57.

which will allow such children to integrate individual data into usable percepts.

Two procedures for perceiving environmental information haptically have been proposed: touching and being touched. The second procedure may be labeled "passive touch" and physiologically involves only receptors in the skin and underlying tissue. The first procedure may be labeled "active touch" and involved receptors in the skin and underlying tissue and also in the joints and tendons (Gibson 1962, p. 478). It might also be labeled "purposive touch," for it involves exploration of the qualities of an object. The first procedure is the concern of this study, for it is this particular haptic perceptual activity which is invoked by a number of educators in the belief that its use will alleviate difficulties which many children experience in our schools.

Among the factors which may affect perception by active touch and which have been considered by several investigators are age, sex, and intelligence.[1]

At least two investigators have considered a fourth factor: brain damage, the subject of this study, about which the writer has asked: "Is there a difference in haptic perceptual ability (specifically, in active touch) between 'normal' and 'brain-damaged' individuals?" Demonstration of a difference may affect (1) the employment of educational practices which utilize active touch as an instructional modality and (2) the usefulness of medical diagnosis for educational practices.

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[1]Appendix "B" contains a description of studies which have examined these factors.

Definitions

"Normal" subjects in the context of the comparison made in this experimental study are children who have been examined by one of two neurologists at Vancouver General Hospital and who, as a result, have been diagnosed as not having a neurological impairment.

"Minimally brain-damaged" subjects (mbd subjects) are those children who have been examined by one of two neurologists at Vancouver General Hospital or by psychologists at G. E. Pearkes Clinic, and who as a result have been diagnosed as having some signs of neurological impairment without gross motor involvement.

The viability of the term "minimal brain damage" has been disputed, especially in regard to its implication that there is an organic basis for the dysfunctions associated with the mbd syndrome and whether this organic basis may be similar in kind but less in the extent of its effect to the more severe and easily identifiable brain injury suffered by individuals who cannot, as a result of such injury, readily control certain muscular activities.

Strauss and Lehtinen (1947) stated that children may have intellectual and behavioral problems caused by brain injury and proposed a complete diagnosis of minor brain injury which is still widely accepted by educators and psychologists:

(1) a history showing evidence of injury to the brain by trauma or inflammatory processes before, during or shortly after birth
(2) slight neurological signs are present which indicate a brain lesion
(3) measurable retardation (which is not common to other siblings or parents)
(4) perceptual and conceptual disturbances observed in performance on various psychological tests. (Strauss and Lehtinen 1947, p. 112)

Birch (1964) defined brain injury as "any anatomical or physiological alteration of a pathologic kind present in the nerve tissues of the brain" and noted that the consequences could range from no observable alteration in behavior to paralysis and death. Furthermore, because brain damage varies with respect to a number of factors (etiology, extent, type of lesion, locus, etc.), Birch feels that there is no stereotypic brain-damaged child but rather many varieties of brain-damaged children. He apparently objected to the use of mbd because it was nonspecific and stereotypic and also because ". . . all of our designations of nervous system damage, whether this be described as minimal, as diffuse or as nonfocal, remain presumptive in the absence of well established data demonstrating the nature of the damage to the underlying structure itself."

Cruickshank et al. (1968), however, asserted that

> . . . the hypothesis of brain injury will be borne out with the vast majority of children now labeled hyperactive, dyslexic, children with special or specific learning problems, exogenous, hyperkinetic, children with maturational lag, or any of a variety of different labels. In the majority of cases these are children who have most likely experienced brain injury at some stage of their early development. . . . (Cruickshank et al. 1968, p. 11)

There have been other explanations of the basis for the mbd syndrome presented: these include chemical lesions, physiological immaturity, unusual home environments and the currently popular "food additives." There may not be definitive evidence for the existence of brain injury as a determinant for the children who are characterized by the mbd syndrome, but there is, however, the suspicion of such a possibility. Because of this and because of the continued use of the term by many educators, psychologists and parents, the author felt it would be appropriate to include in this study subjects who are believed to represent the term.

"Severely brain-damaged subjects" (sbd subjects) are those children who have been examined by neurologists in the Vancouver or Voctoria area and who, as a result have been diagnosed as having cerebral palsy of the spastic hemiplegic variety.

"Intra-modal" activity refers to stimulus-recognition activity which occurs within one modality; for example, haptic intra-modal activity occurs when a subject is presented with a stimulus object to explore by active touch and then is presented with a second object to explore by active touch and subsequently is asked to indicate if the objects are similar or not similar. The subject is not allowed access to the objects through any other modality although the operation of the auditory modality is essential for the subject's understanding of the task, and the integration of auditory percepts with motor activity is necessary for the correct completion of the task. (It is especially plausible that brain-injured subjects may form an imperfect understanding of the task or be unable to integrate aural information with appropriate motor responses.)

"Cross-modal" activity refers to stimulus-recognition activity which involves two modalities; for example, a subject may inspect a stimulus object through the visual modality to compare it with another object which can be inspected only through the haptic modality.

"Simultaneous" presentation refers to a condition in which a subject is presented with stimulus and recognition objects at the same moment; for example, a subject may explore a stimulus object with one hand while the other hand explores a recognition object.

"Consecutive" presentation refers to a condition in which the presentation of a stimulus object is separated from the presentation of a recognition object by a temporal interval; for example, a subject may inspect a stimulus object haptically, relinquish it and then inspect one or more recognition objects haptically or visually for the purpose of comparison. Memory is a more important factor in this condition than in the condition of simultaneous presentation.

Hypothesis

The purpose of this study is to investigate the possibility that the three groups of children described above differ with respect to their haptic abilities to recognize the qualities of size, shape, and texture. The null hypothesis is that there is no difference between normal, mbd, and sbd subjects in their abilities to recognize the qualities of size, shape, and texture by the use of active touch.

It is proposed that injury to that part (or those parts) of the brain which is involved in sensori-motor activity will so affect performance on a test of tactile perception that the scores of such brain injured subjects will differ significantly from the scores of subjects who have not suffered brain injury. It is further proposed that subjects with more extensive injury will be less successful on the tasks than will be subjects with relatively minor injury (assuming that the injuries differ in degree and not in kind). A minimally brain-damaged subject should have a lower score than a normal subject while a severely-brain-damaged subject should have a still lower score.

If there is an organic basis for the mbd syndrome such that these subjects differ in degree but not in kind from sbd subjects, two motivations for this study become apparent: (1) certain learning theorists (Barsh 1967, Kephart 1971, Radler 1959) have posited instructional strategies which rely on active touch; results of this study may suggest a reevaluation of these strategies; (2) there is the possibility that additional information for discriminating brain-injured from normal children may be provided.

CHAPTER II

SURVEY OF LITERATURE

The study described later in this paper focuses on one subject parameter: the effect of brain injury on the scores obtained by the administration of a task of active touch to three groups of children. Very little research was found which explores this parameter, but a number of peripheral references which are described in some detail in Appendix B explored age, sex, intelligence, and personality. Although criticisms may be directed to these studies, it would appear that: (1) the variable of sex has no significant influence of haptic perception obtained through active touch; (2) intelligence does not appear to significantly influence perception obtained through active touch; (3) evidence for the influence of personality is inconclusive; and (4) age seems to be an important variable although there is disagreement concerning which age between the years of three and nine is important to the development of perception by active touch.

Haptic perception may be said to occur when cutaneous and kinesthetic information is processed centrally and synthesized. This processing appears to be located in the posterior parietal lobe of the brain and in the somato-sensory cortex (Milner 1970, p. 173). Inability to perceive haptically information from a particular hand indicates a possible lesion in the contralateral sensory cortex and parietal area and possibly in the insilateral motor cortex as well. Lesions may produce observable deficits in complex activities (e.g., dressing, and copying block designs), and severe sensorimotor lesions with parietal area damage may produce the behavior of the spastic hemiplegic if the lesions are confined to one side (lesions may affect the pyramidal tract as well in spastic hemiplegia; 60 percent of the axons originate in the precentral and postcentral gyri): involuntary contraction of the affected muscles if they are suddenly stretched and visual-motor disability and tactile disturbance of the affected side (Milner 1970, p. 175).

If cerebral palsy is likely to be associated with relatively widespread brain injury, then on a scale of brain damage, ranging from healthy to severely injured, there is placement for less severe brain injury which would not manifest itself in the usually obvious behavior deficits of cerebral palsy but which might display more subtle deficits of minimal brain damage.[1] Denhoff and Novak (1967) state that the past histories of individuals diagnosed as having minimal brain damage (whether or not organic involvement can be shown) may be similar to the histories of individuals diagnosed as having cerebral palsy. "There is growing evidence to suggest that . . . children who have articulation defects, slight hearing losses, and learning problems are mild or subclinical cases of cerebral palsy and as such are included in the minimal brain dysfunction category" (Denhoff and Novak 1967, p. 365).

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[1]The most often cited signs and symptoms of mbd are: (1) hyperactivity; (2) perceptual-motor impairments; (3) emotional lability; (4) general coordination deficits; (5) disorders of attention; (6) impulsivity; (7) disorders of memory and thinking; (8) specific learning disabilities (reading, writing, arithmetic, spelling); (9) disorders of speech and hearing; (10) equivocal neurological signs and electroencephalographic irregularities (Clements 1966, p. 13).

The somato-sensory cortex (anterior and posterior central gyri) is considered to be the area which interprets and controls certain tactile stimuli (form and size especially, Milner 1970, p. 176). Injury in this area, not so severe as to cause the behavioral deficits of cerebral palsy, might cause impairments associated with the mbd syndrome. Semmes et al. (1955) found that injury to the parietal lobe (which includes the post central gyrus) was apparently responsible for inferior performance on intra-modal visual and cross-modal (visual-tactile) map-following tasks. Her subjects were adult war veterans who had suffered penetrating missile wounds to the brain and were divided into groups according to the locus of injury (established by medical records). Analysis of task scores indicated a significant difference between parietals and non-parietals. Because no significant difference between intra-modal and cross-modal presentation was found, the authors concluded there was a spatial disorientation factor operating across modality lines.

Semmes et al. (1965) returned to this non-modality-specific factor to ask if tactual sensory impairment and astereognosis (inability to recognize object dimensions) could occur separately. They found (using the veterans again) that performance on intra-modal tactile recognition with successive presentation was severely impaired when sensory defect[1] was present. In addition the performance of brain-injured subjects without sensory defect was significantly impaired when compared to

---

[1]The authors defined sensory defect as abnormal performance on one of four passive tests of tactile perception: (1) pressure sensitivity; (2) two-point discrimination; (3) point localization; and (4) sense of passive movement.

the performance of normal subjects on tests of form and pattern but was not impaired on roughness, texture, and size evaluations. The authors concluded that sensory defect and spatial disorientation were separate functions which tended to occur together with right hemisphere parietal lesions (perhaps because these functions are not localized in the right hemisphere) and separately with left hemisphere parietal lesions.

Several criticisms of these findings seem necessary: (1) the number of cases was small, and a statistical analysis supporting the conclusion was not performed; (2) anatomical verification of the brain injuries was not possible; (3) the tests of form may have been confounded by the variable of size;[1] (4) the time allowed for tactile inspection of stimulus objects was very short (five seconds), and there is no description of the nature of the motor handicap (if any) of those brain-injured subjects with sensory deficits in their hands; the low scores of the brain-injured subjects might be attributed to motor difficulty in palpating the stimulus objects, especially in the short time allowed.

The brain injuries of soldiers traumatized by missile wounds may not be sufficiently similar to congenital or disease-caused brain injuries as to allow their symptoms to be generalized to individuals belonging to the latter group. There are also differences between individuals who have lost a function and those who have never had it. Nevertheless, the authors' postulation of separate locations for spatial

---

[1]It is difficult to avoid this problem. How does a rectangle differ from a square in other than the length of its sides? See Appendix B, pp. 53-54, for a discussion of this obstacle.

perception, form perception, and tactile perception of other qualities is very interesting and should be investigated further.

Solomon's (1957) research is similar to that of this investigation. Scores of normal and brain-injured subjects were compared on tests of tactile perception of size, shape, texture, and weight. Analyses were performed on the influence of sex, age, handedness, preference, and on their interactions.

Solomon's brain injured subjects (48 in total) were divided into those with (32) and those without (16) motor involvement of one hand. Presentation of stimulus objects was successive. For normal subjects the following variables were found to be significant: (1) age (five to nine years) on all subtests; (2) handedness on size and form subtests; and (3) sex on size and texture. For brain injured subjects motor involvement was significant for size, weight, and texture; handedness was significant for shape; age was significant for texture. When scores for normal and brain injured subjects were compared, significant differences were found for size and texture discrimination and no difference for weight. No difference was found for shape between normal and brain-injured subjects with motor involvement.

Several criticisms of this study are possible: (1) each subject viewed the tactile test materials and had them demonstrated before each subtest was administered; it does not seem reasonable to regard this as a test of intra-modal haptic perception, if visual memory was permitted to play a role; (2) the reader is not informed of how the subjects palpate the pool of recognition objects; that is, it is not known whether the objects are placed in the subject's hand or if the subject searches; (3) the criteria for the selection of the normal subjects was not as rigorous as for the selection of brain-injured subjects; that is, they were not examined by neurologists; (4) the brain-injured subjects were using different medications which according to the author improved their performance; this is a questionable assumption, which, even if true, introduces a further set of poorly controlled variables to the study.

The research reviewed above and in Appendix B appears to be contaminated by unintentional cross-modal interference or by inaccurate descriptions of what is being measured or by inadequately controlled subtest administration (which permits uncontrolled labeling and variations in search for and palpation of stimulus and recognition objects). These difficulties are compounded by lack of knowledge of what efficient haptic perception is, the length of time it requires to operate and its relation to vision. The writer's research described below has attempted to eliminate some of these difficulties.

CHAPTER III

METHODOLOGY

Subjects

Three subject groups were used in the main study: group one was composed of twelve normal children (controls in a study of low birth-weight infants at Vancouver General Hospital) who had been examined by a neurologist and assessed as having no neurological impairments; group two was composed of twelve subjects, ten from the above study of low birth-weight infants who had been examined by a neurologist and diagnosed as having minimal brain damage and two from the Pearkes Clinic in Victoria thought by psychologists to have minimal brain damage (but not examined by a neurologist); group three was composed of twelve subjects from the G. F. Strong Rehabilitation Center, Surrey Treatment Center, and G. R. Pearkes Clinic who had been diagnosed as having cerebral palsy of the spastic hemiplegic variety. Six were most impaired in the right hand, six were most impaired in the left.

The ages of the subjects ranged from eight years, zero months, to ten years, eleven months. The first two groups were mostly eight or nine years old, while the third group was more evenly distributed over the age range. Income levels of families appeared to range from lower to upper middle.

Subjects' parents were contacted by telephone. If they agreed to testing at school, a form letter was sent to them for their signature, giving the writer permission to test their child at school; if they desired testing at home, arrangements were made at their convenience. Sample selection was determined by (1) the availability of subjects within the Lower Mainland and Victoria area, and (2) the willingness of parents and children to participate.

Materials

The tasks used for the study were based on a series of tasks constructed by Kendall and Kendall (1969) and applied by them to a normal population of children aged three to eight years. (In this study, and in a follow-up by Dumaresq, it was found that little improvement of scores occurred after age six and that normal four-year-olds were able to comprehend and carry out tasks involving haptic discrimination.)

The task objects consisted of geometric forms and a small number of common objects.[1] The task was composed of seven subtasks, each of which attempted to evaluate performance on one or more of the qualities of size, shape, and texture, as indicated:

Subtask I: shape
Subtask II: size
Subtask III: texture
Subtask IV: shape and size
Subtask V: size, shape, and texture
Subtask VI: cross-modal shape
Subtask VII: cross-modal size

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[1] Most of the objects are shown on p. 18 (Figure I).

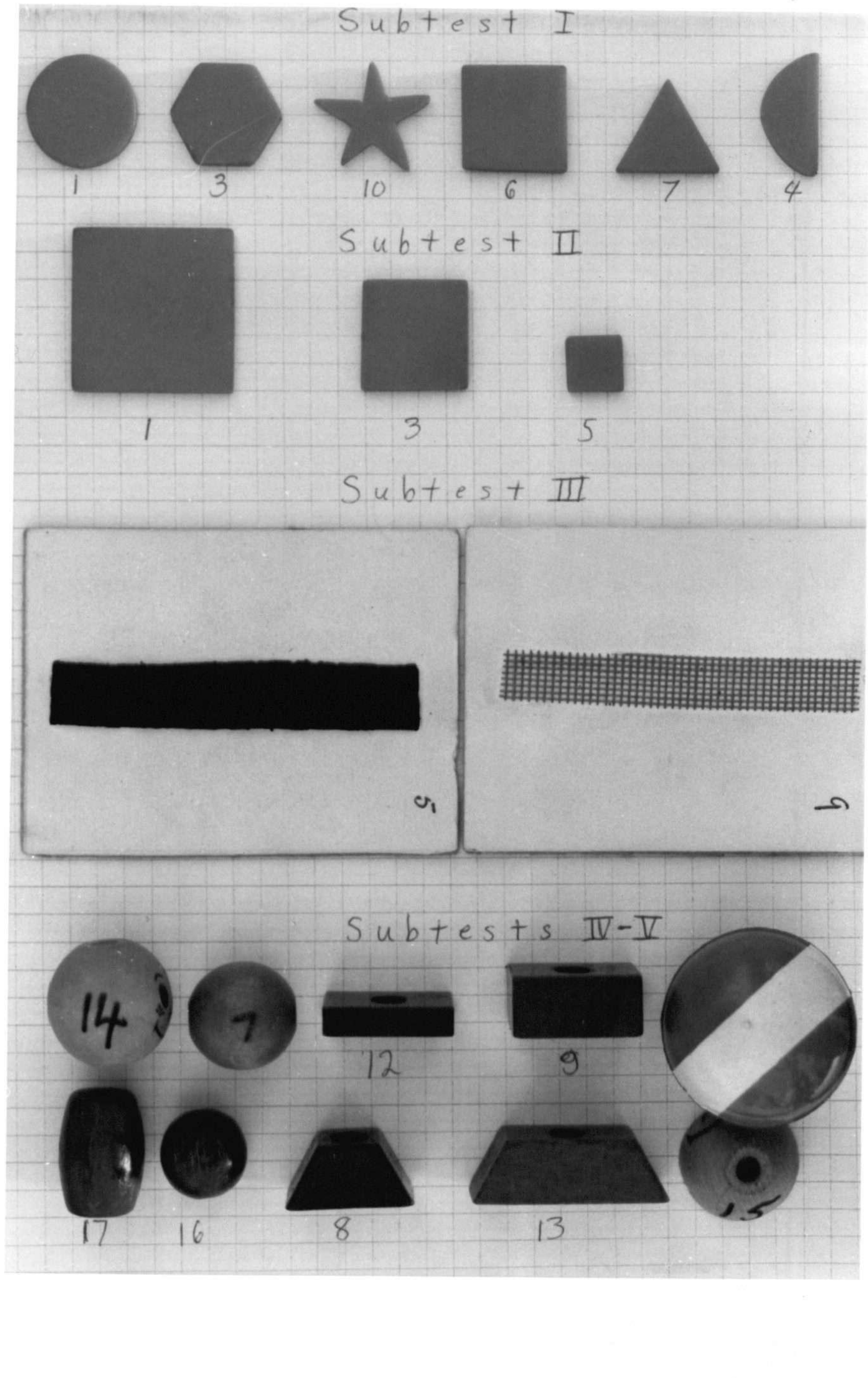
Subtest I
1
3
10
6
7
4
Subtest II
1
3
5
Subtest III
5
6
Subtests IV-V
14
7
12
9
17
16
8
13
15

FIGURE I

Subtask I objects were geometric designs (circle, square, triangle, octagon, and five-pointed star) made of smooth plastic of uniform thickness and surface area. Subtask II objects were smooth plastic squares of uniform thickness and three different sizes. Subtask III objects were strips of materials of uniform size and shape with six different surfaces ranging from rough to smooth, pasted on cardboard surfaces of uniform shape and area. Subtask IV objects were three-dimensional wooden solids of varying size and shape. Subtask V used three-dimensional geometric and common objects (play-size spoon, knife, fork, and coins) which differed in one, two, or three qualities from each other. Subtasks VI and VII used the objects of the first two subtasks in a cross-modal condition.[1]

Procedure

All testing was carried out by the writer. Subjects were tested either in their schools or in their homes, usually alone. Each subject sat on a low chair so that his/her arms could be comfortably thrust into the curtained front of a student's school desk. A cardboard divider separated his/her arms inside the desk, and a curtain helped to conceal the inside of the desk from the subject (Figures II and III). The writer sat on the floor on the opposite side of the desk (from which the back had been removed) so that he could place the objects in the subject's

---

[1]Subtasks I-III examined three separate dimensions of the sensitivity of active touch intra-modally. Subtasks IV and V were intended to examine sensitivity to more than one difference, intra-modally, and subtasks VI and VII were intended to examine the effect of the introduction of the visual modality.

FIGURE II

FIGURE III

hands in the appropriate sequence and observe the activity of the hands.

For the first trial of each of the first five subtasks, a stimulus object was placed in the preferred hand (i.e., the hand used by the subject to write his/her name) and while it was being held and examined (within the desk) two pool objects were placed successively in the other hand. The subject was asked to indicate orally whether each "pool" object was the "same" or "different" when compared to the stimulus object in the preferred hand. The subjects were told that if the objects were the same, the correct response would be "same" but that if they differed in even one way, the correct response would be "different." Oral naming was discouraged.

For the second trial in each of the first five subtasks the stimulus objects were placed in the non-preferred hand, and the pool objects were placed in the preferred hand. Subsequent trials continued this alternation.

The first trial for subtasks VI and VII required the stimulus object to be placed in the preferred hand beneath the desk top while the pool objects were placed on the desk top in view of the subject who was asked to point to but not touch the "same" object with the non-preferred hand. The subject was warned that both objects might be "different." The second trial required the stimulus object to be placed on the desk top and the pool objects to be placed successively in the preferred hand; an oral response was requested. The third and fourth trials repeated the procedure of the first and second trials, using the non-preferred hand to palpate the objects. The last four trials repeated the entire procedure.

Objects were presented simultaneously to minimize the effect of memory. Thirty seconds were allowed for each response before prompting; the average time taken was fifteen seconds for most subjects (who finished the task in about twenty-five minutes). Because searching was not considered as part of the task, objects were placed in each subject's hands. So that exploration for each subject would be as similar as possible, the hemiplegic subjects were given the additional help of having the fingers of the affected hand wrapped around the objects when necessary and also when necessary having the objects rotated in their hands.

Task objects were not seen by the subjects during the administration of subtasks I to V which were administered before the last two subtasks. The order of administration of subtasks I to V was varied to minimize the effect of training.

Scoring

There were a total of forty-eight trials in the task, six in the first four subtasks and eight in the last three subtasks. Two responses were required for each trial, and both had to be correct for the trial to be considered as correct. Most trials required a "same" and a "different" response; two required two "same" responses; three required two "different" responses. Each trial was marked on an answer sheet out of the subject's sight after the two responses were made.[1]

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[1] See Appendix A, pp. 46-50.

Pilot Study

Because the revision of the task composed by Kendall and Kendall was extensive, it was felt necessary to determine whether or not normal subjects could score well on it before the experimental study was begun.

To evaluate the revision, to provide a criteria for normal scores and to allow the writer to develop field experience with the task, a pilot study was undertaken with twenty-one elementary students, aged eight to ten, representing both sexes, who were considered by their teachers and principal to be normal or average students in academic and physical activities.

It was decided that any item missed by more than two of the subjects in the pilot study would be eliminated or rearranged. Several such alterations were made while testing the first fourteen subjects. The final version was administered to seven subjects (four male and three female) whose scores ranged from 42 to 47 with a mean of 44.5. Although the sample size is not large, it appeared to the writer that these results indicated that a normal subject should be able to score reasonably well on the revision.

Design

The experimental study proposed to measure assumed degrees of brain damage against a scale of active touch. A multi-factorial ANOVA design was employed to analyze differences in task means for the three groups of subjects. When the null hypothesis was rejected, multiple comparisons were performed to discover which subtask differences were responsible for the MANOVA results, and 95 percent confidence intervals were calculated.

Hypothesis

The null hypothesis is that there is no significant difference between the abilities of normal, mbd and sbd subjects to discriminate the qualities of size, shape, and texture by the employment of active touch in intra-modal and cross-modal conditions. The alternate hypothesis is that there is a difference. The level of significane was set at .05.

CHAPTER IV

CONCLUSION

Results[1]

Hoyt's ANOVA was employed to examine the reliability of each subtask for all subjects combined and for each group of subjects. These data are presented in Tables I to IV.

The reliability coefficients for the normals (Table I) are considerably lower than for the other groups for subtasks I and II and especially for subtasks III, IV, VI, and VII. It would appear that chance has played a much greater role in the determination of scores than has the task design, although the relatively small n and the small number of errors suggests that these coefficients should be regarded with suspicion. The coefficient for subtask V, on the other hand, is infinitely large; no errors were made. Reliability calculated for the total task for the normals is mediocre.

Coefficients for the mbd and sbd groups are relatively high (Tables II and III), especially for the administration of the total task to each group. Table IV indicates that for the combined groups reliability is very respectable (.93 for the total).

Inspection of Tables I to III also discloses the differing means

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[1]The writer is indebted to Dr. Richard Bennett who selected the statistical analysis and performed the necessary operations at the U.B.C. Computing Center.

TABLE I

NORMAL SCORES

Subtask	High Score	Low Score	Mean	Standard Deviation	Percent Correct	r	Cronbach's Alpha
I	6	3	5.42	.90	90	.36	
II	6	4	5.5	.79	92	.29	
III	5	3	4.67	.65	78	-0.0	
IV	6	4	5.17	.83	86	-0.0	
V	8	8	8.0	0.0	100		
VI	8	7	7.92	.29	99	0.0	
VII	8	7	7.83	.39	98	-0.0	
Total	47	39	44.5	2.39	93	.50	.60

TABLE II

mbd SCORES

Subtask	High Score	Low Score	Mean	Standard Deviation	Percent Correct	r	Cronbach's Alpha
I	6	0	4.42	1.56	74	.68	
II	6	3	4.83	1.19	81	.38	
III	5	2	4.0	.85	66	-0.0	
IV	6	1	4.08	1.73	68	.65	
V	8	2	6.58	1.78	81	.74	
VI	8	3	7.42	1.44	93	.83	
VII	8	5	6.92	1.16	86	.83	
Total	46	18	38.25	7.44	80	.89	.87

TABLE III

sbd SCORES

Subtask	High Score	Low Score	Mean	Standard Deviation	Percent Correct	r	Cronbach's Alpha
I	5	0	2.42	1.56	40	.46	
II	5	1	3.0	1.41	50	.32	
III	6	0	2.92	1.62	49	.87	
IV	5	0	3.25	1.82	54	.66	
V	7	1	3.67	2.19	46	.65	
VI	8	4	6.17	1.4	77	.44	
VII	8	2	6.08	1.78	76	.61	
Total	42	15	27.5	7.99	59	.85	.80

TABLE IV

COMBINED GROUPS

Subtask	High Score	Low Score	Mean	Standard Deviation	Percent Correct	r	Cronbach's Alpha
I	6	0	4.08	1.84	68	.74	
II	6	1	4.44	1.56	74	.64	
III	6	0	3.86	1.31	64	.43	
IV	6	0	4.17	1.68	70	.66	
V	8	1	6.08	2.42	76	.86	
VI	8	3	7.17	1.36	90	.69	
VII	8	2	6.94	1.41	87	.64	
Total	47	15	36.75	9.48	77	.93	.91

of the groups on the subtasks and the whole task. A MANOVA Likelihood Ratio Test with six dependent variables[1] was performed on the data to determine if the means differed significantly. Because it is desirable to discover the source of significance[2] for an "F" value which exceeded the .05 level of significance, multiple comparisons were performed between all possible pairs of subtasks. The following hypotheses were examined for each subtask:

$$H_0: \bar{X}_n = \bar{X}_m = \bar{X}_s{}^3$$

$$H_1: \bar{X}_n \neq \bar{X}_m \neq \bar{X}_s$$

and in the event that the null hypothesis could be rejected in favor of the alternate hypothesis, the multiple comparisons for each subtask were:

$H_{01}: \bar{X}_n = \bar{X}_m$ $\qquad$ $H_{11}: \bar{X}_n \neq \bar{X}_m$

$H_{02}: \bar{X}_m = \bar{X}_s$ $\qquad$ $H_{12}: \bar{X}_m \neq \bar{X}_s$

$H_{03}: \bar{X}_n = \bar{X}_s$ $\qquad$ $H_{13}: \bar{X}_n \neq \bar{X}_s$

The MANOVA calculations showed an F-value significant at the .05 level [$F_{(12,56)} = 2.66$, $p < .01$] for the whole task. Table V describes confidence intervals for the differences between the means for all subtasks: the differences between the means for the normal and sbd groups

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[1]Subtask V was excluded from this calculation because of failure to meet the assumption of homogeneity of variance.

[2]Glass and Stanley, pp. 381-83.

[3]$\bar{X}_n$ refers to the mean of the normal group; $\bar{X}_m$ refers to the mean of the minimally brain damaged group; $\bar{X}_s$ refers to the mean of the severely brain-damaged group.

TABLE V

SUBTASK COMPARISONS

Subtask	Groups	95% Confidence Intervals
I Shape	n vs. mbd	-1.72 to 3.72
	mbd vs. sbd	-0.72 to 4.72
	n vs. sbd	0.28 to 5.72*
II Size	n vs. mbd	-1.63 to 2.96
	mbd vs. sbd	-0.46 to 4.13
	n vs. sbd	0.20 to 4.80*
III Texture	n vs. mbd	-1.55 to 2.88
	mbd vs. sbd	-1.13 to 3.30
	n vs. sbd	-0.47 to 3.97
IV Size, Shape	n vs. mbd	-1.93 to 4.10
	mbd vs. sbd	-2.18 to 3.85
	n vs. sbd	-1.09 to 4.93
VI Cross-modal Shape	n vs. mbd	-1.82 to 2.82
	mbd vs. sbd	-1.07 to 3.57
	n vs. sbd	-0.56 to 4.07
VII Cross-modal Size	n vs. mbd	-1.55 to 3.38
	mbd vs. sbd	-1.63 to 3.30
	n vs. sbd	-0.72 to 4.28

*Significant at the 95 percent level of confidence.

are significant for subtasks I and II; differences between normal and mbd groups and between mbd and sbd groups are not significant at the .05 level.

Assuming the task to be valid,[1] the results indicate: (1) that there is no difference between the active touch perceptual skills of the normal and mbd subjects tested; (2) that there is a difference between the active touch perceptual skills of the normal and sbd subjects tested; and (3) that there is no difference between the active touch perceptual skills of the mbd and sbd subjects tested. The null hypothesis is rejected for differences between normal and sbd means on subtasks I and II and the whole task; it is not rejected for differences between normal and mbd means or between normal and sbd means on subtasks III to VII or between mbd and sbd means (excluding subtask V).

Discussion

The low reliability coefficient for the normal group may be the result of the writer's attempt to construct a task on which normals would score very well. This may have distorted the variance of normal scores and perhaps acted as a ceiling to depress the means of the normal group. Calculation of Cronbach's reliability (Table I) indicates that

[1]The validity of the task is based upon consideration of what is being measured (see Kerlinger, pp. 445-47, for a discussion of "content validity" and how it can be measured). The items and procedures used are similar to those of other studies although the author particularly attempted to control the effect of language, memory, visual intrusions, and the vagaries of searching and grasping. Confusion of size and shape was also controlled insofar as possible. The writer believes that this task may be regarded as being as valid as any described in the Review of Literature or Appendix B.

increased reliability might be obtained by lengthening the task. This could lower reliability for the other groups and the groups combined (Tables II to IV) but not by as much as it might raise reliability for the normal group.

Rejection of the null hypothesis for normal and sbd means on subtasks I and II demonstrates that even with assistance from the task administrator to eliminate the effect of motor dysfunction the hemiplegic subjects did not appear to perceive the qualities of size and shape as well as the normal subjects did.

Acceptance of the null hypothesis for subtask III and examination of the means indicates that the quality of texture was difficult for all subjects to discriminate. The normal and mbd groups acheived their lowest percent correct on subtask III and the sbd group achieved its second lowest. Subtask IV, where the null hypothesis was also accepted, was the second most difficult section for the normal and mbd groups but only the fifth most difficult for the sbd group. The writer expected scores on this subtask to be higher than for the first three subtasks because of the additional information (more than one quality) available to the subjects. It would appear that the normal and mbd subjects were either confused by the additional information or neglected it.

Subtask V was not included in the MANOVA procedure because the scores of the normal group were regarded as violating the prerequisite of homogeneity of variance; the writer succeeded perhaps too well in the construction of a subtask on which normals would achieve high scores. Inspection of the percentage correct (Tables I to III) shows the widest spread between the means of all the subtasks, and it is not unreasonable to suggest that this subtask does discriminate at least between normals and sbd subjects. It is possible that the additional information (up to three qualities) available on each object stimulated the curiosity of the normal subjects, causing them to explore more carefully. Severely brain-damaged subjects may have been confused by the increased data.

All groups achieved their greatest percentage correct on subtasks VI and VII (excluding subtask V for the normal subjects) which are essentially repetitions of subtasks I and II in a cross-modal condition. All groups increased their percentage correct more on the quality of shape than on size, especially the sbd subjects for whom the cross-modal condition seemed to be most beneficial. The improvement in sbd scores was so considerable that no significant difference emerged.

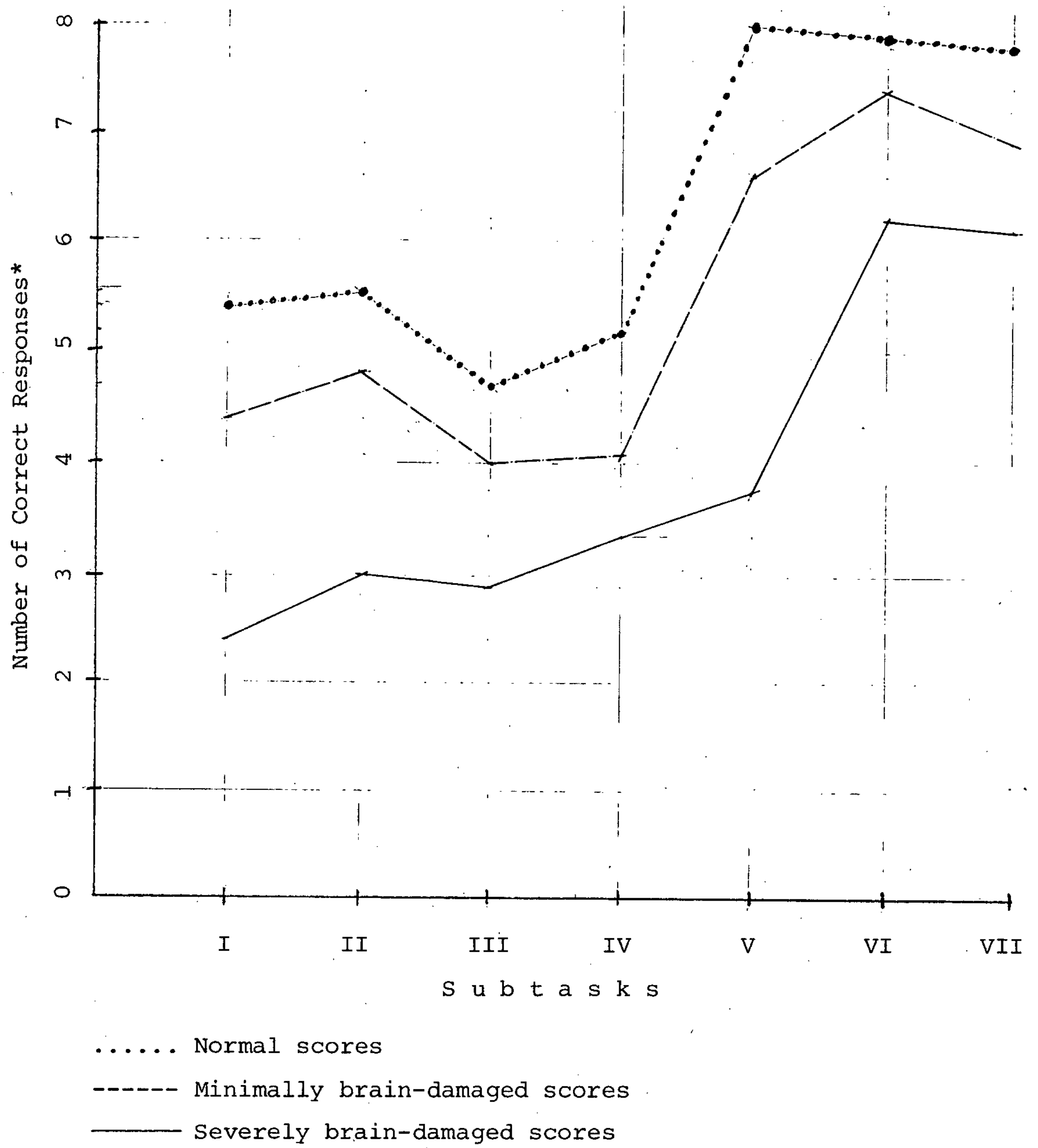
Acceptance of the null hypothesis for the means of the mbd subjects indicates that these are not distinguishable from those of sbd subjects. This suggests a dysfunction similar to that of the sbd subjects in relation to involvement of those areas of the brain responsible for haptition, and this in turn suggests that the argument for an organic basis for the mbd syndrome is not without foundation. The mbd means are also, however, not distinguished significantly from the means of the normal subjects; that is, in relation to haptition, mbd subjects probably do not differ by organic or other factors from normal subjects. Three possibilities emerge: (1) the definition of minimal brain damage is ambiguous; (2) there may be an incidence of haptic deficiency in the mbd subjects which ranges from none to a deficiency similar to that in sbd subjects (including the possibility of organic involvement); and (3) certain features of the mbd syndrome such as hyperactivity or disorders of attention may have acted to depress some mbd subjects' scores.

The graph below (Figure IV) does not repeal any of the verdicts of nonsignificance, nor does it support directly any of the three possibilities mentioned above; it does show a pattern of scores for the groups which resembles that anticipated by the writer before testing began. The normal scores are the highest; the mbd scores are the second highest; the sbd scores are the lowest. Possibilities (2) and (3) seem more reasonable, especially in view of the fact that the sample sizes are not large.

To summarize: subtasks I and II differentiate the normal and sbd groups; subtask III does not, perhaps because textures are difficult for any subject to discriminate; subtask IV does not differentiate, and there is no apparent reason why it should not; subtask V was not analyzed, but there is a strong suggestion that it could differentiate at least normal from sbd subjects; subtasks VI and VII also do not reject the null hypothesis, apparently because of the effect of the employment of vision by the sbd subjects.

Educational Implications

Differentiation between normal and sbd subjects on a task of haptition is surely not a revelation; the probability that the difference may not extend to the quality of texture and that cross-modal conditions allow considerable improvement for sbd subjects in relation to haptic perception suggests that instructional techniques for sbd children should



*The maximum number of correct responses for subtasks I to IV is six. The maximum for subtasks V to VII is eight.

FIGURE IV

SUBTASK MEANS

utilize intra-modal visual and cross-modal methods which do not emphasize haptition. Cross-modal conditions may have the effect of allowing sbd children to perceive haptic information as well as normal children do. Activities which emphasize the development of active touch may be either irrelevant or even a frustrating waste of time.

Nonsignificance of differences between mbd means and those of other groups suggests that children who might be diagnosed as having minimal brain damage should be treated educationally according to their functional skills; it is possible that some of the mbd subjects tested who scored within one S.D. of the sbd mean might have similar perceptual dysfunctions (which may or may not be organically based). If so, appropriate instruction and expectations must be applied to their situation. In this respect, the subtasks could be used as a screening instrument to evaluate an individual's haptic perception in regard to its utility as an educational modality.

Limitations

A number of problems, foreseen and unforeseen, arose in the course of this study which may be regarded as inimical to the results presented above:

1) subjects within each group were not randomly selected; difficulty in obtaining subjects required the writer to test whomever he could find and obtain permission to test;
2) task validity is not established;
3) the administration of subtasks VI and VII was so complex that the writer several times administered trials to the wrong hand.

Because of the difficulty of obtaining subjects these scores were not excluded from analysis;[1]

4) there was little control over how well objects were explored; sometimes responses were made before there was complete exploration; and

5) definition of the groups did not provide homogeneous groupings; motor involvement varied considerably among sbd subjects, and mbd subjects presented varying expressions of the mbd syndrome. The validity and usefulness of the definitions is questionable.

Future Research

The following suggestions are made for future research:

1) while comparatively great effort has been expended for research on vision, there is still much that is not known about the operation of that modality. Relatively little effort has been expended for research on haptition, and there is likely even more that is not known about it. Visual acuity, for example, can be measured; we do not know how to measure haptic acuity (if such a parallel concept is permissible). Questions such as "What is good haptition?" and "What is the minimum temporal interval required to perceive an object haptically?" must be answered;

2) further investigation of what is being perceived by active touch

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[1] At the time of testing, all available sbd subjects (who did not have other serious disorders) in the Lower Mainland and Victoria area were used. The sbd sample, therefore, is close to a total population.

is necessary; for example, it would be desirable to discover how shape and size can best be separated for measurement;

3) correlations of visual and haptic perception of qualities would be desirable;

4) replication of this study which would include a correlation with a measure of attention span might allow us to judge the effect of brain injury more clearly;

5) some comparisons for the differences between group means approach significance in this study at the .05 level. Refinement of the task (especially subtasks III and V) and explorations with larger groups seem desirable before the null hypothesis is permanently accepted or rejected;

6) individual subjects who scored more than one standard deviation from the mean should be evaluated with other psychological and educational instruments to determine if these subjects manifest other exceptional characteristics. The data available on them is neither complete nor so standard as to be comparable;

7) the effect on haptic discrimination of combinations of qualities should be compared; that is, are objects differing by size and texture (with shape remaining static) more easily discriminable than those differing by shape and texture (with size remaining static)? and

8) the effect of personality variables and cognitive style should also be considered (see Appendix B, p. 64).

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APPENDIX A

INSTRUCTIONS AND DATA-GATHERING FORM

Task Administration

1. Request the subject to write his/her name to establish the "preferred" hand (or ask with which hand does the subject write).
2. Note sex, age, group, and date.
3. Establish whether or not subject knows "same-different" with picture cards. Do not continue if the child is unable to tell why pictures are same or different.
4. Do three explanatory trials with the large wooden blocks; if the subject is unsuccessful, administer the first subtask chosen. If the responses are all incorrect, terminate testing.
5. Begin the testing with the stimulus object in the child's preferred hand; place pool objects in other hand successively and ask subject to indicate "same" or "different"; record responses when completed (both must be correct if the response sheet is to be marked as correct). Switch hands for the second trial and alternate in this fashion for each of the first five subtasks. For the last two subtasks, begin by placing the stimulus object in the preferred hand and the pool objects on the desk top; for the second trial place the stimulus object on the desk top and place the pool objects in the preferred hand, successively. Do the next two trials with the non-preferred hand; the next two with the preferred hand, etc.
6. *Allow* thirty seconds before prompting. *Choose* subtask order before testing begins (for I to V). Always administer VI and VII last.
7. *Position* the subject on a low chair on the curtained side of the desk with arms thrust into the desk on each side of the divider. Be

careful to conceal objects from subject.

8. *Vary* the chosen order of the first five subtasks, if necessary, to maintain the subject's attention.

ACTIVE TOUCH

group C-P
date 15

Name: Allan

Handedness: Left

Age: 10

Sex: (M) F

Grade: 4

(from Survey Tr. Center)

(-12) 36/47

I. Shape

Stimulous	Pool	Response
1	4, 1	✓
4	7, 4	✓
6	6, 6	✓
7	10, 7	✓
3	3, 7	✓
3	3, 1	✓

II. Size

1	1, 3	✓
3	3, 5	✓
5	5, 3	✓
3	3, 1	X
5	3, 5	✓
1	3, 5	✓

-1

III. Texture

Stimulous	Pool	Response
4	4, 10	✓
5	6, 5	X
6	5, 4	X
9	9, 10	X
10	10, 6	X
5	2, 10	X

4

IV. Two Parameters

7	7, 14	X
9	12, 9	X
14	14, 17	✓
11	11, 12	✓
16	16, 14	✓
13	6, 8	✓

2

V. Three Parameters

spoon	knife, spoon	X
17	17, 16	✓
penny	penny, quarter	✓
13	12, 13	✓
rubber ball	rubber ball, 14	✓
9	9, 15	X
6	17, 6	✓
15	14, 15	✓

2

VI. Cross Modality: shape

Stimulous	Pool	Response
1	4, 1	✓
3	3, 1	✓
4	6, 4	✓
6	7, 6	✗
7	10, 7	✓
3	3, 7	✗
1	1, 6	✓
3	4, 3	✗

-3

VII. Cross Modality: size

1	1, 3	✓
3	1, 5	✓
5	5, 3	✓
3	3, 1	✓
5	3, 5	✓
3	3, 5	✓
3	3, 3	✓
1	1, 3	✓

APPENDIX B

RELATED LITERATURE

A number of researchers have investigated active touch in intra-modal and cross-modal conditions. While their experiments are not directly pertinent to the study presented above, they are relevant in terms of the materials and procedures used by the writer. Part I deals with materials and procedures and is subdivided into: form, size, texture, and cross-modal condition. Part II contains descriptions of subject parameters: sex, age, brain injury, intelligence, personality, and deafness.

I. Material Parameters and Conditions

A. Shape: Ability to identify shape seems to be the most frequently examined subject of inquiry into material qualities. Methods involve the use of geometrical solids which have two or three dimensions, common household objects and topological solids which vary in the number of protuberances or indentations. These are presented in either intra-modal or cross-modal conditions, simultaneously or successively. Memory and labelling may be encouraged (or ignored). Actual manipulation or fingertip exploration may be allowed.

Conclusions from research into shape perception tend to be introspective because it is not known how shape is perceived. It is believed that the angular position of the finger bones helps to determine perception of the form of an object with which they are in contact (O'Donnell 1969, p.56). Gibson, who has investigated haptition more fully than most investigators, states that the hand "is sensitive to the variables of solid geometry, not those of plane. . . . The hand can detect all of the following properties: the slant of a surface, the convexity or concavity of a surface, the edge or corner at the junction of two or more surfaces, and the separation of two edges" (Gibson 1963, p. 6). The skin is analogous to the retina in terms of the function of its receptors in receiving data on form.

Benton (1960) devised a test of active touch which employed two-dimensional geometric forms[1] in simultaneous presentation in a cross-modal condition. The forms were covered with sandpaper and were presented to the subject for fingertip exploration while a pool of twelve drawings was presented visually. The subject was asked to choose the matching form. Gliner (1967) employed two-dimensional forms in an intra-modal tactile condition with simultaneous presentation. Her subjects tried to match a stimulus object in one hand with pool objects in the other.

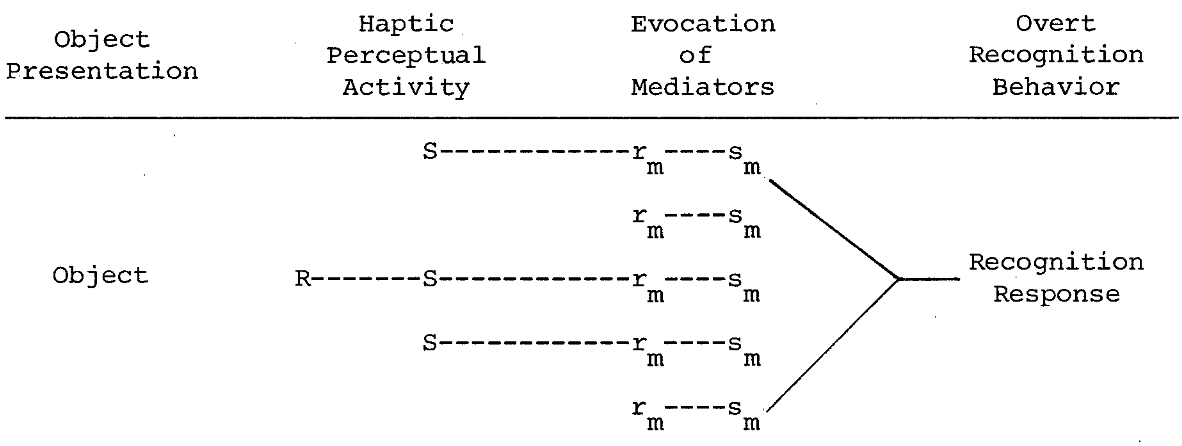
Fisher (1965) employed three-dimensional forms in a cross-modal condition with simultaneous presentation. His experiment shares several difficulties with Benton's and Gliner's: (1) the characteristics of the forms are not systematically varied (except for Gliner's forms which are all ellipses); the relationship of one form to another is not described, and the reader does not know to what extent they can be discriminated from each other; (2) the variable being measured may not be that of form; Gliner's ellipses grow longer or shorter as compared to the stimulus object. Is shape or size being measured? (A similar question may be posed for the other experiments.); (3) the comparative difficulty

[1]The forms are not actually two-dimensional; they are constructed from thin pieces of wood or hardboard so that the dimension of thickness is minimal and static between objects.

of discriminating each object is undetermined (this is common to all haptic experiments because of the lack of knowledge of what is being explored).

The employment of some forms to investigate shape is more acceptable than the employment of others. For example, it is easier to be assured that the discrimination between a two-inch circle and a two-inch octagon is based on the perception of form (thickness and texture being static) than it is that the discrimination between a rectangle and a square is based on the perception of shape.

A consideration of the qualities subjects are able to discriminate in an experimental situation is presented by Krantz who offers us a diagram of haptition (Krantz 1969, p. 20):



R is exploration hand movements; S is proximal stimulation; r_m----s_m is a haptic mediator.

Four stages occur in the experimental procedure: (1) the object is presented; (2) a series of haptic information gathering or scanning behaviors occur (these are a complex product of tactile and kinesthetic experience, and the proximal stimulation which results cannot be directly measured nor completely specified even when the physical makeup of the object is easily measured); (3) the proximal stimulus evokes a series of haptic mediators which have been previously associated with the object; each is characterized by a specific intensity in relation to a particular object (intensity is a continuous property of all mediators), and for each mediator is described a qualitatively continuous dimension which is itself assigned to a separate axis in a multi-dimensional system--all dimensions cross at a single point corresponding to the center of the coordinate system, and the multivariate space defined by this system is termed "haptic space"; (4) if each haptic mediator evoked corresponds to a dimension of the stimulus objects, the subject can indicate correctly on an isolated scale dimensions corresponding to those represented by the mediators (Krantz, pp. 20-23).

Krantz employed common household objects in a cross-modal condition of successive presentation with eight-year-old children. He isolated five haptic mediators: (1) resistance (to muscular exertion); (2) rough-smooth (friction); (3) size (distance between thumb and forefinger and fingers); (4) warmth (temperature); and (5) sharpness (angularity). A subject defines haptic space with these mediators.

The definition of a form could easily involve the operation of (3) and (5); (3) could easily act as a confounding variable in many experiments or could actually replace what the experimenter believes is being measured.

B. Size: Finger span is an important source of information about smaller objects; together with the angle of the finger joints it may produce an accurate percept of the dimensions of small objects. Larger objects can be studied by extending both arms, involving shoulders, elbows, wrists, and finger joints. Bartley (1953) states that this suggests that "Tactile exploration is a piecemeal affair, and some 'tactile' means must exist to integrate the material into a unit to represent the object, if it is to be said that the observer apprehends shape, size, etc. tactually" (Bartley, p. 401).

After a series of experiments, Bartley concluded that haptic appreciation of size operated with principles similar to those of vision; for example, the farther away an object is the smaller it is perceived to be, regardless of size. Other experimenters have not dealt with size as a primary subject for inquiry.

C. Texture: It is possible for an observer to distinguish between two surfaces, one of which is rigid and one of which is yielding, by pressing them with his fingers (Gibson, 1963). When combined with the friction created by sliding fingers over a surface, the resistance to muscular exertion of an object held or pressed can serve as a source of information on the texture of the surface of that object.

Texture may be considered as the haptic equivalent of color (Siegal and Vance, 1970). Gliner (1967) noted a significantly better discrimination performance for her subjects when materials were comparatively rough rather than smooth.

Texture does not appear to be as important to haptition as size and shape. Siegal and Vance conducted a comparison of visual and haptic preference for form, size, color, and texture with five, six, and eight-year-olds. For three-dimensional objects presented simultaneously, form was the dominant preference from six years on, visually and haptically. Texture was not dominant at any age.

D. Cross-modal: Relatively few experiments are limited solely to consideration of haptic information. Most involve a comparison of the four possible combinations of inspection and recognition of stimulus and pool objects: visual-visual; visual-haptic; haptic-visual; and haptic-haptic.

Zinchenko and Ruzkaya (1967) postulate that the tools of perception are determined or created by reactions to the problem of perceiving the environment in the most efficient way possible. Vision is more efficient for most information-gathering purposes; therefore, the normal man operates primarily with visual forms; he may transfer forms from other modalities into visual form but rarely vice-versa. Zinchenko and Ruzkaya's experiments show the results of visual inspection after visual recognition to be significantly better than the results of haptic recognition after haptic inspection; moreover, the intra-modal visual condition is better than either cross-modal condition. They also reported that the haptic-visual condition permitted better comparisons than the intra-modal haptic condition; visual-haptic comparisons were poorest of all. An effective exchange between the modalities, they noted, requires distinct forms for both inspection and recognition, and becomes possible only at the end of preschool age (six to seven years old).

Ryan (1970) investigated asymmetrical cross-modal relationships with transfer of training tasks and concluded that "certain stimulus dimensions are more salient for certain modalities than are other dimensions . . ." (p. 57). "Cross-modal transfer was significantly better for the modality order of vision to touch than for touch to vision . . ." (p. 33).

Wlodarski (1966) reported somewhat different findings from those of Zinchenko-Ruzkaya. Employing successive presentation with two-dimensional figures, he reported that the intra-modal haptic condition allowed better matching than either cross-modal condition. He noted that all discriminations improved with his subjects' age and suggested a developmental relationship between the modalities which improves with age.

Analysis of data from a preference test for visual and haptic searching led Northman (1970) to report that more time was spent in haptic exploration than in visual exploration, but he suggests that this may not mean that the haptic modality was "preferred"; it may indicate that the visual modality is more efficient. He reported visual memory to be superior to haptic memory and posited a "central organizor" (or necessity?) to determine the most appropriate strategy for perception.

Connolly and Jones (1970) devised a transfer of training comparison involving duplication of a line segment presented haptically and estimation of a line segment presented visually. Like Wlodarski, they also reported that both intra-modal performances were superior to cross-modal performances, and like Zinchenko and Ruzkaya, they found the haptic-visual sequence to be superior to the visual-haptic sequence.

Eastman's (1967) results are similar to those of Connolly and

Jones. Blank et al. (1968) reported the visual-haptic sequence to be superior to the haptic-visual sequence, but three-dimensional objects were used, and it is not inconceivable that the additional information required for discrimination with these objects may have produced this reversal.

In this connection Fillipov (1965) used visual training followed by haptic stimulation and visual recognition with simultaneous presentation and concluded that the success of the training transfer depended on the complexity of the elements to be perceived, their size, and their position in space. Structures most easily recognized by the fingertip did not exceed $64mm^2$ and were not composed of more than two elements.[1] It seems reasonable to suppose, at least by analogy, that similar limitations may be applied to exploration by the entire hand, and that relative to vision, haptition is simply not able to perceive as much data. This conclusion seems especially likely given Piaget's description of haptic perception as a series of "centrations" (impressions of parts of an object) (Piaget and Inhelder, 1963) and the suggestion of Connolly and Jones and Northman that haptic storage is more subject to temporal decay than is visual storage of memories.

E. Summary of materials and procedures: To compare the experiments above is very difficult because almost their only common factor is the

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[1]Although Fillipov's article may be translated as "On the question of the Adequacy of Perception of the Passively-Touched Object," the procedure requires the application of the fingertip to some figures, rather than having the figures applied to it, so I have included the article in this discussion.

investigation of the limits of active touch. It would appear that all authors who have compared intra-modal and cross-modal matching or transfer of training agree that the intra-modal visual condition is best; the ranking of the other three conditions is disputed. Given the use of simple, distinct "two-dimensional" materials, the haptic-visual condition seems to be superior to the visual-haptic condition.

There is the problem of confounding the quality of form with that of size, and the effect of the discriminability of materials requires more investigation as does the size and number of the pool objects, the function of memory, the roll of labelling (voiced or unvoiced), differing training practices, and the type of response demanded from the subjects.

II. Subject Parameters

A. Sex: Vaught (1968) reported significant female superiority on discrimination of two-dimensional forms in a passive touch situation; in an active touch situation, he found no sex difference. Siegal and Vance (1970), Benton and Schultz (1949) and Spreen and Gaddes' norms (1969) of Benton's Stereognostic Test (1960) did not discriminate active touch scores significantly by sex.

B. Age: Haptic perception develops gradually (Piaget and Inhelder 1963): (1) stage I lasts from about two-and-a-half to four years of age; by the end of this period the child is able to recognize familiar shapes haptically (in a tactile to visual condition), but he does not explore and "contents himself" with initial impressions of parts of an object ("centrations"); (2) stage II lasts from about four-and-a-half to six or seven years; in this period the child begins to explore objects globally and establishes relationships between some extremeties of objects but is still non-methodical; by the end of the period he can recognize some euclidean figures differentiated by angles in a cross-modal condition; (3) stage III begins at six-and-a-half or seven years and lasts through adulthood; the child begins systematic exploration of objects--he is able to return to the point initially felt and use it as a point of reference; in a cross-modal condition he can recognize complex forms.

In these stages the child progresses from recognizing by active touch common household objects to recognizing topological shapes (objects without definite geometric form) to recognizing geometric shapes. A process of "decentration" occurs (the transposition of one centration onto another so that a generalization is possible) as the child grows older (Piaget and Inhelder 1963, pp. 37-41).

Benton and Schultz (1949) conducted a cross-modal examination of children three to six-years-old, employing household objects, memory, and labelling. They reported that "under the specific investigations of testing of tactual appreciation utilized in this investigation, stereognostic capacity shows some growth in the range of three to six years" and that stereognostic capacity extends back into very early childhood and in all probability antedates the motor language skills involved in naming visually perceived objects. The experiments of Spreen and Gaddes, Ryan, Solomons, Connolly and Jones, Gliner, and Zinchenko and Ruzkaya show results which tend to agree with the schema of Piaget and Inhelder.

Blank et al., however, reported evidence of cross-modal transfer of form discrimination training using three-dimensional geometric objects (visual to haptic condition) for children of three to four years. Part of Fisher's experiment reports that children are able to discriminate linear shapes more easily than topological shapes by age four. These results (which are as valid as any) suggest that the age guidelines described by Piaget and Inhelder may not be accurate and that the sequence of development from topological to geometric shape recognition may not be adequately described.

C. Brain Injury: The most pertinent literature has been discussed above.

All studies which have investigated this parameter must contend with the fact that direct evidence of brain injury is very rare. The development of neurological examinations based on some physical and much psychological evidence allows physicians to postulate the existence of brain injury in specific locations but the difficulty of empirical verification does not permit complete trust in these diagnoses.

Educationally, consideration of brain injury is important in that a number of programs which postulate brain injury or dysfunction as a cause for certain difficulties in school have been presented as necessary procedures to eliminate these difficulties. "A major issue in training is whether or not haptic processing disabilities can be influenced by various forms of training exercises or whether or not it is necessary to work with the residual abilities and allow the subject to compensate by utilizing his assets" (O'Donnell 1969, p. 46).

D. Measured Intelligence: Hermelin and O'Connor (1961) compared normal children about five years old (chronologically) with a group of children about twelve years old who had a mean mental age of 5.4 years. Intra-modal and cross-modal conditions used two-dimensional Greek and Russian alphabet letters with successive presentation. The authors reported that the normal sample maintained similar recognition scores in all conditions. The retarded sample produced significantly superior scores in the intra-modal haptic condition but did not differ significantly from the normal group in the other conditions.

Medinnus and Johnson (1966) performed a similar experiment, using an intra-modal haptic discrimination task employing two-dimensional nonsense blocks. They reported no significant differences between the scores of their groups. It must be noted, however, that the measured intelligence of their retarded sample was higher than that of the sample employed by Hermelin and O'Connor.

MacKay and Macmillan performed an experiment more comparable to that of Hermelin and O'Connor in terms of the degree of retardation measured in the experimental group. Their results were similar to those of Hermelin and O'Connor, and they suggest that haptition is controlled by areas of the brain which may not be involved in the types of cerebral insult which are associated with severe retardation. This function may develop further so that when matched with normal children for mental age, the tactile discrimination of retarded children will be superior.

E. Personality: This parameter has not been researched with reference to haptic perception; however, if the operation of the haptic modality is postulated to be analogous to the operation of the visual modality (Bartley 1953; Gibson 1963), it is possible that personality variables such as those found to affect vision may also affect haptition. Within the context of this consideration, two experiments can be cited.

Perez (1961) compared scores of normals and individuals diagnosed as schizophrenic on a size constancy task (a preference task for form, size, and color). He reported that the schizophrenic group demonstrated a higher degree of size constancy than non-schizophrenics; that is, their discrimination of objects was based more on size than any other parameter; normals discriminated objects on parameters other than size.

Kauffer (1961) reported in an experiment on size-distance relationships that the subjects judged to be "moving-toward" (seeking interpersonal relationships to fill needs of dependency, etc.) perceived visual stimuli as larger and closer than subjects who had been judged as "moving-away" (seeking detachment from inter-personal relationships). These were not severely pathological definitions of people, but simply alternate categories to which subjects were assigned by a panel of judges.

F. Deafness: Deaf and hard-of-hearing children have been regarded by some writers as having comparatively poor visual motor skills (Myklebust 1962). Wormeli (unpublished, 1973) compared haptic perception of normal children to that of deaf children, using the task employed in the experimental study above. No significant differences were found.

Assuming the task to be valid, it would appear that whatever may affect visuo-motor skills in the deaf does not affect haptition in intra-modal and cross-modal conditions.

G. Summary of Subject Parameters: There is no strong evidence to indicate that sex has an effect on active touch. There is much evidence to indicate that age does between three and nine years. Explanations for the effect of age include the development of language, development of visual perception, improvement of an internal translation mechanism, enlargement of haptic knowledge, and improved attentional skills.

Brain injury appears to have a significant effect, especially when associated with severe motor involvement of the upper limbs as a symptom. The effect of minimal brain damage does not appear to be significant.

In regard to measured intelligence, it is possible to state that general intellectual retardation does not appear to reduce the haptic perception of those affected. Nor does auditory dysfunction seem to be significantly associated with a difference in haptic ability. The effect of personality is unknown except by extension of its possible influence on visual perception.