BODY SCHEMA DEVELOPMENT IN 3 TO 6 YEAR OLD CHILDREN

by

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ABSTRACT

This developmental study attempted to distinguish between the preference differentiation, sensorimotor differentiation and language differentiation of body parts by 3 to 6 year old children. The development of the body schema defined as the neurological model of the sensorimotor aspects of body parts was emphasized.

Sixty-four children served as subjects in this study. There were eight boys and eight girls in each age category. These subjects were selected from a group of 3 to 6 year old children with play school experience at Sunset Recreation Centre.

Four Task Series were administered; Task Series I was sensorimotor finger localization; Task Series II was sensorimotor hand-finger orientation; Task Series III was hand preference and foot preference; Task Series IV was the verbal understanding of body parts with respect to the right and left co-ordinates of the body.

Four different experimental conditions that involved visual presentations and tactual-kinesthetic presentations for visual movement response and non-visual movement response were used in Task Series I and Task Series II.

The data of Task Series I and II was submitted to bivariste frequency analysis and an analysis of variance. In Task Series III and Task Series IV age group percentiles for correct responses across trials were calculated.

This data analyses indicated that the major development in the differentiation of body parts at 3 to 6 years of age is at the sensorimotor level of organization. This sensorimotor development reflected a reliance upon the tactual-kinesthetic sensory system.

The results were discussed in terms of the applicability of the neurological term body schema to the research in developmental and educational psychology concerned with the developmental significance of body awareness in 3 to 6 year old children; the implications for the relationships reported between neurological disorders; and the considerations for the limited research in integrative processing.

Future directions for physical education research in the developmental study of effective cues for motor learning were indicated.

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CHAPTER I

INTRODUCTION

For years, the developmental significance of body schema has perplexed researchers in developmental psychology (Gesell, 1946; Goodenough, 1945; Piaget, 1956), educational psychology (Kephart, 1960; McCarthy and McCarthy, 1970), and developmental medicine (Benton, 1959, 1962; Head, 1920; Lange, 1930; Stengel, 1944). More recently, the phenomenon of body schema has been re-examined in terms of the motor utilization of this schema (Berges and Lezine, 1965; Lefford, 1970).

Numerous theories pertaining to the developmental significance of a child forming an organized model of his body have been proposed. Moreover, practical applications of these theoretical contentions have been construed and disseminated. What is peculiar to this research area is the relative neglect of two intermediary phases which are typically present in the scientific advancement of knowledge: first, the collection of systematic data and second, the accumulation of relevant findings across the concerned disciplines (Bruner, 1964). The absence of a generally accepted definition of body awareness, body concept, body representation or body schema may explain why the scientific study of this phenomenon has often been inadequate. Closely associated with this, is the lack of precise and valid measures for the study of this phenomenon (Chalfant and Scheffin, 1969).

In view of the above, the present investigation has been directed towards a clearer understanding of body schema and its developmental significance.

Body Schema

In his original formulation, Head (1920) conceived that afferent sensory components are unified and synthesized into the body schema. Head (1920) considered the body schema to be a sensory mechanism. More recently, Berges and Lezine (1965) have argued that while the organization of the body schema is based on past impressions, predominantly kinesthetic and proprioceptive, the significance of this physiological and subconscious model lies in its use. Berges and Lezine (1965) have, thus, considered the body schema to be a sensorimotor mechanism. This has been supported by Ayres' and Reid's (1966) description of the body schema as the neurological model of the sensorimotor aspects of body parts. This definition of body schema has been adopted for use in the present investigation.

Psychological Considerations

The significance attached to body schema has stemmed to a large degree, from the works of one of the major theorists in developmental psychology, Jean Piaget. Piaget's (1953) theory of logical thought development has been based on the hypothesis that schemata (sets of actions) are the structures of the intellect responsible for the child's adaptation to the environment. Piaget

(1953) has also suggested that the notions of the pre-school child are predominantly tied to sensorimotor schemata. Within this theoretical framework, the development of the notion of space has been said by Piaget (1954) to depend on 1) a comprehension of objects and object relationships, and 2) a comprehension of the individual's own shifts in position. During his early movements, the child is active in a space which is limited for him by the extent of his movement. If as Piaget (1953) has argued, the child can only organize space as he interacts with objects in space, the differentiation of body parts and body part relationships necessarily precedes the differentiation of similar spatial relationship outside of the self (Kephart, 1960). Thus, differentiation of the components of the body has been seen as a significant factor in the sensorimotor organization of space.

Within this theoretical context, laterality or the internal understanding of the right and left co-ordinates of the body has been said to be the first notion of space to develop (Radler and Kephart, 1960). The procedures which have been used to measure this concept have varied widely (Chalfant and Scheffiin, 1969). A brief discussion of the categories studied in the development of neurological functioning may explain this diversity.

Neurological Considerations

Not unlike Piaget's (1953) hierarchial organization of schemata from external, observable actions to internal, unobservable actions, Denhoff et al. (1968) and Semmes et al. (1968) have suggested that the neurological lateralization of function proceeds from simple, preference differentiation, through intermediary, sensorimotor differentiation to complex, language differentiation. While the precise nature of this neurological organization has not been revealed, the sensorimotor functions which do not require a high degree of symbolic processing have been reported to stabilize around 5 to 6 years of age (Benton, 1959, 1962). Right-left detection and finger localization procedures have been used to arrive at this finding. Right-left detection procedures have also been used to study laterality (Kephart, 1960). Finger localization procedures have also been used as a somatosensory spatial measure for years (Stone, 1968). Kephart (1960) has reported that 'body awareness' and laterality are established in the typical child by school age. Stone (1968) reviewed the findings of several finger localization studies and reported that, if response complexity is minimized, this sensorimotor ability stabilizes around 5 to 6 years of age.

It would seem reasonable, in view of the above, to suggest that while body differentiation has been a useful developmental and educational psychology construct, the developmental importance of body schema may be rooted in the neurological development of the child.

Two studies which examined the motor utilization of the organized body model in 3 to 6 year old children have given direction to the formulated hypotheses of this investigation.

Berges and Lezine (1965)

In an attempt to provide procedures for the neurological examination of pre-school children, by pediatricians, Berges and Lezine (1965) studied the ability of 3 to 6 year old children to imitate a gesture of the experimenter. The gestures were considered to be simple or complex depending on the relationship between 1) the level of visual perceptual organization required (gestalt, spatial orientation) and 2) the level of motor co-ordination required. All gestures involved either the upper limb schemata or the hand-finger schemata. The 3 year old children had difficulty with the simple gestures, while the 4 to 6 year old children displayed difficulty only on the complex gestures performance. Accuracy along the dominant side of the body was seen to precede accuracy along the non-dominant side of the body. No difference was observed between the performance of boys and girls at each age level studied.

Lefford (1970)

Lefford's (1970) study used 12 finger localization tasks to examine the development of voluntary actions in 3 to 6 year old children. Four different response actions were studied under three presentation conditions 1) visual and tactual 2) visual and 3) tactual-kinesthetic.

Lefford's findings were extensive and are discussed in the next chapter. In short, he suggested that the visual hand-finger schemata appeared to be more advanced at the 3 year old level than did the tactual-kinesthetic hand-finger schemata. By 4 years of age, Lefford found that hand-finger schemata were equally differentiated across the visual system and the tactual-kinesthetic system. Response complexity was found to be significantly related to differentiation accuracy.

Statement of the Problem

The concern of this investigation is to study the body schema development of the 3 to 6 year old child as reflected in the development of his ability to make differentiated voluntary movements on two series of hand-finger sensorimotor tasks.

Subproblems

There are two secondary concerns in this investigation. First, the ability of 3 to 6 year old children to make preference differentiations of the body parts is studied. Second, the ability of 3 to 6 year old children to make language differentiations of the body parts with respect to the right and left co-ordinates of the body is studied.

Hypotheses

It is hypothesized that:

(1) The major development in the differentiation of body parts is at the sensorimotor level, as opposed to the preference level and the language level, in 3 to 6 year old children. The age of the child, not the sex of the child, is the determining factor in this development.

It is hypothesized that the sensorimotor development of hand-finger schemata in 3 to 6 year old children is characterized by the following trends:

(2) The ability to make voluntary movement differentiations is dependent upon the sensorimotor aspects, not only the sensory aspects, of the task.

(3) The ability to make voluntary movement differentiations requiring visual organization precedes the ability to make voluntary movement differentiations requiring tactual-kinesthetic organization.

(4) The ability to make voluntary movement differentiations on tasks requiring intra-modal integration develops in advance of the ability to make voluntary movement differentiations on the tasks requiring inter-modal integration.

(5) The ability to make voluntary movement differentiations along the dominant side of the body precedes the ability to make voluntary movement differentiations along the non-dominant side of the body.

Definitions

Body Schema	The neurological model of the sensorimotor aspects of body parts (Ayres and Reid, 1966)
Differentiation	The ability to utilize discriminated sensory stimuli for response (Chalfant and Schefflin, 1969). This ability reflects the three levels of psychoneurological functioning preference, sensorimotor and language (Denhoff et al, 1968)
Egocentricity	Taking the position of self as the permanent centre of reference in spatial organization of the environment. During the ages 2½ - 5 years (approximately), children typically progress from this point to awareness of the effect of changes in self position on the position of objects (Piaget, 1970).
Fine Motor Skill	Neuromuscular co-ordination which involves precision oriented control of small muscle groups; this often refers to eye-hand co-ordination.
Gross Motor Skill	Neuromuscular co-ordination which involves control of the large muscle groups; this

	often refers to the movement of the whole body.
Integration	The organization of both incoming and outgoing neural events (Chalfant and Schefflin, 1969).
Kinethesis	In behavioral terms, kinesthesis includes the discrimination of the position of body parts, the discrimination of movement and amplitude of movement of body parts both actively and passively produced (Howard and Templeton, 1966).
Lateralization of function	The cross-over principle that applies to both the ascending and descending corticospinal tracts (Reitan, 1971).
Modality	An avenue of acquiring sensation: the visual, auditory, tactile and kinesthetic systems are considered the most important modalities in learning (Chalfant and Schefflin, 1969).
Neurology	The biological study of the nervous system (Chalfant and Schefflin, 1969).
Perceptual-motor theory	The essence of this theory is that complex learnings are built upon earlier integrative learnings in a sequential and hierarchal fashion (McCarthy and McCarthy, 1970).
Pre-operational stage of logical thought development	Thought development during this stage moves from external to internal actions. The development of images enhances the child's ability to organize and adapt to the environment (Piaget, 1956).
Sensorimotor neurology	Integration of incoming sensory information for motor response. In terms of neurological organization this level is intermediary to preference and language lateralization (Chelfant and Schefflin, 1969; Denhoff et al, 1968; Semmes et al, 1960).
Sensorimotor developmental psychology	Piaget (1956) refers to the sensorimotor stage of logical thought development as the initial phase where actions are predominantly external.

Limitations

The usual delimitations of study (the small sample size, the same socio-economic grouping) apply; in addition, the children who participated as subjects in this study all had play school experience.

Significance of the Study

The long-term objective of research concerned with body schema development in pre-school children lies in revealing the precise nature of this phenomenon and its developmental significance.

The relevance of this study to the field of human performance and motor learning may be explained in several ways. As very little is known about the pre-school development of the kinesthetic system and its interco-ordinations with other sensory systems (Chalfant and Scheflin, 1969), this study may provide direction for future research in the kinesthetic integration of children. The study may contribute to the limited research which has been reported on the development of voluntary movements in the pre-school child. Furthermore, it may provide information for the re-examination of voluntary movement development in terms of related developments in sensory integration. Perhaps the accuracy of voluntary movement differentiation is dependent on the presentation of information to a particular sensory system or interco-ordinated systems and varies with age. This consideration would seem to be of particular importance in determining effective cues for motor learning. This aspect of the investigation would appear to hold broad implications for physical educators.

CHAPTER II

REVIEW OF THE LITERATURE

The developmental study of the body schema is complex in that it has been directly or indirectly considered by researchers in developmental psychology, educational psychology, neuropsychology, and neurology. For the purposes of this study, body schema has been defined as the neurological model of the sensorimotor aspects of the body parts and studied in an interdisciplinary manner.

This chapter has been subdivided as follows: psychological considerations, both developmental and educational in nature; neurological considerations and integrative processing considerations.

Since this investigation has received direction from each of the above research areas, the inter-relationships between these areas with respect to body schema development will also be discussed. It should be clarified, however, that such intercoordinations have not been commonly reported. As a result, the formulated relationships have, with few exceptions, been drawn from the findings of researchers working in the various disciplines.

Psychological Considerations

Cognitive Development

To date, the precise nature of cognitive development has not been resolved. Due to the lack of refined procedures in the behavioral study of cognitive growth and the absence of techniques for the direct examination of the processes involved in cognitive growth (differentiation, integration and representation) (Bruner, 1964) our understanding of this phenomenon has remained, predominantly, theoretical in nature. According to Elkind and Flavell (1969), the theoretical framework presently used for the developmental study of the cognitive processes has stemmed, almost in its entirety, from the works of Jean Piaget. The significance attached to the development of body schema by developmental and educational psychologists has originated with Piaget's works.

Piaget's Theory of Logical Thought Development

Piaget (1953) has based his theory of logical thought development on the hypothesis that schemata (sets of actions) are the structures of the intellect. Thus, spatial schemata, motor schemata, body schemata and so on have been considered the basis of integrated representations of the environment. Piaget has also associated adaptation to the environment with the growth of intelligence. In Piagetian terms, adaptation is a process of assimilating external and internal environmental information to form models of the environment, and then, testing the applicability of these models through interaction with the environment. Logical thought development then, has been conceived by Piaget as an active inward and outward building process. Adaptation has been seen to begin with external, observable actions and to proceed to internal, unobservable actions. Bruner's (1964) contention that cognitive growth occurs, in a major way, from the outside in as well as from the inside out has been based on the replication of Piagetian studies.

While the significance of body awareness, within these disciplines, has been based on the sensorimotor organization of space prior to and during the pre-operational stage of logical thought development, the above discussion would seem to indicate that the development of body awareness is significant in itself. One may deduce that the development of an organized model of the self, not unlike other psychological constructs, is based on the continual assimilation of sensory information regarding the body and the continual accomodation of the organized schemata until a body schema effective for interaction with the environment becomes established. The development of this phenomenon, then, would seem to be dependent upon the neurological development of the child: in particular, the sensorimotor development of the child.

The Development of Spatial Organization

Poincaire (1953) has stated that there is no space irrespective of objects; the notion of space can only be understood as a function of objects and object relationships. According to Piaget's (1954) Construction of Reality in the Child, two factors have been considered to be essential in the organization of space:

(1) a comprehension of the spatial relations between objects and object parts,

(2) a comprehension of the individual's own shifts in body position.

This reasoning is consistent with Piaget's (1953) contention that the developing understanding of the environment requires inward and outward building. In neurological terms this development requires an integration of incoming and outgoing neural events.

It follows that the organization of space can not be separated from the sensory and motor development of the child. Spatial organization has been said to originate very early in the phylogentic development of the human organism with the movement and external actions of the child (Piaget, 1954). At first, the child treats the objects he manipulates as a part of a simple undifferentiated body activity. As the child's motor activity becomes less diffuse and undifferentiated his actions lose their global nature. One could describe the child as first acting with the object, then acting on it, and finally acting without it. Similarily, as the child's sensory differentiation of the topography of the body becomes more acute, he loses his egocentric approach to space; no longer incorporating himself as the central reference point for understanding the spatial aspects of the environment. Piaget's (1953) Pre-operational stage of logical thought development (approximately 2 - 7 years) has been seen to characterize this development of spatial organization.

Educational Hypotheses

Within this theoretical framework, the understanding of body parts and body part relationships has been seen to develop in advance of the understanding of object and object relationships outside of the self (Piaget, 1954). The first notion of space said to develop is that of laterality or the internal understanding of right and left. Furthermore, Kephart (1960) and Piaget (1954) have suggested that the concrete projection of laterality, directionality, must be established before the more abstract notions of space can be formulated. According to Kephart, laterality has been found to be established in the typical child by 6 years of age or by the time the child enters formal school (Radler and Kephart, 1960). This finding, in combination with the tenet that form (space an object occupies) and distance (space between objects) are the most important aspects of directionality (Piaget, 1954) has provided the basis for Kephart's (1960) theory. In this perceptual-motor theory, Kephart has inter-related the establishment of body awareness, laterality, directionality and visual-motor integration with reading ability.

If a child displays difficulty in learning to read, Kephart (1960) and Radler and Kephart (1960) have argued that the concrete aspects of space (laterality, directionality) and the integrative abilities which underlie these notions have not been clearly established in the child. As a result, Godfrey and Kephart (1964), Kephart (1960), and Radler and Kephart (1960) have provided ideas for remediating reading difficulty through visual-motor, laterality and directionality training. These ideas have been utilized in the designs of numerous "perceptual-motor" programmes for children with reading disabilities (McCarthy and McCarthy, 1970). The inadequacies of this developmental trend lie first in the broad generalization, rather than specific focalization, of reading difficulty causes and second, in the lack of data on the development of spatial organization in the pre-school child. The literature pertaining to the neurological development of the child may be related to the literature in developmental and educational psychology to provide a clearer understanding of spatial organization development in the child.

Neurological Considerations

Kephart (1960) and Piaget (1954) have emphasized the importance of an internal understanding of the right and left co-ordinates of the body in the spatial organization development of the pre-school child. Moreover, research findings in space concept development at the Pre-operational stage (Piaget, 1953) have reported that the ability to utilize particular space concepts is not necessarily accompanied by the ability to verbally explain these concepts (Ames and Learned, 1948; Asso and Wyke, 1971; Court, 1920; Gesell, 1940, 1946; King, 1971; Meyer (1940). In view of the categories commonly employed in the study of neurological development in children (Semmes et al, 1960)

(1) preference differentiation

(2) sensorimotor differentiation

(3) language differentiation

the pre-school child has not developed a sophisticated language differentiation of space. The relevance of an internal understanding of the right and left co-ordinates of the body may be further interpreted by considering the literature in the cerebral lateralization of function.

Cerebral Lateralization Considerations

Pathways that conduct sensory stimulation to the higher levels of the neuraxis, and pathways that conduct motor impulses from higher to lower levels, ascend and descend over the entire length of the neuraxis. Peculiar to both the descending cortico-spinal tracts and the ascending sensory tracts is the cross-over to the opposite side at the medullary level. This cross-over phenomenon has been referred to as the lateralization of functioning (Reitan, 1971). It has been associated with all three categories of neurological organization. It is reflected at the preference level by foot and hand preference; at the sensorimotor level by performance on right-left detection and finger localization procedures presenting sensory information for motor response; at the language level by performance on right-left detection, finger localization, procedures presenting verbal labels for movements (pointing) indication or movement (pointing) indication for verbal response (Denhoff et al, 1968).

Kephart (1960) has employed sensorimotor right-left detection procedures to arrive at the conclusion that laterality is established in the typical child by formal school age. Benton (1959, 1962) has reported that the right-left detection and the finger localization abilities which are not symbolic stabilize around 5 to 6 years of age. It would seem reasonable to suggest, that the educational hypotheses relating body awareness, laterality, and directionality to reading ability do not need to be based on the theoretical extension of Piaget's hypothesis pertaining to spatial understanding development in the pre-school child, but, may be based on the neurological development of sensorimotor functions in the child. The consideration of neuropathological literature concerned with the cerebral organization of spatial functioning should solidify this reasoning.

Neuropathological Considerations

In this section, neuropathological evidence related to the differences of the cerebral hemispheric organization of spatial abilities will be presented. While not all researchers have reported differences in the functioning of the right and left cerebral hemispheres (Smith, 1966) numerous researchers have indicated a difference.

Functional inequivalence of the cerebral hemispheres. Based on the findings of Arrigoni and De Renzi (1964), with 175 brain damaged adults, which showed that constructional apraxia was significantly higher when right cerebral lesions were the cause of brain damage and spatial disorientation was significantly higher when left cerebral lesions were the cause of brain damage, De Renzi and Piero (1967) studied 137 brain damaged adults to determine hemispheric differences in spatial functioning. De Renzi's and Piero's (1967) findings suggested that spatial abilities may indeed be differently organized in the two hemispheres; their representation being more focalized on the left side of the brain and more diffuse on the right side of the brain. Consideration of the purported distinction between the functions of the right and left parietal lobes may clarify this contention.

Functional inequivalence of the parietal lobes. According to Reitan (1971), Semmes (1968) and Sparrow and Satz (1970b) there have been many studies which have shown that the right and left lobes are not functionally equivalent. Further, the differences have generally been seen to lie in the sphere of sensorimotor and language disorders. The disorders commonly referred to are (Reitan, 1971):

(1) Agnosia — defects in the identification and recognition of familiar objects e.g. finger agnosia

(2) Apraxia — defects in the development of concepts for sequencing actions for purposive movement

(3) Aphasia — defects in the comprehension of more complex, symbolic language activities

(4) Anomolies of spatial orientation.

The apraxias, as indicated by De Renzi and Piero (1967), have been associated with right hemispheric lesions (Arrigoni and De Renzi, 1964; Critchley, 1968; Reuben and Bakwin, 1965). Apraxic behavior has also been associated with lesions in the pre-motor cortical region assumed to be responsible for sequencing abilities (Luria, 1964).

In contradistinction to the above, the aphasias, agnosias and anomolies of spatial orientation have been commonly linked with lesions in the left parietal region (Semmes et al.,1960).

Left parietal region - body image. During the past forty years, a number of investigators have suggested that damage to the left parietal regions often disturbs the concept of body image (Benson and Geschwind, 1968). This distrubance has further been seen in combination with:

(1) Apraxic behavior: Lange, 1940; Reitan, 1971; Reubin and Bakwin, 1968.

(2) Aphasic behavior: Critchley, 1964, 1968; Sparrow and Satz, 1970a, b; Spreen and Benton, 1965; Weinstein, 1968.

(3) Visual-motor spatial disorientation: Birch and Bortner, 1960; Reitan, 1971; Rubin and Braun, 1968.

In view of this it would seem reasonable that Kephart (1960) has associated reading disability with developmental delays in body awareness and visual-motor integration establishment. If one were to adopt Myklebust's (1964) view that many children with learning disabilities have a minimal brain dysfunction, this association may be more clear. The query that remains lies in the explanation of why these behaviors have been shown to be related in some instances and not in others (Chalfant and Schefflin, 1969). The relationship between body image disturbances and Gerstmann's syndrome may provide an initial rationale for explaining this inconsistency.

Gerstmann's syndrome: left parietal-occipital region. Gerstmann's syndrome has in the past been seen to result from damage to the parietal-occipital region of the left hemisphere (Kinsbourne, 1968; Stone, 1963). The symptoms of this syndrome, which is at present out of neurological favour (Stone, 1968) are:

(1) dyscalculia

(2) dysgraphia

(3) right-left disorientation

(4) finger agnosia

Furthermore Gerstmann's syndrome has been associated with (Lange, 1940; Stengel, 1944):

(1) body image disturbances

(2) constructional apraxia

(3) spatial orientation anomolies

More recently, Poeck and Orgass (1966) found that Gerstmann's syndrome rarely occurs without aphasia. In view of this, Poeck and Orgass (1966) suggested that aphasia is the common denominator for the four symptoms of this syndrome.

Reference to the categories typically employed in the study of neurological organization would reveal that the symptoms of Gerstmann's syndrome reflect deficits at the sensorimotor level, not the preference or language levels, of neurological organization. Furthermore the literature dealing with the cerebral lateralization of function indicated that right-left detection and finger localization procedures are commonly used to study sensorimotor lateralization (Benton, 1959, 1962); while Kephart (1960) has measured laterality establishment by employing right-left detection measures. It would seem possible that the relationships between the neurological disorders enumerated in this section as well as the developmental delays inter-related by Kephart (1960) may have resulted from the inherent similarity in the procedures used to assess these behaviors. Another explanation, pertaining to the manner in which incoming and outgoing neural events become integrated, has been reported.

Cross-modal integration: left parietal lobe. Geschwind (1965), cited by Butters and Brody (1968), has proposed that the left inferior parietal lobe (angular gyrus region) receives afferent inputs from the visual, auditory, and somatosensory cortices of both hemispheres; thereby mediating cross-modal associations. Butters and Brody (1968) investigated this proposal and found that patients with left parietal damage displayed deficits in cross-modal integration and reading skills. As has already been stated, lesions in the left parietal region have been associated with body image disturbance, agnosia, aphasia, and spatial disorientation. These behaviors have also been related to reading disability. It would seem to be a logical deduction, then, that integration, at a sensorimotor level may explain the developmental significance of body schema. Unfortunately the development of integrative processing abilities in children has not received wide attention. The following section will discuss the few research studies which have been reported.

Integrative Processing Considerations

As was mentioned in the introductory chapter, Head (1920) originally conceived the body schema to be a synthesis of afferent sensory components relating to the body. Berges and Lezine (1965) have suggested that while this may be the way in which the body schema becomes established, the significance of this physiological and subconscious model lies in its use. Similarly, researchers concerned with integrative processing have concentrated on the central synthesis of multiple stimuli which are presented to the same sensory modality or different sensory modalities. Chalfant and Schefflin (1969),Konorski (1967), Munn (1965), Myklebust (1964), Rubin and Braun (1968) and others have suggested that the ability to discriminate and unify sensory information, per se, is difficult to measure with the unrefined black-box procedures presently available. These researchers contend that the assessment of differentiation abilities (the ability to utilize discriminated sensory stimuli) could yield more meaningful data. Bryant (1968) has suggested that input, processing and output requirements of a task should all be considered in drawing conclusions from experimental findings. Chalfant and Schefflin (1969) presented a format for consideration of these variables; this has been shown in Table 1. Few research studies in integrative processing have clearly described these variables; as a result the research findings reported have been difficult to interpret. Before discussing these findings, the sensory systems considered to be unified into the body schema are discussed.

Sensory Systems

Based predominantly on clinical findings with brain damaged adults, Konorski (1967) has postulated that the body schema develops independently of language. This supports the definition of body schema which has been adopted in the present investigation (Ayres and Reid, 1966).

Konorski (1967) has also hypothesized that the information

Table 1. Significant Variables Which Should be Considered under SOR (Chalfant and Schefflin, 1969, p. 57).

Mode of Stimuli	Organism	Mode of Response
Intramodal	Sex	Intramodal
Intermodal	C.A.	Intermodal
Simultaneous presentation	M.A.	Symbolic
Successive presentation	I.Q.	a. motor
Symbolic stimuli	Organic involvement	b. vocal
Non-symbolic stimuli	Prior experience or training	Non-symbolic
Intensity		a. motor
Number of units		b. vocal
Rate		Production
Duration		a. latency of response
Interval		b. duration of response
Instructions		c. frequency of response
Order		d. intensity of response
Complexity		Judgemental Response
Distortion		a. same
		b. different
		c. recognition
		d. recall
		e. equivalence
		f. correspondence
		g. recoding to a rule

coming from the angular displacement of the joints (position information) is the predominant sensory system in body schema acquisition. This system is, Konorski (1967) contended, inter-co-ordinated with the movement feedback system and the visual aspects of the limb, at the associational cortices level. Schilder (1950), cited by Berges and Lezine (1965) has hypothesized that the sensory systems involved with the understanding of movement and the maintenance of posture provide information about the body schema. Berges and Lezine have reported that the body schema is dependent on past impressions predominantly kinesthetic and tactual. In view of these contentions it would appear that the visual, tactual and kinesthetic systems are predominantly responsible for the acquisition of the body schema. The research findings related to the intrasensory and intersensory integrations of these systems will be discussed below.

Sensory Integration

The original works of Sherrington (1950) and Birch (1954) asserted that intramodal integration (the integration of sensory stimuli along one modality) is a necessary antecedent to intermodal integration (the integration of sensory stimuli between two or more modalities).

More recently, Munn (1965) and Konorski (1967) have suggested that even the simple sensory functioning of one modality is affected or modified by that of other sensory systems. Of particular relevance to the direction of this study is Piaget's (1953) contention that very early in the infant's development visual information becomes interco-ordinated with other sensory systems.

While numerous researchers have suggested that visual information is the predominant sensory system during the first seven years of the child's development (Chalfant and Schefflin, 1969), other researchers have ascertained that organisms differ phylogenetically in their reliance upon different sensory modalities. Montessori (1964) has argued that the development of the tactual system precedes that of vision and audition. Munn (1965) has suggested that initially, reliance is placed on the tactile, olfactory, gustatory and kinesthetic systems, then gradually more demands are placed on the visual and auditory modalities.

There has only been theoretical agreement to the effect that the nervous system develops in a manner characterized by progression from a relatively global condition, through increasing differentiated functions, to a hierarchial integration and co-ordination of functioning (Hebb, 1944; Luria, 1964; Munn, 1965; Piaget, 1953, 1954).

In the view of developmental and educational psychology the understanding of body relationships precedes the understanding of object relationships (in particular form and distance) outside of the self. The developmental studies which have concommitantly examined the spatial organization of object forms and integrative processing in pre-school children are discussed below.

Form Perception Tasks

It has only been within the last decade that research concommitantly concerned with the development of form perception and cross-modal integration has been reported. These experiments have been classified as cross-modal matching studies. They have been designed to test the ability of children to treat two identical stimuli as equivalent when information about each stimulus comes through two sensory modalities. The variables which Chalfant and Scheffiin (1969) have considered to be significant in integrative processing research (Table 1) have been used to concisely describe three cross-modal matching experiments in Table 2.

Birch and Lefford (1963) found that cross-modal integration improves with age (Table 2). Furthermore, their findings showed visual-haptic matching to be easier than both visual-kinesthetic matching and haptic-kinesthetic matching at 5 years of age. Blank and Bridger (1964) and Conners et al. (1967) reported similar findings.

The above experiments however, omitted within-modality conditions (visual-visual, haptic-haptic, kinesthetic-kinesthetic). As a result it might be argued that the improvement of cross-modal integration with chronological age may result from an increased ability to differentiate and integrate along one modality (Bryant, 1968). The studies of Balter and Fogarty (1971) and Rudel and Teuber (1964) separated within-modality effects from between-modality effects.

Balter and Fogarty (1971) and Rudel and Teuber (1964) found that across all age levels studied more errors were made on the haptic-haptic intramodal matching condition than on the cross-modal matching conditions utilizing haptic and visual information (Table 2). Visual-visual matching errors were lowest across all

Table 2. Significant Factors in Three Cross-Modal Form Perception Developmental Studies

Study	Age Range	Shape of Object	Modality Conditions	Mode of Presentation	Mode of Response	Analysis	Findings Modality	Findings Presentation
Birch and Lefford (1963)	5-11 yrs.	geometric	visual-haptic visual-kinesthetic haptic-kinesthetic haptic: active manipulation of object kinesthetic: E passive moving S's hand with stylus around object	successive presentation of pairs	verbal report "same" or different	Correct number of responses	1) visual-haptic was easiest condition: 17% of 5 yr.olds made no errors 2) visual-kinesthetic, haptic-kinesthetic: no 5 yr.olds scored perfectly 3) integration of kinesthetic with haptic and visual modalities occurs at 6-7 yrs.	
Rudel and Teuber (1964)	3-6 yrs.	Series I: geometric Series II: abstract	visual-visual haptic-haptic visual-haptic haptic-visual	successive BUT simultaneous on Series I for 3 yr. olds; Series II 4 yr. olds present standard 5 comparisons (5 sec.)	"is this it" for 5 variable stimuli yes or no verbal report	correct number of responses	1) easiest to hardest visual-visual, visual-haptic, haptic-visual haptic-haptic. 2) accuracy increased with age.	successive presentation impossible for 3 yr. olds on Series I, 4 yr. olds on Series II, but they could do it if presented simultaneously
Salter and Fogarty (1971)	4 yrs 2 mos. to 5 yrs. 11 mos.	visual-geometric	visual-visual haptic-haptic visual-haptic	successive and simultaneous for each of the 3 conditions -pairs (5 sec)	verbal report "same" or "different"	correct # of responses ANOVA Neuman-Keuls	1) easiest to hardest visual-visual, visual-haptic, haptic-haptic 2) significant (.01) difference between conditions 3) Neuman-Keuls: significant difference between visual-visual and haptic-haptic only. 4) no sig. interaction between mode of presentation and modality.	successive presentation not significantly different from simultaneous presentation

conditions and age levels. These researchers attributed the improvement in the cross-modal matching between the visual and haptic systems to an increased ability to differentiate along the haptic system.

This trend would seem to support Birch and Lefford's (1963) and Pick's et al.(1966) argument that haptic and kinesthetic information merely serves to reinforce visual information until the age of 5 - 7 years when the increased ability to differentiate kinesthetic and haptic information causes rapid improvement in the cross-modal integrations involving these systems.

Rudel and Teuber (1964) suggested that while form perception tasks indicate a visual-visual, visual-haptic, haptic-visual, haptic-haptic developmental trend for sensory integration, a task more conducive to haptic differentiation (texture) may yield a different trend. One might extrapolate to suggest that the differentiation of the topography of the body may reflect the reliance on the system responsible for the information coming from the angular displacement of the joints. Presentation of this information is called passive movement, one aspect of the kinesthetic system. As mentioned earlier in this study, the difficulty of extracting tactual information from kinesthetic system for testing purposes has led to the consideration of the tactual-kinesthetic system in the present study.

As was mentioned in the introductory chapter of this study, two studies have been influential in the design of the present investigation. These studies are discussed below.

Berges and Lezine (1965)

This study was based on the tenet that the body is oriented in space by activity before the child knows its component parts or before the child can name these component parts. Moreover, Berges and Lezine (1965) have suggested that the development of motor activity is accomplished in space in relationship to the body.

The development of hand-finger schemata and upper limb schemata in 364 children, 3 to 6 years old, was investigated by using procedures referred to as the imitation of gestures. The gestures were varied in terms of the

(1) spatial organization of the stimulus,

(2) motor organization of the response.

Two levels of task complexity (simple, complex) based on these variables were examined. One condition, the continual presentation of a visual stimulus (E gesture) for a visual-kinesthetic response (S imitation of the gesture) was studied.

While these investigators were directly concerned with developing standardized procedures for the neurological, in particular apraxic, examination of pre-school children, several aspects of this study have been significant in the formulated hypotheses of this investigation. The more complex a gesture, the less accurate was its imitation. Simple gestures were reproduced accurately at age 6 while the complex gestures still presented difficulty at this age level.

Across all age levels, there was an interaction between the spatial organization required and the motor schema required. There was a tendency for children to place reliance on the dominant arm or hand in the gestures which were difficult for them.

Lefford, (1970)

Lefford (1970) studied the development of voluntary actions in 167 children 3 to 5½ years of age. Twelve finger differentiation tasks which were varied with respect to response complexity and integrative conditions were employed. These tasks have been concisely described and numbered for reference, ranging from the easiest to the most difficult task, in Table 3.

Response complexity. Lefford found that tasks requiring finger-thumb opposition and pointing to self responses were significantly easier than the tasks requiring the imitation of finger movements and model indication responses. This may be explained by considering that the imitation of finger movements required a well organized fine motor schema. Furthermore if reversals were involved in these last two response categories (not reported) this is readily understandable. Benton (1968), and Rice (1968) have reported that finger differentiation and right-left detection abilities requiring reversals are difficult even at the level of adult functioning which is reportedly reached around 11 - 12 years of age.

Stimulus presentation. Lefford's study indicated that responses were easiest when information was presented to both the visual and tactual-kinesthetic systems (Table 3). This would seem to support Piaget's (1953) contention that visual information becomes interco-ordinated with other sensory systems very early

Table 3. Description of Finger Differentiation Tasks (Lefford, 1970)

Condition number	Modality in which fingers were indicated to subject	Response required of the subject	Modalities available to guide response
(1)	visual, tactual-kinesthetic	finger-thumb opposition	visual, proprioceptive
(2)	visual, tactual-kinesthetic	pointing to self	visual, proprioceptive
(3)	visual	pointing to self	visual, proprioceptive
(4)	visual	finger-thumb opposition	visual, proprioceptive
(5)	tactual-kinesthetic	finger-thumb opposition	proprioceptive
(6)	tactual-kinesthetic	finger-thumb opposition	visual proprioceptive
(7)	tactual-kinesthetic	pointing to self	visual, proprioceptive
(8)	visual	visual imitation	visual, proprioceptive
(9)	visual, tactual-kinesthetic	pointing to model	visual
(10)	visual	pointing to model	visual
(11)	visual	non-visual imitation	proprioceptive
(12)	tactual-kinesthetic	pointing to model	visual

in the development of the infant, as well as the findings in cross-modal integration research (Table 1, p. 24). Visual presentation was found to be significantly easier than tactual-kinesthetic presentation for the two easiest response conditions (Table 3: (1)-(4)). It is interesting to note that when tactual-kinesthetic information was presented in (5) and (6) (Table 3) the non-visual movement response (5) was easier than the visual movement response (6).

Developmental trends. Lefford found that by 4 years of age over 90% of his subjects could fully differentiate the topography of the hand when perceived by both the visual and tactual-kinesthetic modalities. While no significant difference between tactual-kinesthetic schemata and visual schemata was found at the 4 year old level, Lefford's data indicated that visual schemata may be more advanced in 3 year olds than tactual-kinesthetic schemata.

CHAPTER III

METHODS AND PROCEDURES

The hypotheses of the present investigation were studied by employing four series of body part differentiation tasks.

Task Series I: The sensorimotor differentiation of body parts, as reflected in the subject's ability to make accurate voluntary movements on finger localization tasks.

Task Series II: The sensorimotor differentiation of body parts as reflected in the subject's ability to make accurate voluntary movement reproductions of spatial orientation positions of the hands and fingers.

Task Series III: The differentation of body parts as reflected in the subject's hand preference and foot preference.

Task Series IV: The differentation of body parts as reflected in the subject's ability to

(a) point to the body part verbally indicated by the experimenter, and

(b) give the verbal label of the body part pointed to by the experimenter.

Subjects

The subjects were sixty-four 3 to 6 year old children, 8 girls and 8 boys in each age category. The age categories were delimited to 3 years ± 3 months, 4 years ± 3 months, 5 years ± 3 months, and 6 years ± 3 months. The subjects were drawn from a population of children with play school experience who, at the time of testing, were attending programmes at Sunset Recreation Centre. This Centre, according to census data, is located in a low-middle income socio-economic area. The same 64 subjects participated in the 4 Task Series. Each subject was present for 2 testing sessions subsequently referred to as Day I and Day II. All tasks were administered to the Subject (S) by the Experimenter (E).

Apparatus

The testing sessions were conducted in a room adjoining the Play School Facilities at Sunset Recreation Centre.

Free Play

At the beginning and the end of each S's testing session there was an opportunity for free play. The equipment available for this included cosom hockey sticks and pucks, mats, playground balls, a slide, a tricycle and a wagon.

Task Series I and II

These Task Series were administered in an area of the testing room away from the play equipment.

S was seated at a table 18" in height; E was seated across the table facing S.

A wooden frame 22" x 10" x 5" was placed on the table. A curtain was attached to the front of the frame (S;s view) and was open at the rear (E's view). This apparatus was designed to allow

E to absent visual information from S, on the sensorimotor tasks involving the tactual-kinesthetic system, while permitting E to present stimulus information and to record responses (Appendix A).

The photographs used in Task Series I are shown in Appendix B. The photographs used in Task Series II are shown in Appendix C.

Task Series III

A playground ball 4" in diameter was used to observe S's hand preference and foot preference.

Task Series IV

No equipment was needed for this Task Series.

Experimental Conditions and Procedures

The experimental conditions and procedures are discussed under the headings of Task Series I, Task Series II, Task Series III and Task Series IV.

The specific instructions given to S by E are included in Appendix E.

Table 4. Experimental Conditions in Task Series I and Task Series II

Condition Number	Name of the Condition	Stimulus	Modalities Available for Stimulus Differentiation	Response	Modalities Available for Response
(1)	visual for visual movement	visual indication (photograph)	visual	visual movement	visual, tactual-kinesthetic
(2)	visual for non-visual movement	visual indication (photograph)	visual	non-visual movement	tactual-kinesthetic
(3)	tactual-kinesthetic for visual movement	passive movement on the subject	tactual-kinesthetic	visual movement	visual, tactual-kinesthetic
(4)	tactual-kinesthetic for non visual movement	passive movement on the subject	tactual-kinesthetic	non-visual movement	tactual-kinesthetic

Task Series I

Experimental Conditions

Here S was required to identify the fingers of the right hand and the left hand indicated to S by E. The experimental conditions are described in terms of E's indication (presentation) and S's response.

Presentation. Each of S's 10 fingers were isolated and presented in 2 ways:

(1) visual indication of the isolated finger on the photograph (Appendix B),

(2) passive movement of the isolated finger on S.

Each finger was presented to S for 3 seconds; then S responded (successive presentation for response).

Response. 1 voluntary movement was studied in 2 ways:

(1) lifting movement of the isolated finger with visual cues,

(2) lifting movement of the isolated finger without visual cues.

Table 4 shows how these presentations and responses were incorporated into the 4 experimental conditions.

Experimental Procedures

Each of S's 10 fingers was presented once in each experimental condition.

Presentation. In conditions (1) and (2) (Table 4), E indicated the fingers visually to S by pointing to a finger for 3 seconds on the corresponding photograph of the hand (Appendix B).

During these presentations both photographs were placed on top of the frame apparatus for S's view. In conditions (3) and (4) (Table 4) E indicated the fingers by passively moving S's finger up and down for 3 seconds. S's hands were hidden from S's view underneath the curtain of the frame apparatus. S's hands were kept in a constant prone position with the fingers pointing towards E and pressed down on the table between presentations and responses.

Response. The voluntary movement response studied across all 4 experimental conditions (Table 4) was a lifting action of the isolated finger with the remaining fingers pressed down on the table. The visual voluntary movement responses in conditions (1) and (3) (Table 4) were given with S's hands placed on the frame apparatus for S's view. The non-visual voluntary movement responses in conditions (2) and (4) (Table 4) were given with S's hands underneath the curtain of the frame apparatus; visual information of the hands and fingers was not available for responses.

Method of recording responses. In each of the 4 experimental conditions, 5 responses of the right hand and 5 responses of the left hand were required.

> Correct voluntary movement differentiations of each finger were assigned the numerical value of 1.
>
> Incorrect voluntary movement differentiations of each finger were assigned the numerical value of 0.

The ordinal scale ranged from 0 - 5 for each hand in each experimental condition (Appendix D).

Task Series II

In this Series, S was required to reproduce the spatial orientation positions of the hands and the fingers indicated to S by E. The experimental conditions are described in terms of E's indication (presentation) and S's response.

Experimental Conditions

Presentation. The 6 positions (Appendix C) were individually presented in 2 ways.

(1) visual presentation of the position on a photograph,

(2) passive movement presentation of the position on the subject.

Each position was presented for 3 seconds; S then responded (successive presentation for response).

Response. S's voluntary movement reproductions of the positions presented were studied in 2 ways.

(1) movement reproduction of the position with visual cues,

(2) movement reproduction of the position without visual cues.

Table 4 shows how these presentations and responses were incorporated in the 4 experimental conditions.

Experimental Procedures

Each of the 6 positions (Appendix C) was presented once in each experimental condition.

Presentation. In conditions (1) and (2) (Table 4) E presented the position photographs on top of the frame apparatus for 3 seconds. In conditions (3) and (4) E presented the positions to S by passively moving S's hands and fingers to the position required. This position was held for 3 seconds. S's hands were hidden underneath the frame apparatus in conditions (3) and (4) to absent visual information about the hands and fingers. S's hands were kept in a constant prone position with S's fingers pointing towards E, between presentations and responses.

Response. The voluntary movement response studied across all 4 experimental conditions was S's final position accuracy in the reproduction of the position indicated to S by E. In conditions (1) and (3) (Table 4) the movement reproductions were given with S's hands on top of the frame apparatus for S's view. In condition (2) and (4) (Table 4), the movement reproductions were given with the subject's hands underneath the frame apparatus so that visual information of the hands and fingers was not available for the response.

Method of recording responses. In each of the 4 experimental conditions, 6 positions which involved positioning both the right hand and the left hand were presented.

> Correct voluntary movement differentiations of each hand in each position were assigned the numerical value of 1.
>
> Incorrect voluntary movement differentiations of each hand in each position were assigned the numerical value of 0.

The ordinal scale ranged from 0 - 6 for each hand in each experimental condition. In addition to this ordinal data, observations of the development of the voluntary movement differentiations of the dominant hand and the non-dominant hand with respect to each position were recorded (Appendix D).

Task Series III

Experimental Procedures

Task Series III was not included in the experimental design and may be best described in terms of the procedures employed.

Hand preference. S was asked to throw a ball with one hand. There were 4 trials on Day I and 4 trials on Day II.

Foot preference. S was asked to kick a ball. There were 4 trials on Day I and 4 trials on Day II.

Method of recording responses. The number of right hand and right foot responses and the number of left hand and left foot responses on each trial series was recorded (Appendix D).

Task Series IV

Experimental Procedures

Task Series IV was not included in the experimental design and may be best described in terms of the procedures used.

Verbal presentation. E indicated verbally a body part (right eye) and S was required to point to the body part on himself. There were 3 trials on Day I and 3 trials on Day II (right eye, left foot, right hand).

Verbal response. E indicated a body part by pointing to it on S. S was then required to give the verbal labels of this body part (left eye, right foot, left hand). There were 3 trials on Day I and 3 trials on Day II.

Method of recording responses. The number of correct body part differentiations and the number of correct right-left differentiations on each trial series were recorded (Appendix D).

Experimental Design

The experimental design for Task Series I and Task Series II was a 4 x 2 x 2 x 2 x 4 factorial with repeated measures on the last 3 factors. A Latin Square was used to counterbalance the 4 experimental conditions and the 2 orders of stimulus presentations of each Task Series (Appendix D). The factors and levels were:

Factor I: Age

A1: 3 years
A2: 4 years
A3: 5 years
A4: 6 years

Factor II: Sex (Age)

G1: boys
G2: girls

Factor III: Task Series

I1: Task Series I
I2: Task Series II

Factor IV: Dominance

D1: Dominant Hand
D2: Non-dominant Hand

Factor V: Conditions

C1: Visual presentation for visual movement response

C2: Visual presentation for non-visual movement response
C3: Tactual-kinesthetic presentation for visual movement response
C4: Tactual-kinesthetic presentation for non-visual movement response.

Data Analyses

The data from Task Series I and Task Series II was submitted to the following statistical analysis.

Bivariate Frequency Analysis

The dependent measure for the bivariate frequency analysis of Task Series I was the score on an ordinal scale of (0-5); for Task Series II it was the score on an ordinal scale of (0-6). These analyses were conducted to determine the frequency distributions of scores for each age level on each of the 4 experimental conditions of Task Series I and Task Series II.

Analysis of Variance

The dependent measures on Task Series II were multiplied by 5/6, thus giving a scale of 0.5. This permitted comparisons between the mean scores of Task Series I and Task Series II in the 4 x 2 x 2 x 2 x 4 parametric ANOVA with repeated measures on the last 3 factors.

A parametric ANOVA was used as non-parametric statistical tools for analyzing factorial designs with repeated measures were not available.

While non-parametric statistical tests have been said to be more appropriate for data collected on an ordinal or ranking scale of measurement, the case in the present study, Brumback (1969) has argued that the legitimacy of a statistical test in the evaluation of collected data does not depend upon the measurement scale used, but, rather upon the distribution of scale values. Reference to the frequency distribution tables in Appendix F, reveals that while there appeared to be a ceiling effect on the 6 year olds Task Series I and Task Series II scores and, to a lesser degree, on the 5 year olds Task Series I scores, the remaining bivariate categories showed relatively normal distributions. The presence of a ceiling effect does, however, reduce intra-cell variability and therefore decreases the denominator in the F ratio. Thus, any statistical significance has to be interpreted cautiously.

Methods for Testing the Hypotheses

The hypotheses of this investigation are to be tested by the following methods.

Hypothesis 1, p. 6

In order to accept this hypothesis it must initially be shown, as indicated by Berges and Lezine (1965), that the mean scores on Task Series III (preference differentiation) and on Task Series IV (language differentiation) do not reflect continual development at each age level in the 3 to 6 year old age range studied. To test this, the percentage of subjects at each age level who obtained maximum scores on Task Series III and Task Series IV are to be examined.

Further, in order to accept hypothesis 1, an F test must reveal that the difference between the mean scores for the Age main effect is significant while the F ratio for the Sex (Age) main effect is not significant.

<u>Hypothesis 2, p. 7</u>

In order to accept hypothesis 2 it must be established that sensorimotor differentiation abilities are affected by both the input and output aspects of the differentiation task. To test this, the mean scores for the Age x Task Series interaction are to be, initially, considered in terms of the relative differences in the input and output aspects required for the neuromuscular responses of each Task Series. The input aspects of sensorimotor differentiation can, then, be discussed in terms of the Age x Task Series x Conditions interaction, while the Age x Task Series x Dominance interaction can be used to discuss the output aspects of sensorimotor differentiation.

If the above interactions are shown to be statistically significant and can be meaningfully interpreted, this would indicate that the output aspects of sensorimotor differentiation as well as the input aspects of sensorimotor differentiation are the determinants of 3 to 6 year old performance on the tasks studied. Thus, under these findings hypothesis 2 could be accepted.

<u>Hypothesis 3, p. 7</u>

To test for the effects of input in terms of sensory presentation at two levels, tactual-kinesthetic and visual, on sensorimotor differentiation abilities at each age level the mean scores for the Age x Conditions interaction are to be examined. If this interaction is shown to be statistically significant and the differences between the mean scores for conditions can be interpreted in terms of the trend for visual (conditions 1 and 2) mean scores being higher than the trend for tactual-kinesthetic mean scores (condition 3 and condition 4) across the age levels studied, hypothesis 3 can be accepted. This hypothesis can be further discussed in terms of a significant Age x Task Series x Conditions interaction, if this is obtained in the analyses.

<u>Hypothesis 4, p. 7</u>

To test for the effects of intramodal integration and intermodal integration on sensorimotor differentiation abilities at each age level, the mean scores for the Age x Conditions interaction are to be examined. If this interaction is shown to be statistically significant and can be interpreted in terms of the trend for intramodal integration (conditions 1 and 4) being higher than the trend for intermodal integration (conditions 2 and 3) across the age levels studied, then hypothesis 4 can be accepted. This hypothesis can be further interpreted in terms of the Age x Task Series x Conditions interaction if this is shown to be statistically significant.

<u>Hypothesis 5, p. 7</u>

To test for the effects of dominance on sensorimotor differentiation, the mean scores for the dominant hand and the non-dominant hand at each age level in the Age x Dominance interaction are to be considered. If this interaction is shown to be statistically significant and can be interpreted in terms of the trend for the dominant hand scores being higher than the trend for the non-dominant hand scores across the age levels studied, hypothesis 5 can be accepted. If the Age x Task Series x Dominance interaction is significant, hypothesis 5 may be discussed further.

CHAPTER IV

RESULTS AND DISCUSSION

The findings of the investigation indicate that there is a significant development in the body schema, as defined and studied, in 3 to 6 year old children.

The major findings of the data submitted to statistical analyses are presented in terms of the hypotheses that were formulated. Before these findings are presented the observations that were made during the actual testing sessions, and that were considered pertinent to the neurological development of 3 to 6 year old children will be outlined.

Observations

The ability of children to attend to presented information appeared to improve as a function of chronological age. The majority of 3 year old children tested found it difficult to be attentive for more than one experimental condition of both Task Series I and Task Series II. As a result, free play periods were introducted between experimental conditions when the child was noticeably distracted. By 6 years of age, the majority of children could complete the 4 experimental conditions of Task Series I or Task Series II without displaying the outward signs of inattentiveness.

Closely associated with the above observations was the length of time children took to initiate their response in Task Series I and to position their hands in Task Series II. This response time was observed to decrease over the ages studied, becoming immediate at the 6 year old level.

The development of gross motor co-ordination showed advances over the 3 to 6 year old age levels. At 3 years of age, hitting the puck from a stationary position seemed to be a continuous trial and error process. It appeared that the difficulty in this task was attributable to the motor aspects of directing the stick to the puck, as the children seemed to fixate on the puck. By 6 years of age, hitting the puck from a stationary position did not appear to be a difficult task, but the same task from a moving position seemed more complex as the children displayed difficulty in judging distances and timing.

Results and Discussion of the Hypotheses

The statistical results are presented under the 5 hypotheses of this study. The dependent measures that were calculated were: in Task Series I the score obtained on an ordinal scale of 0-5, in Task Series II the score obtained on an ordinal scale of 0-6, and in Task Series III and IV the number of correct responses. The data of Task Series I and Task Series II was submitted to bivariate frequency analysis and variance analysis. The data on Task Series II was transformed to an ordinal scale of 0-5 for the analysis of variance. The bivariate frequency distributions for

Task Series I and Task Series II are shown in Appendix F. These distributions showed that the scores obtained by the subjects shifted over the age levels studied. There was a ceiling effect on the scores in Task Series I for 5 year olds and 6 year olds and in Task Series II for 6 year olds. The ANOVA table is shown in Appendix G.

Hypothesis 1

It was hypothesized that:

> The major development in the differentiation of body parts is at the sensorimotor level as opposed to the preference level and the language level, in 3 to 6 year old children. The age of the child, not the sex of the child, is the determining factor in this development.

To test this hypothesis the data obtained in Task Series III and Task Series IV was considered. Table 5 shows the percentage of children, at each age level, who continually used the same hand to throw a ball on 8 trials and the same foot to kick a ball on 8 trials. The data collected indicates that the major development in preference differentiation occurs prior to age 3 years. While this supports the findings of Berges and Lezine (1965) that dominance can be extracted even at the 3 year old level, it does not support a body of research which suggests the dominance is usually not established until age 5 years in the typical child (Benton, 1962; Kephart, 1960). The methods employed in the present study may have confounded the findings indicated. The data in Table 5 does suggest, however, that the organization required for preference differentiation did not continually improve at each age level studied.

Table 5. Age Percentages for Hand Preference and Foot Preference

Age	Hand Preference	Foot Preference
3 years	93.75%	100.00%
4 years	100.00%	100.00%
5 years	100.00%	100.00%
6 years	100.00%	100.00%

Table 6 shows the percentage of children, at each age level who, on tasks requiring either a verbal response to indication of the body part on the subject, or an indication response on self to verbal commands, correctly identified the eye, hand, and foot on 12 trials and the right and left aspects of these body parts on 12 trials. The data in Table 10 presumably indicates that the understanding of the verbal labels, eye, hand, foot, was established by 3 years of age. Significant developments in the understanding of the verbal labels, right and left, was not clearly apparent until 6 years of age. Thus, the language differentiation tasks studied did not show continued improvement at each age level.

It would seem reasonable, then, to examine the Task Series requiring sensorimotor differentiation in an attempt to determine if the developmental significance of body part differentiation lies at this level of neurological organization.

Table 6. Age Percentages for the Language Differentiation of Body Parts, Right/Left

Age	Body Parts	Right/Left
3 years	100.00%	0.00%
4 years	100.00%	0.00%
5 years	100.00%	6.25%
6 years	100.00%	75.00%

The effects of Age on sensorimotor differentiation, did, as shown in Table 7, reflect continual improvement at each age level studied. An F test revealed that the differences between the mean scores for Ages in Table 7 were significant, thus, the Age main effect was significant ($F = 269.40$, $p < .01$). The Sex (Age) main effect was not statistically significant ($F = .031$, $p < .05$). Further interactions of Sex (Age) were also non-significant. Hypothesis 1 can be accepted; there was a significant difference in the mean scores for age levels but the performance at each age level was not affected by the sex of the child.

Table 7. Mean Scores for the Age and Sex (Age) Main Effects

Age	Boys and Girls	Boys	Girls
3	1.8	1.8	1.7
4	3.3	3.3	3.2
5	2.9	3.8	3.9
6	4.4	4.4	4.5

The remaining hypotheses are concerned with the nature of this developmental trend for sensorimotor differentiation.

Hypothesis 2

> The ability to make voluntary movement differentiations is dependent upon the sensorimotor aspects, not only the sensory aspects of the task.

To test this hypothesis the mean scores for the Age x Task Series interaction were considered to determine if the output aspects of the sensorimotor differentiation tasks studied as well as the input aspects of the sensorimotor differentiation tasks studied affected performance scores at each age level. Before discussing these findings, it should be clarified that the output requirements of Task Series I appeared to require a more precise neuromuscular co-ordination than did the output requirements for Task Series II. The input requirements for Task Series II, alternatively, appeared to require a more comprehensive spatial organization than did the input requirements of Task Series I.

The mean scores for the Age x Task Series interaction are shown in Table 8. An F test revealed that the difference between these mean scores was significant. While the mean scores continually improved as a function of increases in chronological age in both Task Series I and Task Series II; Table 8 shows that the differences between the mean scores for both Task Series, at each age level were not always in the same direction.

Table 8. Mean Scores for the Age x Task Series Interaction

Age	Task Series I	Task Series II
3 years	1.5	2.0
4 years	3.3	3.3
5 years	4.3	3.9
6 years	4.6	4.4

The mean scores for the Age x Task Series interaction, then, suggest that the input and output variables of sensorimotor differentiation do not affect performance consistently at each age level studied. While the Task Series I function appeared to be steeper than the Task Series II function (Figure 1) suggesting that the motor organization required for Task Series I progressed more rapidly during 3 to 6 years of age than did the spatial organization required for Task Series II, the design of these sensorimotor tasks does not permit the conclusion that the output aspects of sensorimotor differentiation are the most important factors in the performance scores of 3 to 6 year olds. Similarly, while performance scores under tactual-kinesthetic presentations were higher than performance scores under visual presentations, these input factors can not be considered the most important aspect of the sensorimotor differentiations as the ability to organize the sensory information presented was inter-related with the output variables required for movement differentiation on each Task Series.

At 3 years of age, the mean score for Task Series II was higher than the mean score for Task Series I (Figure 1). The motor organization variable, then, appeared to be the determining factor in performance at this age level.

The majority of children could differentiate the fingers more accurately if they used a pointing response, as opposed to the isolated finger action required. Although this pointing response to the finger indicated was not studied in this investigation, it was a more automatic response at each age level studied. The use of this pointing response indicated that the children could discriminate between the fingers before they could use them for the movement differentiation required on Task Series I. The findings illustrated in Figure 1, then, presumably indicate that the motor organization required for Task Series I was only minimally developed at 3 years of age. By 4 years of age, the mean score for Task Series I closely approximated the mean score for Task Series II (Figure 3). This would seem to suggest that the motor organization required for Task Series I had progressed to the point where the simple level of motor or output organization required for Task Series II was not the determining factor in Task Series comparisons, and both the input and output aspects were the determinants of sensorimotor differentiations. By 5 years of age the ability to organize the input and the output aspects of Task Series I seems to have progressed to the point where a ceiling effect was place on the mean scores. Similar findings were observed on Task Series II at the 6 year old level, but, only on the conditions requiring tactual-kinesthetic organization of the information presented.

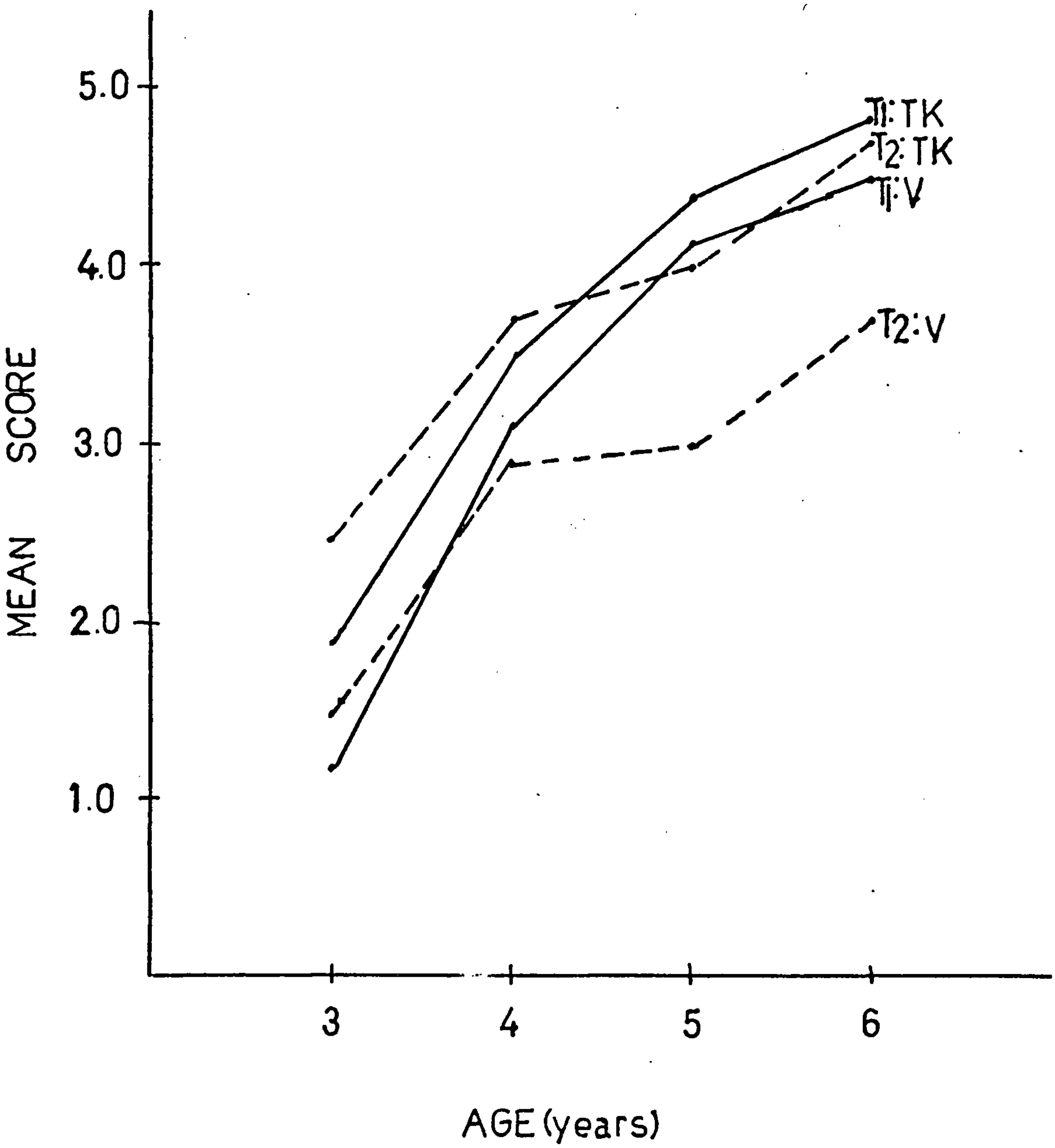


Figure 1. Mean Scores for Tactual-Kinesthetic Presentations and Visual Presentations on Task Series by Age.

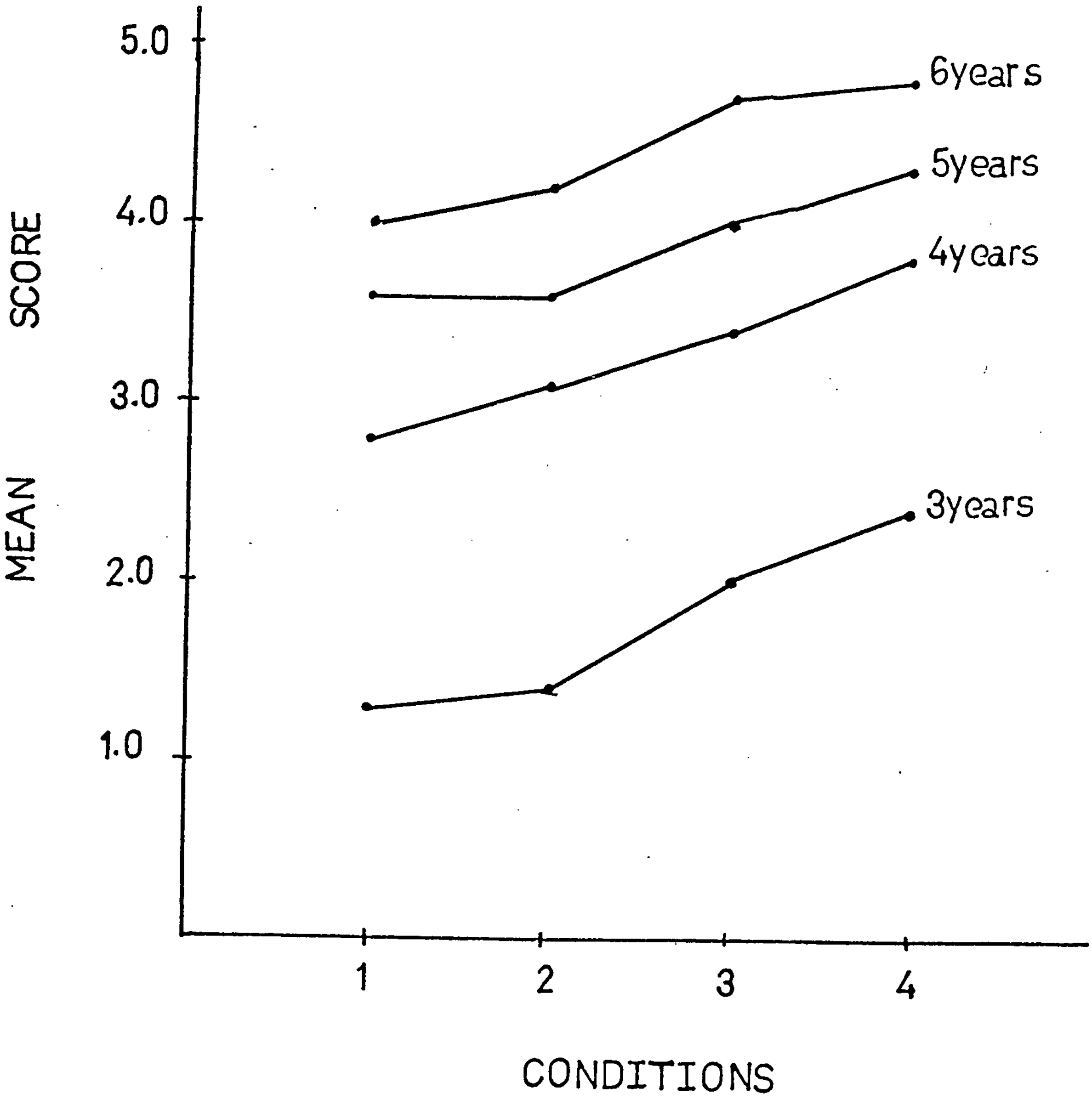


Figure 2. Mean Scores for the Age X Conditions Interaction.

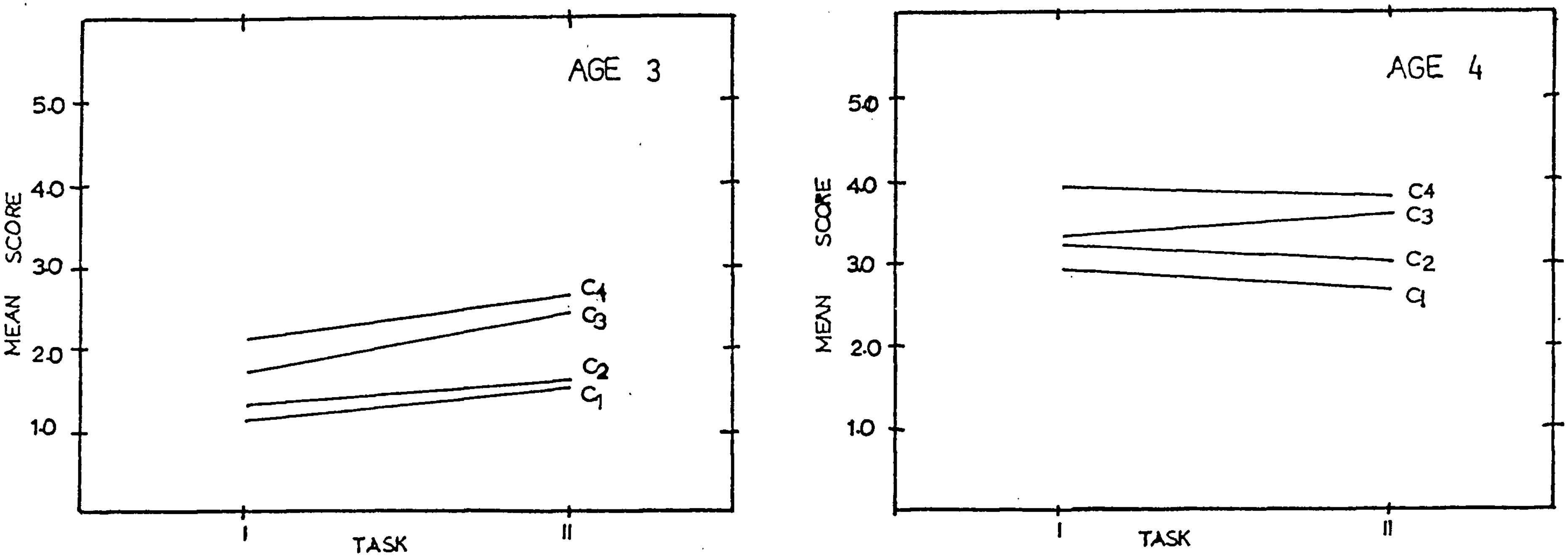
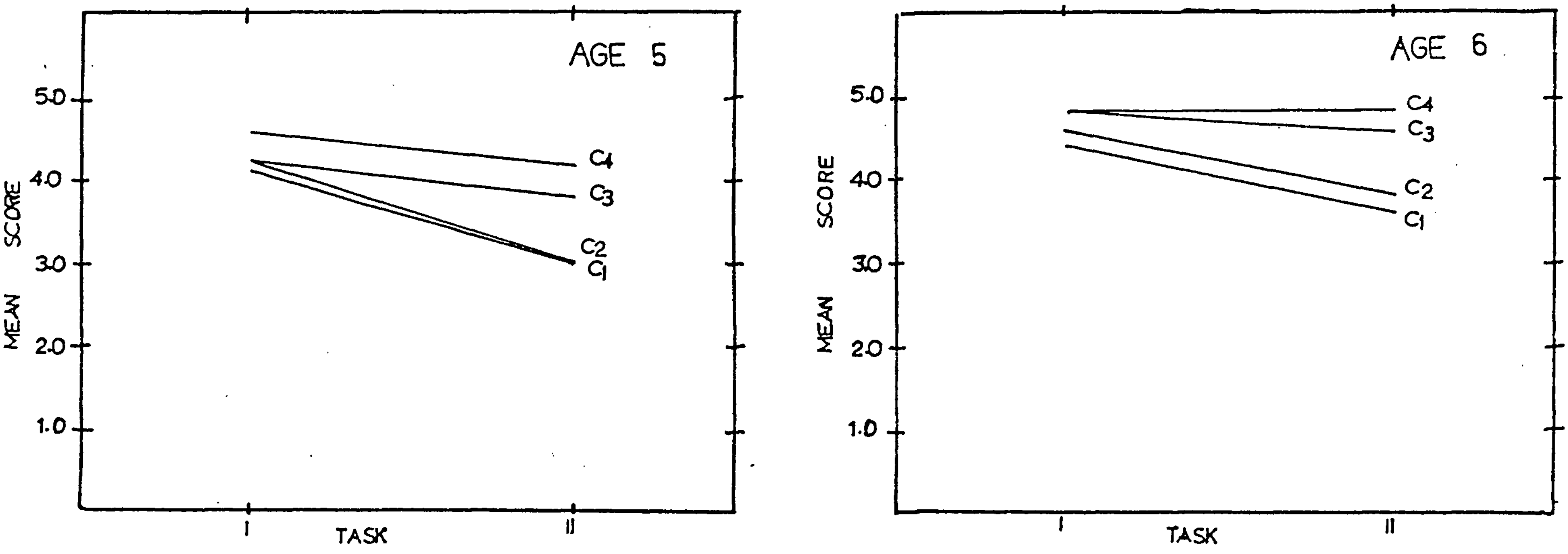


Figure 3. Mean Scores for the Age X Tasks X Conditions Interaction.



It does seem, then, that at each age level both the input and the output aspects of the sensorimotor differentiation tasks studied were the determinants of performance. Hypothesis 2, was supported.

Hypothesis 3

> The ability to make voluntary movement differentiations requiring visual organization precedes the ability to make voluntary movement differentiations requiring tactual-kinesthetic organization.

The mean scores for the Age x Condition interaction are shown in Table 9. While an F test revealed that the difference betweem these mean scores was significant, the graphic analysis in Figure 3 indicates that this statistical finding was not meaningful. The same trend for conditions was found at each age level. Ranging from the easiest condition to the hardest condition, this trend was

condition 4: tactual-kinesthetic presentation for non-visual movement response

condition 3: tactual-kinesthetic presentation for visual movement response

condition 2: visual presentation for non-visual movement response

condition 1: visual presentation for visual movement response.

Hypothesis 3 was, thus, refuted. The difference between mean scores for the significant Conditions main effect ($F = 185.56$), $p < .01$) appears to be attributable to the difference between tactual-kinesthetic presentations and visual presentations (Table 7).

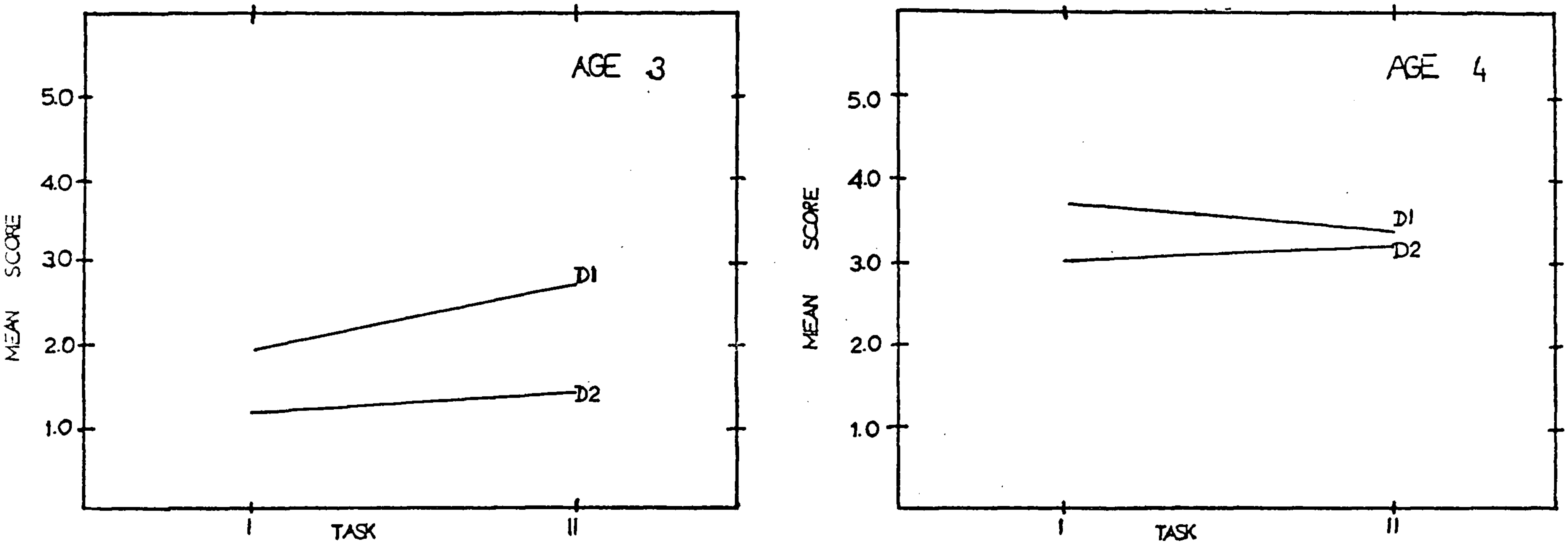


Figure 4. Mean Scores for the Age X Task Series X Dominance Interaction
(D1 = Dominant; D2 = Non-Dominant)

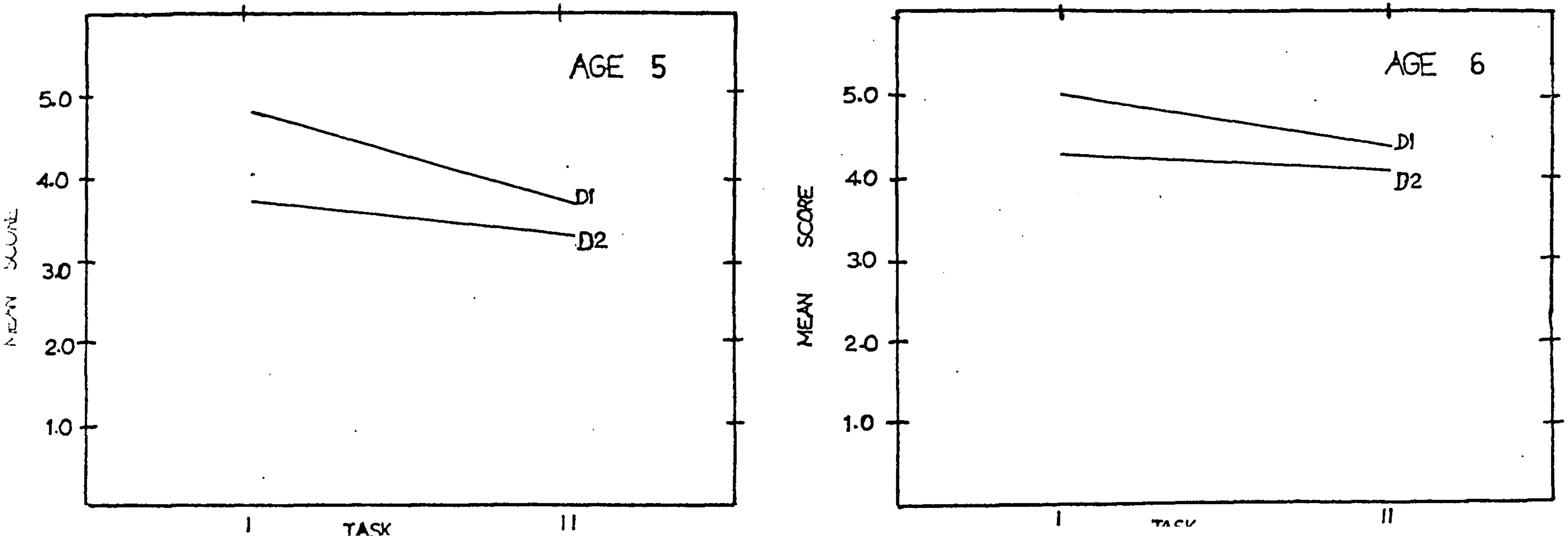


Table 9. Mean Scores for the Age x Conditions Interaction

Age	Visual -- Visual Movement	Visual-- Non-visual Movement	Tactual-kinesthetic -- visual movement	Tactual-kinesthetic -- Non-visual movement
3 years	1.3	1.4	2.1	2.4
4 years	2.8	3.1	3.4	3.8
5 years	3.6	3.6	4.0	4.4
6 years	4.0	4.1	4.7	4.8
	11.7	12.2	14.2	15.4

<u>Hypothesis 4</u>

It was hypothesized that

(4) The ability to make voluntary movement differentiations on tasks requiring intra-modal integration develops in advance of the ability to make voluntary movement differentiations on the tasks requiring inter-modal integration.

At the time when this hypothesis was formulated, the investigator interpreted the visual presentation for visual movement response (condition 1) to be an intra-modal condition. This was an incorrect assumption. Previous integrative processing studies had described this type of condition as intra-modal (Bryant, 1968; Lefford, 1970) but the movement response employed seem to require minimal motor organization (pointing on self) in comparison to the actions studied in this investigation. The research in integrative processing had revealed that visual intra-modal integration develops in advance of inter-modal processing involving visual information in the response or in the presentation and intra-modal haptic and kinesthetic processing (Balter and Fogarty, 1971; Birch and Lefford, 1963; Lefford, 1970; Rudel and Teuber, 1964). One would expect, then, that Task Series II which required a lesser degree of motor organization for the response relative to Task Series I would reflect the reported reliance on visual information for visual movement response at the 3 year old level in particular (Lefford, 1970). This was not shown (Figure 1).

It was concluded, then, that the only intra-modal condition in the experimental design of this study was condition 4, the tactual-kinesthetic presentation (passive movement without visual cues) for non-visual movement (active movement without visual cues). The mean scores for this condition were higher than the remaining mean scores for conditions on both Task Series and at each age level studied. Hypothesis 4 if revised to read 'intra-modal task' and not 'intra-modal tasks' was supported.

During the actual testing sessions, it was observed that the availability of visual information for response (conditions 1 and 3) often confused the children. While the modality through which information regarding the hands and fingers is obtained appears to be the significant aspect of the conditions employed in this study, the slight differences between the mean scores of conditions 1 and 2 and between the mean scores of conditions 3 and 4 should not be totally discounted. The data does seem to support however, Rudel's and Teuber's (1964) suggestion that the developmental trends for integrative processing may be dependent upon the modality which most readily permits differentiation on the task employed (visual for object form differentiation, haptic for texture differentiation, tactual-kinesthetic for body part differentiation).

Hypothesis 5

It was hypothesized that:

(5) The ability to make voluntary movement differentiations along the dominant side of the body precedes the ability to make voluntary movement differentiations along the non-dominant side of the body.

An F test revealed a significant Dominant main effect ($F = 199.06$, $p < .01$) further interactions with Dominance were also significant (Appendix G). The mean scores for the Age x Dominance interaction are shown in Table 10.

Table 10. Mean Scores for the Age x Dominance Interaction

Age	Dominant Hand	Non-Dominant Hand
3 years	2.3	1.3
4 years	3.5	3.0
5 years	4.2	3.5
6 years	4.7	4.2

Table 10 shows that dominant hand mean scores were higher than non-dominant hand mean scores at each age level studied. It was further determined in the significant Age x Task Series x Dominance interaction ($F = 4.58$, $p < .01$) that this trend applied to both Task Series (Figure 4). One would expect that the difference between these mean scores would be more noticeable on Task Series I which required a complex motor organization in comparison to Task Series II. This result was obtained at the 4, 5 and 6 year old levels but not at the 3 year old level. The consideration of the positions used in Task Series II and the way in which the children reproduced these positions may clarify this apparent inconsistency. All 6 positions presented involved both the right hand and the left hand. The majority of 3 year old children approached their position reproductions by leading with the dominant hand. They would position this hand and then try to determine the relationship of the non-dominant hand. If the dominant hand was placed in the correct position it was recorded as a correct differentiation and assigned (1). By 4 years of age, this approach to the reproduction of the position showed a more comprehensive interpretation of the gestalt of the 2 hands in orientation as they were moved together. It was not as readily observable whether the incorrect positionings were attributable to the dominant or the non-dominant hand. As a result, the differences between these variables on Task Series II were not as noticeable as on Task Series I. There was, however a reliance on the dominant hand in the crossover positions (2 and 3), as, until 6 years of age the dominant hand was with few exceptions, positioned on top of the non-dominant hand regardless of the actual position presented.

The findings, then, presumably qualify the manner in which motor organization proceeds. Hypothesis 5 was supported; and seems to support the findings of Task Series III that dominance effects can be extracted as early as 3 years of age.

The data of this investigation suggests that developmental significance of an organized model of the body lies in the sensorimotor development of the 3 to 6 year old child.

General Discussion

The findings of this investigation seem to indicate that the relevance of body part differentiation to the neurological and cognitive development of the 3 to 6 year old child lies in the organization of sensorimotor functions.

Body Schema

The findings of this study are in agreement with the view adopted by Berges and Lezine (1965); if the development of the body schema is studied by observing the motor utilization of this subconscious,physiological model, the perceptual-motor factors of the pre-school child's development predominate over the perceptual factors considered essential to this synthesized schema formulated by Head (1920). While the topography of the hands and fingers appeared to be more readily differentiated when perceived by the tactual-kinesthetic system than by the visual system; this perceptual aspect was inter-related with motor organization on both Task Series and at each age level (Figures 1 and 2).

The findings of this study related to higher mean scores for tactual-kinesthetic presentations in comparison to visual presentations do seem to support, however, Konorski's (1967) contention that information coming from the angular displacement of the joints (position information, in this study presented through passive movement or the tactual-kinesthetic system in the absence of visual information) is the predominant sensory system in body schema acquisition.

In view of Head's (1920) tenet that hand-finger schemata may be used as an excellent indication of the development of the total body schema, the findings of this investigation indicate that the development of the body schema stabilizes around 5 to 6 years of age. The tactual-kinesthetic organization of the body, apparently, stabilizing before the visual organization of the body (Figure 2).

Psychological Considerations

Piaget (1954) has attributed the significance of body awareness to the development of spatial schemata at the pre-operational stage of logical thought development (approximately 2 to 7 years). Furthermore, Piaget (1953) has suggested that the notion of space, at this level, is predominantly tied to sensori-motor schemata. It would seem, in light of the present investigation, that the use of the neurological term, body schema as a synthesis of body schemata (hand-finger schemata) is an appropriate, more operational definition of body awareness.

Piaget (1954) has also emphasized the importance of differentiated motor activity for the development of an understanding of space. The findings of this investigation (Figure 1; hypothesis 2), discussed in the previous section would seem to support this contention.

Within Piaget's (1954) theoretical framework for the development of spatial comprehension, laterality or the internal understanding of the right and left co-ordinates of the body is the first notion of space said to develop. Kephart (1960) has suggested that laterality is established in the typical child by formal school age. It would seem, then, that these psychologists have used the term laterality to refer to the understanding of right and left at the sensorimotor level of neurological organization, as the findings of this investigation indicate that sensorimotor functions, pertaining to the body, stabilize around 5 to 6 years of age (Figure 3, Appendix F).

Kephart (1960) suggested that in the projection of laterality, termed directionality, form and distance are the most important aspects in learning to read. In addition to the establishment of laterality and directionality, Kephart (1960) and Radler and Kephart (1960) have contended that the establishment of visual-motor integration is necessary for learning to read. According to Radler and Kephart (1960), the corollary of this also holds; if a child displays reading difficulty he should be given training in these skills. Now, in the present study it was indicated that the sensorimotor organization of body part differentiation is not the same as the sensorimotor organization required for form perception (Balter and Fogarty, 1971; Birch and Lefford, 1963;

Rudel and Teuber, 1964). It may be argued, then, that if a child displays reading difficulty the nature of this difficulty should be initially established. If the problem lies in sensorimotor organization, the specific organizational difficulty should be identified to ensure that the remedial training is appropriate to developing the sensorimotor abilities required.

Neurological Considerations

In view of this investigation, it would seem that Geschwind's (1965) proposal, cited by Butters and Brody (1968), referring to the left parietal-occipital region as the mediator for cross-modal integrations may explain the relationships between the spatial disorders, including body image disturbance, associated with cerebral lesions in the left parietal lobe.

If the cerebral area responsible for inter-modal integration is damaged it would seem to follow that behaviors requiring this ability would be affected detrimentally. Moreover, if the procedures used to measure these abilities are closely approximated in terms of specific integrative demands required it would seem that recorded performances would be necessarily similar. The neuropathological conditions disoussed in Chapter II all required spatial organization of a visual-motor nature (excluding some measurements of aphasia); it does not seem unusual, then, that positive relationships between these disorders have frequently been reported. It may be deduced that the dissimilar reports of associated relationships may be attributable to the inherent differences in the functional measures of these behaviors employed by various researchers. A similar argument could be used to explain the conflicting findings reported for reading disability correlates (Chalfant and Schefflin, 1969).

Integrative Processing Considerations

The sensory integration studies in form perception (Balter and Fogarty, 1971; Birch and Lefford, 1963; and Rudel and Teuber, 1964) have investigated the ability of pre-school children to treat stimuli presented to one modality or to two modalities as the 'same' or 'different'. It has been discussed elsewhere in this chapter that the developmental trend reported for these studies is different from the developmental trend indicated in this study. This distinction is elaborated below.

The findings of these form perception studies have indicated that initially reliance is placed on the visual system, irrespective of the intra-modal (minimal motor response required) or the inter-modal aspects of the task. Not until 5 to 7 years of age was an equivalence between the visual system and the kinesthetic system (Birch and Lefford, 1963) or between the visual system and the haptic system (Balter and Fogarty, 1971; Rudel and Teuber, 1964) reported. While these investigators have referred to an equivalence between these systems, it may be as was the case in the present study, that the design of the sensorimotor tasks placed a ceiling effect on the performance scores of 5 and 6 year old children.

In this study, reliance seemed to be placed on the tactual-kinesthetic system as opposed to the visual system. The findings of the present investigation, then, seem to be in agreement with Konorski's (1967) contention that position information (tactual-kinesthetic presentations) is the predominant sensory system in the acquisition of the body schema.

The results of this investigation will now be discussed in terms of Lefford's (1970) study which concommitantly examined the development of 4 voluntary actions in 3 to 5½ year old children with the development of the sensory aspects of the hand-finger schemata.

By 4 years of age, Lefford suggested that the topography of the hands and fingers was equally differentiated when perceived visually or tactually-kinesthetically. This may have been attributable to the ceiling effect on performance as revealed in the present study.

Lefford also suggested that the visual hand-finger schemata appeared to be more advanced at the 3 year old level, than the tactual-kinesthetic schemata. This was not indicated in the present study and may be partially explained by considering that Lefford's tactual-kinesthetic presentations were described as heavy touch outside of the field of vision while the presentations in this study were passive movements without visual information available. Perhaps, the information conveyed by these two distinguishable tactual-kinesthetic presentations was of a different nature.

Lefford further suggested that his findings indicated that the sensory systems are initially unrelated and become interco-ordinated with the development of the child. The findings of this study support Lefford's reasoning; and presumably indicate the importance of neurological organization to the psychological development of the child with which Lefford (1970) was concerned. Lefford interpreted these sensory integration findings in terms of the development of motor responses:

> .....it must be evident that when the execution of a movement or an action depends on the translation of information from one sensory modality to another, the action cannot be effected until an equivalence between the schemata in the different sensory domains is established.
>
> Lefford (1970)

In view of the findings in this study, it seems that Lefford was suggesting that voluntary movement differentiations inherently require an understanding of the tactual-kinesthetic topography of the body. Until an equivalence is approached between the visual organization and the tactual-kinesthetic organization of the body required for the voluntary movement response required, actions requiring interco-ordination, between these two organizational systems will not be effective. Thus, it seems that the development of voluntary movements during the pre-school years must be studied concommitantly with the sensory organization of the topography of the body required.

CHAPTER V

SUMMARY AND CONCLUSIONS

This developmental study attempted to distinguish between the preference differentiation, sensorimotor differentiation, and language differentiation of body parts by 3 to 6 year old children. The development of the body schema defined as the neurological model of the sensorimotor aspects of body parts was emphasized.

Summary

Head (1920) originally formulated the term body schema and conceived this phenomenon to be a synthesis of the sensory afferents pertaining to the body. Berges and Lezine (1965) have suggested that the significance of this subconscious model lies in its use. The findings of this investigation indicate that Berges' and Lezine's (1965) approach may dissipate the confusion in the interdisciplinary research concerned with the relevance of this organized model of the body in the development of preschool children.

Experimental conditions and procedures

Four Task Series were administered; Task Series I was sensorimotor finger localization; Task Series II was sensorimotor hand-finger orientation; Task Series III was hand preference and foot preference; Task Series IV was the verbal understanding of body parts with respect to the right and left co-ordinates of the body.

Four different experimental conditions that involved visual presentations and tactual-kinesthetic presentations for visual movement response and non-visual movement response were used in Task Series I and Task Series II. The movement response studied in Task Series I was the isolated movement of the one finger presented; the movement response studied in Task Series II was the placement of the hands and fingers in the orientation position presented. Task Series I required a more complex motor schema than did Task II, while Task II required a more complex spatial schema than did Task I. In each experimental condition of Task Series I, the 5 fingers of each hand were presented for differentiation. The dependent measures studied was the score on an ordinal scale of 0 -5. In Task Series II, 6 hand-finger orientation positions involving both hands were presented in each experimental condition. The dependent measure studied was the score on an ordinal scale of 0 - 5.

Task Series III involved 4 trials of throwing a ball with one hand (hand preference) and 4 trials of kicking a ball (foot preference). This Task Series was administered twice and no intra-individual variability was obtained.

Task Series IV required the identification of the eye, hand and foot with respect to the left and right co-ordinates of the body on 6 trials. These trials involved S's verbal response to the body part indicated by E on S (3 trials); and S's indication of the body part on self to the verbal instructions given by E to S (3 trials). This Task Series was administered twice; until 6 years of age intra-individual variability in the Day I and Day II performance was high. This presumably indicates the verbal instructions requiring a comprehension of right and left was an invalid procedure for testing body part differentiations of 3 to 5 year old children.

Subjects. Sixty-four 3 to 6 year old children, 8 boys and 8 girls in each category, participated as subjects in this study.

Experimental analyses. The data of Task Series III and IV was discussed in terms of the percentage of children at each age level completing the tasks in a manner that would indicate that the ability tested was established.

The data of Task Series I and Task Series II was submitted to bivariate frequency analyses and a 4 x 2 x 2 x 2 x 4 parametric ANOVA with repeated measures on the last 3 factors. To analyze the differences between mean scores the scores for Task Series II were transformed to the 0-5 ordinal scale used in Task Series I. The statistical significance shown in this parametric statistical test was interpreted cautiously with the use of graphic analyses.

Experimental findings. It was determined that the major development in the preference organization required for Task Series III occurred prior to 3 years of age. There was a significant development in the performance scores on Task Series IV observed at 6 years of age, presumably indicating that the language organization required for this Task Series improved rapidly between

5 and 6 years of age. The major developments observed in this study were on the sensorimotor tasks.

The analysis of variance revealed that the Age, Task Series, Conditions, and Dominance main effects and first order interactions were significant. The significant Age X Conditions interaction was not meaningful as the same trend for conditions was observed at each age level. The Sex (Age) main effect was not significant and further interactions with this variable were also non-significant.

The increase in Task I mean scores was more rapid across 3 to 6 years than the increase in Task II mean scores. This presumably indicates that the motor organization improved more than the spatial organization required for the hand-finger schemata studied over the age range investigated. These organizational abilities were, however, inter-related with the sensory aspects of the hands and fingers at each age level. Until 5 years of age, the visual organization of the topography of the hands and fingers did not appear to be as developed as the tactual-kinesthetic organization of the topography of the hands and fingers. This comparison was drawn from the mean scores of Task Series I in the Age X Task Series X Conditions interaction. Similar findings were not obtained when Task Series II was considered. Even at 6 years of age, the mean scores for tactual-kinesthetic presentations of Task Series II were higher than those for visual presentations.

The above findings support Berges' and Lezine's (1965) view that the body schema should be studied as a sensory-motor mechanism and not as a sensory mechanism. These findings also support Konorski's (1967) contention that the information coming from the changes in the angular displacement of the joints is the predominant sensory system in the acquisition of the body schema.

It was further determined that until an equivalence is approached between the visual organization and the tactual-kinesthetic organization of the hands and fingers, actions requiring interco-ordinations between these two organizational systems will not be as effective as the actions requiring tactual-kinesthetic intra-modal translation. Thus, it seems that the development of voluntary movements in the pre-school child is tied to the development of the integration of sensory impressions on the body.

Conclusions

The following conclusions are based on the experimental findings of this study.

1. The significance of the developmental phenomenon describing the ability of pre-school children to form an organized model of their body appears to lie in the neurological development of the child at the sensorimotor level of organization. This suggests that the neurological term body schema is applicable to the research in developmental and educational psychology concerned with the development of body awareness in the pre-school child.

2. In studying the motor utilization of the body schema, the perceptual-motor organization appears to be more determinant than the perceptual organization required for hand-finger differentiation.

3. The development of body schema appears to stabilize around 5 to 6 years of age if the tactual-kinesthetic hand-finger schemata are used as an indication of the establishment of this phenomenon.

4. Until the visual organization of the topography of the hands and fingers approximates the tactual-

kinesthetic organization of the topography of the hands and fingers voluntary movements requiring interco-ordinations between these systems will not be as effective as those requiring tactual-kinesthetic intra-modal translation.

Directions for Future Research

The findings of this study have indicated avenues for further developmental research concerned with the associations between voluntary movement differentiation and sensory integration in children.

1. There would seem to be a need for research concerned with the effects of sensory integration on the development of voluntary movements in children.

2. There would seem to be a need for research concerned with the development of the kinesthetic system and its interco-ordination with other sensory systems for more precise differentiations than those used in this study.

3. There would seem to be a need for research concerned with the effectiveness of different cues for motor learning or movement differentiation at various age levels.

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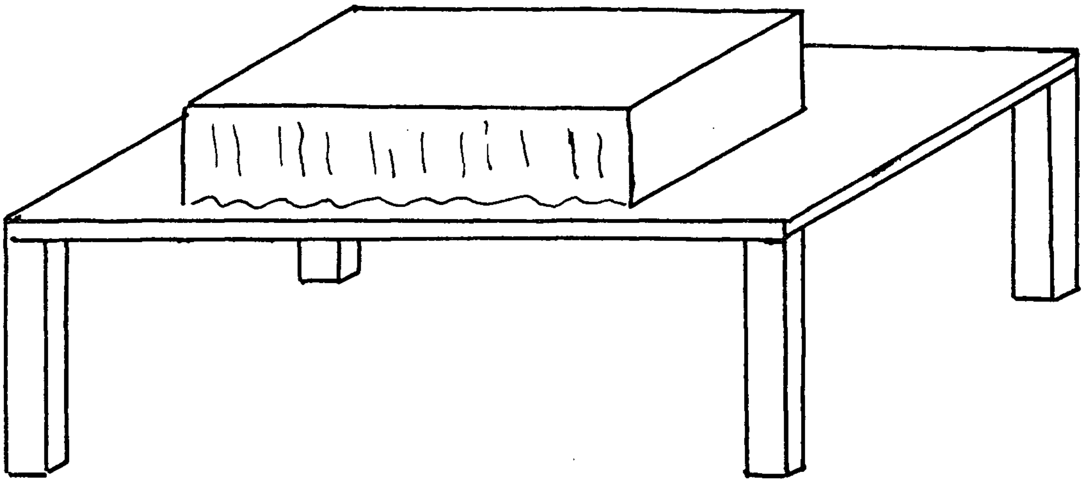
APPENDIX A

WOODEN FRAME APPARATUS

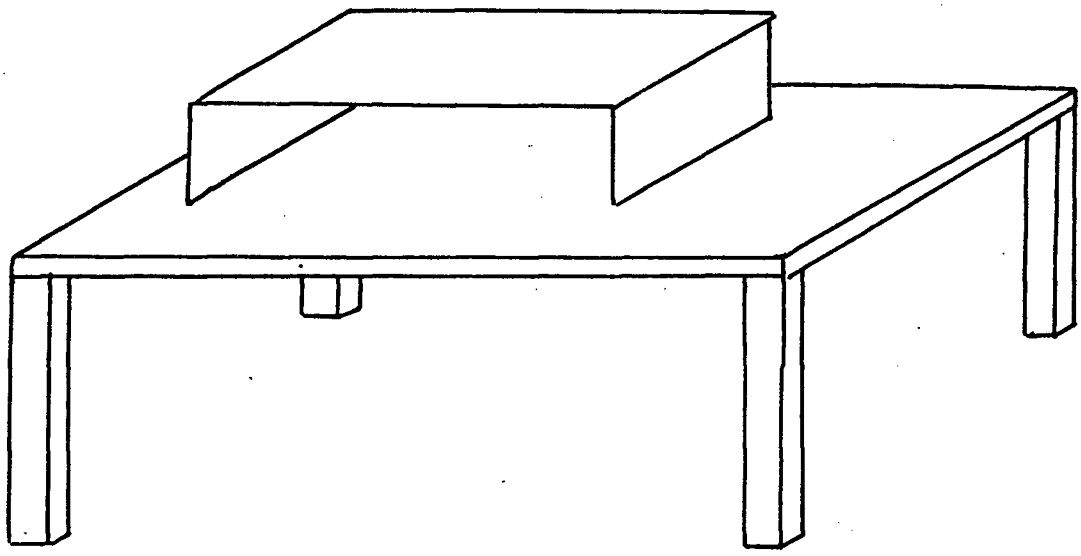
FOR

TASK SERIES I AND II

APPENDIX A



Subject's View



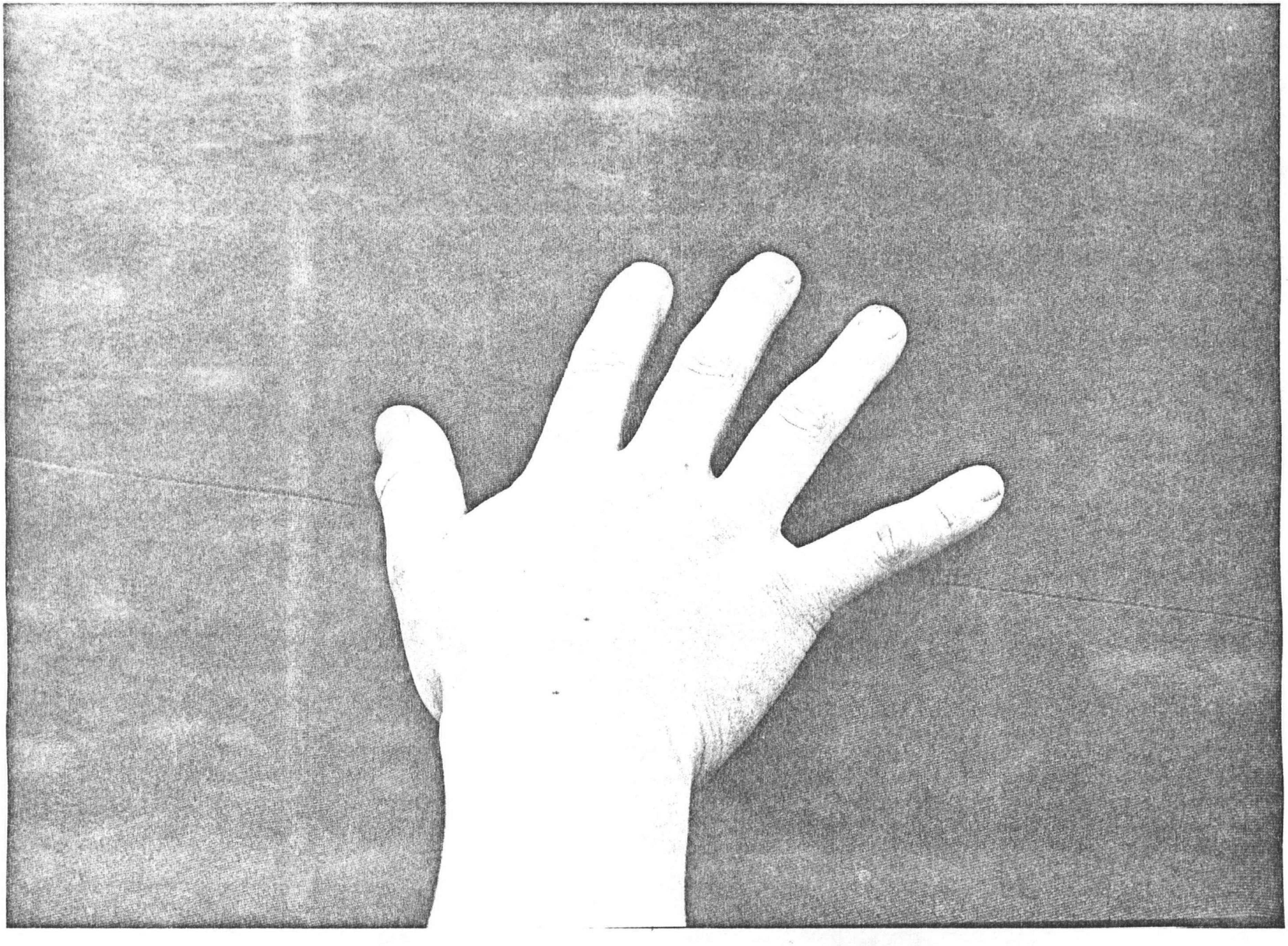
Experimenter's View

Scale: 1/10" = 1"

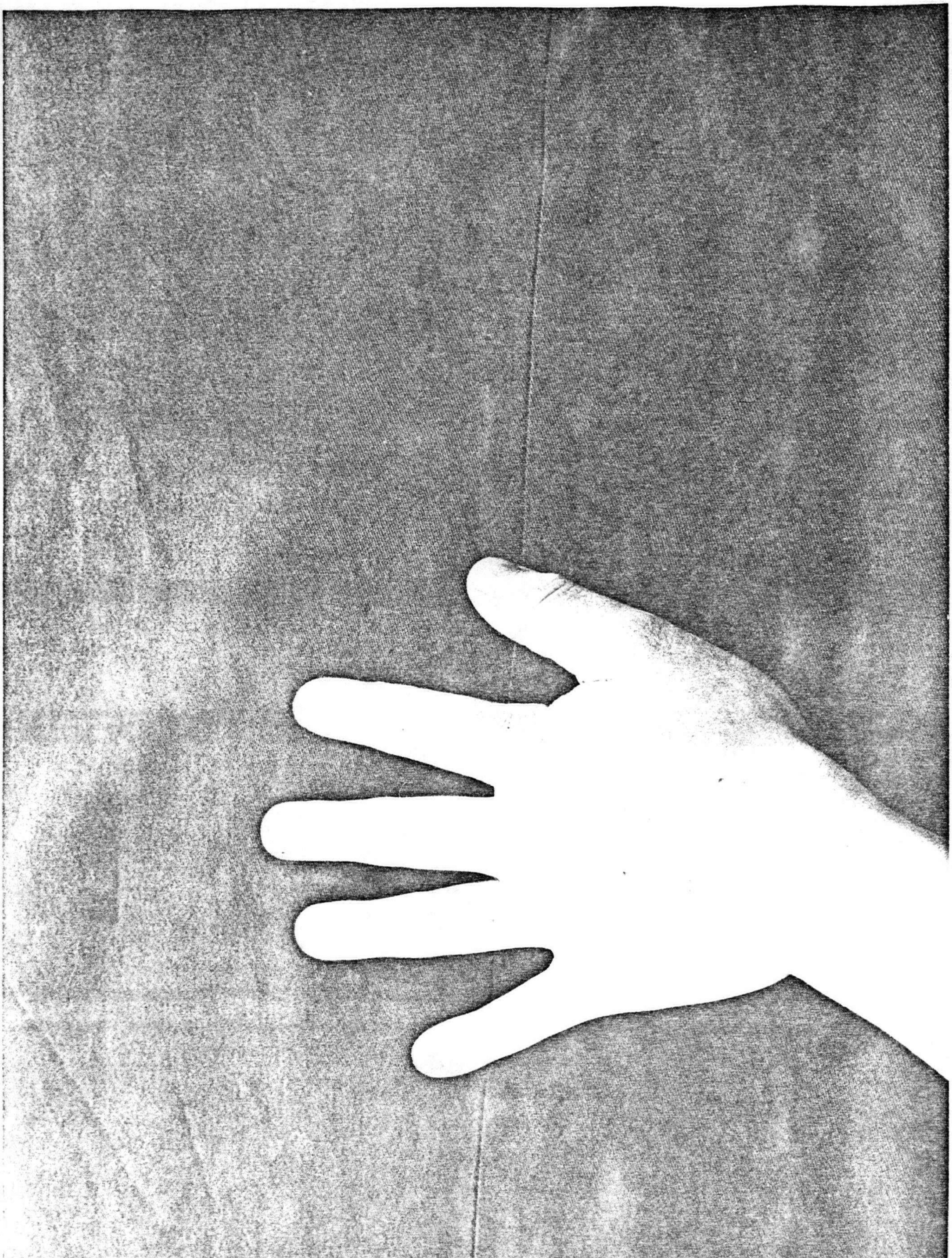
Wooden Frame Apparatus for Task Series I and II

APPENDIX B

PHOTOGRAPHS FOR TASK SERIES I



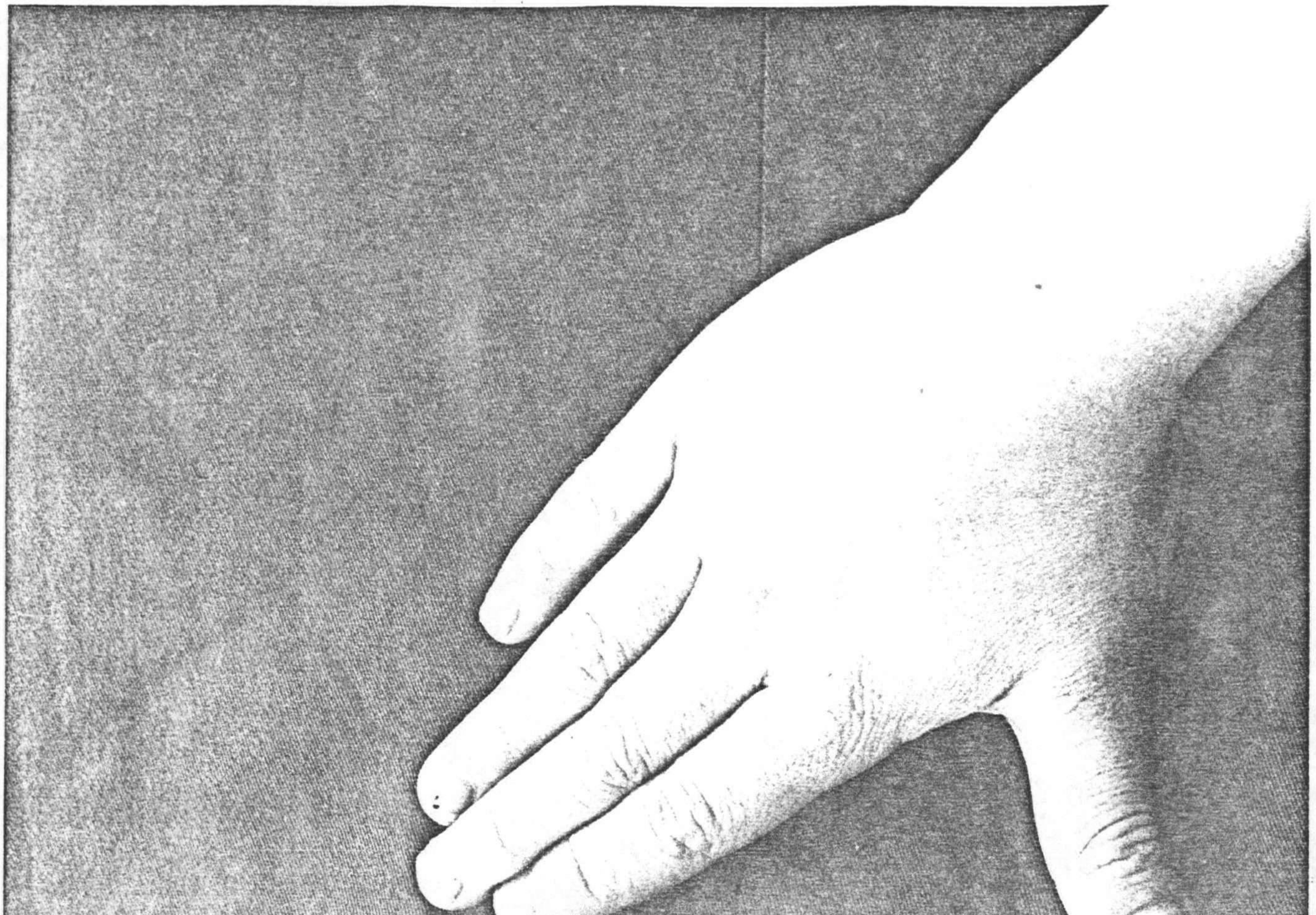
Right Hand



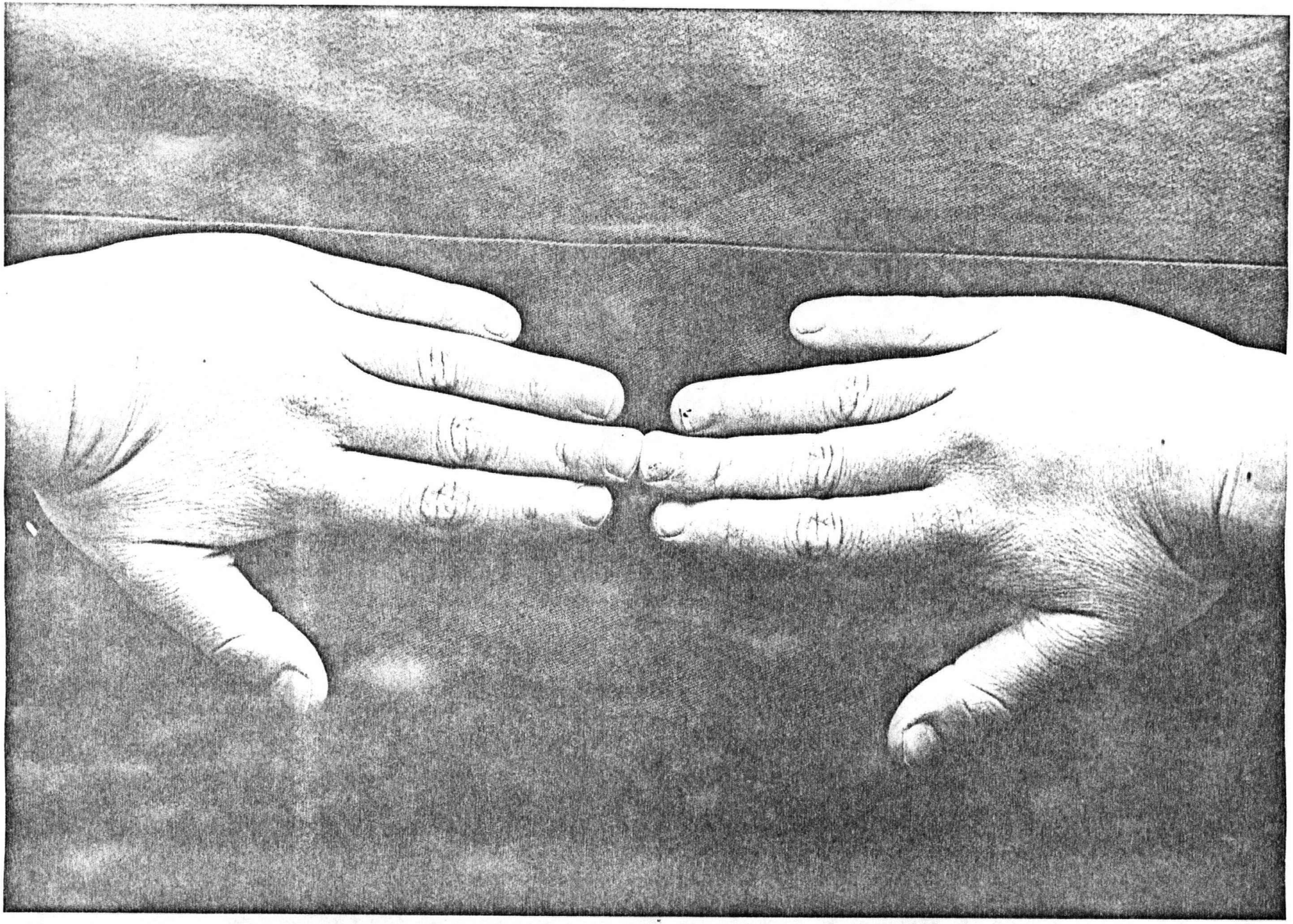
Left Hand

APPENDIX C

PHOTOGRAPHS FOR TASK SERIES II

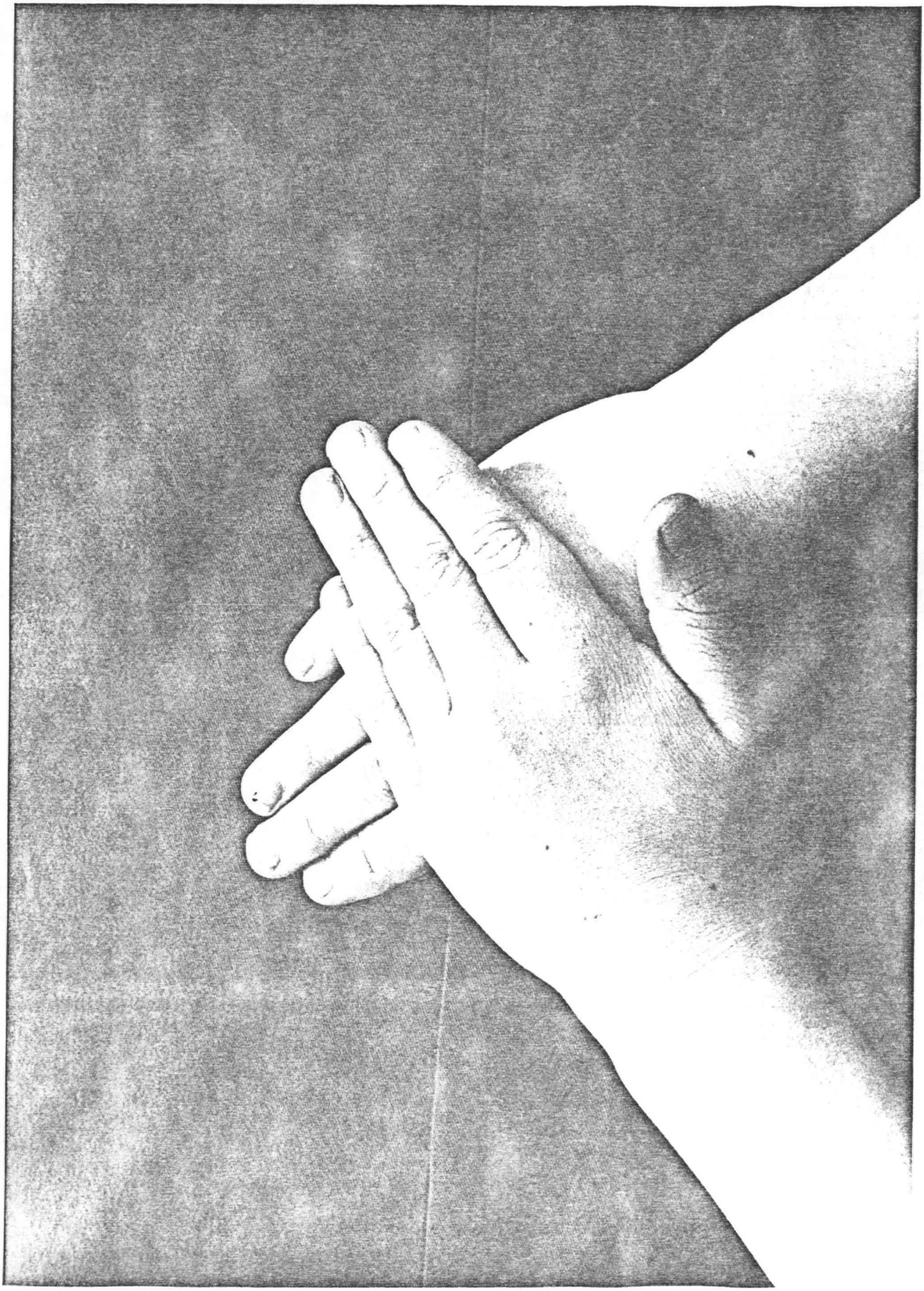


Trial Photograph

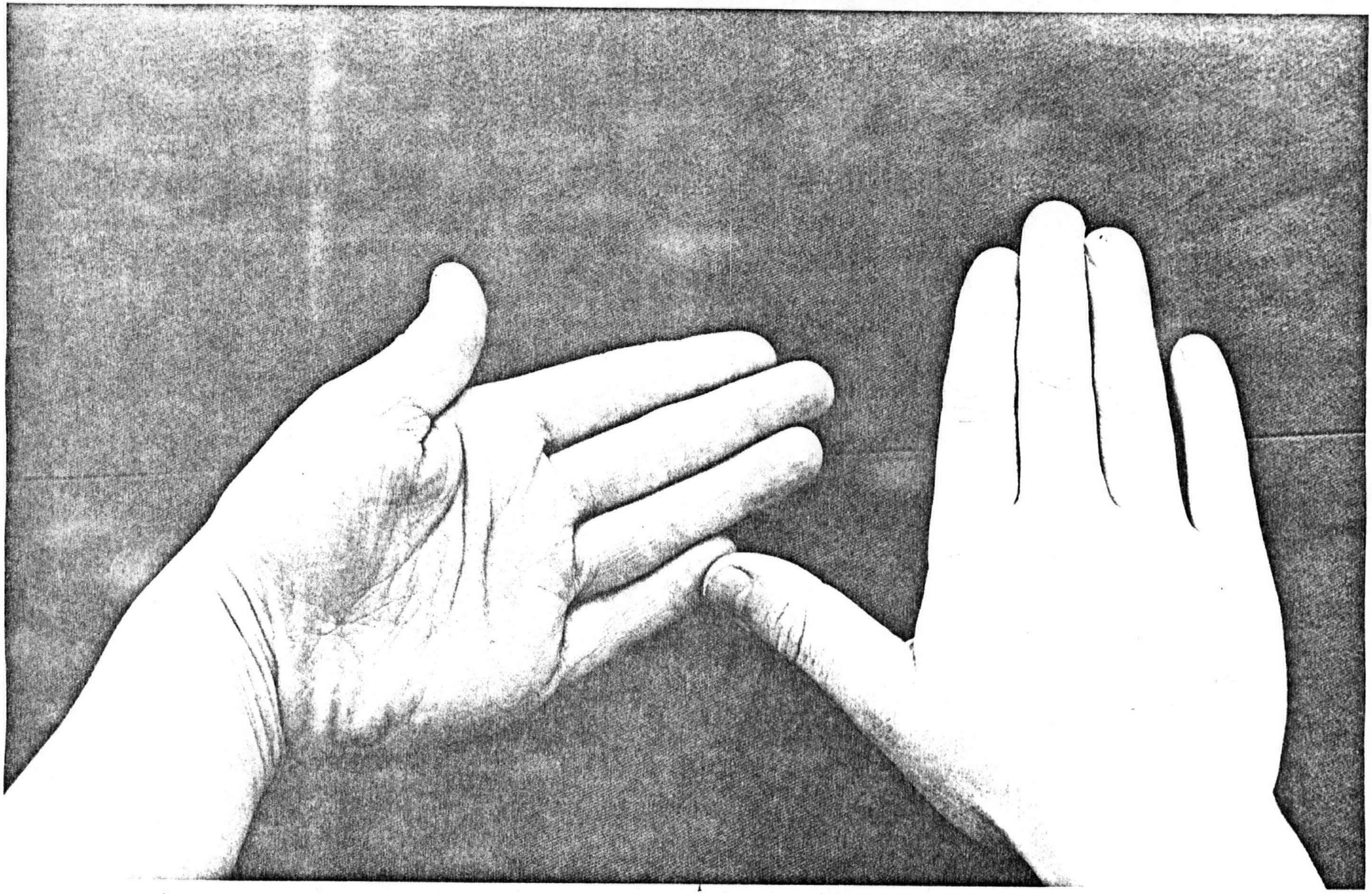


Position 1

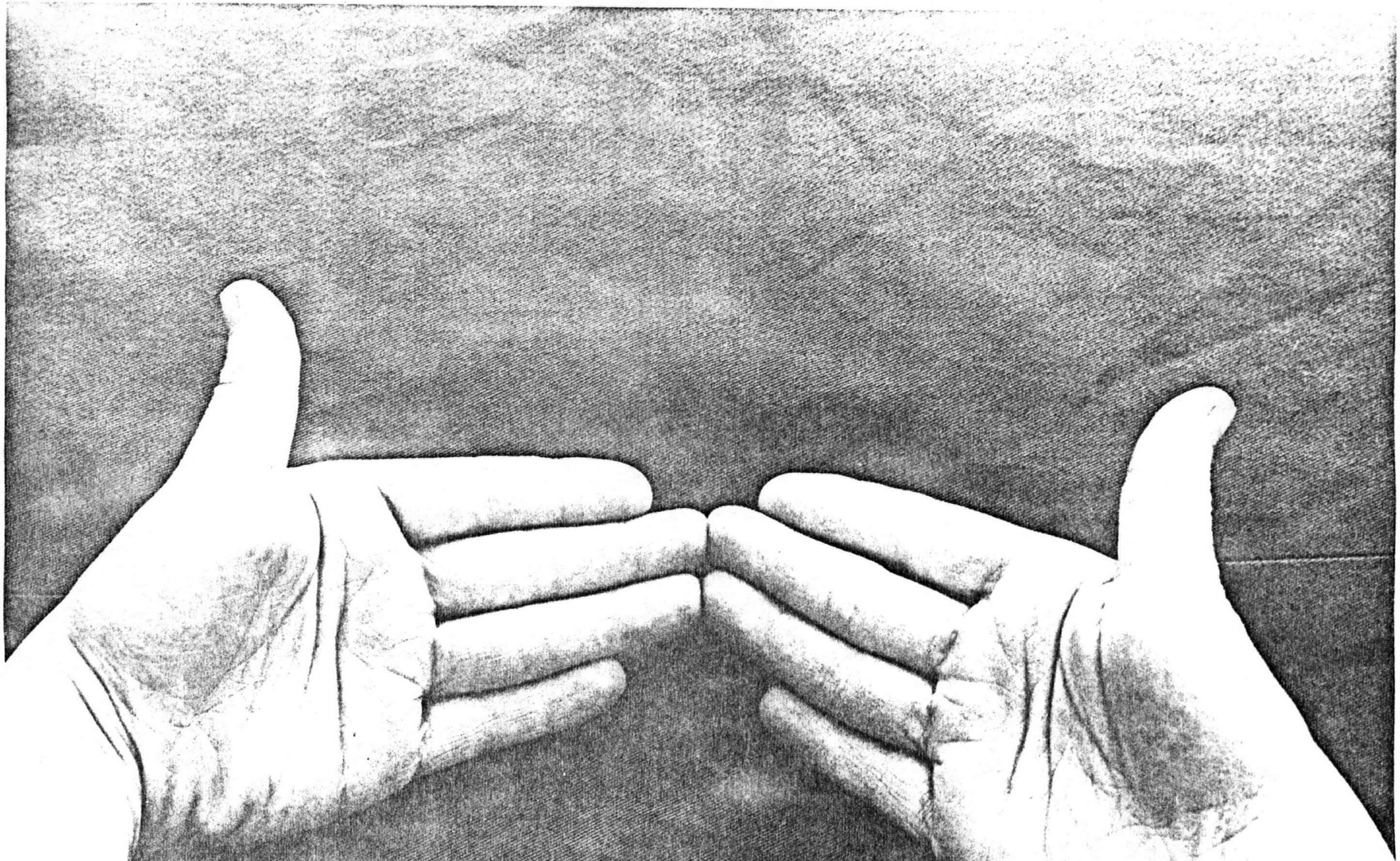
Position 2



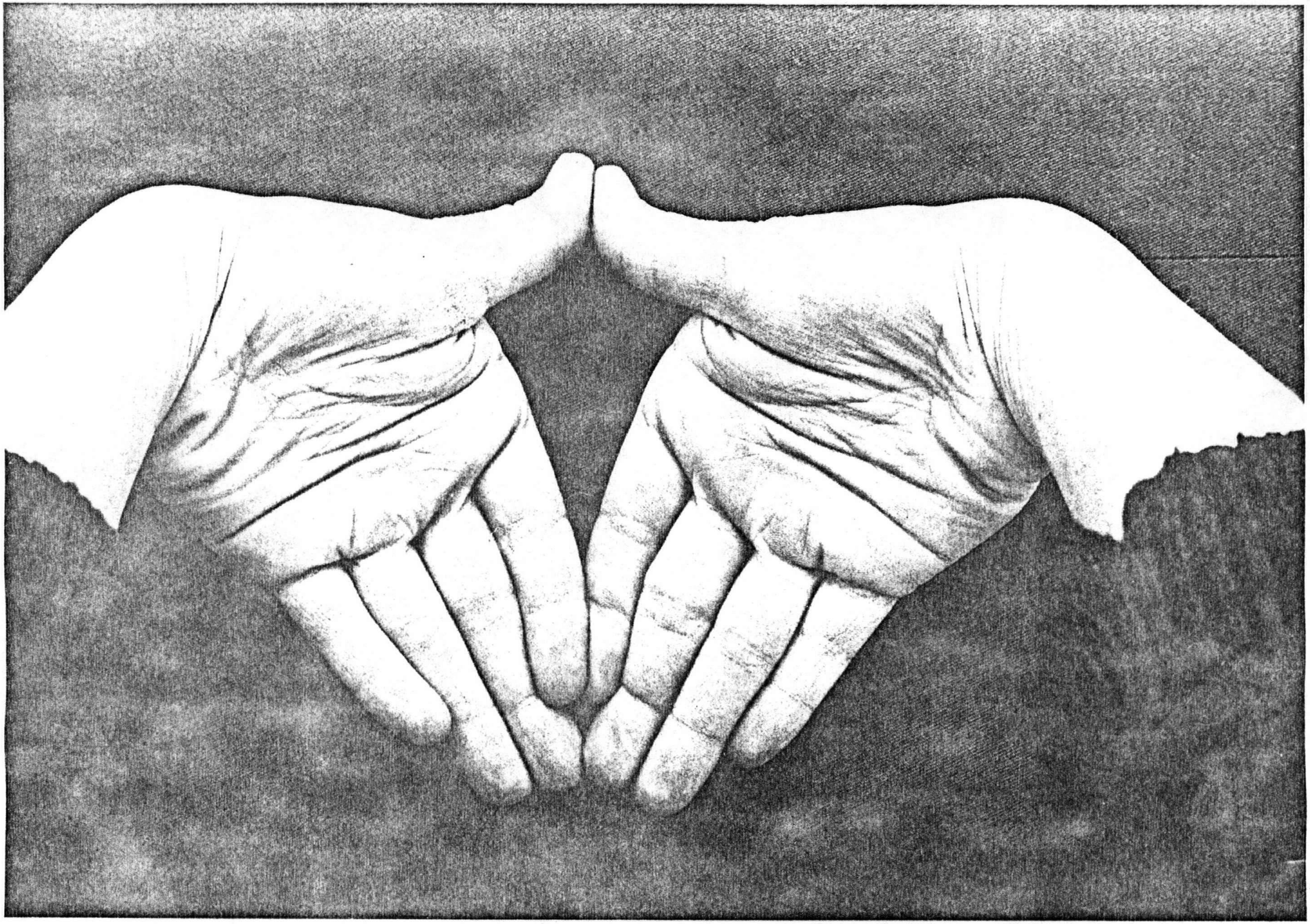
Position 3



Position 4



Position 5



Position 6

APPENDIX D

EXPERIMENTAL DESIGN

Order of Presentation

The order of presentation of the fingers in Task Series I and the positions in Task Series II was randomly selected from a table of random numbers for Order I and was reversed for Order II.

Task Series I. The little finger of the right hand was designated (1) and the little finger of the left hand was designated (10). The numbers ranged across the right hand to the left hand from (1) to (10).

Order 1	5	1	6	9	3	8	2	10	4	7
Order 2	7	4	10	2	8	3	9	6	1	5

Task Series II. The 6 positions were randomly assigned a number (Appendix C).

Order 1	1	3	6	5	2	4
Order 2	4	2	5	6	3	1

Latin Square

The conditions and orders of presentation were counterbalanced by replicating the following Latin Square for each Age X Sex group (e.g. 3 year old males).

Table 1.1. Latin Square Replicated for each Age X Sex Group

Order of Stimulus Presentation		Order of Condition Presentation			
OI	OII				
S1	S5	C4	C1	C2	C3
S2	S6	C1	C3	C4	C2
S3	S7	C2	C4	C3	C1
S4	S8	C3	C2	C1	C4

Table 1.2. 4 x 2 x 2 x 2 x 4 Experimental Design for the Sensorimotor Task Series I and II

		Task Series I								Task Series II							
		Dominant Hand				Non-Dominant Hand				Dominant Hand				Non-Dominant Hand			
		C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4
		(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)
6 years	Boys																
	Girls																
5 years	Boys																
	Girls																
4 years	Boys																
	Girls																
3 years	Boys																
	Girls																

Table 1.3. Method of Recording Responses in the 4 Experimental Conditions of Task Series I.

Individual finger presentation	Left Index (7)	Right Index (4)	Left Little (10)	Right Ring (2)	Left Middle (8)	Right Middle (3)	Left Ring (9)	Left Thumb (6)	Right Thumb (5)	Left Little (1)	Totals Right Hand	Totals Left Hand
Movement Differentiation Correct (1) Incorrect (0)	-	-	-	-	-	-	-	-	-	-		
Nature of the Error												
Difficulty in isolating finger movement	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL		
	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL		
Wrong finger	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL	Rt: TIMRL		
	Lt: RIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL	Lt: TIMRL		

Table 1.4. Method of Recording Responses in Task Series III

Testing Session	Hand Preference Right	Hand Preference Left	Foot Preference Right	Foot Preference Left
Day I 4 trials	-	-	-	-
Day II 4 trials	-	-	-	-
Total	-	-	-	-

Table 1. 5. Method of Recording Responses in Task Series IV

Body Part	Day I		Day II	
	Body Part	Right-Left	Body Part	Right-Left
Verbal indication				
right eye				
left foot				
right hand				
Verbal response				
right foot				
left eye				
left hand				
Totals				

APPENDIX E

INSTRUCTIONS FOR TASK SERIES I-IV

APPENDIX E

Instructions for Task Series I - IV

Day	Investigation Phase	Verbal Instructions given to the subject	Clarification of Instructions
Day I	Approach to subject	Would you like to play some games with me?	S: No; E did not force the child into the testing situation
			S: Yes; E took child to the testing room
Day I	Hand, foot	Would you like to play with the ball or the bike or the slide	Free play
		Why don't we play with the ball? Can you throw it to me?	If two hand used initially, S asked to use one hand for throwing. Hand preference on 4 trials observed
		Good, now can you kick the ball?	Foot preference on 4 trials observed
		Now I'll cover this eye, is your finger still pointing at the spot?	Left eye covered.
	Hand-finger differentiation	Let's play some finger games now. Come with me and we'll sit down at the table	Appendix A
	Condition 1 visual-visual	Do you know what these are?	Photographs of the hands shown
		Now I want you to put your hands on the box, like this. Push your fingers down on the box, like this. Good!	Appendix A
		In this finger game I'm going to point to <u>one</u> finger on the picture, like this	Little finger of the left hand indicated

APPENDIX E (continued)

Day	Investigation Phase	Verbal instructions given to the subject	Clarification of Instructions
		Then I'm going to hide the picture finger, like this	Cardboard placed over both photographs for successive presentation
		As soon as I hide the finger I want you to find the <u>one</u> finger on your hand and show it to me	
		Try to show me the <u>one</u> finger by moving it up and down like this. If you can't do that show me the <u>one</u> finger anyway you like, then try and wiggle the <u>one</u> finger, like this	Point to the finger, then curl all the other fingers under then wiggle it.
		Let's try it	Little finger on left hand indicated for 3 sec. to clarify instructions
		Good, now let's try some more. Remember show me the <u>one</u> finger that I pointed to on the picture. Let's go!	Proceed as the order of finger presentation indicates, record as in Appendix D
	Condition 2 visual-kinesthetic	In this game I want you to put your hands in the box like this, and push them down on the table. Good!	Hands kept in a constant prone position throughout presentations Appendix A
		In this finger game, I'm going to point to <u>one</u> finger on the picture like this	little finger on the left hand indicated
		Then I'm going to hide the picture finger, like this	Cardboard placed over both photographs for successive presentation

APPENDIX E (continued)

Day	Investigation Phase	Verbal instructions given to the subject	Clarification of Instructions
		As soon as I hide the picture finger I want you to find the <u>one</u> finger on your hand and show it to me. But you have to keep your hands hiding in the box all the time.	
		Try to show me the <u>one</u> finger by moving it up and down, like this. If you can't do that, show me the <u>one</u> finger any way you like but then try and wiggle it, like this	point to it with opposite hand or curl all other fingers under then wiggle it
		Let's try it	Little finger on the left hand indicated for 3 sec. to clarify instructions
		Good, now let's try some more. Remember show me the <u>one</u> finger that I point to on the picture. Let's go!	Proceed as the order of finger presentation indicates, record as in Appendix D
	Condition 3 kinesthetic-visual	In this game I want you to put your hands in the box, like this, and push down on the table	Hands kept in a constant prone position throughout presentations Appendix A
		In this finger game, I'm going to move <u>one</u> of your fingers up and down like this	Little finger on the left hand indicated
		When I stop moving your <u>one</u> finger I want take your hands out of the box, like this (fast) put them on top of the box, like this	
		Try to show me the <u>one</u> finger that I moved by moving it up and down	

APPENDIX E (continued)

Day	Investigation Phase	Verbal instructions given to the subject	Clarification of Instructions
		like this. If you can't do that show the one finger any way you like, then try and wiggle the one finger like this	
		Let's try it!	Little finger on the left hand indicated by moving it up and down 3 times, 3 sec. to clarify instructions
		Good, now let's try some more! Remember to show me the one finger I move. Let's go!	Proceed as order of finger presentation indicates, record as in Appendix D
	Condition 4 kinesthetic-kinesthetic	In this game I want you to put your hands in the box like this, and push down on the table	Hands kept in a constant prone position throughout presentations. Appendix
		In this finger game, I'm going to move one of fingers up and down like this	Little finger on left hand indicated for 3 seconds to clarify instructions
		When I stop moving your one finger I want you to try and show me the one finger I moved by moving it up and down like this. If you can't do that show me the one finger any way you like, then try and wiggle the one finger like this. you have to keep your hands hiding in the box	
		Let's try it	Little finger on the left hand indicated by moving it up and down 3 times, 3 secs. to clarify instructions
		Good, let's try some more! Remember show me the one finger I move. Let's go.	Proceeds order of finger presentation indicates, record as in Appendix D

APPENDIX E (continued)

Day	Investigation Phase	Verbal instructions given to the subject	Clarification of Instructions
Day I	Verbal comprehension of right and left with respect to body part identification	Let's try another game now	Presented after the first 2 conditions in each subject's Day I testing session. Move away from table to offset boredom and learning
	Clarification of instructions	What's this? What's this? Which ear? What's it's name?	nose indicated right arm indicated right and left clarified
	E verbal-S pointing	Can you find your right eye and point to it? Can you find your left foot and point to it? Can you find your right hand and point to it?	
	E pointing-S verbal	What's this? What's this? What's this?	left eye indicated right foot indicated left hand indicated
Day II	Approach to Subject	"Hi_____ did you like the games we played last time? Do you want to play some more?"	S: "No". E played with child until ready to come for testing S:"Yes". E took child to the testing room immediately
	Hand-foot preference	"Let's play with the ball again...."	Hand-foot preference observed in the same manner as Day I
	Hand-finger orientations	"We've got some new finger games today. New pictures too - Look!" "You sit at the table right here and I'll sit over here, put your hands on the box, like this."	Trial photographs shown Appendix C Appendix A

APPENDIX E (continued)

Day	Investigation Phase	Verbal instructions given to the subject	Clarification of Instructions
	Condition 1 visual-visual	Now I'm going to show you a picture like this	Trial photograph (Appendix C) presented for 3 secs.
		Then I'll hide the hands in the picture like this	Cardboard placed over the photograph
		And then I want you to do the same things with your hands as the picture hands did	
		"Let's try it. Remember it's a quiet game, watch closely!"	This photograph (Appendix C) shown for 3 sec. S response, to ensure instructions clear
		"Good, let's try some more"	Proceed as orientation order indicates; Record as in Appendix D
	Condition 2 Visual-kinesthetic	"In this game I want you to keep your hands in the box like this"	Hands kept in a constant prone position between responses
		"Now I'm going to show you a picture like this"	Trial photograph (Appendix C) shown
		"Then I'm going to hide the hands in the picture like this"	Cardboard placed over the photograph
		"And I want you to do the same thing, with your hands in the box as the picture hands did"	
		"Let's try it. Remember it's a quiet game, watch closely"	Trial photograph (Appendix C) shown for 3 secs.
		"Good, let's try some more"	Proceed as orientation order indicates; record as in Appendix

APPENDIX E (continued)

Day	Investigation Phase	Verbal instructions given to the subject	Clarification of Instructions
	Condition 3 kinesthetic-visual	"In this game I want you to put your hands in the box like this"	Constant prone position in between S's response and E's passive movement of the S's hands
		"Now I'm going to move your hands into a position like this"	E always starts with thumbs, proceeds to little fingers in positioning
		"Then you bring them out of the box, put them on top of the box like this (fast)	
		"And then you show me what I did to your hands"	
		"Let's try it. Remember it's a quiet game!"	Trial position Appendix C, held for 3 secs. response, to ensure instructions clear
		"Good let's try some more	Proceed as orientation order indicates; record as in Appendix D
	Condition 4 kinesthetic-kinesethetic	In this game I want you to put your hands in the box	Constant prone position in between S's response and E's passive movement of the S's hands
		Now I'm going to move them like this	E always starts with thumbs, proceeds to little fingers in positioning
		"Then I'm going to put them back, like this"	
		"And then you show me what I did to your hands, but, you have to keep them in the box."	

APPENDIX E (continued)

Day	Investigation phase	Verbal instructions given to the subject	Clarification of Instructions
		"Let's try it, Remember it's a quiet game"	Trial position (Appendix C) held for 3 secs.
		"Good, let's try some more!"	Proceed as orientation order indicates; record as in Appendix D
Day II	Verbal comprehension of right and left with respect to body part identification	"Let's try another game now!"	Presented after each S's first 2 conditions; conducted in the same manner as on Day I
Day II	Conclusion	Thanks for playing with me....that was fun!	

APPENDIX F

BIVARIATE FREQUENCY DISTRIBUTIONS FOR TASK SERIES I AND TASK SERIES II

APPENDIX F

Table 1.6 . Bivariate Frequency Distribution for Scores in Task Series I. Ordinal Scale (0-5)

	6 years								5 years							
	Dominant Hand				Non Dominant Hand				Dominant Hand				Non Dominant Hand			
	V-V	V-P	P-V	P-P	V-V	V-P	P-V	P-P	V-V	V-P	P-V	P-P	V-V	V-P	P-V	P-P
0																
1																
2																
3					7	6					1		10	8	9	1
4	1	1			3	3	8	7	4	4	1	1	4	7	4	11
5	15	15	16	16	6	7	8	9	12	12	14	15	2	1	3	4
Total	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
	4 years								3 years							
0									1	5			8	6		
1	1				4	2	0		6	10	2		6	7	9	2
2	1	1			2	2	4		9	1	12	11	2	3	7	13
3	7	5	6	4	9	11	8				2	5				1
4	5	8	10	9		1	4	6								
5	2	2		3	1			10								
Total	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

Table 1.7. Bivariate Frequency Distribution for Scores in Task Series II. Ordinal Scale (0-6)

	6 years								5 years							
	Dominant Hand				Non Dominant Hand				Dominant Hand				Non Dominant Hand			
	V-V	V-P	P-V	P-P	V-V	V-P	P-V	P-P	V-V	V-P	P-V	P-P	V-V	V-P	P-V	P-P
0																
1																
2													1		4	
3					5	2			6	3			9	10	8	
4	3	4			8	5	1		6	12	2		5	5	3	5
5	13	12	5	5	3	9	5	5	3	1	13	13	1	1	1	7
6	—	—	11	12	—	—	10	11	—	—	1	3	—	—	—	4
Total	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

	4 years								3 years							
0													7	5		
1													8	7		5
2					4				1		1		1	4	10	9
3	9	7			11	7	3		15	7	8				6	2
4	6	6	9	6		9	10	9		6	7	8				
5		3	7	10			1	4		3		8				
6	1	—	—	—	1	—	2	3	—	—	—	—	—	—	—	—
Total	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

APPENDIX G

ANALYSIS OF VARIANCE TABLE FOR TASK SERIES I AND TASK SERIES II

APPENDIX G

Table 1.8. Analysis of Variance for Scores in Task Series I and II.

	Source of Variance	df	Mean Square	F	P
Age	A	3	332.20	269.40	< .01
Sex(Age)	G(A)	4	0.39		
	Sw G(A)	56	1.23		
Task Series	I	1	7.27	16.45	<.01
	A X I	3	17.67	39.96	<.01
	G(A) X I	4	0.25	-	
	SwG(A) X I	56	0.44		
Conditions	C	3	45.85	185.56	<.01
	A X C	9	0.70	2.85	<.01
	G(A) X C	12	0.75	-	
	SwG(A) X C	168	0.25		
Dominance	D	1	118.61	199.06	<.01
	A X D	3	3.43	5.76	<.01
	G(A) X D	4	0.56		
	SwG(A) X D	56	0.60		
	I X C	3	5.33	25.15	<.01
	A X I X C	9	0.43	2.03	.05
	G(A) X I X C	12	0.85		
	SwG(A) X I X C	168	0.21		
	I X D	1	3.46	9.08	
	A X I X D	3	12.03	4.58	<.01
	G(A) X I X D	4	0.28		
	SwG(A) X I X D	56	0.38		
	C X D	3	4.75	18.70	<.01
	A X C X D	9	0.57	2.26	<.05
	G(A) X C X D	12	0.65		
	SwG(A) X C X D	168	0.25		