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SENSORIMOTOR EXPERIENCE AND CONCEPT FORMATION IN EARLY CHILDHOOD. FINAL REPORT.

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IN ORDER TO INVESTIGATE THE RELATIONSHIP BETWEEN SENSORIMOTOR EXPERIENCE AND THE FORMATION OF CONCEPTS IN CHILDHOOD, 2 GROUPS OF CHILDREN--1 MOTORICALLY NORMAL, THE OTHER COMPOSED OF CEREBRAL PALSIED CHILDREN--WERE COMPARED FOR ACQUISITION OF SIMPLE ACTION AND OBJECT CONCEPTS. THREE HYPOTHESES WERE TESTED. IT WAS PREDICTED (1) THAT CEREBRAL PALSIED CHILDREN WOULD IDENTIFY FEWER ACTION CONCEPTS THAN NONHANDICAPPED CHILDREN, (2) THAT PREVIOUS SENSORIMOTOR EXPERIENCE WOULD DETERMINE WHETHER CHILDREN WOULD UTILIZE A MOTORIC OR NONMOTORIC MODE OF PROBLEM SOLVING, AND (3) THAT CEREBRAL PALSIED CHILDREN WOULD HAVE POORER WEIGHT DISCRIMINATION THAN NORMAL CHILDREN. THE EXPERIMENT WAS A SIMPLE EX POST FACTO COMPARISON OF 2 GROUPS AND HAD THE DISADVANTAGE THAT THE INDEPENDENT VARIABLE-- SENSORIMOTOR EXPERIENCE--WAS NOT CONTROLLED. TWO GROUPS OF 40 CHILDREN RANGING IN AGE FROM 42 TO 66 MONTHS MADE UP THE SAMPLE. THE MAJOR CRITERION FOR INCLUSION WAS THE ABILITY TO RESPOND TO THE EXAMPLE PLATES OF THE PEABODY PICTURE VOCABULARY TEST (PPVT). THE CHILDREN WERE GIVEN 4 TESTS--(1) THE PPVT, FORM A, (2) A MODIFIED PPVT DESIGNED TO ALLOW AN ACTION OR CONCEPT PICTORIAL IDENTIFICATION IN RESPONSE TO A WORD, (3) A TEST OF WEIGHT DISCRIMINATION, AND (4) A TEST OF ADAPTIVE MODE. CHI-SQUARE ANALYSIS OF THE TEST SCORES OF THE 2 GROUPS STRONGLY SUPPORTED THE ACCEPTANCE OF ALL 3 HYPOTHESES. THE MAJOR CONCLUSION THAT CAN BE DRAWN IS THAT CONSIDERABLE SUPPORT IS GIVEN TO CURRENT THEORIES THAT SENSORIMOTOR EXPERIENCE IN INFANCY IS AN IMPORTANT FACTOR IN CONCEPT FORMATION. ONE EDUCATIONAL IMPLICATION IS THAT SEVERELY CEREBRAL PALSIED CHILDREN MIGHT PROFIT FROM SPECIALLY DESIGNED EDUCATIONAL PROGRAMS. (DR)

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The University of Texas

Austin, Texas

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D.M.
R.F.P.

INTRODUCTION

Valuable knowledge has been developed in recent years about the manner in which human beings go about the task of organizing, incorporating and utilizing new stimuli. The "cognitive styles" of Kline (31), the "learning sets" of Harlow (22), the "schemata" of Piaget (19), the "strategies" of Bruner (8), and the "personal constructs" of Kelly (29) are examples of fruitful theoretical formulations that have been developed. However, much of the research stimulated by these theories has been concerned primarily with the cognitive process as it operates <u>after</u> humans have already acquired a substantial repertoire of concepts. Thus, one of the consequences of this area of study has been to direct researchers to the very foundations of the learning process, namely, the way in which infants <u>learn</u> to learn.

Statement of the Problem

For some years now several antecedent conditions have been observed to correlate with retarded motor and cognitive development in infants. Early observations by Ribble (46) and Spitz (52) indicated that lack of "mothering" in the early months of life seriously impaired the infant's ability to cope effectively with its surroundings. Serious consequences were reported, such as physical deterioration, and in a few cases, death. Such extreme results of maternal deprivation were later shown to lack scientific support (43). More recently, however, controlled observations by Dennis (15) in foundling homes in Tehran revealed that children who lack a normal amount of relevant experience in infancy are retarded in their motor development. He observed, for example, that only fifteen per cent of the orphanage children who were between three and four years of age walked alone, whereas most home-reared children walk by two years. Moreover, the orphanage children, rather than increasing in motor activity and attention to their environment with maturation tended to decrease their movements to the point where they would lie listless and motionless hour upon hour. Other studies have found little or no serious intellectual retardation or behavioral disturbances in children who were institutionalized in infancy (17) (18). The issue is difficult to resolve, as Yarrow (64) points out, because of the many relevant variables involved. Yet, one point seems to be generally accepted. Most children, if neglected in infancy, will develop impairments, in varying degrees, in their capacity for conceptual thinking; for controlling impulses; and their ability in forming close affectational relationships. These deficits may be correctable, or may leave more or less permanent residual impairments (45). In any event, one of the most obvious factors that normal adult attention provides the child is tension-release stimulation of many kinds: verbal, visual, tactual, etc. (36). Lacking such stimulations, children's perceptual abilities apparently can fail to develop properly.

Solley and Murphy (50) believe that the development of perception is an interactive process involving the organism with an external stimulating agent, and remark that "as a process, perception can best be conceptualized as an instrumental act which structures stimulation" (p. 33). Apparently, then, there is a process through which children "learn" to learn early in life (20) (22) (50). And, learning to learn seems to depend somehow upon the individual's development of the ability to conceptualize.

Two factors seem implicit in much of the foregoing discussion. One is that motor experience may be a major factor in development of the ability to structure and evaluate stimuli; and second, that the amount, and perhaps quality, of interpersonal contact is positively correlated with the level of the child's motor activity. On the second point, Casler (10) has rendered the opinion that:

> In the psychologically unhealthy institutions studied by Spitz, Dennis and Najarian, and others, all of the important sensory modalities were understimulated. It may be appropriate, therefore, to refer the disturbances found among

> institutionalized children (at least in those cases when separation from the mother occurred before the age of six months) to "perceptual deprivation," including tactile and kinesthetic... (p. 18).

The purpose of this study is to investigate an aspect of the first mentioned factor, namely, the relationship between sensorimotor experience and the formation of concepts in childhood.

Intuitively, it has long been recognized that such a relationship might exist. Ausubel (2) notes that:

> John Dewey had correctly recognized that meaningful understanding of abstract concepts and principles in childhood must be built on a foundation of direct, empirical experiences.

And before Dewey, William James (27) said, "Infants must go through a long education of the eye and ear before they can perceive the realities which adults perceive." Bruner (7) organized and extended the principle of motor experience in infancy into a system of cognitive development. Human beings, according to his view, "construct models of their world: through action, through imagery, and through language." Developmentally, he says, the child's modes of representing the environment appear in this order, and each mode depends on the previous one for its development.

Kephart (30) has explicated the relationship between motor learning and intellectual development. He writes:

> The early motor or muscular responses of the child, which are the earliest behavioral responses of the human organism, represent the beginnings of a long process of development and learning. Through these first motor explorations, the child begins to find out about himself and the world around him, and his motor experimentation and his motor learnings become the foundation upon which such knowledge is built (p. 35).

Werner (59) is even more explicit. He considers the affective, perceptual, cognitive, sensory, and motor functions to operate syncretically in the young child. There is "relatively limited differentiation of object and subject, of perception and pure feeling, of idea and action, etc." (p. 59). Thus, he concluded that because of the high degree of unity between subject and object--which is mediated by motor-affective reactivity--the organism apprehends events in a dynamic rather static fashion.

Stott and Ball (53), in discussing the nature of intelligence, go a step further and assert that it is not possible to separate motor learning from intelligence. They write:

> Another coming conceptual change concerning the nature of intelligence, which we feel is overdue, is related to the dichotomy of "motor behavior versus mental or central processes." The infant begins to know and cope with his environment through his motor responses to stimulation (p. 2).

At first there is no central representation of these responses, but through experience and maturation the child learns to differentiate objects and to respond to them individually. He becomes cognitively aware of things and persons.

> All his motor manipulations--eye-hand, fine motor, and gross motor coordinations--appear now to be centrally mediated and are directed toward some kind of adjustment to, or coping with, the environment....In short, the motor behavior of the young child is mental behavior (p. 2).

In spite of the awareness that later aptitude for learning is somehow dependent on early motor activity, the specific ways in which early motor activity influences or develops learning aptitudes are still largely unknown. Do motor activities in infancy have a demonstrable bearing on the formation and usage of simple concepts in early cognitive development, which in turn are assumed to be the basis of the more complex "cognitive structures" of the organism? This is the essence of the problem to be considered in this study.

To investigate the problem, two groups of children were compared for acquisition of simple action and object concepts. One group was motorically normal; the other was composed of cerebral palsied children who had been restricted in motoric development since birth. Group N's = 40; and the age range 42 to 66 months.

Concept Formation and Verbal Representation

At this point, the term "concept" should be defined as it will be used in this investigation. A concept is a representation within the organism for a class of objects or events. For example, the concept "table," for a given individual, has been formed out of his experience with all "tables" he has encountered during his lifetime. The word "table," representing the concept, has been put in quotation marks to emphasize that the concept it-self is operative at the non-verbal level. An important property of a concept is that it is able to include future encounters with structurally similar objects or events. Thus, a concept for an action, such as "jumping," will include the organism's experience with a complex but similar sequence of neuro-muscular activations by organisms in varieties of situations, and will allow him to recognize such future actions. The concept, then, has specific as well as general properties. The concept "dog," for a given person could include a whole class of animals with such dissimilar subclasses as "Greyhounds" and "Dachshunds," as well as his own pet dog. It would also include developmental possibilities within the species that might be created by crossbreeding. Concepts are added to observation by the individual, and with them he theoretically can anticipate similar future events.

Logically, it follows that an individual's concepts should be idiosyncratic early in life.

Later, as he interacts with environmental objects and events, his concepts should become similar to concepts held by other persons in his culture. Vygotsky (56) contends that true concepts do not develop until the period of puberty. However, before puberty there are intellectual formations that perform functions similar to those of genuine concepts. These formations are functional equivalent of concepts and stand in the same relationship to true concepts as the embryo to the mature organism. Therefore, in this report when the term "concept" is used in regard to children, the above distinction is implied.

Spoken language, obviously, is a prime mediator in childrens' concept development. An important point, however, is that children learn many rudimentary concepts before they learn words to represent them. Months before the infant can speak he can consistently respond to commands that require his action upon a given object, such as, "close the door," "go get your coat," etc. He is able to generalize actions such as <u>close</u>, <u>go</u>, <u>get</u>, etc., and objects such as <u>door</u>, <u>coat</u>, and so on, to such a degree that it is clear he has formed rudimentary concepts of these actions and objects. The childs' concepts, according to Vygotsky (56) are concrete and factual, as distinguished from the abstract or logical nature of the adult's. As the child continued in the process of concept development he begins to verbalize the words he has learned to associate with objects and actions.

The present investigation was undertaken on the assumption that there is, in fact, a qualitative difference between object and action concepts in the early stages of their development. It was further assumed that the development of action concepts is more dependent on sensorimotor experience than development of object concepts. To study the validity of these assumptions, two groups of children-as described earlier-were compared for number and type of acquired concepts. Furthermore, the way in which the groups used concepts for solving means-end problems common to their age was also studied.

Theoretical Considerations on

Concept Development

Three rather complete reviews of the literature on concept development have appeared at intervals during recent years. Russell (47) discusses concepts, the development of concepts, the percept-concept sequence, reasoning in concept formation, and, errors in children's concepts. Fowler (20) traces the historical development of the study of sensorimotor processes in children and their relationship to cognitive learning and language development. Sigel (49) reviews the two major theories of concept development. He presents a thorough discussion of the "stage-dependent" theories, represented principally by the work of Piaget and Werner, and in less detail, he discusses the "learning by experience" theories, e.g., Ausubel's (2), Hunt's (25).

One basic theoretical question is whether or not cognitive development proceeds in a sequential, invariant order. Those theorists who subscribe to this point of view maintain that a child must pass through Stage 1 in his development before he can arrive at Stage 2, etc. Functioning at any given stage is dependent on the mastery of intellectual operations of the preceding stages.

Some critics of the "stage-dependent" theory of cognitive development believe that the child is a product of his learning experiences. The rate and quality of development is a function of the variety and quality of experiences, (2) (48). Another critical question that has not been answered experimentally by stage-dependent theorists, is how the transition from one period to the next occurs. The question remains open. Nevertheless, within flexible age limits, cross-sectional and longitudinal studies have supported the concept of stage-to-stage ontogenetic development of cognitive operations.

Piaget's cognitive theory starts from the central postulate that motor action is the source from which mental operations emerge. Motor action is adaptive, and Piaget's biological orientation is reflected in his assertion that intelligence is an adaptation.

Four general developmental periods or stages have been postulated by Piaget that account for the evolution of infantile sensorimotor behavior to adult abstract thinking. These stages are perhaps one of the best known aspects of Piaget's work, yet he has not been altogether consistent in the number or the names assigned them. Moreover the age ranges associated with the stages are not to be considered fixed or rigid. With these reservations, the stages are: (a) sensorimotor period, birth to about two years; (b) pre-operational period, from about two to seven years; (c) concrete operations, from about seven to eleven years; and (d) formal operations, eleven years onwards.

The first two periods are especially pertinent to the present investigation. The sensorimotor period is one in which the child develops from the simple, but adaptive, reflex-activities present at birth to more organized motor acts which allow increased mastery of objects in the immediate environment. The child functions only in the areas of perception and movement during this period. As he progresses through this stage he changes from a body-centered world to one in which he can discriminate objects as different from self. Multiple perceptions, such as vision, touch, sound, and movement are coordinated into a single concept of space. Objects--earlier responded to on the basis of their dominant sensory properties--become <u>things</u> with permanence and relationship to other things. This stage comprises a most important set of intellectual achievements.

The next stage--the pre-operational--is one in which the child moves from motoric handling of objects to symbolic thinking and reasoning about objects. This is the important period when language is acquired. The child develops the ability to utilize symbols as referents for objects. His thought, however, is still egocentric with respect to his symbolic activities. He conceptualizes on single salient features of the environment and judges things at face value. His classificatory systems are still rudimentary. The major difference between this stage and the one preceding is that the child can approach material in a symbolic way, rather than through direct motor action. As this ability develops, the child begins to think in terms of classes, to see relationships, and to handle number concepts. For example, he can disregard the shape of several objects in order to consider their number. He has thus produced a simple abstraction.

Perceptual Development

Perception plays a dominant role in concept formation. Vinacke (55) has described the process of concept formation as one of perception-abstraction-generalization.

Perception is a term difficult to define, as many authors agree. One major difficulty in definition is that the term denotes both a process and a product, that is, perceiving and percept respectively. In either case, however, perception is inferred from behavior and the conditions of behavior. Solley and Murphy (1) say:

> It is universally agreed that a physical stimulus must be present and excite some sense receptor or receptors before perception occurs. A sense receptor may be stimulated without perception occurring but perception never occurs without prior sense receptor stimulation (p. 17).

Piaget's interest in perception has been in discovering laws in perceptual development, and the difference between perceptual and cognitive functions. He regards perceptual development as essentially continuous, in contrast to the sequential stages postulated in his system of cognitive development. Wohlwill (62) has suggested that the reason for this difference is that particular logical operations have been discovered which differentiate the stages of conceptual development, while perceptual achievements appear to differ only quantitatively. A study by Gibson (21) bears out the latter point. In comparing the perceptual development of discrimination of depth to discrimination of flat graphic symbols, she found that solid objects, which possess depth at their edges, are discriminated earlier than two-dimensional pictures or line drawings. These later discriminations appear to be perceptual refinements of the edge discriminations of solid objects.

Wohlwill (62) has proposed criteria which can distinguish between perception and conception. If perception and conception are considered to be opposite poles of a continuum, one criterion for conception would be the opportunity for the subject to supplement or replace sensory data with information not present in the immediate sensory field. Conception and perception can then be related along three dimensions as follows:

1. Redundancy: As one proceeds from perception to conception, the amount of redundant information required decreases.

2. Selectivity: As one proceeds from perception to conception, the amount of irrelevant information than can be tolerated without affecting the response increases.

3. Contiguity: As one proceeds from perception to conception, the spatial and temporal separation over which the total information contained in the stimulus field can be integrated increases.

While these distinctions provide a very useful means for discriminating the two processes in persons who have gained some measure of worldly experience, the distinction is less clear when the criteria are applied to perception and conception in the human neonate. Here, Harlow's "learning set" theory (23) seems to provide insight into the problem. When an organism perceives an object, the experience results in an increased ability for the organism to perceive the object upon subsequent encounters. The intervening variable that facilitates perception is considered a learning set. Zaporozhets (65) reports a Russian study by Lisens and Venger which demonstrates that responses to objects by neonates become sharply differentiated during the first few months of life. Babies, age two to four months, were shown two three-dimensional geometric objects. All children spent approximately equal lengths of time looking at each object. Later, two objects were again presented, this time using one of the familiar objects and a new unfamiliar object. Average time of fixation on the old object was 17.4 seconds, and on the new 37.8 seconds. From these data it could not be inferred that the baby had formed a concept of the old geometric object, yet past experience apparently set up some form of mediating mechanism that allowed more rapid differentiation of the object upon the subsequent encounter. Harlow's learning set theory seems to account for this kind of phenomenon and includes the three criteria outlined by Wohlwill. Harlow does not attempt to describe the locus of the learning sets, rather he demonstrates their operation with learning curves in comparative experiments. The Russians go a step further (42) (65) and believe that upon perception of an object the human produces an internal copy of it. The copy is formed by input through the receptors with feedback through motor movements. Movements are guided by the real object, and the movements themselves are important in the perception. Perhaps the truth of the matter lies somewhere between this rather materialistic formulation and Harlow's more hypothetical one--Piaget's "reflex schema" and Hebb's "motor schema," for example. (The major difference between the latter two is that Hebb emphasizes the phenomenon of motor equivalence.) Nevertheless, the evidence suggests that such a process operates in perception and must be considered an elemental function on the percept-concept continuum.

Differences in Perception Between Cerebral Palsied and Non-Handicapped Children

Perception, then, is a necessary precursor to concept formation in young children. Moreover, since a considerable amount of research has been done concerning perceptual development in brain-damaged and cerebral palsied children, it seems appropriate to review some of the major findings. One common assumption has been that cerebral palsied children generally have perceptual deficits in most, if not all, sensory modes. Evidence shows, however, that while cerebral palsied children have general perceptual deficits as a group, there is little correlation between impairments in the various perceptual modalities.

Cerebral palsy is a general term which refers to motor dysfunction associated with brain lesions. An oft quoted, diagnostically oriented definition is Pearlstein's (44), which states that "cerebral palsy is a condition characterized by paralysis, weakness, in-coordination, or any aberration of motor function due to pathology of the motor centers of the brain." Cerebral palsy is usually of prenatal origin, but a small percentage of cases result from postnatal brain injury. Of 2,310 cases of cerebral palsy surveyed, Wolfe and Reid (63) found that it was present at birth in 90.4 percent. The balance acquired cerebral palsy after birth due to disease or accident.

After their review of the literature from 1949 to 1956, Cruickshank, Bice, and Wallen (13) pointed out that the consensus of researchers was that injury to the brain is associated with impaired performance on perceptual tasks in both the visual and tactual areas. However, since much of the research of that period was with brain-injured adults, these authors cautioned against credulous generalization of findings to children.

Their own research was designed to study non-mentally retarded cerebral palsied children and non-handicapped children on tasks designed to investigate the figure-ground aspects of perception.

Children's ages were from six to sixteen; minimum I.Q. was 75, and minimum M.A. was six years. The tasks involved visual and tactual stimuli. Children produced drawings of forms presented through those modes. To minimize the effect of impaired motor control, the restriction of minimal arm involvement was imposed on the cerebral palsied group.

Four tests which differentiated the groups were: (a) a tactual motor test in which subjects tactually scanned raised Bender-Gestalt figures on boards with and without thumb-tack backgrounds; (b) a modified Syracuse Visual Figure-Background Test, in which pictures of common objects were projected with and without patterned backgrounds of varying geometric complexity; (c) a marble board test in which subjects copied geometric designs by placement of marbles on a board, and (d) a maze learning test of the stylus-groove type. Analysis showed the cerebral palsied group to function significantly poorer on these tests. However, intercorrelation showed few significant correlations between perceptual tasks, indicating that the notion that cerebral palsied children are generally deficient in all perceptual modes is untenable.

Wendell (57) further investigated the role of visual perception in matching and placing tests. He also concluded that impairment of visual perception is not a general concomitant of cerebral palsy. One task in his study involved matchings of figures traced by a point of light. Werner and Thuma (60), in a somewhat similar task found brain-damaged children to be unimpaired in perception of real motion, but deficient in perception of apparent motion. This observation is interesting, since normal children are more susceptible to the phenomenon of apparent motion at younger rather than later ages (61). Werner theorized that apparent motion perception requires neural integration of successive stimuli, a point to be considered later in this discussion.

A study by Nielson (39) corroborates the evidence of Cruickshank <u>et. al</u>. (13) that cerebral palsied children are perceptually impaired, but that impairment is not generalized across perceptual modes. In a series of three visual-motor tasks, cerebral palsied children did poorer than controls, yet there was low intercorrelation between the tasks. His results were consistent with those of Wendell, that spastic hemiplegic children show significantly greater visual perceptual difficulties than other cerebral palsied children. Cobrinik's (12) evidence on this point is somewhat contradictory. Results of cerebral palsied children's performance on hidden figures tasks indicated that extent of brain damage, rather than locus, seemed to account for perceptual deficiency.

In the Cruickshank et. al. study (13), one test which did not discriminate between cerebral palsied and non-cerebral palsied children was one in which children tactually perceived geometrically shaped discs and then drew them (Disc Test I), and another one in which they tactually identified similar shapes (Disc Test II). It will be recalled that one criterion for inclusion in the cerebral palsied sample was motor-skill ability for figure drawing. A similar task was used in a study by Bortner and Birch (6) in which they studied cerebral palsied children's ability to reproduce and recognize WISC block designs. Their assumption was that the usual criterion, ability to reproduce a design, is not a fair test of perception since the response process requires translating percept into appropriate motor patterns. However, their results indicated a decreased ability to recognize (match) block designs with increased motor involvement. It would be interesting to test more severely involved children with the Disc Tests of Cruickshank et. al., to see if this pattern would also hold true for tactual perception. Blank (5) says that the growth of hand skills seems to be of particular importance in sensorimotor intelligence--a point also recognized by Piaget (19). From the above studies, evidence suggests, on a gross basis at least, that there is correspondence between severity of impairment of motor movement and degree of perceptual difficulty in cerebral palsied children.

In a study which investigated visual perception in greater detail, Nelson and Wise (38) found that cerebral palsied children have special difficulty with problems involving edge discriminations. The task required detecting and coursing of paths using vision alone. Cerebral palsied children were not able to detect nor course edges, nor deal with form as well as was to be expected on the basis of ability and age.

This brief review presents evidence that cerebral palsied children display certain symptoms of perceptual deficit in the visual, tactual, and kinesthetic modes, but that impairment in one mode does not necessarily mean impairment in other modes. Indeed, Birch and Leffort (4) present evidence indicating that inter-sensory modes are not strongly related even in young "normal" children. They studied the relationship between visual, haptic, and kinesthetic sense modes in children (N = 154, ages 5-11) and found that information received through one sense is not directly transduced to another sensory modality. Moreover, different age sequences were characterized by the development of intermodal equivalence among the different senses. The authors say that it can be argued that the emergence of such equivalence is developmental.

Blank (5) has proposed a "focal periods" hypothesis that could account for the development of equivalence. This hypothesis states that at certain developmental periods in infancy, the infant centers his attention and energy in developing specific sensorimotor activities. Data support this hypothesis in the development of hand skills. The author says:

> The question is then raised as to whether other sensorimotor areas (e.g., locomotion, vocalization, etc.) become focal at different ages during the infant period. There is some evidence that this does occur.

This presents an intriguing question for developmental psychology. For our purposes, though, there appears to be sufficient evidence to suggest that perceptual deficits in cerebral palsied children, while partly neurological in origin, may also be developmental in character.

Hypotheses

The relationship between sensorimotor experience and the formation of two specific kinds of basic concepts, i.e., object and action, has not been experimentally studied. Sigel (49) points out that only a few investigations, notably those of Piaget, have even studied object concept formation. Object concepts, he says, are "one of the most fundamental and taken-for-granted concepts a child has to acquire (p. 224);" and while the formation of action concepts has not been studied <u>per se</u>, it has been empirically demonstrated with picture vocabulary tests that young children can identify action as well as object concepts from an equivalent pictorial referent.

Upon investigating simple action and object concepts, there seem to be several major differences in their development. An object is structurally static, and the child can look at it repeatedly, feel it, mouth it, throw it, etc. It is external to his body. Many modes of perception can be used to develop a concept of the object. An action, on the other hand, is structurally dynamic. It consists of a complicated series of integrated muscular flexions and extensions. It is internal, and the initial perceptual mode for learning concepts for actions would seem to be proprioceptive. An action moves through space and time and is transitive. An object has permanence; and motion, while often possible, is not one of its intrinsic properties.

<u>Hypothesis I</u>

A reasonable assumption concerning the difference between perceiving actions and objects, and forming concepts of them, would be that more sensorimotor experience is required to develop action concepts than object concepts. The perceptual experience necessary for developing object concepts, and their names, is primarily visual-aural, while the experience needed to form action concepts, and their names, is primarily motor-aural. Thus, it is predicted that cerebral palsied children, because of their restricted motor experience, will identify fewer action concepts (pictorially presented) in a free choice situation than will non-handicapped children.

Hypothesis I, Summary: Cerebral palsied children will tend to develop object concepts in greater ratio to action concepts than non-handicapped children due to their lack of full range of sensorimotor experiences during the first few years of life.

Hypothesis II

The second hypothesis is that children, when faced with an age appropriate problem, will utilize predominantly either a motoric or a non-motoric mode of problem solving, depending upon their sensorimotor experience. Murray (37) introduced an idea that clarifies the matter considerably. He wrote the following formula to represent a behavioral event that is marked off by a relatively clear cut beginning and ending:

$$B.S. \rightarrow A. \rightarrow E.S.$$

> Where B. S. stands for the condition that exists at the initiation of activity; E.S. for the conditions that exist at the cessation of activity; and A for the action pattern, motor or verbal, of the organism (p. 53).

He pointed out that the word "action" could not be used for "A" in the formula because it is commonly used to refer both to movements and the effects of movements. Therefore, he introduced the term actone to denote only bodily movements as such, i.e., the mechanisms, means, ways modes. He further qualified that "action patterns are mostly of two sorts" and divided actones into: motones (muscular-motor action patterns) and verbones (verbal action patterns). "A motone is a temporal series of more or less organized muscular contractions and a verbone is a temporal series of more or less organized words or written symbols (p. 56)."

According to this reasoning, it would seem that individuals would develop modes of actone usage--

roughly on a continuum from motorically active to motorically passive--to achieve effects necessary for living.

Hypothesis II, Summary: In means-end situations, children who have been restricted in motor experience will tend to utilize non-motoric modes for their solution significantly more than less restricted children.

Hypothesis III

Proprioceptive perceptual abilities are necessary for awareness of one's own actions. Impairment of such perceptual abilities would seem to hamper or retard action concept formation. Thus, in a test of kinesthetic perception, it is predicted that the cerebral palsied group will perform more poorly than the non-cerebral palsied group.

The test to be used will be a weight discrimination test. The perception of weight, according to Russell (47) depends partly on the proprioceptive stimuli associated with movement and partly on the tactual stimuli associated with pressure, when visual stimuli associated with object size are held constant. Thus, two perceptual components, one of which is theoretically related to the first two hypotheses, are involved in this test.

Hypothesis III, Summary: Cerebral palsied children will perform significantly poorer than normal children in discrimination of weights.

METHOD

Research Design

The design is an _ex post facto_ comparison of two groups of children, one normal and one motorically handicapped. The independent variable, motor disability, will be considered to have taken effect at birth. Dependent variables will be (a) the ratio of correctly identified action concepts to object concepts, and (b) mode of concept usage, _motoric_ or _non-motoric_. The inherent short-comings of this type of design--mainly that the independent variable cannot be manipulated--are discussed by Kerlinger (31, p. 297).

Description of Sample

Originally it was proposed to draw the sample from male, middle class children who were three and four years of age, and who were attending either a cerebral palsy day care center or a kindergarten. These restrictions were to control for social class and sex differences, as well as preschool experience. This was a naive proposition.

It was soon found that three-year-olds were not good subjects. They had difficulty attending to the test material, and the examiners had difficulty in establishing rapport with many of them. Thus, it was decided to advance the age range. Difficulty in securing cerebral palsied subjects forced a change in the sex and social class restrictions. Final criteria for inclusion in the sample were:

1. The ability, both perceptual and cognitive, to respond to the example plates of the PPVT. (This restriction eliminated about one out of every three cerebral palsied children available at the centers where testing was done).

2. Enrollment in a day care cerebral palsy treatment center and/or nursery school.

The final sample consisted of two groups of 40 children, one non-handicapped and one cerebral palsied. Table I shows the characteristics of the group by age and sex.

The Test Battery

Three tests were specially constructed for use in this study. They are: (a) A Modified Peabody Picture Vocabulary Test,[1] designed to test Hypothesis I, (b) A test of Adaptive Mode, designed to test Hypothesis II, and (c) A weight discrimination test, designed to test Hypothesis III. In addition, the PPVT, Form A was administered to all subjects to establish a base for comparison of concept repertories.

The Modified Peabody Picture Vocabulary Test

This test was designed to produce an instrument that would allow either an action or object concept identification, via a pictorial referent, to one stimulus word.

Test of Adaptive Mode

A series of age appropriate means-end situations was developed, each of which could be illustrated by simple drawings, that could be solved either by a motoric or non-motoric mode of action.

Weight Discrimination Test

This test consisted of five weights which ranged from 30 to 70 grams in 10 gram increments. Weight size was constant.

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[1] The writer is grateful to Dr. Lloyd Dunn for giving permission for the test modification.

TABLE I

COMPARISON OF GROUPS BY AGE AND SEX

Group	Male	Female	Age	
			Range	Mean
C.P.	29	12	3.17-5.33	4.50
Non-C.P.	21	19	3.50-5.33	4.64

The Peabody Picture Vocabulary Test

The PPVT was used to provide a means of comparing concept repertoire of the groups. Dunn (16) says the test provides an estimate of a subject's verbal intelligence through measuring his hearing vocabulary. In addition, the pictures serve as referents for concepts, according to the definition stated earlier. The nature of the PPVT is such that cerebral palsied subjects are not handicapped by the testing procedure. (See Appendix A for a detailed description of tests.)

Testing Procedures

Tests were given in this order: (a) PPVT, Form A, (b) the Modified PPVT, (c) the weight discrimination tests, and (d) the Test of Adaptive Modes. Standard presentation was used for the PPVT, except that all subjects began with item 11, the first "action" item on the test. After each subject was tested, the examiner rated the subject on a five point Test Activity Index scale. The subject's therapist or teacher made a Degree of Disability rating - described below - and a General Activity Index rating. The latter was a five point scale similar to the Test Activity Index. Both were rating scales for gross motor activity.

Statistical Procedures

Special Groupings. Several sub-groupings of subjects provide the possibility of a more thorough analysis of the data. Tallies of the pilot study scores suggested that there might be significant differences between severely-and mildly-involved cerebral palsied children. This would be consistent with Hypothesis I. Therefore, the cerebral palsied group was subdivided as severe or mild. Criteria were as follows:

1. Severe. Subjects who were rated as having a severe disability in any limb, or moderate disability in one or both upper extremities and in one or both

lower extremities.

2. Mild. Subjects rated as mild in one or more extremities or moderate in either one or both upper or lower extremities.

Another sub-grouping, based on the activity indices was done on the following basis: (On a five point scale, the most active category was designated as (1), etc.)

1. High Activity Group: Subjects who were rated 1 or 2, on the General Activity Index, and had corresponding ratings on the Test Activity Index in any of the following combinations: 1-1, 1-2, 1-3, 2-1, 2-2. (Two-three's were excluded from both groups.)

2. Low Activity Group: Subjects who were rated 3, 4, or 5 on the General Activity Index (only one subject in total sample was rated 5), and who had the following corresponding ratings on the Test Activity Index: 3-3, 3-4, 4-3, 4-4. (Three-two's were excluded from both groups.)

This method of selection produced dichotomous sub-groups for both samples. It should be pointed out that the rating scales cannot be considered equivalent for both groups, since raters compared individual subjects with their respective groups.

Table II is a summary of ratings for the General Activity Index and the Test Activity Index. Interjudge reliability of ratings on the respective scales for each group were .48 for the cerebral palsied group, and .55 for the non-cerebral palsied group, ($p < .01$ in both cases).

Finally several analyses were made with data from the Test of Adaptive Mode by dividing groups by sexes. This division was decided upon because of the possibility that responses to the kinds of activities depicted in this test might be influenced partially by sex-typing (11) (33) (34).

TABLE II

GENERAL ACTIVITY AND TEST ACTIVITY RATINGS
BY GROUPS

General Index

Category	Group C.P.	Group Non-C.P.
1. Vivacious, very active.	8	8
2. Interested, active.	20	14
3. Cooperative, matter-of-fact.	5	9
4. Quiet, reserved.	6	9
5. Withdrawn.	1	0
	40	40

Test Index

Category	Group C.P.	Group Non-C.P.
1. Vivacious, very active.	5	5
2. Interested, active.	17	17
3. Cooperative, matter-of-fact.	11	16
4. Quiet, reserved.	6	2
5. Withdrawn.	1	0
	40	40

Interjudge reliability:

C.P. group	$r = .48$	$p < .01$
Non-C.P. group	$r = .55$	$p < .01$

Data Analysis

Data analysis was performed by a C. D. C. 1604 computer using programs developed by Dr. Donald Veldman.

Hypothesis I was tested by a multiple linear regression analysis of covariance model, and by chi-square analysis. Data from both the PPVT and the Modified PPVT were analyzed by these methods.

RESULTS

Hypothesis I

This hypothesis stated that cerebral palsied children, in comparison to non-handicapped children, would show a deficit of action concepts to object concepts in their concept repertoire, which would be related to their restricted sensorimotor experience.

PPVT analysis. Chi-square analysis[2] of the action and object errors of the main groups and two sub-groupings are presented in Table III.

III, A: Expected frequencies for the C.P. group were predicted from the non-C.P. group. Chi-square was 32.03, which is significant beyond the .01 level. The null hypothesis that the groups do not differ on the number of action to object errors made can be rejected.

III, B: Expected frequencies for the severe C.P. group were predicted from the mild C.P. group. Chi-square was 10.66. This is significant beyond the .01 level, and allows rejection of the null

[2]All chi-square computations are corrected for continuity.

TABLE III

CHI SQUARE ANALYSIS OF PPVT ERRORS

A. C.P. Group (Expected numbers from Non-C.P. Group)

Frequencies	Action Errors	Object Errors	Chi Square	*p*
Observed	137	396	32.03	<.01
Expected	88	445		

B. Severe C.P. Group (Expected numbers from Mild C.P. Group)

Frequencies	Action Errors	Object Errors	Chi Square	*p*
Observed	57	119	10.66	<.01
Expected	39	137		

C. Mild C.P. Group (Expected numbers from Non-C.P. Group)

Frequencies	Action Errors	Object Errors	Chi Square	*p*
Observed	80	277	8.62	<.01
Expected	59	298		

hypothesis that the groups do not differ on action and object errors.

III, C: Expected frequencies for the mild C.P. group were predicted from the non-C.P. group. Chi-square was 8.62. This is significant beyond the .01 level, and allows rejection of the null hypothesis that the groups do not differ on these variables.

Another sub-group chi-square comparison was done on the groups that were differentiated by the Activity Index ratings described in the preceding chapter. Results of analyses of action and object errors are shown in Table IV.

IV, A: Expected frequencies of the non-C.P. "low activity" group were predicted from the non-C.P. "high activity" group. Chi-square was 8.04, which is significant beyond the .01 level. Thus, the null hypothesis that the groups do not differ in action and object errors can be rejected.

IV, B: Expected frequencies of the C.P. "low activity" group were predicted by the C.P. "high activity" group. Chi-square was .017, and is not significant. The null hypothesis that the groups are the same cannot be rejected. There is evidence, however, that the ratings were not consistent within the total C.P. group. From Table II, it can be seen that therapists tended to rate cerebral palsied children toward the active end of the scale, while teacher's ratings of non-handicapped children were not skewed as much in that direction. In fact, it may well be that therapists were, in effect, rating two groups of cerebral palsied children, the severely handicapped and the mildly handicapped, each to their own reference group. A quick tally of ratings of the "severe" group supports this possibility. Ten subjects out of 14 in this group were given ratings in the two most active categories, whereas 18 of 24 "mild" subjects were rated in these categories. Logically, it would seem that the "severe" group should have been rated lower, had the raters been comparing those individuals with the total cerebral palsied group. At any rate chi-square analysis did not differentiate the groups.

TABLE IV

PPVT ACTION AND OBJECT ERRORS ANALYSIS
BY MOTOR ACTIVITY RATINGS

A. Non-C.P. "Low Activity" Group
(Expected numbers from Non-C.P. "High Activity" Group)

Frequencies	Errors: Action	Errors: Object	Chi Square	*p*
Observed	35	154	8.04	<.01
Expected	22	167		

B. C.P. "Low Activity" Group
(Expected numbers from C.P. "High Activity" Group)

Frequencies	Errors: Action	Errors: Object	Chi Square	*p*
Observed	29.0	94.0	.017	n.s.
Expected	29.7	93.3		

Results of chi-square analyses support the hypothesis that cerebral palsied children differ from non-cerebral palsied children in the number of action concepts they fail to identify on the PPVT. Moreover, "low active" non-cerebral palsied children differ from "high active" children in the same respect.

The multiple linear regression model of analysis of covariance was performed on the main groups and two sub-groups (Appendix B). Table V summarizes these results.

For the non-C.P. versus C.P. groups, the F-ratio is 7.69, and $P < .01$. Information about I.Q. plus group membership accounts for 21.79 percent of the variance on action errors; whereas the information about I.Q. alone accounts for 13.98 per cent of the variance. Group membership alone accounts for 7.81 per cent of the variance. Hence, group membership contributes significantly to action errors, as predicted.

Considering, now, the severe C. P. versus mild C.P. groups, the F-ratio is 7.061, and $p = .011$. This result supports the sub-hypothesis that severity of motor restriction contributes to action concept errors on the PPVT.

In the comparison of non-C.P. to severe C.P., the F-ratio is 14.707, and $p = .0006$. This further supports the hypothesis that degree of motor restriction contributes significantly to inability to identify action concepts.

Modified PPVT analysis. Chi-square analyses of the two main groups, as well as the severe C.P. versus mild C.P. groups are presented in Table VI.

VI, A: Expected frequencies for the C.P. group were predicted from the non-C.P. group. Chi-square was 20.83, which is significant beyond the .01 level.

VI, B: Expected frequencies for the severe C.P. group were predicted from the mild C.P. group. Chi-square was 2.20, which was not significant.

TABLE V

PPVT

MULTIPLE LINEAR REGRESSION ANALYSIS OF COVARIANCE

Groups	R^2 full	R^2 restricted	R^2 difference	F-ratio	p
Non C.P. vs. C.P.	.2179	.1398	.0781	7.695	.001
Severe C.P. vs. Mild C.P.	.1640	.0000	.1640	7.061	.011
Non C.P. vs. Severe C.P.	.3548	.1790	.1757	14.707	.001

TABLE VI

MODIFIED PPVT ACTION AND OBJECT CHOICE ANALYSIS

A. C.P. Group
(Expected numbers from non-C.P. Group)

Frequencies	Action	Object	Chi Square	p
Observed	261	448	20.83	<.01
Expected	322	387		

B. "Severe C.P. Group
(Expected numbers from "Mild" C.P. Group)

Frequencies	Action	Object	Chi Square	p
Observed	81	160	2.20	n.s.
Expected	93	148		

These analyses indicate that the null hypothesis that the non-C.P. and C.P. groups are alike in action and object choices on the Modified PPVT can be rejected, but that the null hypothesis that the severe C.P. and mild C.P. groups are the same in this respect cannot be rejected.

Multiple linear regression analysis of covariance was performed on the main groups and two sub-groupings. Table VII summarizes the results.

Analysis of the non-C.P. vs. C.P. groups produced an F-ratio of 3.623, and p = .0576. Information about I.Q. plus group membership accounted for 16.85 per cent of the variance on the action-object choice ratio, while the information about I.Q. alone accounted for 12.89 per cent of the A/O variance. Hence group membership alone accounted for 3.96 per cent of the variance. This approached significance at the .05 level.

In the analysis of severe C.P. versus mild C.P., p = .6130. Group membership contribution to A/O variance was not significant. Likewise, in the analysis of non-C.P. versus severe C.P., p = .6220, and group membership contribution to A/O variance was not significant.

Comparison of results of similar analyses of covariance on the PPVT and Modified PPVT indicates that the PPVT was a more powerful discriminator between the groups. The PPVT results support the hypothesis, and the non-C.P. versus C.P. analysis of the Modified PPVT, while not significant at the accepted .05 level, is close enough to lend some support to the hypothesis.

Hypothesis II

This hypothesis stated that children in this age range would utilize predominately motoric or non-motoric modes of handling means-ends situations, depending upon their sensorimotor experience.

Table VIII summarizes the chi-square analyses of the main groups and two sub-groupings of the subjects with respect to problem solution modes.

TABLE VII

MODIFIED PPVT

MULTIPLE LINEAR REGRESSION ANALYSIS OF COVARIANCE

Groups	R^2 full	R^2 restricted	R^2 difference	F-ratio	p
Non-C.P. vs. C.P.	.1685	.1289	.0396	3.623	.057
Severe C.P. vs. Mild C.P.	.0186	.0113	.0073	.269	.613
Non-C.P. vs. Severe C.P.	.1698	.1575	.0123	.802	.622

TABLE VIII

CHI SQUARE ANALYSIS OF TEST OF ADAPTIVE MODES

A. C.P. Group
(Expected numbers from Non-C.P. Group)

Frequencies	Mode		Chi Square	p
	Motor	Non-motor		
Observed	140	140	20.46	<.01
Expected	177	103		

B. C. P. Group, Males
(Expected numbers from Non-C.P. Group, Males)

Frequencies	Mode		Chi Square	p
	Motor	Non-motor		
Observed	96	100	12.96	<.01
Expected	121	75		

C. C. P. Group, Female
(Expected numbers from Non-C.P. Group, Females)

Frequencies	Mode		Chi Square	p
	Motor	Non-motor		
Observed	44.0	40.0	5.00	<.05
Expected	53.3	29.7		

VIII, A: Expected frequencies for the C.P. groups were predicted from the non-C.P. group. Chi-square is 20.46, and p is less than .01. The null hypothesis that the groups do not differ on this variable can be rejected.

VIII, B: Expected frequencies for C.P. males were predicted from non-C.P. males. Chi-square is 12.96, and $p < .01$. The null hypothesis can also be rejected that the groups do not differ.

VIII, C: Expected frequencies for C.P. females were predicted from non-C.P. females. Chi-square is 5.00, and p is less than .05.

These results support the hypothesis that motorically active children choose more motoric modes in solving means-end problems than motorically less active children. Females, perhaps, differ less in this respect than males. The results do not indicate whether the adaptive modes are preferrential or developmental.

Hypothesis III

This hypothesis stated that the cerebral palsied group would show a deficit in kinesthetic perception. The weight test used involved tactile perception and perception of movement. Analysis of variance produced an F-ratio of 36.523, p = .00. Group discrimination means were 11.50 grams for the non-cerebral palsied group, and 21.75 grams for the cerebral palsied group. These results support the hypothesis.

In summary, the analyses of data support the three major hypotheses of this study. Cerebral palsied children are deficient in perceptual motor ability. They do not develop concepts of actions in the same ratio to object concepts as children who are not motorically handicapped. Lastly, they tend to resolve means-end situations by activity modes that involve less overt motoric action than non-cerebral palsied children.

DISCUSSION

In general, it appears that the hypotheses offered, and their rationale, provide a relatively complete account for the data. The major conclusion that can be drawn is that the results of this study support, in several ways, the currently popular theories that sensorimotor experience in infancy is one of the main factors in concept development. Data from both the PPVT, and the Modified PPVT, which were conceptually independent of one another, showed the same kind of contrast between the groups on the action-object concept dimension. Motorically active children apparently develop more total concepts, as well as a higher ratio of action to object concepts than less active children. Perhaps the most reinforcing evidence for this conclusion was the chi-square analysis of the PPVT which indicated that high-active normal children differ significantly from low-active normals in the action-object error ratio.

This finding suggests that, in addition to neurological factors, sensorimotor experience is also a major factor in intellectual development of cerebral palsied children. Moreover, it appears there is a difference between severely and mildly involved cerebral palsied children with respect to concept learning. Educational implications of this finding will be discussed later.

Certain limitations were inherent in this investigation. The study, which appeared to be of reasonable size in the beginning, almost turned out to be too big to handle properly. It was difficult to keep the test battery within the known physical limits of the cerebral palsied group. Too much was attempted, and as a result, the Test of Adaptive Mode, especially, was too limited in scope. Moreover, it was discovered after the data had been collected that two of the items were not theoretically "clean." Items four and five, quite literally, are reversals in the adult-child roles. Because of this, the validity of the test is reduced. Moreover, the test was quite short, and it would have been desirable to have had more items.

The sample itself was rather small. Difficulty in securing cerebral palsied subjects forced certain limitations on the sample that were not desirable. For one thing, the assumption had to be made that treatment and pre-school training was approximately equivalent across treatment centers. Also it would have been preferable to match the subjects more closely in such variables as educational training, sex and parental background.

The Modified PPVT apparently has too many flaws to bother with trying to improve it. The rationale underlying the test was that in a free choice situation the child would choose the picture representing the most potent concept associated with the stimulus word. Theoretically, children who had had more motoric experience would choose more action pictures than those who had been restricted in motor activity. However, observation of subjects' search patterns indicated that some chose the first correct picture they saw. Moreover, some scanned from the bottom of the page up, while some scanned from left to right. It was further observed that some children apparently focused on the object within the action pictures, where such objects existed. On the sample item "nail," for example, some pointed to the small nail in the fence. Thus, while the subject was scored an action choice, he had actually searched out an object. The modified PPVT, therefore, has too many internal sources of error.

Analysis has shown the standard PPVT to discriminate a cerebral palsied group from a non-cerebral palsied group on action concept errors. Considering that only about 20 per cent of the items for preschool children are action items, it would seem that a very powerful test for this kind of discrimination would result if action items on Forms A and B of the test were combined, and a corresponding number of object errors were eliminated. Such a test would then contain about 40 per cent action items, and should be more sensitive to the effects of sensorimotor restrictions in early childhood.

The ex post facto research design, as pointed out by Kerlinger (31), is often inadequate in studying cause-effect relationships. Certain assumptions must be made that cannot be proved. In this study, the assumption of limitation of motor experience, while acceptable on a gross basis, was not open to quantitative measures or qualitative estimates during the period when the variable was theoretically most operative.

Finally, the study would have certainly provided richer information for analysis had medical diagnoses of the cerebral palsied children been made at the time of testing. Unfortunately, this provision was not possible within the scope of this study. It would be interesting to study the interactive effect between neurological damage and restricted sensorimotor experience on intellectual development of cerebral palsied children.

IMPLICATIONS

While little research has been done on the formation of action concepts, in contrast with the abundant concept formation research concerning objects, number, color, form, etc., the role of action in concept formation has certainly been recognized. A quote from Flavell (19) tells of Piaget's views on the subject.

> According to Piaget, action performed by the subject constitutes the substance or raw material of all intellectual and perceptual adaptation. In infancy, the actions...are relatively overt, sensory-motor ones....With development, intelligent actions become progressively internalized and covert....Thus, the overt, slow-paced <u>actions</u> of the neonate eventually get transformed into lightening-quick, highly organized systems of internal operations. Cognition is at all genetic levels a matter of real actions performed by the subject (p. 82).

The results of this study support Piaget's position, for they have shown that sensorimotor experience is directly related to concept learning in general, and action concept learning in particular.

One educational implication of this study is that severely involved cerebral palsied children might profit from a specially designed education program. Often there is little differential classroom treatment for them in the pre-school program. Yet, on the basis of results of this study, special provisions for perceptual learning seem in order. Kaspar and Schulman (28) have shown, for example, that brain-damaged children could be trained to reduce a specific perceptual error. Training involved, among other things, the addition of stimuli in an additional sensory mode. Burrows (9) found that cerebral palsied children showed improvements of 20 per cent to 70 per cent in body image after an intensive sensorimotor training program in which they moved and touched various parts of their body with paired visual and verbal cues. Such an educational program would, of course, be analogous to the experimental treatment suggested for the infant group. The difference would be that <u>concept</u> learning would be stressed for the older group, <u>perceptual</u> learning for the infants.

A new use of the Peabody Picture Vocabulary Test is also suggested. On a group basis, it could be used to test progress in action concept learning for children up to M.A. of six years, especially if the action to object item ratio were doubled, as outlined earlier.

SUMMARY

This study attempted to answer two questions: (a) Is there a relationship between sensorimotor experience in early childhood and concept formation, and (b) are there modes--motoric and non-motoric--by which children employ concepts in means-end situations? A comparative study was designed in which two groups of children were compared for acquisition of simple action and object concepts. One group was motorically handicapped (cerebral palsied); the other was not. N = 40 in each group; mean age was 4.57 years. The independent variable, motor disability, was considered to have taken effect at birth.

Three hypotheses were tested. The first was that handicapped children would show a deficit of action concepts in their concept repertoire, which would be related to their restricted sensorimotor experience. The second was that the children would predominantly utilize a motoric or non-motoric mode of dealing with means-ends situations. The third was that the handicapped group would show deficits in tactile and motion perception.

The Peabody Picture Vocabulary Test (PPVT) was administered to provide a comparative estimate of concept repertoire. To test Hypothesis I, the PPVT was used, and in addition, a Modified PPVT was constructed. The latter consisted of 20 plates in which the subject had a choice of two correct answers--one an object, the other an action -- out of four pictures. Tests were scored for action and object choices. Analysis was by a multiple linear regression model of analysis of covariance in which PPVT I.Q. scores were allowed to covary with PPVT action errors in one analysis, and with Modified PPVT "action" choices in another. This allowed the exposition of the relationship between sensorimotor experience and action concept formation. Another analysis was done by chi-square comparison of action/object choice totals on the standard PPVT. Results of both methods supported the hypothesis. Hypothesis II was tested by using a newly designed Test of Adaptive Mode (TAM). It consists of a series of illustrated situations, common to children of this age, which can be resolved by either a motoric or non-motoric mode of action. Chi-square analysis supported the hypothesis. Hypothesis III was tested by using a weight discrimination test. Size of weights was constant, which limited discrimination to proprioceptive cues of touch and movement. Empirical tests established the J.N.D. of normals at 10 grams. Analysis of variance showed the groups to differ significantly, confirming the hypothesis.

Limitations of the study were discussed. Conclusions were that, in general, the study supports the theoretical position that sensorimotor experience in early childhood is a necessary precursor to concept formation (e.g., Piaget's). For cerebral palsied children, sensorimotor experience, along with neurological factors, is a major factor in intellectual development.

Educational implications, based on a multiple-mode stimulus hypothesis, for severely cerebral palsied children, were discussed.

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APPENDIX A

TEST DEVELOPMENT

MODIFIED PEABODY PICTURE VOCABULARY TEST

Based on idea that a young childs' concepts are directly related to the motor component associated with his experience with specific actions or objects from which a concept is derived, it was decided to produce a test that would allow the subject either an action or object concept identification to one stimulus word. Certain plates of the PPVT were modified so that there would be an action picture and an object picture for each word.

One criterion for this test was that it should be simple enough for any child to do with few errors who could produce an I.Q. score on the PPVT. About 35 plates were constructed. These were judged for level of difficulty and face-validity, and thirteen plates were eliminated.

A pilot study was conducted using the remaining 22 plates. Afterwards, two more plates were discarded in which the object pictures failed to elicit any responses. Some revision of a few of the remaining 20 plates was necessary to provide more appropriate object pictures and decoys. For example, the stimulus word to item 10 was <u>food</u>. The object picture was originally a hot dog, but was changed to a piece of pie when the hot dog failed to elicit many responses. The final version consisted of 21 plates, four pictures each. One was an example for acquainting the subject with the task, the rest were test items. Instructions for the Modified PPVT were given as follows:

> "Now we are going to look at some more pictures, and this time there will be <u>two</u> pictures for each word. When I say a word, I want you to find the picture with the word in it. Look at this one." (The example plate is presented.) "Now show me <u>nail</u>." When the subject makes his choices the examiner responds by saying, "Yes, here is a nail, and here is a boy nailing." Plate 1 is then presented and the examiner says, "Now show me ball," and so on through the 20 items.

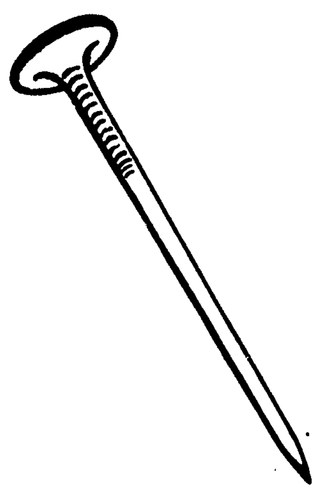
Modified PPVT Items Response Key Words

Example: Nail

1.	Ball	(4,1)
2.	Iron	(2,3)
3.	Chop	(3,2)
4.	Pet	(2,3)
5.	Peel	(1,2)
6.	Ring	(4,2)
7.	Break	(2,3)
8.	Buckle	(2,4)
9.	Wagon	(1,3)
10.	Food	(2,4)
11.	Fish	(1,4)
12.	Sweep	(1,4)
13.	Shovel	(4,1)
14.	Fly	(1,4)
15.	Play	(2,4)
16.	Tie	(2,3)
17.	Brush	(1,2)
18.	Sew	(1,4)
19.	Plug	(2,3)
20.	Fight	(4,2)

Numbers in parentheses indicate correct action and object responses.

EXAMPLE



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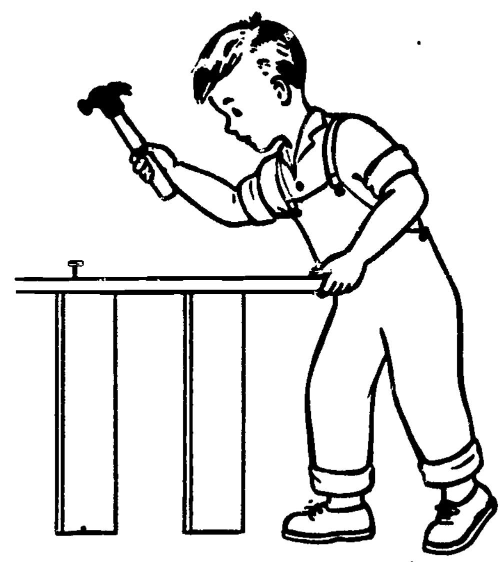

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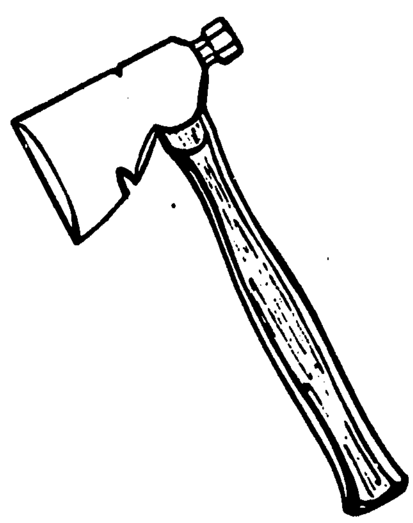

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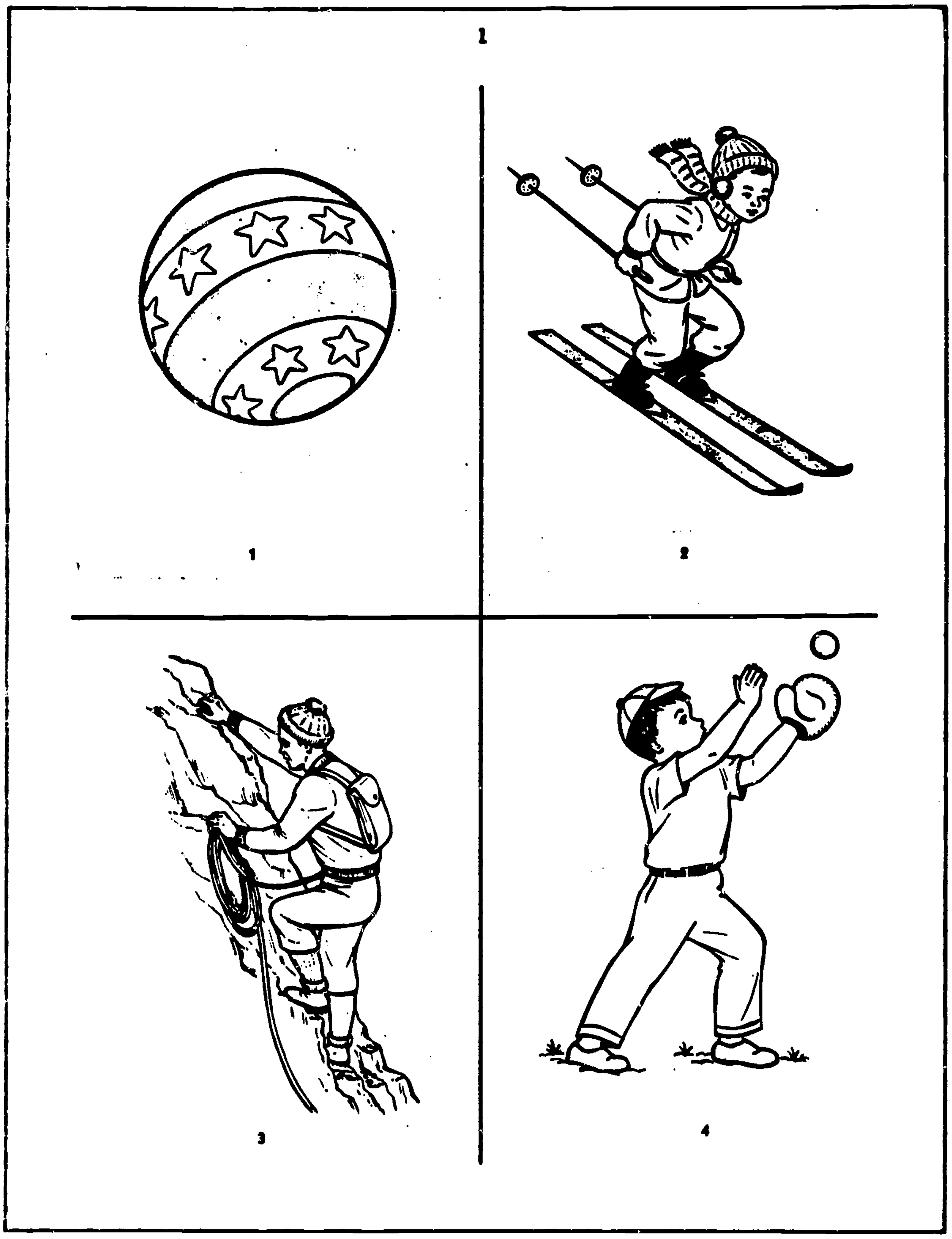
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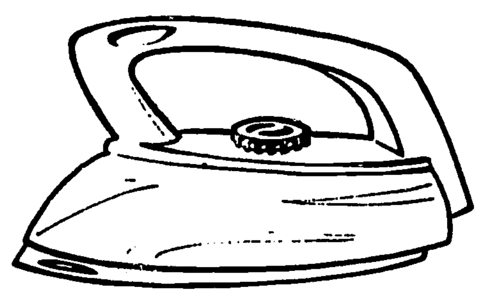

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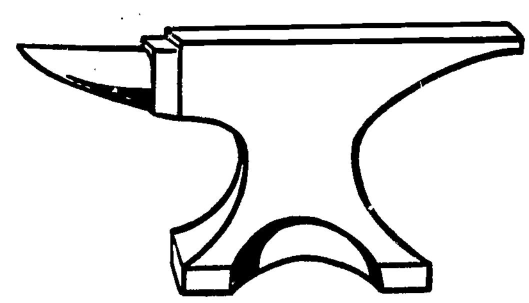

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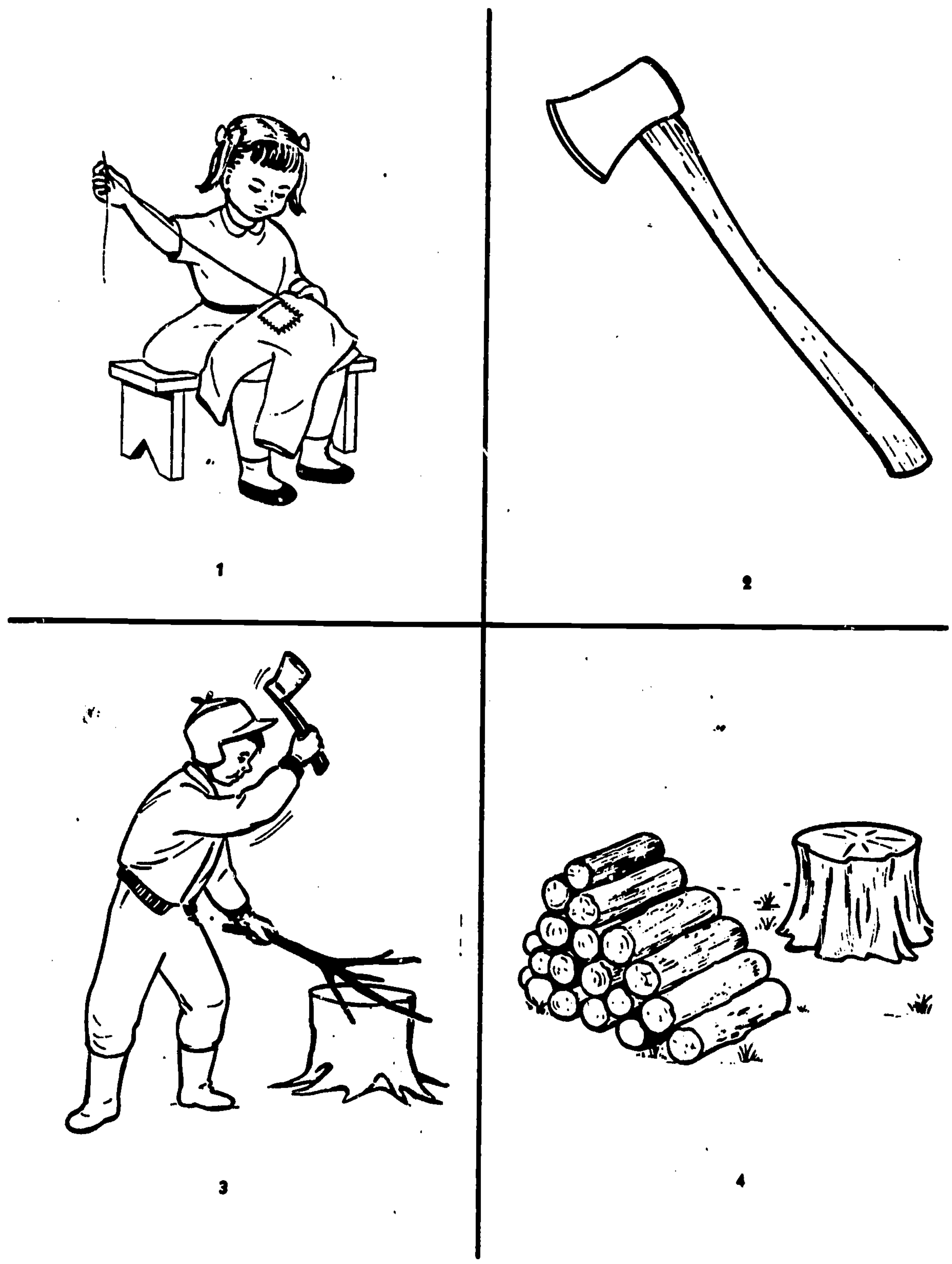

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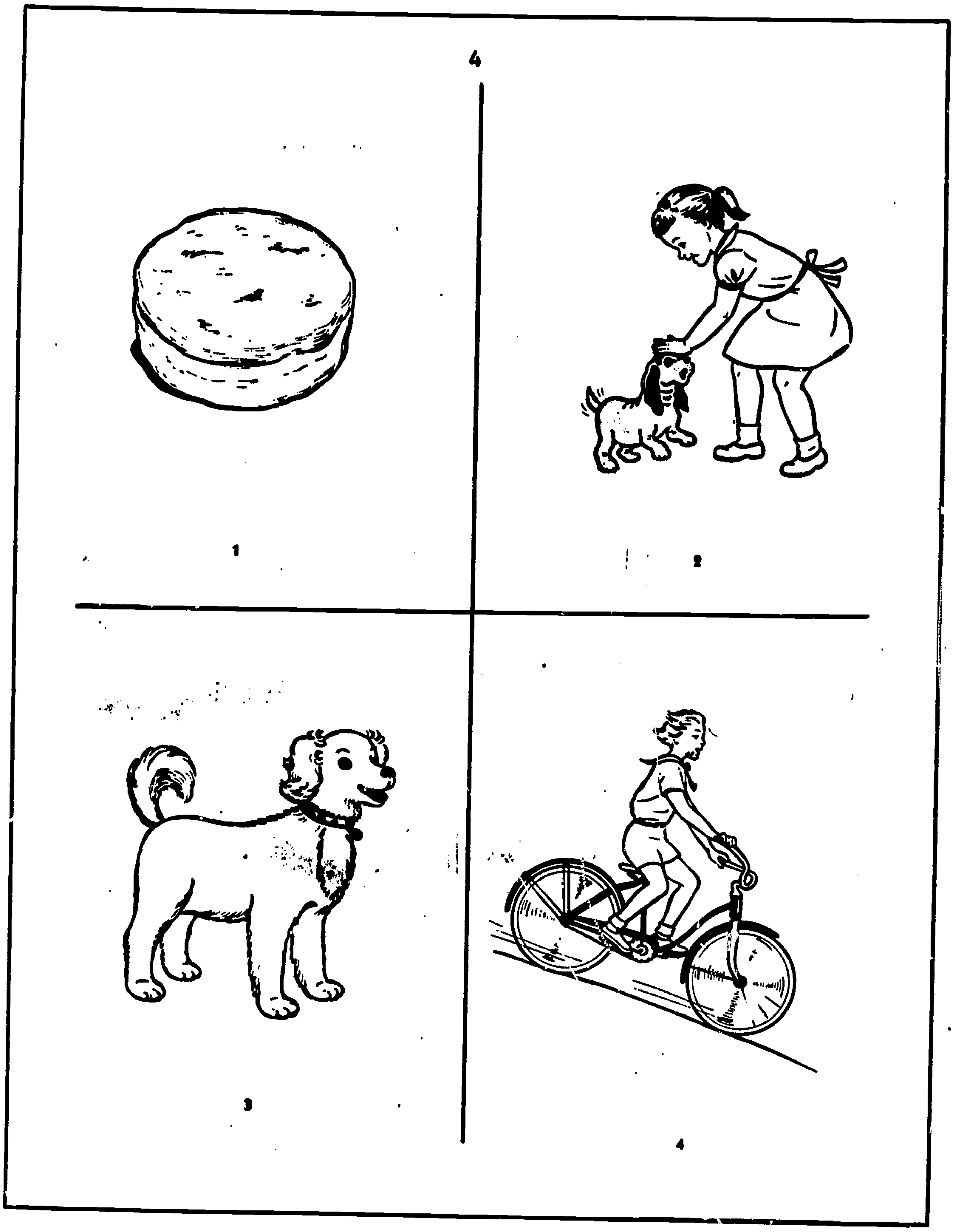
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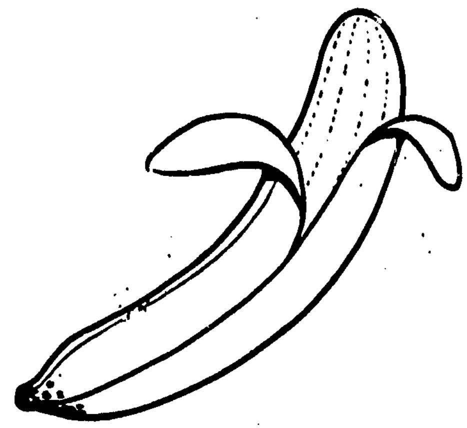

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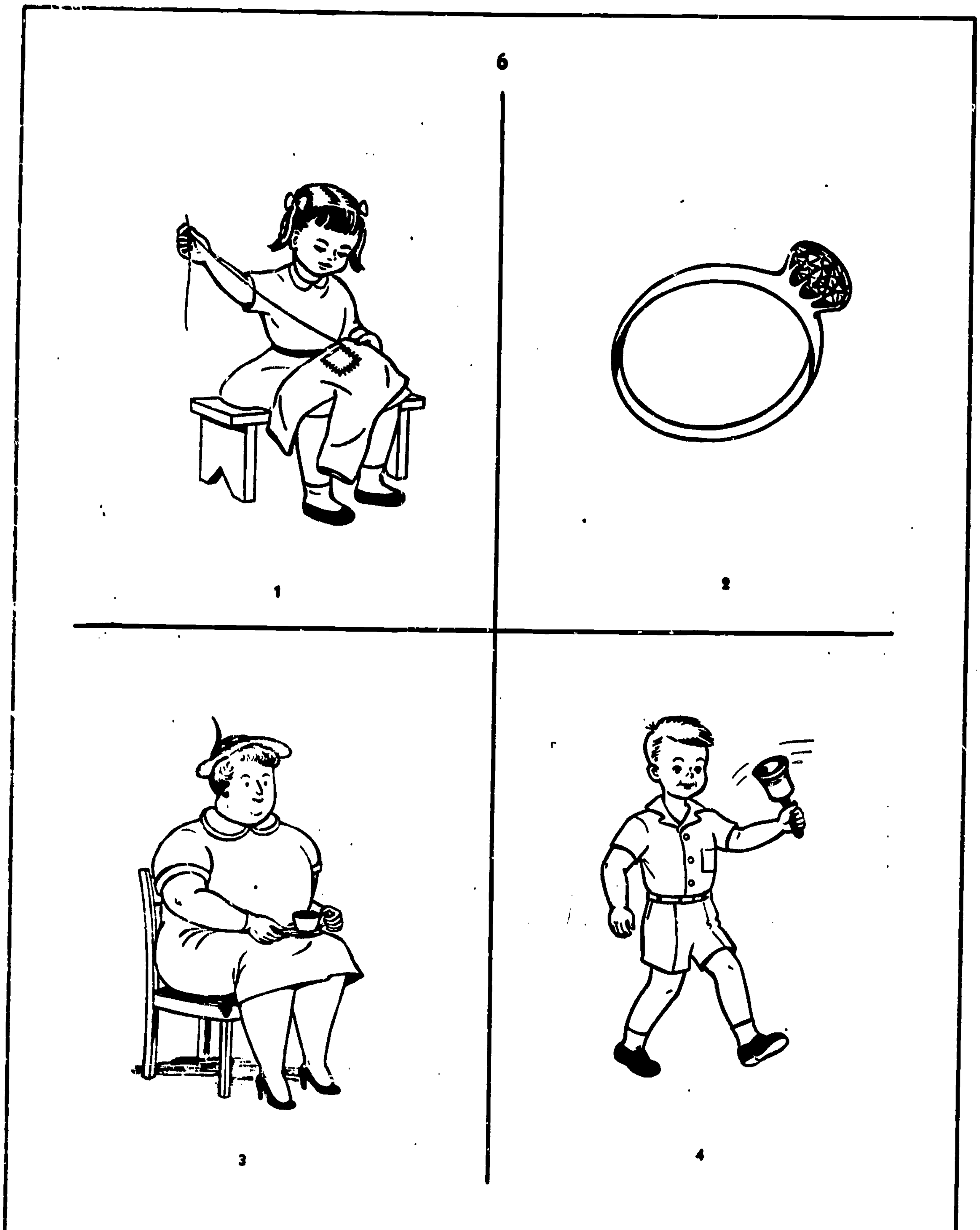
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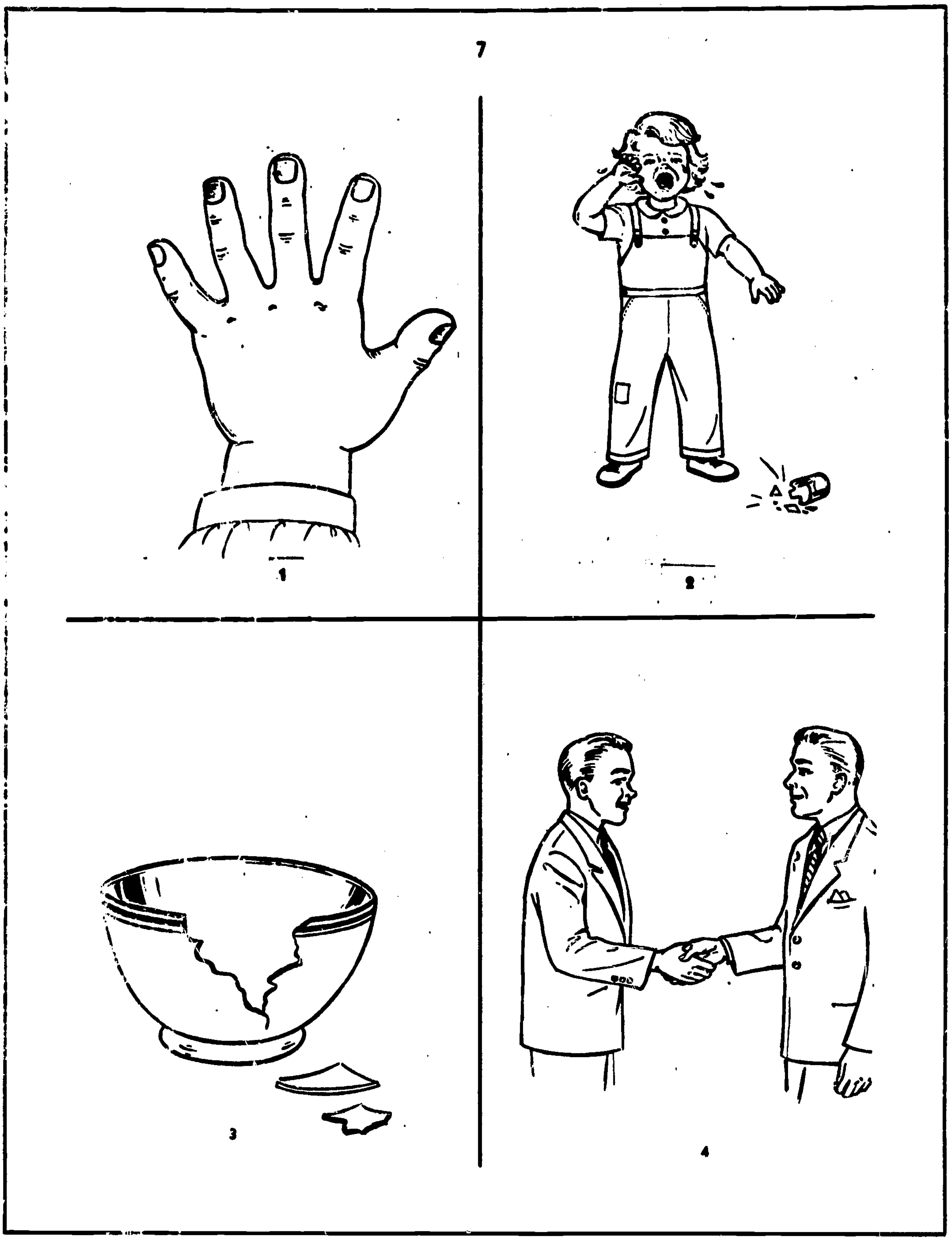
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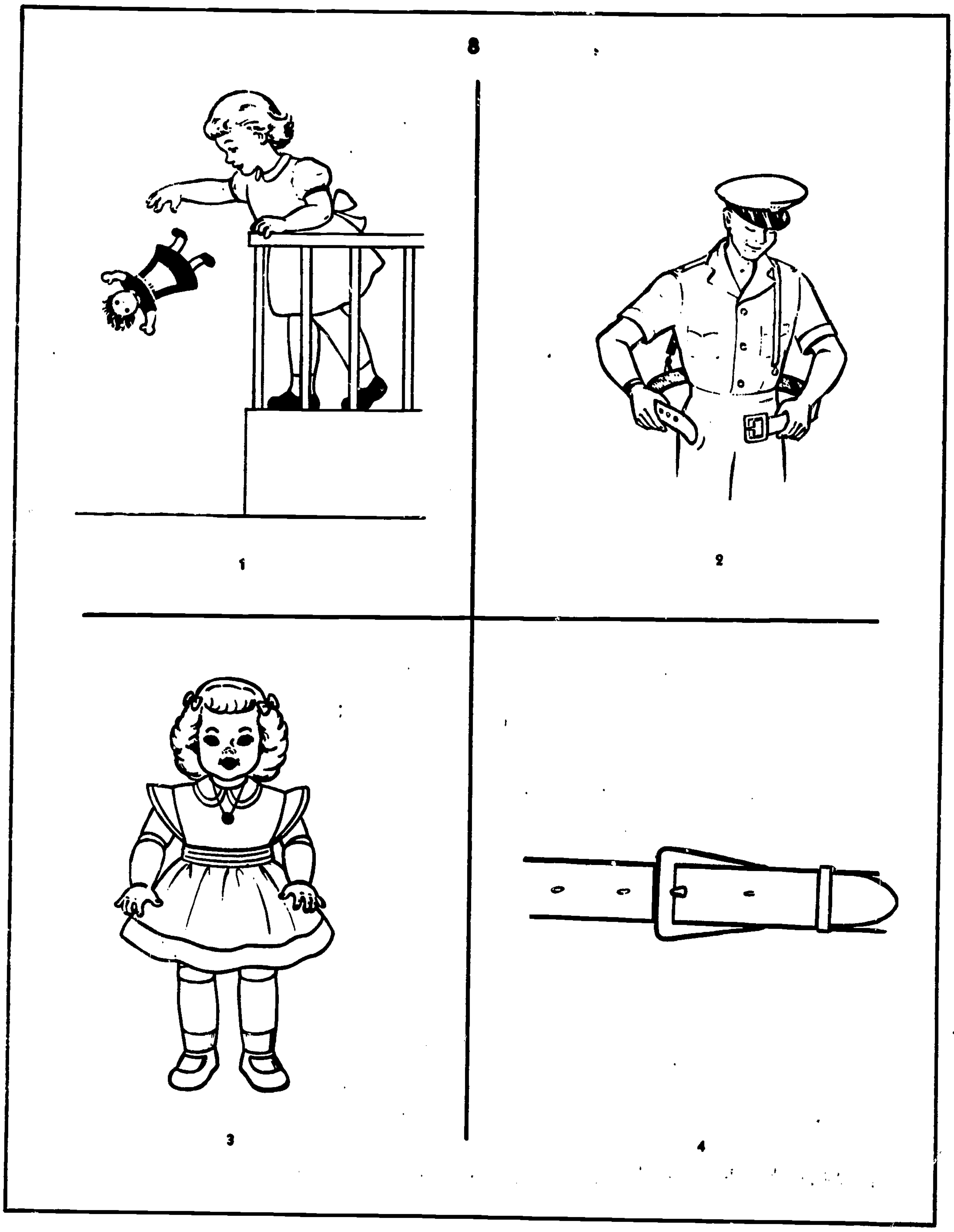
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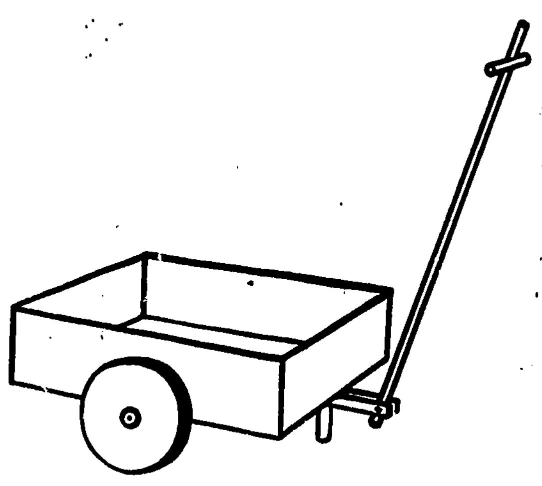

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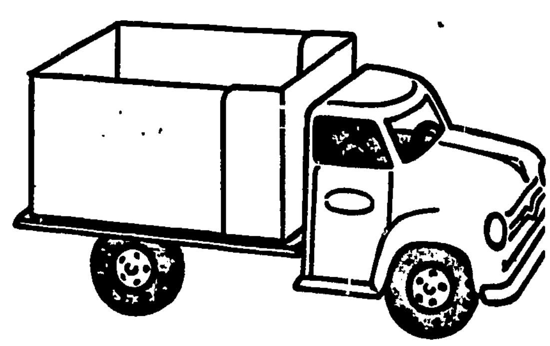

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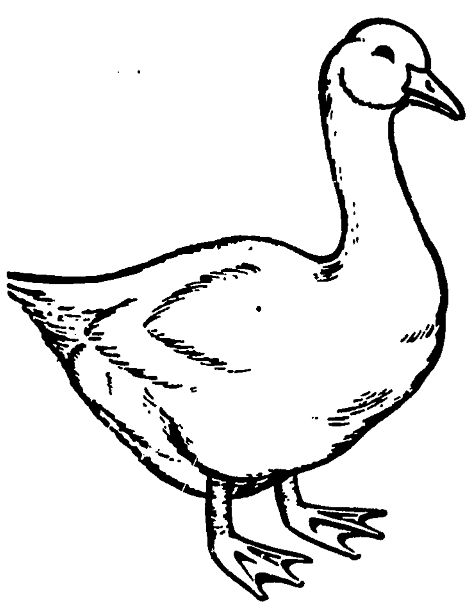

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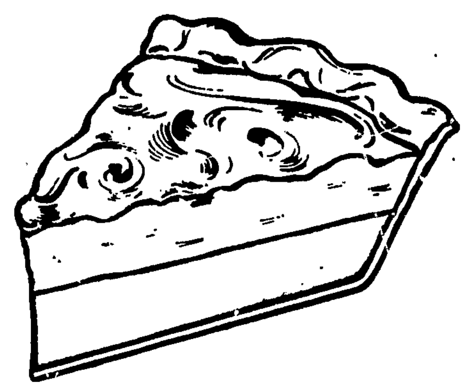

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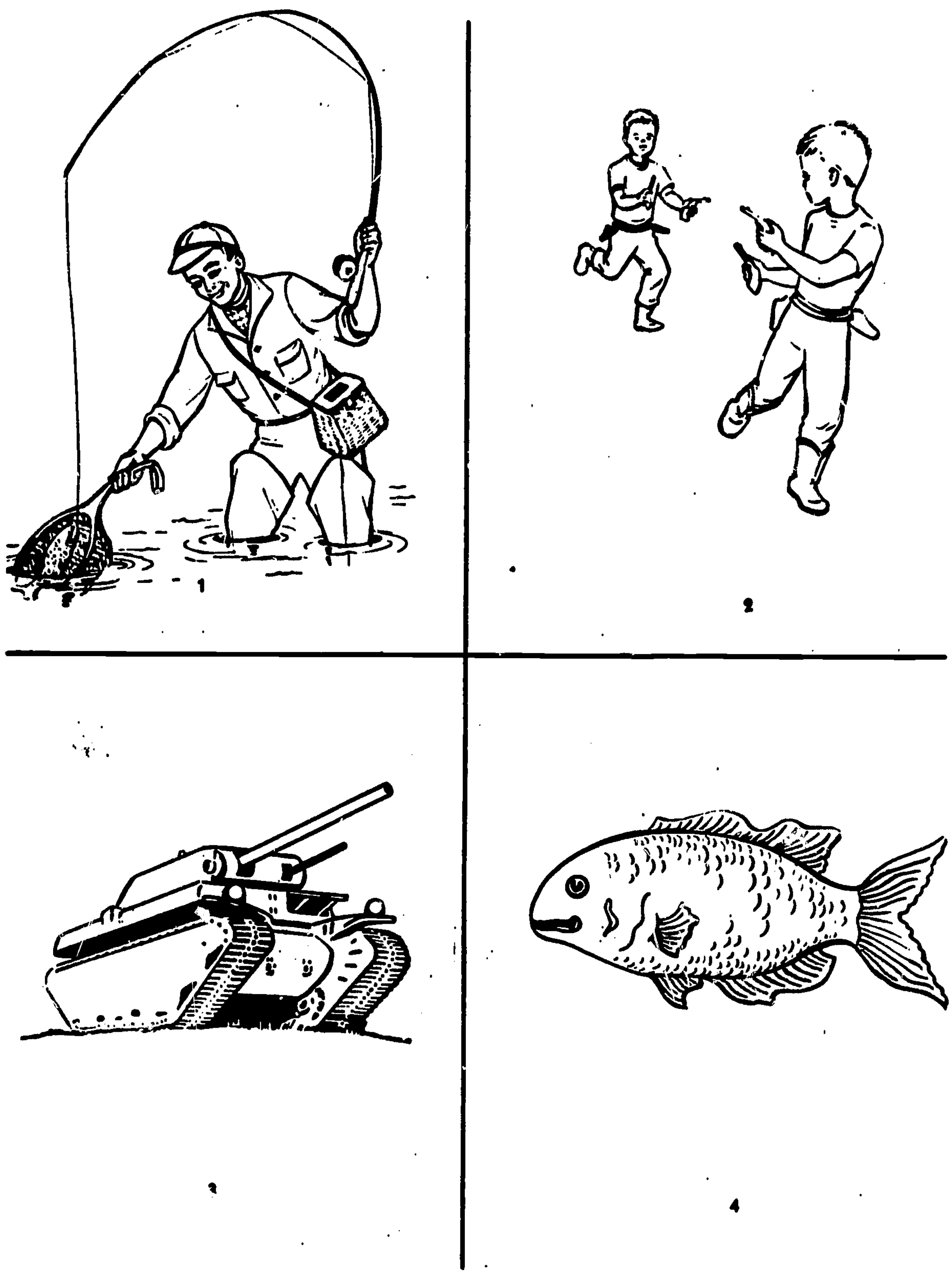


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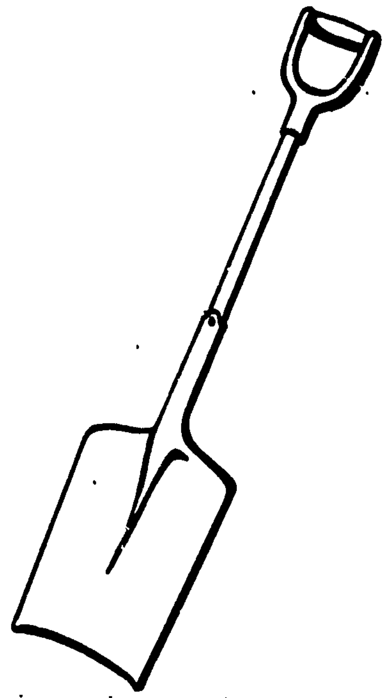

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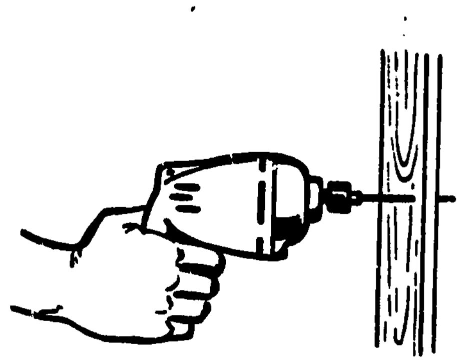

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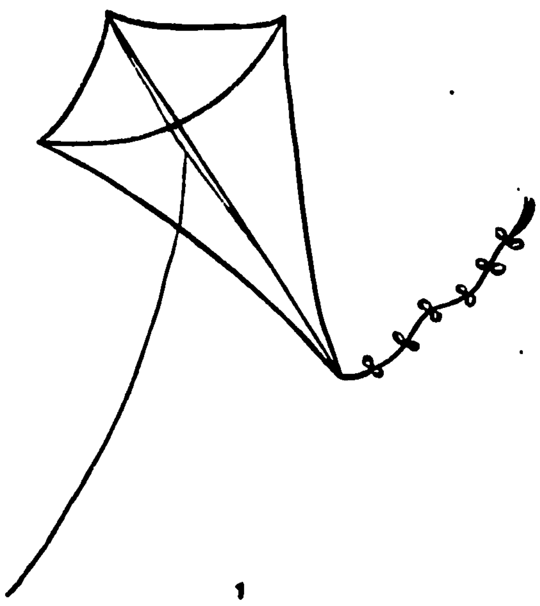

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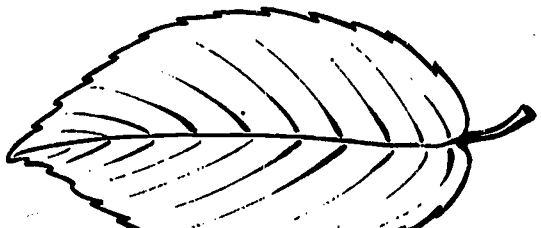

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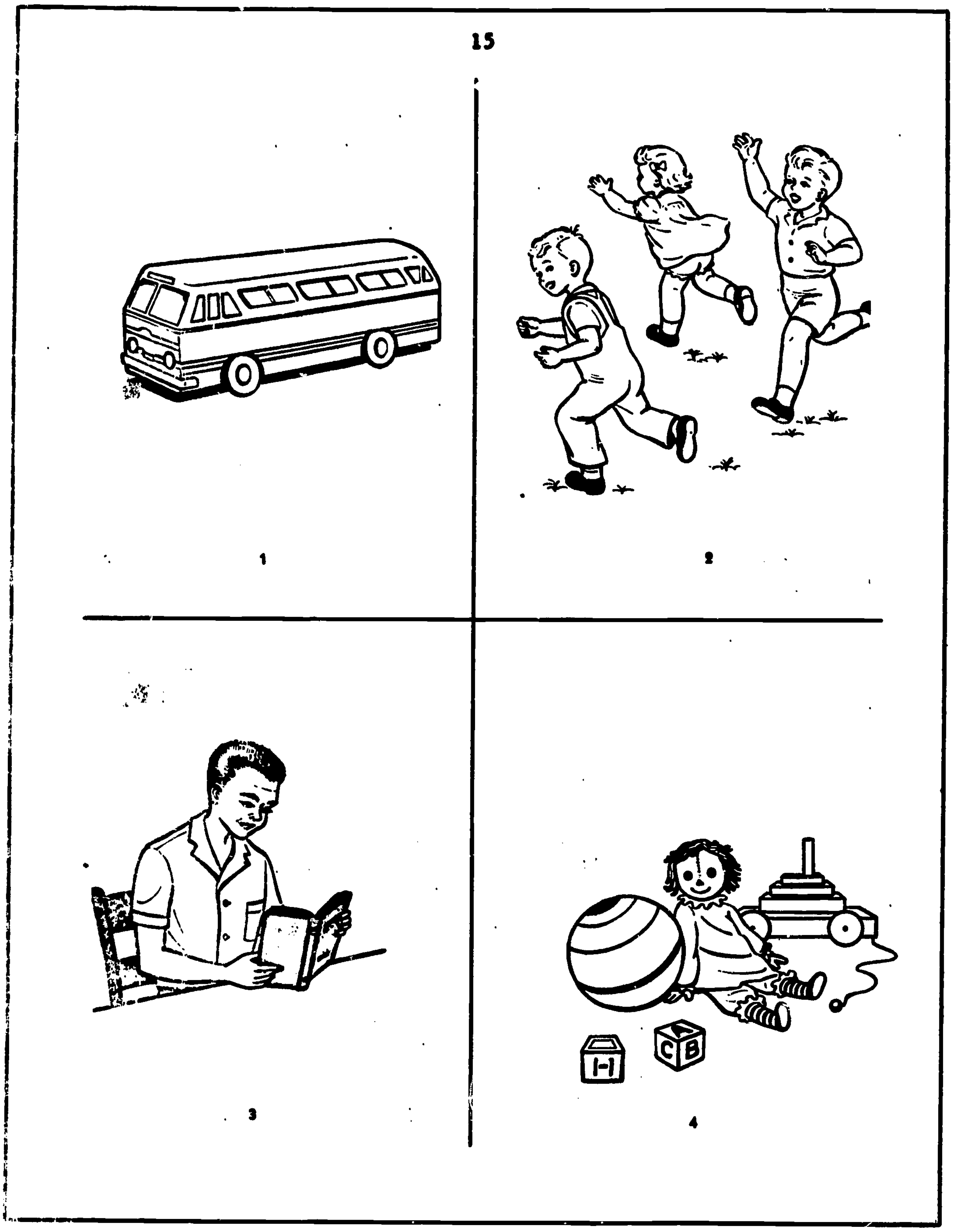
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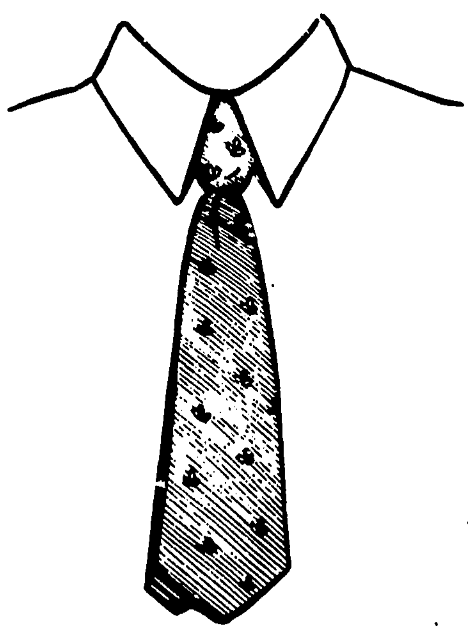

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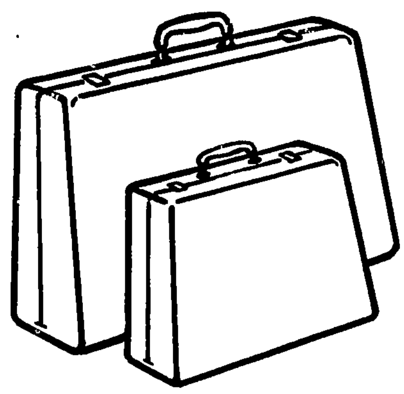

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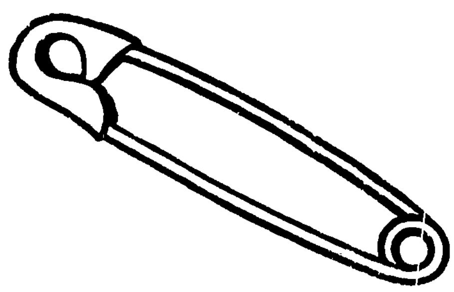

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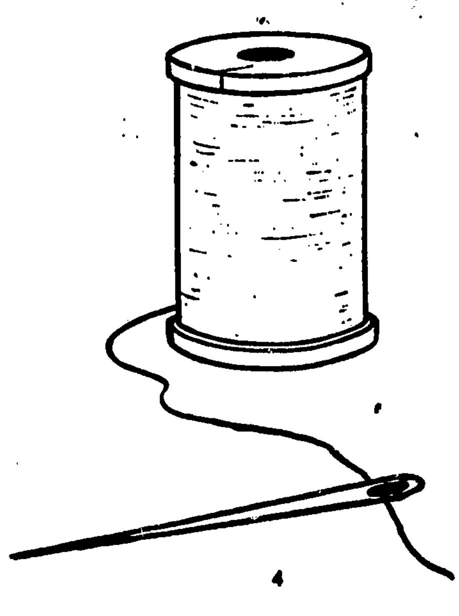

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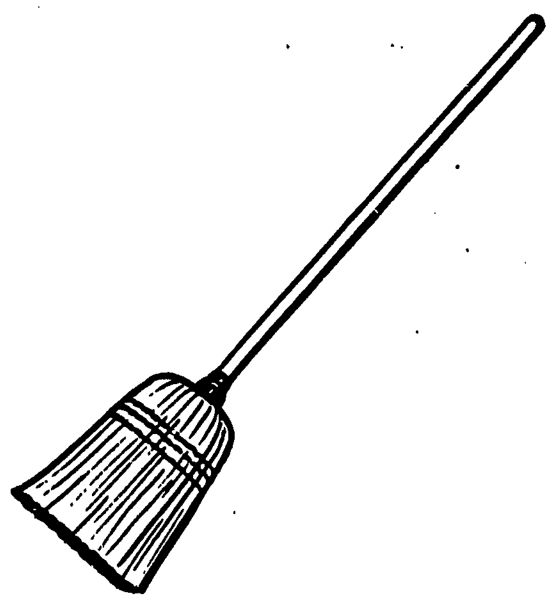

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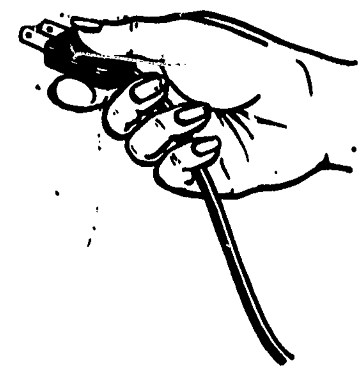

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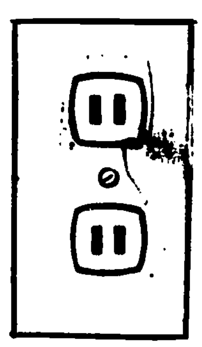

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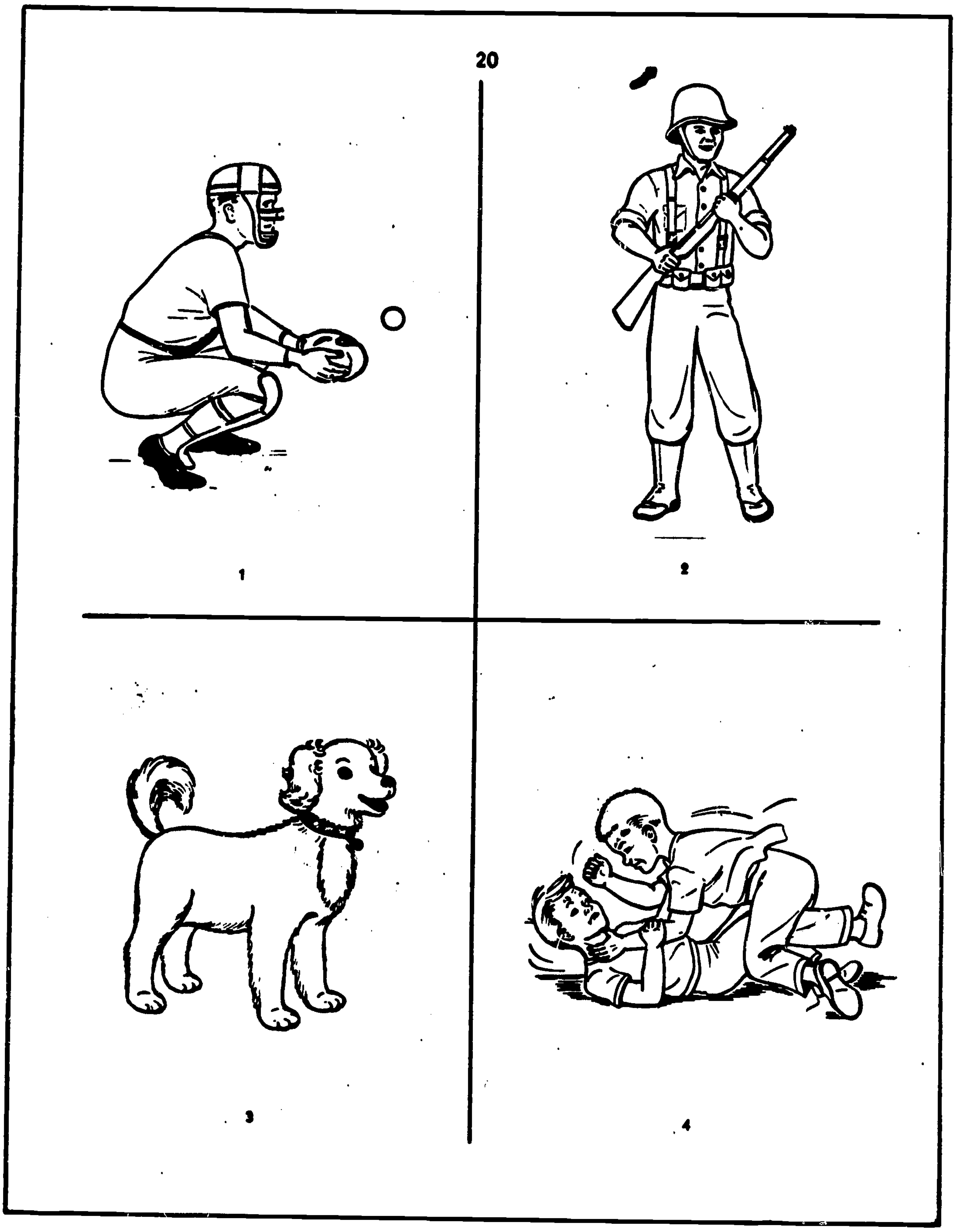
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TEST OF ADAPTIVE MODE

The rationale underlying this test is that a child will tend to solve means-end situations either by a motoric or non-motoric mode of action, depending on his gross motor experience. Therefore, a series of such situations were developed which could be resolved by either mode. Criteria for final selection of situations were:

1. The situation could not be one that was considered excessively prohibited in middle-class homes.

2. The situation should be common to the age range of the children in the sample.

3. The situation should be equally applicable to both sexes so as to eliminate as much sex bias as possible.

Seven situations were judged by a panel of psychologists as adequately conforming to the criteria. Illustrations of these were drawn by an artist and copies used in the tests were watercolored. Each situation consisted of four cards, 4½" X 6".

Instructions for the TAM were these:

"Now I am going to show you some more pictures." The first card of Situation I is presented. Directions for each situation are:

<u>Situation I</u>

Card 1. "Here is a little boy who wants to go outside, but look, (pointing to latch) the door is locked and he can't reach the lock.

Card 3. "But look here; now he is outside. I wonder how the door got unlocked.

Card 2a. "Did he push a chair to the door and get up and unlock it himself, or

Card 2b. "Did he get his mother to unlock it for him? You tell me how the door got unlocked."

Situation II.

Card 1. "Here is a little girl who needs to have her coat on.

Card 3. "Now she has her coat on. We need to find out how.

Card 2a. "Did she get her mommy to put it on for her, or

Card 2b. "Did she put it on herself? You tell me how."

Situation III.

Card 1. "Here is a boy who wants a drink of water, but he can't reach the faucet.

Card 3. "Now he has his drink of water. I wonder how.

Card 2a. "Did he climb up on the chair and get it himself, or

Card 2b. "Did he ask his mother to get it for him? You tell me how."

Situation IV.

Card 1. "Here is a 'daddy' who needs his shoes.

Card 3. "Now he has them on. I wonder who got them.

Card 2a. "Did he go and get them himself, or

Card 2b. "Did his little girl get them for him? Tell me how."

Situation V.

Card 1. "Here is the paperboy throwing the paper.

Card 3. "Now, here is 'mommy' inside the house reading the paper. I wonder who got the paper.

Card 2a. "Did her little boy get it for her, or

Card 2b. "Did she get it herself? You tell me how."

Situation VI.

Card 1. "Here is a little girl who needs to have her coat buttoned.

Card 3. "Now, it is all buttoned up. How did her coat get buttoned?

Card 2a. "Did she get her mommy to button it for her, or

Card 2b. "Did she button it herself? Tell me how the coat got buttoned."

Situation VII.

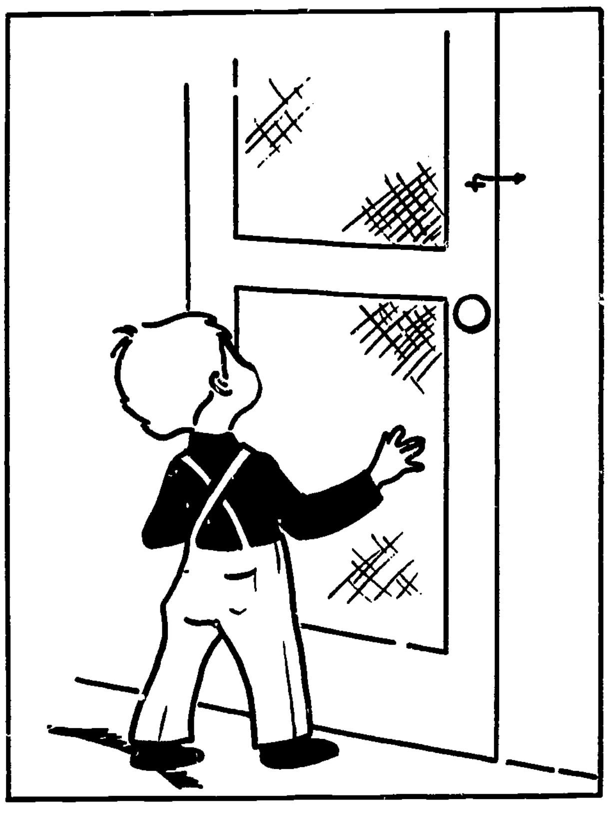
Card 1. "Here is a little boy who is ready to eat dinner. Here is his food, and here is his glass of milk (pointing).

Card 3. "Now he is all finished. His plate is clean and his glass is empty. We want to find out who fed him.

Card 2a. "Did he feed himself, or

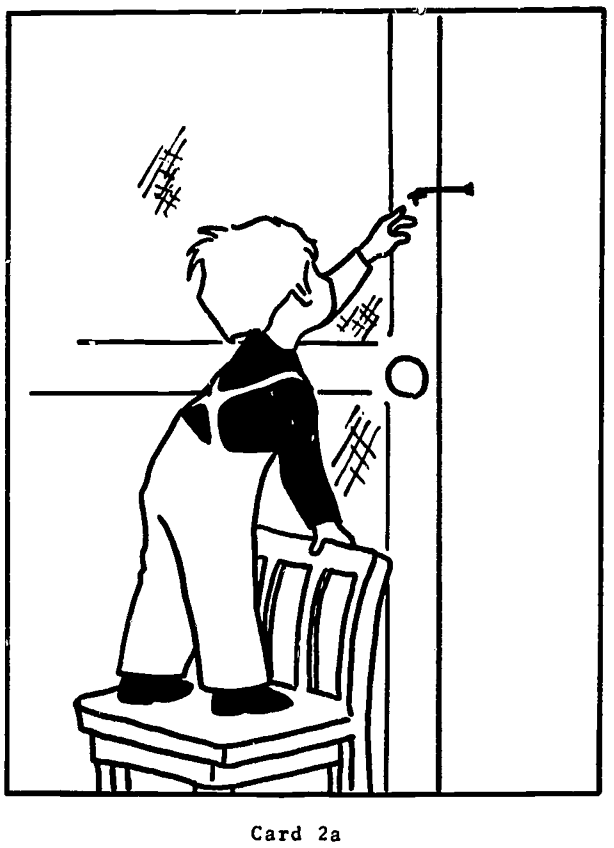
Card 2b. "Did his mommy feed him? You tell me how."

These instructions were designed to avoid any verbal cues that would imply that the child should perform the action himself. In Situation I, for example, it was important to say, "How did the door get opened?" rather than, "How did <u>he</u> get the door opened?"

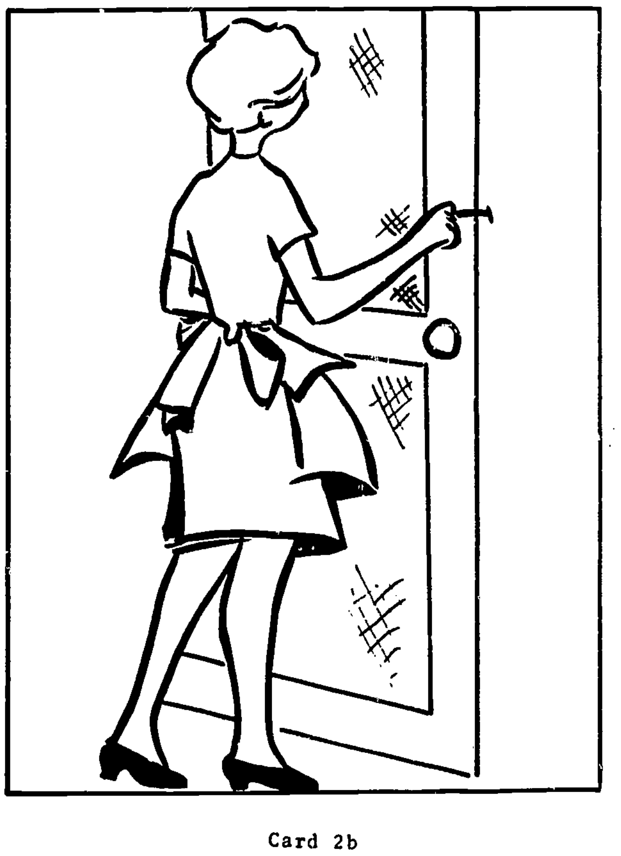


Card 1

Card 3



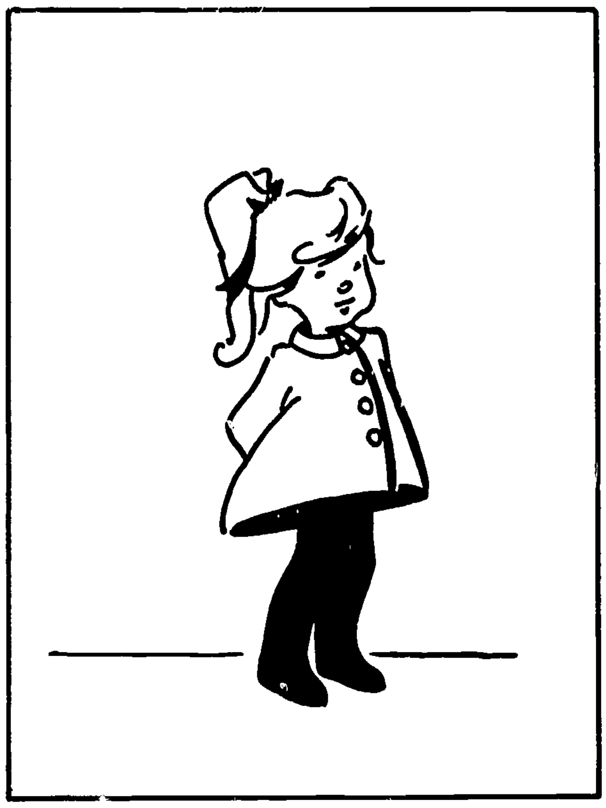
Card 2a



Card 2b

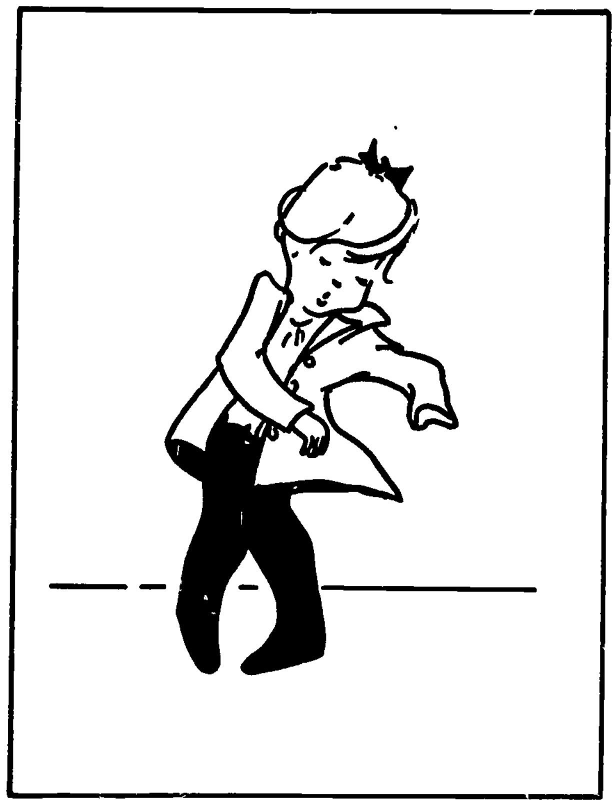
Situation I

Card 1



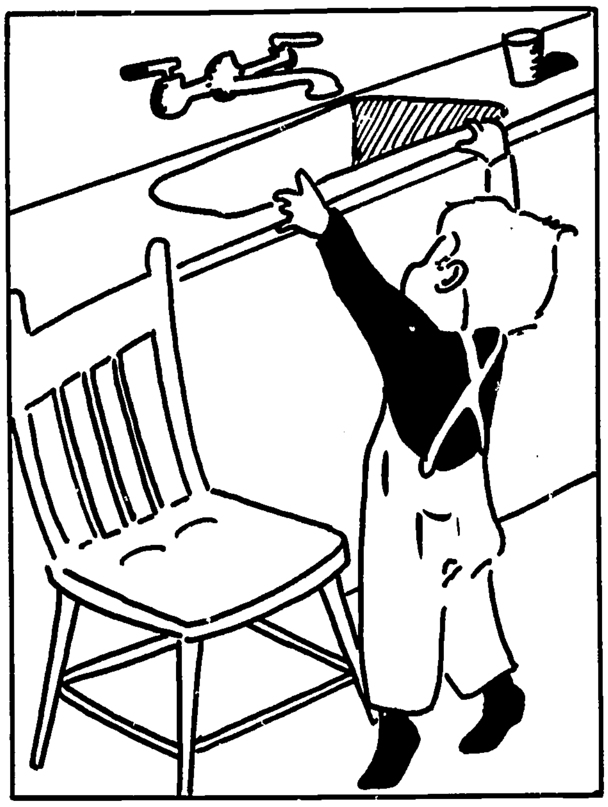
Card 3

Card 2a



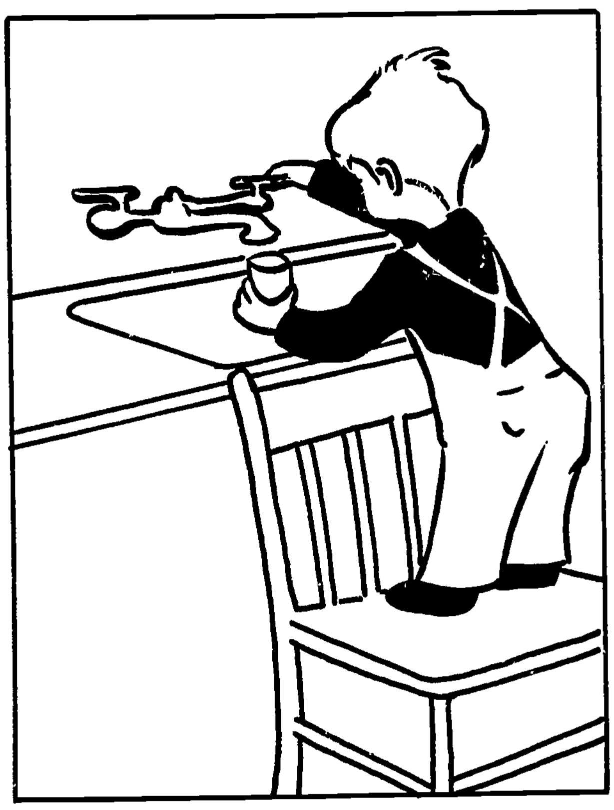
Card 2b

Situation II



Card 1

Card 3

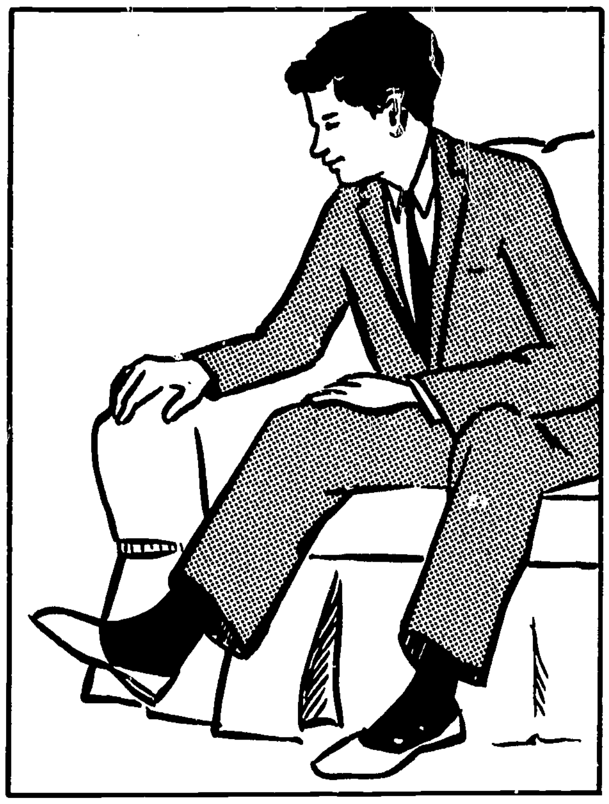


Card 2a

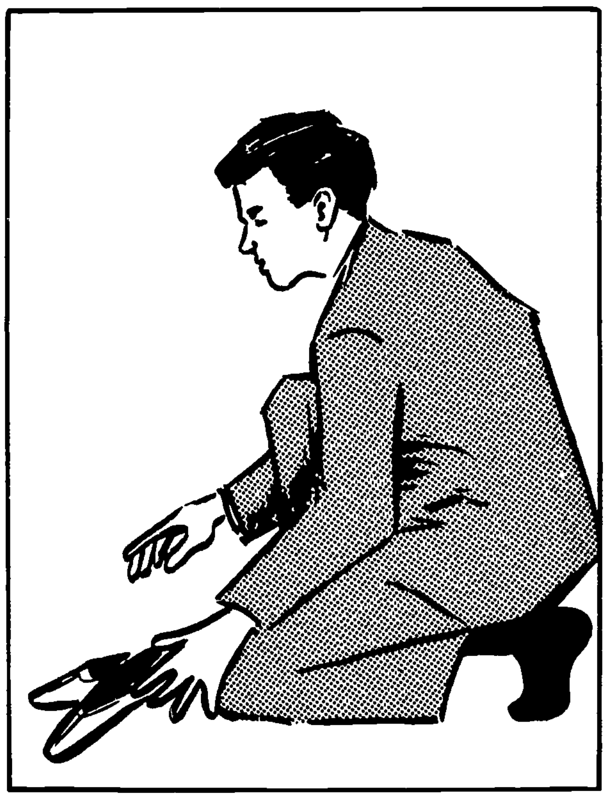
Card 2b

Situation III

Card 1



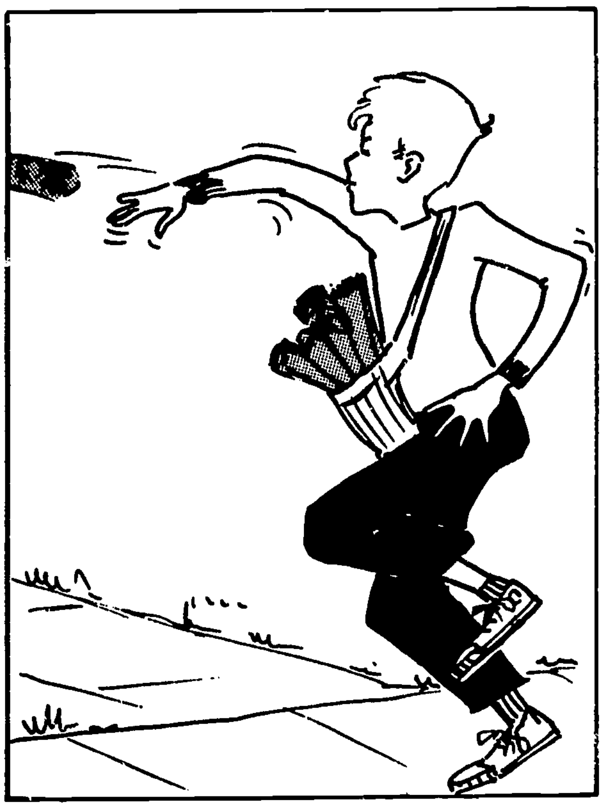
Card 3



Card 2a

Card 2b

Situation IV



Card 1

Card 3

Card 2a

Card 2b

Situation V

Card 1

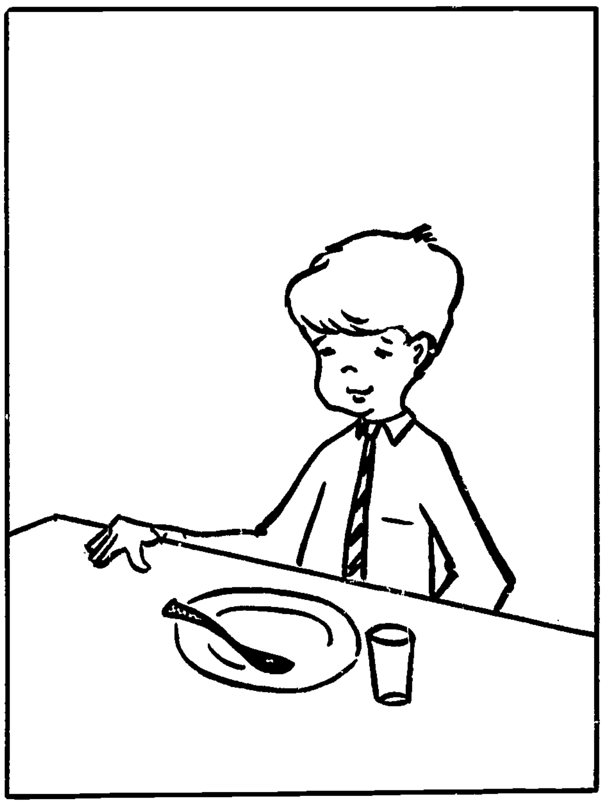
Card 3

Card 2a

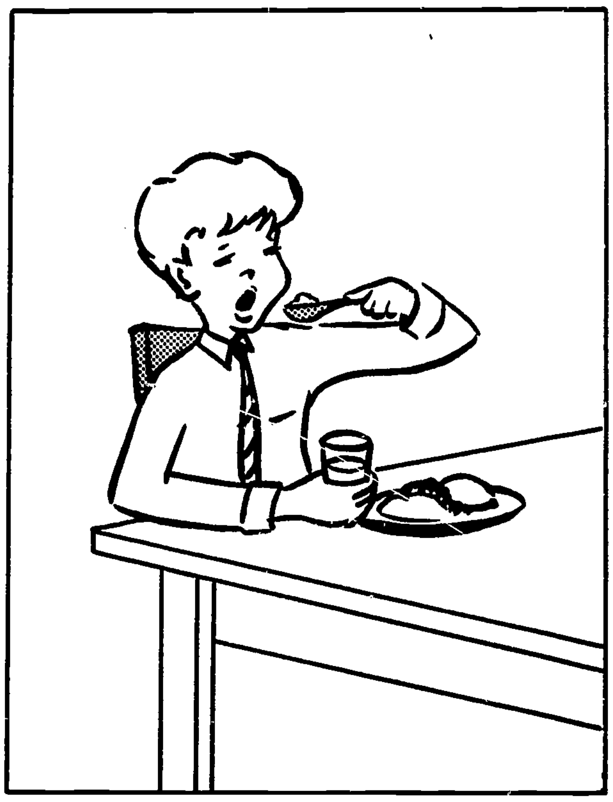
Card 2b

Situation VI

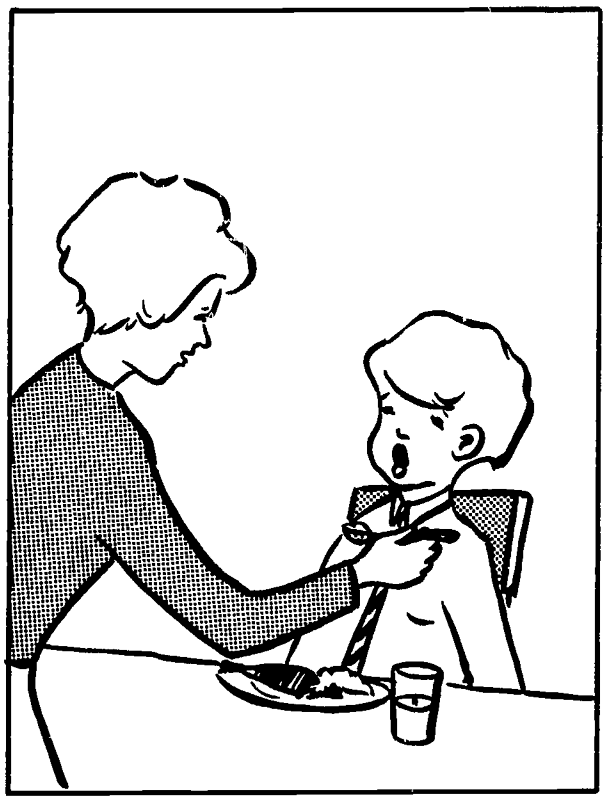
Card 1



Card 3



Card 2a



Card 2b

Situation VII

WEIGHT DESCRIMINATION TEST

This test consisted of five opaque plastic tubes, each 7/8" in diameter and 2" in height. The tubes were weighted in 10 gram increments from 30 to 70 grams.

The 10 gram differential was determined empirically by ascertaining the "just noticeable differences" of a group of normal four-year-old subjects. Weber's Law would predict a two gram differential between the 60 gram and the next heaviest weight as the J.N.D. (35); however, with subjects of this age the law apparently does not hold true.

Presentation of the weight discrimination test follows this order:

1. The subject is presented the 70 and 30 gram weights, to find out if he knows the concept of "heavier than." If he cannot tell the examiner which of the weights is heavier than the other by lifting them successively, he is then trained by demonstrating that one is "harder to pick up" than the other. When the subject has the idea, the examiner says, "Good, now let's try some others."

2. The 60 gram weight is substituted for the 30 gram weight, and the subject is asked which is heavier. His choice is set aside, and the 50 gram weight is compared with the remaining weight, etc.

Subjects were instructed to use one hand only in the test since more accurate discrimination is possible. This presented little difficulty with the cerebral palsied group as many of the children have a better arm which they spontaneously use. Many in the normal group, however, would try to use both hands, picking up one weight in each. Then, the instructions for these subjects became, "Now we are going to play a game with one hand behind our back, etc."

APPENDIX B

DATA ANALYSIS

MULTIPLE LINEAR REGRESSION ANALYSIS OF COVARIANCE

Multiple linear regression analysis of covariance is a statistical procedure in which two regression equations having unequal numbers of variables are compared. Variables common to both equations are equated, which, in effect, holds them constant. Thus, the contribution of the non-common variable to the criterion variation is shown. In the present analysis the association of "group membership" with two criterion variables, action/object item choice ratio on the Modified PPVT, and action item errors on the PPVT, was needed. Also it was necessary to hold I.Q. scores constant so that the results would answer the question: Would members of the different groups with the same I.Q. scores differ on their action/object choice ratios, and on the number of action errors made? The equations for these comparisons are shown in the following sections.

PPVT Analysis

The regression equation for the covariance analysis was as follows:

Full Model $A = \overline{X}_1 \text{ (I.Q.)} + \overline{X}_2 \text{ (Groups)} + \text{Error}$

Restricted Model $A = \overline{X}_1 \text{ (I.Q.)} + \text{Error}$

where A is Action errors on the PPVT, and $\overline{X}_1$ (I.Q.) is the mean I.Q. The resulting F-ratio indicates the amount of variance accounted for by group membership. In other words, it indicates the contribution of group membership to the criterion variance, and answers the question: Do the action errors of members of different groups with the same I.Q. score differ?

For the analysis to have any meaning, it first had to be established that the portions of the PPVT that were in the "failure range" of both groups were equivalent in number and difficulty of action items. This was necessary because the groups' means I.Q.'s differed considerably. Table IX shows the relevant PPVT relationships of the groups. Part A shows the Mean I.Q. to be 77.90 for the cerebral palsied group and 110.85 for the non-cerebral palsied group. Part B is an analysis of errors and ceiling items for both groups. The mean ceiling item and "action errors" were 46 and 13.32, respectively, for the cerebral palsied group; and 64 and 11.97 for the non-cerebral palsied group. Part C shows that action items accounted for 19.54% of the first 46 items (the mean ceiling item of the cerebral palsied group), and for 20.31 per cent of the first 64 items (the mean ceiling item of the non-cerebral palsied group). The theoretical action error to average errors was arrived at by figuring the percentage of action items in the "failure" range to the average errors. This was a check to see that the difficulty of action items within the average failure range was equivalent for both groups. For the cerebral palsied group this percentage was 15.38, and was 16.67 for the non-cerebral palsied group. To find out if the non-cerebral palsied group was like the test norm group, a chi-square test was performed by predicting the expected frequency of action and object choices from the theoretical percentage. Chi-square approached zero, [redacted]. In fact, actual versus theoretical percentage of action errors was 16.49 to 16.67. From these comparisons, it can be assumed that the parts of the test represented by each group's mean ceiling item, error range, and action items are comparable.

<u>Modified PPVT analysis</u>. The analysis of data from this test was analogous to the PPVT analysis. The regression equation was:

Full model $\quad A/O = \overline{X}_1 \text{ (I.Q.)} + \overline{X}_2 \text{ (Groups)} + \text{Error}$

Restricted model $\quad A/O = \overline{X}_1 \text{ (I.Q.)} + \text{Error}$

where A/O is the ratio of action to object choices on the Modified PPVT, and $\overline{X}_1$ (I.Q.) is the mean I.Q. score on the PPVT. By holding I.Q. constant the group membership's contribution to the criterion variance is shown. The difference between this analysis and the similar one for the PPVT is that the A/O ratio is based on choices, while the PPVT analysis is based on action item failures.

TABLE IX

I.Q. AND ERROR ANALYSIS OF THE PEABODY PICTURE VOCABULARY TEST

A. I.Q. Analysis

Group	I.Q. Range	Mean I.Q.	S.D.
C.P.	34-111	77.90	19.00
Non-C.P.	78-133	110.85	11.76

B. Error Analysis

Group	Mean Ceiling Item	Ave. Errors	Ave. Action Errors	Ave. Object Errors
C.P.	46	13.32	3.42	9.90
Non-C.P.	64	11.97	1.72	10.00

C. Action Item Analysis

Group	Action Errors / Mean Ceiling Item	Action Items within Error Range / Total Items within Error Range
C.P.	19.54%	15.38%
Non-C.P.	20.31%	16.67%