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CHAPTER V ONLY
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CONTINUOUS COMPLEX LEARNING OF

PRESCHOOL CHILDREN

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
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ABSTRACT

Instrumental conditioning studies with children have largely been restricted to simple responses. A complete learning theory requires that complex cognitive behaviors be analysed and their acquisition demonstrated in controlled conditions. A longitudinal, experimental study was conducted with eleven preschool children to examine the children's learning of cognitive skills, in particular, the beginning skills of reading, number and writing. Based on an S-R analysis of the materials, the training was conducted daily for an entire school year. Instrumental conditioning methods were used in the individual training of the children. A child training apparatus and a token reinforcer system both designed by Staats were used throughout the study.

The reinforcer system successfully maintained the children's work behaviors throughout the year. The efficacy of training procedures previously developed by Staats was confirmed. Most of the children learned to read the upper and lower case alphabets, to count and to read numerals and to write the alphabet. In addition, four children were trained in a reading concept formation task with regularly spelled words and syllables. Five children were used in an investigation of learning addition through reading procedures. A marked learning-to-learn effect was
It is possible to isolate the early skills essential for the learning of such cognitive skills as reading and number, and to train average four year old children in these skills when their attention and work behaviors are maintained by adequate reinforcement. The S-R analysis of complex learning skills facilitates the design and refining of instructional procedures.
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CHAPTER I
INTRODUCTION

Since 1950 an increasing number of instrumental conditioning experiments have been conducted with children as subjects. Bijou and Baer (1966) have divided the instrumental responses of children studied into those where the response itself is of little interest, except as representative of a response class, and those where the response is of intrinsic interest. Examples of the convenient responses studied with children are bar pressing (Bijou, 1957) and handle turning (Lambert, Lambert and Watson, 1953). Intrinsically interesting responses studied have included smiling (Brackbill, 1958) and vocalizing (Rheingold, Gewirtz and Ross, 1959). Slightly more complex social responses have been manipulated with individual preschool children, where the response has been an undesirable social behavior, such as crawling (Harris, Johnston, Kelley and Wolf, 1964), scratching (Allen and Harris, 1966) or tantrum behavior (Williams, 1959). Experimenters have reduced such unwanted behaviors by extinction procedures, while at the same time increasing the occurrence of competing desirable behaviors by reinforcement, usually of a social nature. Similar studies have increased the occurrence of a rare but desirable behavior in a child by reinforcement of successive approximations to the desired
behavior (Hart, Reynolds, Baer, Brawley and Harris, 1968). The control of the response by the reinforcement and extinction procedures is demonstrated by careful documentation of a baseline period followed by a period of reinforcing the desired behavior or extinguishing the undesired behavior. The experimental period is followed by a return to baseline procedures and finally the experimental procedures are reintroduced. An increase in desired behavior or a decrease in undesired behavior is shown to be controlled by the instituted reinforcement and extinction, if the behavior is affected by the experimental condition and then returns to approximately baseline rate when the baseline procedures are reinstated.

A number of studies of two choice discriminations in children have been conducted to investigate, in children, the occurrence of the phenomenon which Harlow (1949) called "learning set" in his animal experiments. Harlow presented animals with a series of two choice discrimination problems where each problem in the series required the same type of solution. He gave a limited number of trials on each problem before introducing the next, so that the early problems are only partially learned. He found that the ability of the animal to do the problems increased through what he described as the acquisition of a learning set for these problems. The learning set once acquired remained with the animal, facilitating the solution of
similar problems for many months.

Studies of learning set using apparatus very similar to the Wisconsin General Test Apparatus have been conducted with Mongoloid children (Girandeau, 1959) and mentally retarded children (Kaufman and Peterson, 1958; Wischner, Braun and Patton, 1962). Other studies have associated the speed of formation of the learning set with mental age (Koch and Meyer, 1959; Jensen, 1963). Most of these studies demonstrated the occurrence of a learning set which facilitated the learning of a particular type of problem for many months. The discriminations required, however, were simple ones and very easily acquired by normal children. Koch and Meyer (1959) suggest using children under three years old for further learning set experiments as even those tasks found most difficult for monkeys are too simple for older children.

Much more complex responses, including those which are usually called cognitive, have been studied in children by Staats (1968). The acquisition of complex multiple discriminations such as those required for beginning reading or of the chains required in beginning number skills is not short term. Therefore the first requirement for such studies was a reinforcer system which would maintain children's attention and work behaviors over many sessions without satiation. Staats in 1959 in work with problem learners developed a flexible token reinforcer system which
used a variety of immediate and back-up reinforcers (Staats and Butterfield, 1955; Staats, Minke, Finley, Wolf and Brooks, 1964). The reinforcer system was tested successfully with manipulated schedules on normal children (Staats, Finley, Minke and Wolf, 1964) and with retarded children learning a reading task (Heard, 1964).

The token reinforcer system was then utilized in experimental studies of the early cognitive learning of preschool children. Staats (1968) reported several long term studies with individual preschool children and a study of twelve culturally deprived preschool children. These children were trained daily in beginning reading, number and writing skills over many months and a complete record of the stimuli and responses concerned with the tasks was kept. This present study included a replication of some of the procedures used with the previous group, his modifications of earlier procedures and, where children had reached certain criteria, the testing of further of his instructional procedures.

The cognitive responses chosen for study were those basic to most important areas of instruction in traditional schooling, reading and arithmetic. Lest it be supposed that the topics chosen for study with these children in the beginning skills of reading and arithmetic and the methods used were based on a consensus of opinion of educators, it must be stated that there is no such consensus.
Chapters II and III survey the predominant theories of the beginning content and methods for reading and mathematics, but there is a dearth of experimental evidence in support of any of the theoretical viewpoints. However, the necessity for long-term experimental study of children's initial learning of cognitive tasks is well recognized (Chall, 1967; Suydam, 1967).
CHAPTER II
THEORIES OF BEGINNING READING

There are many variations in the theory and practice of beginning reading. The theory held about what reading is influences what methods will be recommended for instruction. Reading theories fall generally into two classifications. There are those who believe that reading, even in the earliest stages, is primarily concerned with meaning and there are those who believe that reading, at least at the beginning, is decoding of graphic symbols to speech.

Reading for Meaning

Reading for meaning theories dominated the American education scene from about 1930 until the last decade when they have been challenged from many directions (Flesch, 1955; Terman and Walcutt, 1958). Reading for meaning theorists believe that at the very beginning of the reading process children should not only recognize words but comprehend and interpret them. For them the unit of beginning instruction is therefore the whole word which is to be recognized at sight because units of less than this size, syllables or letters, have no meaning on their own. Children master a sight vocabulary of 50 to 100 words before any analysis of these words into sounds is attempted. They are encouraged to identify words by context and picture
cues and, often only as a last resort, by phonics, the reason being that sound-spelling correspondence is regarded as so irregular in English as to make emphasis on sounds more misleading than helpful. Many of the most frequently used words in English, for example those on the Dolch list (Dolch, 1943), are irregularly spelled.

Reading for meaning, often called "whole word reading" or "look-say" is rarely begun before the 1st grade and proceeds, slowly at first, with a vocabulary controlled for difficulty. Instruction is usually given to small groups of children. Writing and spelling are taught as separate skills. Beginning reading is thought of as essentially the same as adult reading. The most widely used basal readers completely support these principles and methods (Robinson, Monroe and Artley, 1956; Russell et al., 1961). The basal reading series have been found to be used by almost all American teachers of the first three grades (Barton and Wilder, 1964; Austin and Morrison, 1963), so it is obvious that any viewpoint espoused by these books would be very influential.

These theorists believe that good motivation for reading is rapidly achieved when children read for meaning. Children are motivated by recognizing words from their own speaking vocabulary and by finding the outcome of a story. The motivation value of words which are very meaningful to the children is utilized also in reading
schemes which use each child's personal vocabulary for beginning reading (Ashton-Warner, 1963). Jeanne Chall (1967) concludes after examining many studies comparing "look-say" methods with phonic methods that the "look-say" methods have an initial advantage. Children acquire a vocabulary more quickly at first and this motivates both pupils and teachers, although this initial advantage does not last beyond the 1st grade.

**Decoding**

Chall used the term "code-breakers" to describe those who regard beginning reading as primarily learning the code by which written English is translated into speech (Chall, 1967). Code breaking, by way of phonics, was the predominant method of teaching reading for several years before about 1930 when reading for meaning became the preferred method of most educators. At present there are phonics programs which are meant only to supplement a whole-word reading program (Hay and Wingo, 1960) and there are others which use largely phonics to introduce an entire reading program (McCracken and Walcutt, 1966). Phonics programs may be synthetic, where sounds are taught as separate units and synthesized into words, or analytic, where whole words are taught first and analysed for individual sound correspondences to be understood.

Another method of breaking the code of written English is proffered by linguists such as Leonard Bloomfield (1942)
and Charles Fries (1962). Bloomfield (Bloomfield and Barnhart, 19630 states that English is essentially an alphabet writing in contrast to written Chinese which is a word writing. It is not necessary to teach each word separately in English. He maintains that the code is an alphabet code and that children should be taught, first the alphabet, and next words with regular spelling patterns, such as fan, pan, tan, and introduced to variations in letter-sound correspondence gradually. Eleanor Gibson (1965) states that there is no hard evidence for the advantage of introducing only constant letter-sound correspondences first and that, in fact, transfer may be facilitated by training on variable letter-sound correspondences from the beginning. Gibson suggests spelling patterns as the code units rather than single letters.

Decoding theorists regard beginning reading as a different process from later reading. They suggest that a child has a large vocabulary before he begins to read and that if the code is well taught, the meaning aspect takes care of itself. They advocate reading aloud as the skill to be learned at the beginning because it is the written word into spoken word code that is being broken.

In her survey of reading research, Chall (1967) examines 17 studies which correlate children's knowledge of the alphabet, by name or sound correspondence, with their reading ability. Positive correlations ranging between
.34 and .92 were obtained in all of these studies. Chall concludes that, "letter knowledge has a generally higher association with early reading success than mental ability as measured by various intelligence tests and other tests of language and verbal ability." (p. 149)

Readiness

One strong difference in philosophy which generally divides the word meaning theorists from the code breaking theorists is the subject of readiness. There is no logical reason springing from either theory to lead to conclusions on when children should begin to learn to read. However, word meaning theories have been associated with the progressive education movement which generally stressed delaying formal training in any field until as late as possible. Washburne (1936), Harrison (1939) and others cited six-and-a-half years old as the right mental age for beginning to read, and few schools have taught reading before 1st grade when children are six years old. Sheldon (1963) assembles the arguments against beginning reading training before a child is five or six years old. He contends that early reading may harm children's vision and that they may suffer symbolic confusion, mounting tension, emotional instability and develop unfavorable attitudes towards learning.

As early as 1937, however, Arthur Gates produced experimental evidence that children with a mental age of
five years could successfully undertake reading. Support for an earlier start in reading training has come from several other sources. The linguist, Bloomfield (1963), used his own and his friends' preschool children to test his reading methods on. Glen Dowman (1964) discovered a mother of a brain damaged child teaching him to read to the child's advantage. Dowman developed a system to help other mothers of similar and normal children to teach their children in the same way. He advocates 18 months as a suitable age for beginning reading. Staats (1968) also used his own and other 2, 3 and 4 year old children as subjects in the experimental application of his theories. Whereas the use of young children for reading training was fortuitous for Bloomfield and Dowman, Staats deliberately used the children, assuming that training with good procedures and adequate reinforcement could only enhance their cognitive development. This attitude follows from a tenet held by some learning theorists that an individual's current cognitive stage of development is the summation of his learning experiences (Wesman, 1968).

Dolores Durkin (1961, 1963, 1964) has conducted longitudinal studies on two groups of children who had learned to read at home prior to entering 1st grade. The California group were studied until the end of 6th grade and the New York children until the end of 3rd grade. Although she does not advocate earlier formal reading training,
Durkin has found no evidence that these children were handicapped in any way later in school by their early start in reading. The children, who were selected by test on entrance to 1st grade, had a wide range of I.Q. scores and their families represented a surprisingly large range of social classes, many coming from lower class families. A large control group matched on I.Q. and social class and taught by the same teachers was also studied. The preschool readers at every I.Q. level were reading better than the controls at the end of 6th grade but those of low I.Q. had the most significant advantage over matched children who had not had early reading training.

Learning Theory of Reading

Staats' (1962; 1968) reading theory, on which the methods used in this study are based, stems from an experimental learning theory base. Staats has deduced his theories from basic learning laws and has then proceeded to test them in empirical circumstances.

Staats regards reading as a learning task similar in many ways to the learning of speech. Primarily it consists of discrimination learning, that is, the bringing of a response under the control of a stimulus. In the case of reading, a written word stimulus must control a spoken or silent reading response. The first requirement is that the child attends to the stimulus while responding.

Staats emphasises the many discriminations which must
be learned in reading, which include all the phoneme-grapheme correspondences of single letters or groups of letters. Although he insists that the code breaking elements are essential, he also points out that many hundreds of whole words must eventually be recognized at sight, whether they were first learned by sounding out or by imitation of a trainer directly. The acquisition of a functional reading skill requires a very large number of training trials. Many of these trials take place, for the eventually skilled reader, in the course of reading for himself.

A discriminative stimulus comes to control a response when the response is reinforced in the presence of the stimulus. Most reading theorists recognize implicitly that reinforcement is necessary for learning, hence the emphasis on key vocabulary (Ashton-Warner, 1963), breaking the code (Bloomfield, 1963) and even on specific instructions for social reinforcement (Dowman, 1964). Staats recognizes the arduous nature of beginning reading and the necessity for strong reinforcement to maintain responding throughout the period of skill acquisition. Whereas a child learns to speak gradually over many years, he is expected to learn most of the basics of reading in the first two grades. The reinforcers available in the classroom, according to Staats, are not sufficient to sustain the necessary hard working behavior of many children, especially those who have not learned to be reinforced by
adult approval or who receive no further reinforcement for their skills at home. Also many of the reinforcers available in the classroom are not used contingent upon successful responses.

In his reading training Staats uses extrinsic reinforcers contingent upon attention behavior and correct responding until the child has sufficient skill for the reading itself to be reinforcing. He begins training at the preschool level so that school training will not be so intensive and consequently so aversive.

The elements which Staats believes necessary for beginning reading, which provide the training procedures used in this study are: that the child's attention to the reading stimuli must be maintained, that reading responses (identification of letters, phoneme-grapheme correspondences and words) must be controlled by the written stimuli, that immediate reinforcement must be contingent upon correct responding, and that the training be gradual to avoid the aversiveness of intensive training.
CHAPTER III
THEORIES OF EARLY NUMBER TRAINING

The study of number has long been considered one of the basic elements of education. There are numerous views of what should be taught in this field and how it should be taught. A man's conception of what arithmetic or mathematics is influences what he thinks should be taught to children about these matters, and especially what children should learn at the beginning of their number training.

Traditional Method

Edward L. Thorndike's *The Psychology of Arithmetic* was published in 1922. Thorndike considered the various aspects of number which should be learned by the elementary school child to include: the series meaning of number, the collection meaning of number, the ratio meaning of number and finally the nucleus of facts about a number which he called the relational meaning of number. Few writers since have given as complete a statement of early mathematical skills as Thorndike's.

Thorndike did not believe that children had intuitive knowledge of mathematics but that even distinguishing "one" from "two" must be learned. He believed that most children entering school knew some numbers and many words describing relations and qualities, such as twice, more, again,
and so on, though some of their information was in error. Very few of his teaching examples deal with beginning arithmetic but those which do emphasise practical acquisition of counting and labelling skills and relational vocabulary. Thorndike suggests that formal arithmetic teaching be delayed until the 2nd or 3rd grade or even later on the assumption that hard things are better learned later. There are many hints in the book of the extreme formalism of the current teaching methods and it is this sort of discipline that Thorndike sought to delay rather than the formation of any mathematical connections.

Thorndike has been accused of advocating sheer rote learning (Mayer, 1961). He certainly advocated establishing thoroughly by rote the connections which were necessary for a child, but he insisted that many connections that had been drilled into children were unnecessary and a waste of time. He contended that a careful estimate should be made of just how much practice is needed to establish a connection for the length of time it is needed. These connections or bonds were to be formed in the child to enable him to cope with practical mathematical situations in his present and future life. Thorndike was very critical of problems posed to children that were not very like problems they would meet in life. He envisaged the school as training shoppers, bookkeepers, construction engineers and accountants, rather than mathematicians.
Progressive Method

Progressive educationalists, those who followed the philosophy which dominated American education during the 1930s and 1940s, cared less for rote learning. They agreed with Thorndike that arithmetic should be taught for its practical usefulness, that early number skills are learned incidentally by children in practical situations in the home and early school years, and that formal training in number should be delayed. This delay, incidentally, meant that formal arithmetic training was begun when children already had some reading skill so that this skill could be utilized and children taught largely through verbal methods with little practical apparatus used.

Structured Method

Because of the prevailing educational philosophy in the United States, little notice was taken of Maria Montessori's work because it was considered too structured. Catherine Stern (1949) came from Germany to New York in the 1930s. She developed her methods and materials for beginning mathematics with preschool and school age children. She believed that number concepts were best understood from the basis of measurement. She also believed that children could be guided to discover mathematical principles using structured materials. The basic materials are a set of ten wooden rods. The smallest rod, which is the "one" unit is a perfect cube. The other nine in
the set are of the same height and width as the one unit but are 2, 3, 4, 5, 6, 7, 8, 9, and 10 units long. In guided play with the rods the children 'discover' size, order, equivalence and ratio. Number names and counting order were taught later. Stern believed that no amount of logical thinking could lead children to discover the names of numbers and their order. These things are arbitrary. She taught the number names in association with the rods with which the children were already familiar and the order of the number names as a song. The numerals were used as labels for the rods. Pattern in number was emphasized with equipment called pattern boards where dots were arranged so that addition combinations could easily be seen. One-to-one correspondence, counting, addition and "+" and "-" as directions were also introduced to preschool children on an apparatus called a number track.

Stern made no assumptions of previous knowledge in her young children and did not believe that children learn mathematical concepts incidentally through 'life situations.' Although she believed that three years old was not too young for a child to be introduced to her system, her total school program is not accelerated because of the emphasis on thorough learning of the early concepts. Stern stressed the importance of a grounding in mathematical ideas rather than training for practical computations.
Structured materials like Stern's were also developed by Georges Cuisenaire (1967), a Belgium teacher, and have been widely popularized. Counting and number names are delayed even longer with the Cuisenaire material, because this method introduces early, ideas leading to algebra as well as to arithmetic. Both Stern and Cuisenaire methods emphasize non-verbal acquisitions of mathematical concepts.

Counting Methods

The last two methods mentioned stressed beginning number training with what Thorndike called the relational and ratio meanings of number, but programs which advocated beginning with the series and collection meanings have been far more common. Grossnickle and Brueckner (1959) and Marks, Purdy and Kinney (1958), for instance, both advocate the training of counting skills predominantly in the first year or two of school arithmetic. Addition and subtraction are arrived at through counting procedures and the recommended equipment consists of various objects which can be counted and bundled into tens, and abacuses.

New Mathematics

Some mathematicians have felt that because the expansion of mathematical knowledge in this century has been so great that it has become increasingly difficult for a mathematician to learn enough soon enough to make a contribution. The remedy seemed to be to begin teaching
mathematics earlier and to speed up the acquisition of mathematics by leaving out unnecessary material such as that which is only taught for historical and traditional reasons and to introduce early, ideas which would make the later acquisition of newer branches of mathematics easier.

The School Mathematics Study Group (SMSG) and the University of Illinois Committee of School Mathematics (UICSM), two of the earliest groups working on the reform of school mathematics curriculum, began with secondary school mathematics, but both they and the numerous other commercial and non-commercial committees working on New Mathematics have gradually lowered their sights until at the present time new mathematics language permeates the text books and work books used by kindergarten children. The new curriculums include, from the beginning, the concepts and vocabulary of set theory, vocabulary distinctions of a logical kind such as between "number" and "numeral", and between "cardinal number" and "ordinal number", some vocabulary of physical geometry such as points and lines, addition principles such as the commutative law of addition, and the use of the number line to introduce "+" and "-" as directions. Two commercial mathematics textbooks for kindergarten level, the Greater Cleveland Mathematics Program (Council of Greater Cleveland, 1961) and Modern School Mathematics (Duncan, Capps, Dolciani, Quast and Zweng, 1967) are typical of many published in the
1960s. These include as vocabulary terms set union and separation, line segment, and many others new to the kindergarten classroom. But, vocabulary aside, these programs beginning from one-to-one correspondence are largely counting programs. To find whether sets are equivalent, children must count. To operate the number line, unless material of the Stern or Cuisenaire type is used, it is necessary to count.

It must not be supposed that all mathematicians or mathematics educators agree with these new additions to the early mathematics programs. Howard Fehr (1966) concludes that modern mathematics, per se, has no place in the elementary school. He criticises the use of set theory and formal logic vocabulary and doubts the, as yet untested, usefulness of learning number bases other than ten and Euclidian geometric constructions. J. Fang (1968) denies that the new mathematics programs are succeeding in accelerating the learning of necessary mathematics, because the addition of the extra vocabulary is slowing down the curriculum. Even some of the initiators of new mathematics programs have expressed themselves as disturbed at what has happened to the programs at the hands of less mathematical educators and commercial textbook writers. But Fang sees this as a logical outcome, with the assistance of Parkinson's Law, of the initial axiomatic approach of the new mathematics advocates. Their stress on formal
logic resulted in the proliferation of "quasi-definitions" which fill the pages of the new textbooks.

Inductive or Deductive Method

Reasoning from the axiomatic and deductive nature of mathematics itself, writers of new mathematics texts seem to assume that if a principle is demonstrated, then children will be able to reason deductively from the principle to particular cases. An example of this type of thinking comes from Gagne (1965), concerning principle learning in mathematics, "... the set called '4' is formed by adding a member to set '3'; and so on. Once acquired, these principles make it possible for the child to order numbers, in other words, to count" (p. 179).

This exemplifies one extreme of theory which leads to yet more differences in the design of beginning mathematics instruction. Mathematics is undoubtedly a deductive science and it seems logical to teach it as such. However, it is frequently argued that children actually acquire mathematical concepts inductively (Stern, 1949; Chapman-Taylor, 1967). Mathematicians have sometimes stated that their thought processes leading to a mathematical discovery were inductive although the later justification was deductive (Sawyer, 1957). Most number programs for kindergarten children or younger pay at least lip service to the notion that children must experience many practical examples of a principle before they are able to form a
generally applicable concept.

Readiness

Another matter which has been the subject of controversy is when to begin training children in mathematics. Thorndike (1922) believed that learning was the establishment of connections. He did not believe in abilities in the abstract, such as an ability to do mathematics. Nevertheless he favored postponing formal mathematics training. Stern (1949) began mathematical training with three-year-old children and maintained that these children enjoyed the experience and profited from it. The progressives made much of the concept of readiness in all subject areas, believing that children should reach a certain stage of development before formal training should begin.

Jean Piaget (1953) is a developmentalist who has especially studied the formation of mathematical concepts in children. He states, "It is a great mistake to suppose that a child acquires the notion of number and other mathematical concepts just from teaching. On the contrary, to a remarkable degree he develops them himself, independently and spontaneously" (p. 74). Readiness for the development of number concepts according to Piaget depends on the child's grasp of the principle of conservation of quantity. Conservation is a term given by Piaget to the ability to recognize invariance or genuine change of a specific factor through various rearrangements of other variables.
For example, conservation of weight is tested by asking a child to judge whether a lump of clay weighs the same when made into a different shape.

Children, according to Piaget, must reach the age of six-and-a-half to seven years, on the average, before they can conserve quantity. Piaget relies a good deal on the verbal responses of the children to judge their understanding of the logical concept being tested. Braine (1959) has criticised Piaget's methodology and suggested that if nonverbal methods are used it is possible to lower the age norms established by Piaget by two years. A study by Sawada and Nelson (1967) on conservation of length with nonverbal methods confirms 60% of the children between the ages of 5 years 4 months and 6 years 2 months to be conservers of length.

In a Piagetian experiment on conservation of quantity, the children were presented with two identical rows of 4 pellets and asked if the two rows had the same number of pellets. On this being confirmed, the experimenter added more elements to one row at the same time closing up the pellets so that the row with the most pellets was the shortest. The child was then asked if the rows had the same amount of material or if one had more. The four year old children's failure to conserve was taken to indicate that they did not have the cognitive capacity to reverse situations.
Age groups below 4 years had been ignored in these experiments until Mehler and Bever (1967) studied over 200 children between the ages of 2 years 4 months and 4 years 7 months, using the above procedures. The surprising result in this study was that 100% of the youngest group, those between 2 years 4 months and 2 years 8 months, conserved. The ability to conserve decreased with increasing age, so that only 16% of the group between 3 years 8 months and 3 years 11 months conserved. However, between ages 4 years 4 months and 4 years 7 months nearly 70% of the children succeeded in the test. The experiment was repeated in a nonverbal form using M & M candies instead of clay pellets, the child being invited to take the row of candies he wanted to eat and to eat them all. In this test most of the children in all the age groups conserved. The 3 years 8 months to 3 years 11 months group, where 60% of the children conserved, had the fewest conservers in the nonverbal test. The difference between groups was highly significant in the verbal version of the experiment but non-significant in the nonverbal version.

If the ability to conserve is not something which develops some time after 4 years old for the first time, but is an ability present in 2 year olds and only temporarily obscured around 4 years old in verbal explanations, the strength of Piaget's argument to delay training in number concept seems to be lessened.
Preschool Number Skills

Regardless of when theorists specify children should begin to learn mathematics, they usually assume that the children already know something. Most school programs assume that children on entering 1st grade can count a little, and that they have in their vocabularies many relational and quantitative terms. Studies by Ing and Ames (1951) and Bjonerud (1960) confirm this expectation, but indicate that there is a wide range of attainment among 5 year olds. Children who have not learned some number skills before school age will be at a disadvantage unless, as Bjonerud (1960) suggests, a systematic arithmetic-readiness program replaces, "the incidental approach that is now generally employed." (p. 350).

Learning Analysis

Staats' (1964; 1968) theory on beginning number training, which is the basis for the procedures used in this study, is based on a learning analysis of the early number skills. The child first must acquire a concept of numerosity, that is, he must respond to the "oneness" or "twoness" aspect of stimuli which are complex in many other ways. Staats has found that children can be trained to these concepts by being prompted to respond to this aspect of many different stimuli and being rewarded for the response.

Counting involves other learning mechanisms, according
to Staats. First a verbal chain must be acquired, that is, each response must produce stimuli which elicit the next member of the chain. This chain must then be coordinated with a variety of motor responses, with pointing and moving the eyes or with pulling or pushing items from one place to another. The common component of these motor elements is that each repetition of the particular movement must correspond with the saying of the next number in the verbal chain. Counting becomes functional for children when they have had many trials with many types and arrangements of objects.

Staats believes that the reading of numerals, another necessary early skill, is acquired in the same way as the reading of words (see Chapter II).

Although the beginning of an addition repertoire may be acquired through counting, Staats finds that it is more often acquired through verbal methods. This is even more true of multiplication which is rarely introduced through practical materials. When children learn to add and multiply with numerals, a chain of general procedural responses is established. Staats has made some detailed analyses of these chains (Staats, 1968).
CHAPTER IV
PURPOSES

As described briefly in Chapter I, Staats has developed a new type of method for studying complex human behavior. This method which he calls experimental-longitudinal offers solutions to some of the problems of previous methods. A common traditional method employed in both psychology and education has been the comparison by statistical means of two groups of subjects, randomly selected (if possible) and undergoing different treatments. The treatments might be brief exposure to a learning task or separate teaching methods used over a long period of time. In either case the analysis is made on a few measures (frequently only pretest and posttest) taken of performances. This type of experiment has rarely been found useful to teachers at the practical level. At the theoretical level, the information given is limited by the paucity of the observations or measurements of the behaviors. Traditional longitudinal methods, on the other hand, have been purely descriptive so that while much interesting data was collected, no statements could be made concerning the controlling variables.

Staats' development of the experimental-longitudinal method began in 1959 with a study of remedial reading. He used single subjects at first, primarily his own children
and then several others. During these preliminary studies he developed the learning apparatus (described later), the reinforcer system (see Chapter I) and the step by step procedures wherein the S-R analyses of the cognitive tasks were translated into instructional sequences and teaching materials. At Arizona State University he made advances in the refinement and formalization of the procedures both in the continued experimental-naturalistic investigations and in controlled laboratory experiments (Staats, Finley, Minke and Wolf, 1964).

In 1965, Staats set up a laboratory in a public school in Madison, Wisconsin to study and teach four-year-old children. From the normal preschool classroom, the children were taken individually to an adjoining laboratory where they were trained in the apparatus (described in Chapter V) in cognitive tasks of reading development, number concepts development and writing development. In 1967 Staats set up the same type of laboratory at the University of Hawaii to continue the study of the cognitive development of children using the now well developed materials and methods.

The experimental-longitudinal method involves continuous observation of children during long-term complex learning processes and is also controlled and experimental in nature thus overcoming the deficiencies inherent in both one-shot experiments and longitudinal descriptive studies.
A quantity of data is carefully recorded. Every stimulus and every response concerned with the learning task is written down, as well as the time for each session and the number of reinforcers dispensed. The resulting plenitude of data has not been obviously amenable to analysis by commonly used methods. In could not, for instance, be analysed as the simple operant conditioning studies are. First a variety of responses are elicited rather than a single response; secondly in the operant studies, the control of the reinforcement is demonstrated by the reversibility of the behavior. It is doubtful whether the responses trained in these studies are reversible in the same straightforward way. Even where some of them are reversible it would be undesirable to manipulate them in this way. This would interfere with the ongoing learning process and set up a hierachy of responses to each stimulus rather than strengthening the particular responses. It would therefore be detrimental to functional learning.

The need for detailed, continuous and long term information has been seen by educators searching among research material (Chall, 1967; Bjonerud, 1960), and by Staats whose primary purpose is developing a learning theory adequate to describe complex human behavior, as well as the application of theory to devising better materials and procedures for teaching children. The raw data in his studies, however, though collected in a standard
manner and under controlled circumstances, was not collected to satisfy the requirements of a preconceived statistical design. It was obtained, rather, to fill the need for a type of data not available before. Up to this point the results from the experimental-longitudinal studies have been presented simply in tabular form to support qualitative statements. It was a necessary step to examine how best this data might be presented so that the possible research questions which could be asked of it might be answered with some precision. A primary objective of this present study, therefore, was to find ways of organizing and analysing the data using generally recognized statistical methods where this was possible and useful.

In the analysis the three measures, number of trials, time and number of reinforcers were treated as separate dependent variables. A criterion was decided upon for the learning of each unit and the record of each child on each variable graphed. Where it seemed that means would be representative, those too were graphed. The graphs suggested the statistical methods used: analysis of variance of repeated measures and trend analysis.

Skinner (1953) and Sidman (1960) have felt that the group means have often hidden important effects, particularly where individual records are especially sensitive to stimulus changes. Statisticians, on the other hand, have
felt that generalization is not possible from individual cases. The analysis used in this study aims not so much at getting the best of both these worlds as to avoid concealing data by offering either representative individual records or group data exclusively. Both individual records and group effects were considered important and interesting and the attempt was made to present both.

Other secondary purposes particular to this present study as part of the continuing project, were testing and evaluating the later modifications in the Staats' procedures and materials. Some of these had not previously been tested in formal studies.

In his earlier studies with single subjects it had seemed that the lower case letters were very rapidly acquired if presented paired with previously learned upper case letters. This procedure was tested with the children in this study.

Another experimental study (Staats, 1965) had also showed that a child could abstract the concept of individual grapheme-phoneme units (learn phonic units) when systematically presented with whole words containing these units. Staats had previously and has since used this type of procedure when training his own children in functional reading repertoires. One of the purposes of the present study was to test this type of training with stimulus materials that lend themselves to systematic data collection
and which also use actual words, as had the work with his children.

In the counting procedures, a method which Staats used with his own children was systematically assessed with the present group of children. When a child had learned a basic counting repertoire (of 5 to 10 objects), the counting repertoire was extended verbally without accompanying object counting training. The functionality of the extended chain was tested by asking the child to count a number of objects corresponding to the limit of the new chain. Thus the child could count more objects than he had ever counted before without being trained directly to do this. This evidence of the verbal mediation of counting, previously observed with a single child, constituted a hypothesis to be tested experimentally with additional children in the present study.

Another possibility suggested by the prior work with single children was that addition may be taught through reading procedures. This possibility was also given more systematic testing in this study.
CHAPTER V

EXPERIMENTAL PROCEDURES

The Staats' materials, procedures and apparatus which will be described have been developed in over a decade of his work. The materials are prototypical curriculum materials.\(^1\) In this study the Staats' reading, writing and number concept methods were employed with preschool children for the purposes already summarized. The materials and procedures will be described in this chapter along with other conditions of the present study.

Subjects

Eleven preschool children were the subjects for this study. Two of the original group moved to the mainland and were replaced by Child 1 in late November and Child 2 in January. The children were between 3 years 11 months and 4 years 6 months at the beginning of the study with the exception of Child 2 who was 3 years 7 months at the beginning of her training and had only just turned 4 years old by the end of the school year.

The children were of various racial origins: five Hawaiian-Caucasian, two Japanese, one Japanese-Hawaiian, one Filipino, one Filipino-Japanese and one Chinese.

\(^1\)The procedures and materials described in this chapter are those developed in his previous work with children and are being copyrighted as such.
Almost all the children were from families with lower than average income. Two were sponsored by the Community Action Program and several came from families economically just above this level. All the children had at least one sibling, while two had five siblings each. The children were selected for the Child Learning Laboratory by Hannah Lou Bennet, of the Hawaiian Curriculum Center, in consultation with Professor Staats to include a range of abilities and to include culturally deprived children.

The Child Learning Laboratory

The research was supported by (1) Office of Economic Opportunity funds made available to Professor Staats through a grant to the Headstart Research and Evaluation Center directed by Professor Dorothy Adkins,¹ (2) by funds from the Department of Psychology for supporting the Child Learning Laboratory for purposes of graduate student education, and (3) by funds from the Educational Research and Development Center.

The classroom-laboratory complex that comprises the Child Learning Laboratory consists of a general classroom

¹The research reported herein was in part performed pursuant to a contract with the Office of Economic Opportunity, Executive Office of the President, Washington, D.C. 20506. The opinions expressed herein are those of the author and should not be construed as representing the opinions or policy of any agency of the United States Government. Contract number OEO 4121.
with adjacent office and bathrooms and connected research space, all located in the Hawaiian Curriculum Center.

In the classroom the children engaged in the usual preschool activities, singing, pasting, painting, playing with blocks, dolls, and so on. There was a large playground outside. The teacher was instructed not to give the children unrecorded extra cognitive learning trials in number, or alphabet reading or writing.

One of the children in the classroom had severe emotional difficulties and was the subject of research-treatment not included in the data to be dealt with herein. Several of the children also participated in behavior modification procedures while in the general classroom.

The preschool timetable was arranged for three indoor sessions separated by two outdoor play periods. During the indoor periods the children also left the classroom and received their training with the three experimenter-trainers in the laboratory.

**Apparatus**

The apparatus developed by Staats (1968) for use with his own children, and as also used in a study of twelve preschool children in Wisconsin, was employed. Each of the three pieces of apparatus (see Figure 1) consisted of a flat surface at good table height for the child, with a division between the child and the experimenter on which was a slot for the display of 5" x 8" cards, a hole for
Fig. 1. Staats' learning research and treatment apparatus. (Reprinted from Learning, Language, and Cognition by A. W. Staats, fig. 13.5, p. 324. Copyrighted by Holt, Rinehart and Winston, Inc., 1968.)
marble insertion, and a delivery box for the reinforcers. On the child's left was an upright partition on which was hung four clear plastic tubes of varying sizes. From the top of each tube a black line led to a hook. The experimenter-trainer had room on his side of the partition for marbles, trinkets and edibles, training materials and data recording sheets.

Reinforcement

Standard sized marbles were used as token reinforcers. These marbles could be used to obtain an immediate reinforcement of a trinket or an edible by being put in the hole, or could be saved for a toy already chosen and hung above one of the tubes by being stowed in the relevant tube. The toys were displayed on a table between the door to the basement and the laboratory room so that the children could choose what they wished to work for as they came into session.

Data Recording

The experimenter-trainers recorded every stimulus presented and every response of the child to the stimuli during training, differentiating correct responses, prompts and errors. The time was taken for each session and the number of reinforcers given during each session recorded. If the child made an error response, the nature of this error was recorded. The data sheets were ruled as grids. Each column represented a response and the row
marking indicated which type of stimulus had been presented. A separate data sheet was used for each session. The data was summarized on to a separate sheet at the end of each session.

Standardized Tests

At the beginning of the training three standardized tests were administered to all the children, the Stanford-Binet Intelligence Scale form L-M, the Peabody Picture Vocabulary Test form A, and the Metropolitan Readiness Tests form A. In the last two weeks of the second semester, the children were retested with form L-M of the Stanford-Binet, form B of the Peabody and form B of the Metropolitan.

Types of Training

Three classes of training were given, two more cognitive in nature, number concept formation and alphabet reading, and one largely sensory-motor, printing alphabet letters. Three experimenter-trainers worked with the children each day under the supervision of Professor Staats, to insure the standardization of the training procedures within the learning analysis. Michael Gross conducted all the number training during the two semesters. The present author conducted all the alphabet training for the first semester and the training with seven of the children in the second semester, while supervising a new trainer with the other four. The writing training was
conducted by members of the Child Learning Laboratory class, under Professor Staats' supervision. Each student trained three or four children. A further set of students conducted the writing training during the second semester in the same program.

Introduction for the Training and Reinforcement

The preschool teacher brought the child to the laboratory and introduced him to the experimenter-trainer. After seating the child at the apparatus, the experimenter asked the child to label a picture and when the child responded, delivered a marble. The child was told to put the marble in the hole and when he did this a reinforcer was delivered. Several further pictures were presented and the responses reinforced. During the first session (3-10 responses) the cues were gradually withdrawn.

On the second day the teacher in the classroom gave the child a marble to take to the laboratory. When the child arrived at the apparatus, the experimenter-trainer simply told him to put the marble in the hole and delivered a reinforcer. The same procedure was continued for a week after which the teacher merely told the child when it was his turn to go to the laboratory. One of the children who responded to all new situations with tears was brought to the basement by the teacher for three days, after which she came willingly herself.
Reinforcement During Training

From the second day the cognitive tasks were introduced among the picture naming. Throughout the training new tasks were reinforced continuously but as the response became established the ratio was increased so that ultimately a schedule of reinforcement approximating variable ratio was used with all established responses. The experimenter-trainer was guided in the rate of reinforcement by the child's behavior. If the child showed inattentive behavior or extinction of responses the reinforcement ratio was increased.

For the first three weeks immediate reinforcers were given in exchange for the marbles. By this time some inattentive behavior indicated to the experimenter-trainers that these reinforcers were no longer sufficiently effective and the children were introduced to the second stage of the reinforcement procedures. The child was told to choose a toy from a display of small toys, to work for. This toy was hung above the smallest tube (which holds ten marbles) and the child was instructed when a marble was delivered him that he could put it in the hole for an immediate reinforcer or put it in the tube to save towards the toy.

Social reinforcement was not limited but was used as seemed natural to the experimenter-trainers.
Alphabet Training

The children's reading training began with the upper case letters of the alphabet. Those children who reached the criteria for upper case letters were trained to read the lower case letters. Four children who completed both of these tasks well before the end of the second semester, were used as subjects in a concept formation experiment.

Alphabet Procedures

The alphabet training involved establishing the 26 letter stimuli as discriminative stimuli for 26 verbal responses. The method was to establish one response at a time firmly before the next stimulus was introduced. The vocal responses were found to be within the children's repertoire and were evoked by requesting the child to imitate the trainer.

Materials

1. A set of 100 line drawings of everyday objects and animals mounted on 5" x 8" cards.

2. A set of 5" x 8" cards on each of which was mounted a single upper case letter of the alphabet, in black Para-Type press-on lettering, futura medium style, 72 pt size.

3. A white cardboard display board measuring 10" x 12" on which all the letters were displayed in alphabetical order. The same futura medium lettering was used. The letters were arranged in rows of six letters with 2 inch spacing between letters and between rows.
4. A set of cards with one upper case letter and its corresponding lower case letter on each card.

5. A display board of lower case letters similar to the upper case display board.

**Upper Case Letters**

At the second session, pictures were presented for several trials. The experimenter-trainer then asked the child if he could say A, thus eliciting the vocal response "A". The trainer presented the A card in the frame in the apparatus, told the child that this was A and prompted the response "A" to the card. Prompted trials of A were interspersed among picture trials. The trainer allowed the child time to respond unprompted but was careful to prompt if the child hesitated or seemed about to make some other response. When it was no longer necessary to prompt A, trials on the display board were introduced. Only A and B were shown and the child was asked to point to A and say "A".

When the A response was strong, B was introduced in the same way. At first trials on A and B were kept separate in sessions and the first response of each group was prompted. When both A and B responses were strong, sequences were presented: A cued followed by B cued interspersed with single trials of A. The cuing was then removed cautiously. When A - B sequences were strong, A - A - B, and later A - B - B, A - picture - B, and A - two pictures
- B, were introduced. At each stage the experimenter-trainer was careful to prevent the child from making errors. Trials were given on the display board with A and B shown and the instructions, "Point to A and say 'A'" and "Point to B and say 'B'" given.

C was introduced in the same way when the responses to A and B were strong. Sequence trials with C included A, B, and C. In this manner the upper case letters were trained in order. When several letters had been trained, pictures were dropped out of the procedures. With each new letter, when responses had been established to it, the letter was then presented in sequence with the several previous letters of the alphabet. For example, for P the sequence would be L M N O P. Finally, when P was strong in this sequence it was presented in random sequences with all the earlier letters in the alphabet. Thus the earlier letters were constantly being reviewed. Throughout the training the criterion of rapid, correct responses to all previously known letters when presented randomly was reached before a new letter was presented.

Lower Case Letters

The lower case letters were presented paired with the already known upper case letters, the upper case letters acting as prompts. The prompts were removed by covering the upper case member of the pair. The [A a] card was presented and the child told that the small letter was
also called A. The paired B, C, and D cards were also shown in the same session and the smaller letters identified to the child as the small version of B, C, and D. The cards were then shown to the child in order with the upper case letter covered. If the child hesitated in responding, the cover was removed and the upper case letter then prompted the correct response. These four cards were presented in order until responding was strong and unprompted. The cards were then presented in random order with the same cuing used where necessary until the four responses were strong. Practice was given with a, b, c, and d on the display board. At this stage two or three more letters were introduced and the same sequence of procedures followed. Some of the lower case letters are so similar in shape to their upper case counterparts that they need little cuing, while others such as a, d, and r require more repetitions.

Reading Concept Formation Task
As preliminary training the first four children to learn both the upper and lower case letters were shown these letters in primary type. Several sessions were occupied in practice at responding to primary type letters. Materials
Thirty-six cards were used. On each card was one of the three-letter words from Table I.
TABLE I

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
<th>Set 4</th>
<th>Set 5</th>
<th>Set 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>cad</td>
<td>cam</td>
<td>cap</td>
<td>can</td>
<td>cag</td>
<td>cat</td>
</tr>
<tr>
<td>mad</td>
<td>mam</td>
<td>map</td>
<td>man</td>
<td>mag</td>
<td>mat</td>
</tr>
<tr>
<td>pad</td>
<td>pam</td>
<td>pap</td>
<td>pan</td>
<td>pag</td>
<td>pat</td>
</tr>
<tr>
<td>rad</td>
<td>ram</td>
<td>rap</td>
<td>ran</td>
<td>rag</td>
<td>rat</td>
</tr>
<tr>
<td>sad</td>
<td>sam</td>
<td>sap</td>
<td>san</td>
<td>sag</td>
<td>sat</td>
</tr>
<tr>
<td>tad</td>
<td>tam</td>
<td>tap</td>
<td>tan</td>
<td>tag</td>
<td>tat</td>
</tr>
</tbody>
</table>

In these syllables the six initial consonants c, m, p, r, s and t were combined in all ways with the six a + consonant endings, ad, am, ap, an, ag and at, as shown in Table I.

Reading Training

The first set of cards (Set 1) was presented to the child one at a time, the experimenter-trainer saying the word and the child repeating it while looking at the stimulus card. The set was presented again in the same serial order, the experimenter allowing time for the child to respond unprompted if he could, otherwise prompting as before. The experimenter continued to present the six cards in serial order, reinforcing responding with a marble once or twice in each set not consistently following the same syllable. The presentation of the first set in serial order continued through as many sessions as necessary until the child could respond correctly to the cards unprompted through three continuous presentations of the set. The
cards were then presented in broken serial order, that is, retaining the same order but beginning from a different member of the set on each presentation. After the second criterion of three correct unprompted trials through the set in broken serial order was reached, the cards were presented in random order. The child reached the third criterion when he could respond correctly without prompts to three presentations of the set in random order.

At this stage the first set of cards was set aside and Set 2, with the order of the initial consonants randomly altered, was presented in the same way until the same three criteria had been met.

After this procedure had been followed for the six sets, the experimenter again presented the first set in the same way until the same criteria had been reached, and so on through the six sets. The same six sets were then presented for the third time. Next, the whole of the 36 cards were treated as one set and the same procedure was followed for this large set, that is, presentation was continued until the 36 were read correctly three times. Only one child reached this final stage of the procedures before the end of the semester. However, during the final sessions, regardless of what stage the children had reached, further tests of the generalization of the concepts were made. These tests of generalization of letter concept formation were as follows:
a. A new syllable "cab" containing a new "a + consonant" ending was presented until the child responded correctly, unprompted for three trials in succession. Next, the new ending was presented with other previously learned initial consonants, that is, rab, sab, tab and pab.

b. A new "a + consonant" ending "ax" was presented in isolation until the child responded correctly, unprompted for three trials in succession. Next, the new ending was presented with other previously learned consonants, to form: max, sax, tax and pax.

c. A new initial consonant "b" was presented with a previously learned ending "ad" forming "bad", until the child responded correctly, unprompted for three trials. The new word was then presented among other members of Set 1, (cad, mad, sad, etc.) until the response was strong. The initial consonant "b" was then presented with other known endings, that is, bag, ban and bat.

Number Procedures

The children were pretested on their previous learning of numbers, their ability to label one, two or three objects according to number, to count verbally, to count objects, and to read numbers. The training was begun at a stage corresponding to the child's current status.

Materials

1. A set of line drawings of animals and familiar objects, with either one, two or three pictures on each
5" x 8" card.

2. A set of cards with either one, two or three geometric figures on each.

3. A set of cards with one to ten dots on each and a like set with one to ten squares.

4. Several sets of objects: beads, dominoes, pennies, crayons, and so on.

5. A set of cards with one number in black Para-Type press-on lettering in 72 pt size on each.

Number Training

The children were first given training in labelling one, two and three objects. Next they were taught to count verbally and to count objects. A hypothesis was tested that if the verbal chain was functional to a certain point, it could be extended verbally and then would prove functional without further specific object counting training. Training was then given in reading numerals and finally five children were used to test an addition hypothesis.

Number Labelling

The experimenter-trainer displayed a card with one object on it and prompted the response "one". As soon as this response was unprompted and strong to single items, a two-object card was presented and the response "two" prompted. As the "two" response was readily elicited, sequences of 1-2, 1-1-2, 1-2-2 stimuli were introduced.
Cards with geometric figures were also used. When cards with one or two objects on them were responded to correctly in any random sequence, three-object cards were presented.

**Counting**

The experimenter-trainer displayed a two-dot card, covering one of the dots so that the child responded "one", then uncovering the second dot so that the child responded "two". Demonstrating the procedure, the trainer prompted the child to point to each dot in turn saying, "one - two". Using this same method, three and four dot cards were presented.

When a chain of numbers had been established for pointing and counting on the cards, objects (beads, dominos or pennies) were arranged in a line. The trainer demonstrated pointing to the objects in sequence, left to right, and counting aloud. The child was prompted to do this. Three objects were then presented in an unarranged pile. The trainer demonstrated pulling each object towards him while counting aloud. The child was prompted to count the three objects in this manner. When this pulling over and counting behavior was strong, the counting of four unarranged objects was demonstrated and the child prompted to pull over and count four objects. Within each session two or three different types of objects were utilized for counting trials. When the counting of four
unarranged objects was strong, counting one more object was trained until the limit of the child's verbal counting sequence was reached.

Testing the Hypothesis of Extending the Verbal Sequence

When the children could count verbally and count objects to a certain number which varied from 5 to 14 depending on the child's initial counting status, the experimenter extended the child's verbal counting chain without giving any further counting practice. He instructed the child to count and when the child reached the limit of his chain, the trainer prompted the next number. Several sessions were occupied in this way until the child could count approximately five or six more numbers than he had learned in the previous active counting training. The experimenter then tested the functionality of the verbal sequence at the beginning of a new session. He presented the child with a pile of unarranged objects, as many as the limit of his chain, and asked him to count them.

By this stage of training the functional counting chains of all the children exceeded 10.

Reading Numbers

The same procedures were used in training number reading as were used for alphabet reading. One difference however is that, owing to the counting training, the names of all the numbers were in the children's repertoires. While this meant that the children did not have to learn
these as new verbal responses, it was also a complicating factor in that the child had a whole set of associated responses available when responding to the written number stimuli.

Addition

Five children who completed the number reading training some weeks before the end of the second semester were used as subjects to test an addition training procedure. The children were taught addition chains, 2 and 3 are 5, etc., by verbal methods alone and were tested for the formation of addition concepts and timed to record any savings over successive sets.

Materials

1. A set of cards with number additions up to 10 such as: 6 and 3 are 9, typed on them in primary type.

2. Four sets of cards as follows:

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
<th>Set 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 1 are 2</td>
<td>2 and 1 are 3</td>
<td>3 and 1 are 4</td>
<td>4 and 1 are 5</td>
</tr>
<tr>
<td>1 and 2 are 3</td>
<td>2 and 2 are 4</td>
<td>3 and 2 are 5</td>
<td>4 and 2 are 6</td>
</tr>
<tr>
<td>1 and 3 are 4</td>
<td>2 and 3 are 5</td>
<td>3 and 3 are 6</td>
<td>4 and 3 are 7</td>
</tr>
<tr>
<td>1 and 4 are 5</td>
<td>2 and 4 are 6</td>
<td>3 and 4 are 7</td>
<td>4 and 4 are 8</td>
</tr>
</tbody>
</table>

3. Four sets of cards as follows:

| 1 and 5 are 6 | 2 and 5 are 7 | 3 and 5 are 8 | 4 and 5 are 9 |

Preliminary Training

The children were given some practice in reading numbers in primary type, and were trained to read the words
"and" and "are" in the sentences: 4 and 5 are 9, 2 and 8 are 10, etc.

Procedures
Beginning with the first set of cards, the experimenter told the child to read, prompting where necessary. On the second and succeeding times through the set, the trainer covered the answer, giving the child time to respond before prompting by revealing the answer. The trainer continued to present the set in the same order until the first criterion was reached, that of the whole set in order, correct and unprompted. The cards were then presented to the child in a different sequence, namely: 1 and 2 are 3, 1 and 3 are 4, 1 and 4 are 5, 1 and 1 are 2. Responses were prompted to the cards in this order until this sequence was responded to correctly, unprompted on three successive trials. The cards were then arranged and presented in another broken sequence, namely: 1 and 3 are 4, 1 and 4 are 5, 1 and 1 are 2, 1 and 2 are 3. This sequence was trained to the criterion of three successive, correct, unprompted trials. Finally the four cards of the set were presented in random order until the child could respond correctly, unprompted to three successive random presentations of the four cards. When the four criteria were met, the first set was put aside and the same procedure used with the second set. When the four sets were completed, the experimenter-trainer again presented the
first set using the same procedures.

At the end of the training of each set, the child was presented with an "and 5" card, e.g., 1 and 5 are 6, to test the formation of the addition concept.

Writing Procedures

The writing training consisted of three steps for each stage, tracing, copying, and finally printing without a model. The materials for tracing and copying were duplicated on sheets of paper. The children used a thick crayon or a heavy pencil to print with.

At the beginning of the training and later when it was necessary, the trainer demonstrated the movement to the child.

The components of the upper case letters of the alphabet were ordered so that training was first given on straight lines, then intersecting lines, and lastly circles and curves. As preliminary training for writing upper case A, the children were prompted to join dots through a succession of trials until the outline of A had been made, at which stage the center line was added. B was built up beginning from a straight line and adding the curves. Practice was given on a circle immediately before the C was demonstrated. The size of the model letter for tracing and copying was reduced from the original 2" high to 1" high and then to primary type. The child repeated trials on each letter until he could execute it freely
without a model. Before beginning a new letter, all the previously learned letters were presented in order for copying and then the child was requested to write all the letters without a model.
CHAPTER VI
GENERAL RESULTS AND DISCUSSION

Reinforcer System

The introduction to the laboratory training situation was achieved for most of the children in the first session and within three days for all of the children. Bijou and Baer (1966) record the difficulties that experimenters have had in finding reinforcers which will maintain young children's responding over many experimental sessions without satiation. This reinforcer system, however, maintained the children's regular, willing attendance at their thrice daily sessions. It also assured their concentrated attention to the learning tasks, throughout a complete school year and over a variety of tasks not easily assumed to be "reinforcing in themselves".

The children developed individual ways of using the reinforcer system. Two worked for ten-marble toys for a while and then worked for immediate reinforcers almost exclusively. Others never reverted to immediate reinforcers from the time the ten-marble reinforcers were introduced. The rate of reinforcement and the type available were therefore manipulated by the experimenter-trainers while the child chose the actual reinforcers for any given session. Most of these four-year-olds found edibles strongly reinforcing. While all of the children chose consumables
some of the time, several chose these rewards almost exclusively.

The reinforcers maintained the children's attention behavior and the experimenter-trainers were able to manipulate the children's behavior by intermittently reinforcing correct responses and by not reinforcing incorrect responses. With Child 4, however, it was found necessary to specifically state the contingencies. This child made little progress at the reading tasks, either alphabet or numeral reading, until the experimenter told her clearly that the marble was delivered for correct responses and not for incorrect responses. Her learning rate increased immediately and continued to increase until the end of the semester despite her frequent absences.

The cost of the reinforcements for the year was approximately $10.00 per child.

The purpose of manipulating reinforcers in this longitudinal study was to maintain the response rate of the subjects. Varying the reinforcement to keep up the response rate was a skill which had to be learned by the experimenter-trainers. They needed to learn to recognize signs that the task was too difficult for the child, or that the rate of introduction of new materials was too rapid, so that the reinforcement had to be increased. These signs were in the children's behavior: longer latency of response, movements extraneous to the task, error responses.
Recognition of these signs as cues for modifying training procedures constitutes one of the important findings of Staats' previous research.

Standardized Tests Results

Table II shows the pretest and posttest scores for all the children on the three standardized tests, the Stanford-Binet Intelligence Scale, the Peabody Picture Vocabulary Test and the Metropolitan Readiness Tests. There is considerable variability among the children in the way their scores increase and decrease. Child 8 drops 16 I.Q. points in the Stanford-Binet, gains 17 I.Q. points in the Peabody and moves from the 4th to the 31st percentile rank in the Metropolitan. Most of the children increased their scores between the pretests and posttests. Of the 33 pretest-posttest scores reported, only four move in the negative direction.

**TABLE III. MEANS OF THE STANDARDIZED TESTS**

<table>
<thead>
<tr>
<th></th>
<th>Stanford-Binet</th>
<th>Peabody</th>
<th>Metropolitan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>105.36</td>
<td>91.64</td>
<td>22.36 (5%ile)</td>
</tr>
<tr>
<td>Post</td>
<td>111.73</td>
<td>98.73</td>
<td>36.09 (19%ile)</td>
</tr>
</tbody>
</table>

The difference between the means (see Table III) in the Peabody gave a $t$ of 1.31, and in the Stanford-Binet a $t$ of 1.51 which is significant at the 0.10 level. The $t$ for the difference between the pretest and posttest means of the raw scores of the Metropolitan, however, is 3.92
### Table II

**Results of Standardized Tests**

<table>
<thead>
<tr>
<th>Child</th>
<th>Stanford-Binet Pre/Post</th>
<th>Peabody Picture Vocabulary Pre/Post</th>
<th>Metropolitan Readiness Pre/Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw Score</td>
<td>Percentile</td>
<td>Raw Score</td>
</tr>
<tr>
<td>1</td>
<td>84/90</td>
<td>65/75</td>
<td>19/22</td>
</tr>
<tr>
<td>2</td>
<td>100/105</td>
<td>91/83</td>
<td>20/20</td>
</tr>
<tr>
<td>3</td>
<td>98/101</td>
<td>71/81</td>
<td>23/25</td>
</tr>
<tr>
<td>4</td>
<td>115/101</td>
<td>101/69</td>
<td>29/36</td>
</tr>
<tr>
<td>5</td>
<td>101/112</td>
<td>78/116</td>
<td>28/33</td>
</tr>
<tr>
<td>6</td>
<td>92/116</td>
<td>96/101</td>
<td>33/42</td>
</tr>
<tr>
<td>7</td>
<td>97/112</td>
<td>73/99</td>
<td>9/41</td>
</tr>
<tr>
<td>8</td>
<td>121/105</td>
<td>100/117</td>
<td>20/45</td>
</tr>
<tr>
<td>9</td>
<td>123/125</td>
<td>108/114</td>
<td>15/44</td>
</tr>
<tr>
<td>10</td>
<td>119/127</td>
<td>116/121</td>
<td>27/47</td>
</tr>
<tr>
<td>11</td>
<td>109/135</td>
<td>109/110</td>
<td>23/42</td>
</tr>
</tbody>
</table>
which is significant at beyond the 0.01 level. Not all of the subtests of the Metropolitan were affected equally. The greatest increases in scores occurred in the Alphabet subtest and the Numbers subtest.

The children in the study conducted at Madison, Wisconsin (see Chapter IV) were also given the Stanford-Binet and the Metropolitan at intervals during their training. The Madison children had lower pretest scores than the Hawaiian children, an average I.Q. score of 100.9 and an average Metropolitan percentile rank of 23.3 (Staats, 1968). The Madison children also made greater overall gains. Their average posttest I.Q. score was 112.5 and their average posttest Metropolitan percentile rank was 23.8.

Wesman (1968) suggests that most of the confusion that plagues us about intelligence tests, "is attributable to our ignoring two propositions which should be obvious:

1. Intelligence is an attribute, not an entity.
2. Intelligence is the summation of the learning experiences of the individual." (p. 267). He states that the difference between aptitude, achievement and intelligence measures is the purpose for which the tests are used and sometimes the range of the domain sampled. All these tests sample what an individual has learned and in some cases with the same items. Conversely when training has been given in specific areas, as in this study, it would
be expected that there would be an increase of scores in tests closely related to the specific areas trained. There would be less evidence of the effect of the training in tests with little relationship to the training.

The Peabody test which tests vocabulary more than anything else was the least affected by the training given in this study. The Stanford-Binet has one item at each level which has some relationship with either the number training or the writing training. All of the children, excepting Child 1 and Child 2 who did not reach this level, significantly improved their scores on the number concept item at level VI and on other number and copying items.

As in the previous study (Staats, 1968) the greatest gains in the Metropolitan were on the Alphabet, Numbers and Copying subtests, those subtests, in fact, most closely related to the areas of the training. Wesman (1968) also points out that aptitude tests measure previously learned material which is prerequisite to the given field. The Metropolitan is a school readiness test and number, alphabet and copying skills are considered part of the prerequisite for Grade 1 success. This training then can be assumed to be preparing children for success in school by training the prerequisite skills.

Writing Results

Because very adequate data on writing was collected by Staats (1968) in the Wisconsin study, in this study the
writing training was used for the purpose of giving experience and training to a number of graduate students in a laboratory class. Each student in the Child Learning Laboratory course trained the same three or four children throughout a semester. In the second semester another class of students conducted the training. An attempt was not made to produce precise data in this work. Thus, although records were kept, quantitative data will not be presented.

Qualitatively, it can be said that the children all increased in their ability to handle a writing instrument, pencil or crayon. Moreover, the children learned to write all of the upper case letters that they had learned to read.
CHAPTER VII
READING RESULTS AND DISCUSSION

Alphabet Training Results

One of the children was able to read all but two of the upper case letters of the alphabet, because of previous training by his mother. This boy, Child 10, was trained to read the lower case letters, while the other children began with the upper case letters. None of the other children could read any of the alphabet letters before training began. Of these ten children, seven completed the upper case letters and six of these learned the lower case letters also. Child 4 learned to L by the end of the second semester, at which stage her rate of acquisition of new letters was fast. The remaining two children, 1 and 2, learned A through G and their acquisition pace was increasing only gradually.

The criterion for the number of trials for learning a letter was taken as the number of trials of that letter given before the presentation of the next letter. At this time the reading response to the letter had to be strong, that is, the child had to be able to read the letter spontaneously whenever it was presented in any random combination with previously learned letters. The total number of trials for each letter during the course of training was not used as a criterion because the earlier letters were
continuously used as interspersed material. Presentation of the next letter was also used as the criterion for the time taken to learn each letter and the number of reinforcers used. In the following tables and figures the letters are grouped in fours, A-D, E-H, etc., and the average for the four letters is presented. Groupings of four were chosen because Staats (1968) has suggested on the basis of his previous studies that an increase in learning rate occurs after the first four letters are learned and continues throughout the alphabet training.

Table IV shows for each child the average number of trials to criteria, the average time taken and the average number of reinforcers used for the upper case letters in groups of four. Figures 2, 3, 4, 5, 6 and 7 present the same material graphically, a different patterned line representing each child. Figures 3, 5 and 7 depict the means for the group.

As indicated by Figure 2 the children took fewer trials to learn new letters to criterion as they progressed through the alphabet. An analysis of variance of the trials taken by the seven children who completed the upper case alphabet shows a significant non-chance difference between the number of trials taken to learn each group of four letters (see Table V). The means of the letter groups are in descending order and a trend analysis reveals a very significant linear trend and a smaller quadratic
### Table IV. Summary of Alphabet Training of Individual Children

<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A - D</td>
<td>31.50</td>
<td>18.12</td>
<td>64.50</td>
<td>33.25</td>
<td>16.87</td>
<td>60.25</td>
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<td>E - H</td>
<td>26.75</td>
<td>13.75</td>
<td>46.00</td>
<td>20.00</td>
<td>8.12</td>
<td>27.75</td>
</tr>
<tr>
<td>I - L</td>
<td>12.50</td>
<td>9.12</td>
<td>22.50</td>
<td>17.25</td>
<td>9.50</td>
<td>25.00</td>
</tr>
<tr>
<td>M - P</td>
<td>20.75</td>
<td>9.00</td>
<td>46.00</td>
<td>8.25</td>
<td>2.12</td>
<td>5.00</td>
</tr>
<tr>
<td>Q - T</td>
<td>18.50</td>
<td>13.12</td>
<td>30.25</td>
<td>7.25</td>
<td>2.37</td>
<td>8.50</td>
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<tr>
<td>U - X</td>
<td>9.25</td>
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<td>20.00</td>
<td>3.75</td>
<td>2.12</td>
<td>2.50</td>
</tr>
<tr>
<td>Y-Z</td>
<td>5.00</td>
<td>6.00</td>
<td>2.00</td>
<td>5.00</td>
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<tr>
<td>Total Sessions - 76</td>
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<td>Total Sessions - 52</td>
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</table>

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</thead>
<tbody>
<tr>
<td>A - D</td>
<td>31.50</td>
<td>14.50</td>
<td>58.00</td>
<td>37.75</td>
<td>24.62</td>
<td>84.75</td>
</tr>
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<td>E - H</td>
<td>28.75</td>
<td>12.00</td>
<td>40.25</td>
<td>31.25</td>
<td>13.12</td>
<td>37.50</td>
</tr>
<tr>
<td>I - L</td>
<td>31.25</td>
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<td>49.00</td>
<td>42.25</td>
<td>20.25</td>
<td>47.50</td>
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<tr>
<td>M - P</td>
<td>20.50</td>
<td>13.90</td>
<td>30.25</td>
<td>19.75</td>
<td>13.12</td>
<td>28.50</td>
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<td>Q - T</td>
<td>15.50</td>
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<td>12.75</td>
<td>16.50</td>
<td>13.12</td>
<td>28.00</td>
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<tr>
<td>U - X</td>
<td>16.50</td>
<td>5.70</td>
<td>17.50</td>
<td>14.00</td>
<td>6.12</td>
<td>15.00</td>
</tr>
<tr>
<td>Y-Z</td>
<td>8.00</td>
<td>5.20</td>
<td>5.00</td>
<td>18.25</td>
<td>19.50</td>
<td>46.00</td>
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<td>Total Sessions - 85</td>
<td></td>
<td></td>
<td></td>
<td>Total Sessions - 103</td>
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<td>-------</td>
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</tr>
<tr>
<td>A - D</td>
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<td>47.75</td>
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<td>70.00</td>
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<td>I - L</td>
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<td>9.00</td>
<td>25.25</td>
<td>23.25</td>
<td>32.29</td>
<td>70.00</td>
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<td>M - P</td>
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<td>14.00</td>
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<td>5.00</td>
<td>13.00</td>
<td>6.00</td>
<td>10.25</td>
</tr>
<tr>
<td>Y-Z</td>
<td>2.00</td>
<td>2.00</td>
<td>4.00</td>
<td>9.00</td>
<td>2.90</td>
<td>35.00</td>
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**Total Sessions - 49**

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<tbody>
<tr>
<td>A - D</td>
<td>80.75</td>
<td>48.00</td>
<td>149.25</td>
<td>39.50</td>
<td>22.70</td>
<td>76.25</td>
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<tr>
<td>E - H</td>
<td>35.25</td>
<td>27.50</td>
<td>43.00</td>
<td>40.25</td>
<td>21.37</td>
<td>59.50</td>
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<tr>
<td>I - L</td>
<td>11.25</td>
<td>12.62</td>
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<td>28.00</td>
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<td>56.00</td>
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<tr>
<td>M - P</td>
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<td></td>
<td>16.00</td>
<td>14.00</td>
<td>34.25</td>
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<tr>
<td>Q - T</td>
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<td>6.50</td>
<td>17.25</td>
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<td></td>
</tr>
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<td>U - X</td>
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<td>11.50</td>
<td>31.25</td>
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<td>Y-Z</td>
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**Total Sessions - 100**

**Total Sessions - 111**
TABLE IV. (Continued) SUMMARY OF ALPHABET TRAINING OF INDIVIDUAL CHILDREN

<table>
<thead>
<tr>
<th>Letters</th>
<th>Child 2</th>
<th></th>
<th></th>
<th>Child 1</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Trials</td>
<td>Time</td>
<td>Rein.</td>
<td>Trials</td>
<td>Time</td>
<td>Rein.</td>
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<tr>
<td>A - D</td>
<td>63.50</td>
<td>33.62</td>
<td>110.25</td>
<td>72.25</td>
<td>56.62</td>
<td>166.50</td>
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<tr>
<td>E - G</td>
<td>54.00</td>
<td>30.00</td>
<td>87.30</td>
<td>43.30</td>
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<td>49.00</td>
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<tr>
<td>Total Sessions</td>
<td>72</td>
<td></td>
<td></td>
<td>Total Sessions</td>
<td>95</td>
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</table>
Fig. 2. Trials taken to read letters.
Fig. 3. Mean trials for reading letters.
Fig. 4. Time taken for alphabet reading.
Fig. 5. Mean time to read letters.
Fig. 6. Reinforcements required for reading letters.
Fig. 7. Mean reinforcements for reading letters.
TABLE V. ANALYSIS OF VARIANCE AND TREND ANALYSIS OF NUMBER OF TRIALS TAKEN TO READ LETTERS

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>6</td>
<td>2,913.30</td>
<td>8.79**</td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letters</td>
<td>5</td>
<td>9,499.94</td>
<td>28.66**</td>
</tr>
<tr>
<td>Residual</td>
<td>30</td>
<td>331.52</td>
<td></td>
</tr>
<tr>
<td>F Linear Trend</td>
<td></td>
<td>140.18**</td>
<td>**p &lt; .01</td>
</tr>
<tr>
<td>F Quadratic Trend</td>
<td></td>
<td>6.59*</td>
<td>*p &lt; .05</td>
</tr>
</tbody>
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TABLE VI. ANALYSIS OF VARIANCE AND TREND ANALYSIS OF TIME TAKEN TO READ LETTERS

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
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<td>11,575.66</td>
<td>46.89**</td>
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<tr>
<td>Within Subjects</td>
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</tr>
<tr>
<td>Letters</td>
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<td>3,308.13</td>
<td>13.40**</td>
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<td></td>
</tr>
<tr>
<td>F Linear Trend</td>
<td></td>
<td>56.96**</td>
<td>**p &lt; .01</td>
</tr>
</tbody>
</table>
trend which describes the leveling off towards the end of the training (Table V). In this study the children took fewer trials to learn successive groups of letters. The graphs of the three children who did not complete the alphabet demonstrate the same function.

The measure of the time taken to learn each group of letters (Figure 3) shows the same general function as the graph of the trials, and the analysis of this data confirms a significant difference between groups and a significant linear trend (see Table VI). However, this measure is affected by the speed of the experimenter-trainer as well as the speed of the child's responses. The four children whose graphs rise during the I - L letters were the four who were transferred to another experimenter-trainer, and it seems likely that the increase in the time taken at this point reflects the slower pace of the new trainer. The time variable also includes the time on interspersed material as well as time on learning trials.

The graph of the reinforcers (Figure 5) shows the same general decreasing function which is confirmed by the analysis of variance and the trend analysis (see Table VII). The total time taken to learn the lower case letters was much less in every case than the time taken to learn the upper case letters. Table VIII shows the time taken for each child. The average learning time taken by the children who completed the upper and lower case letters
TABLE VII. ANALYSIS OF VARIANCE AND TREND ANALYSIS OF
REINFORCERS USED IN LETTER READING TASK

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>6</td>
<td>10,579.19</td>
<td>6.96**</td>
</tr>
<tr>
<td>Within Subjects</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforcers</td>
<td>5</td>
<td>40,293.45</td>
<td>26.49**</td>
</tr>
<tr>
<td>Residual</td>
<td>30</td>
<td>1,520.55</td>
<td></td>
</tr>
<tr>
<td>F Linear Trend</td>
<td>125.06**</td>
<td></td>
<td>**p &lt; .01</td>
</tr>
<tr>
<td>F Quadratic Trend</td>
<td>7.74**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child</td>
<td>Letters Completed</td>
<td>Time for UC</td>
<td>Time for LC</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>1</td>
<td>A-G</td>
<td>5hrs 44.5mins*</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>A-G</td>
<td>4hrs 14.5mins*</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>A-Z</td>
<td>6hrs 47.5mins</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>A-L</td>
<td>5hrs 52.5mins*</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>A-Z, a-z</td>
<td>7hrs 30.0mins</td>
<td>43.0mins</td>
</tr>
<tr>
<td>6</td>
<td>A-Z, a-z</td>
<td>2hrs 36.5mins</td>
<td>23.5mins</td>
</tr>
<tr>
<td>7</td>
<td>A-Z, a-z</td>
<td>6hrs 41.5mins</td>
<td>43.0mins</td>
</tr>
<tr>
<td>8</td>
<td>A-Z, a-z</td>
<td>5hrs 17.5mins</td>
<td>39.0mins</td>
</tr>
<tr>
<td>9</td>
<td>A-Z, a-z</td>
<td>2hrs 49.0mins</td>
<td>42.0mins</td>
</tr>
<tr>
<td>11</td>
<td>A-Z, a-z</td>
<td>4hrs 37.0mins</td>
<td>45.0mins</td>
</tr>
</tbody>
</table>

*Incomplete
was 4 hours 25.25 minutes for the upper case letters, and 39.25 minutes for the lower case letters.

Figure 8 shows the changes in response rate, that is, the number of trials per minute, over ten session blocks. This rate is a function both of the latency of response of the child and the speed of the trainer presenting the material. The response rate for all the children was near 4 trials per minute in the first block, rising to an average of almost 8 trials per minute by the third block and fluctuating between 6 and 10 responses per minute thenceforward.

Only three children did not complete the learning of the upper case alphabet, and these cases deserve separate discussion. Child 4, as previously mentioned in the general results on reinforcement, did not respond consistently to the training until the reinforcement contingencies were made explicit. After this was done, however, her progress was very rapid.

Child 2 was the youngest in the class, the last to be admitted to the training and the child to accumulate the most days of absence. Thus she was given only 4 hours 14.5 minutes of training during her five months in the preschool. She slowly progressed during that time to reading G. This child's I.Q. scores according to the Stanford-Binet test were 100/105. Staats' previous studies have indicated that younger children even with high I.Q. scores
Fig. 8. Mean alphabet reading response rate in trials per minute over 10 session blocks.
take longer to learn this material. Child 2 could well be compared with Child 3 who was the youngest child of the initial group and whose progress over the first few letters was correspondingly slow.

Child 1 began training in the middle of November at the age of 3 years and 11 months. He was the youngest of six children and all his elder siblings were considered retarded at school. His behavior would be described similarly. He suffered from a condition of the ear drum which was associated with a constant nasal discharge. His progress with the alphabet training was very slow but he did learn seven letters in 5 hours 44.4 minutes of training. He was also able to discriminate and respond to a known letter when it was on the same card as another unlearned symbol. This child had little intellectual stimulation at home and his vocabulary was very limited but there was no indication that he was unable to learn alphabet names through this training, only that he would take longer than the other children. As far as increasing his school readiness was concerned, he would probably have benefitted from vocabulary extension training as a preliminary to the alphabet training.

All of the children in this study learned at least some of the letters of the alphabet through these training methods. The average time taken for the seven children who learned all of the upper case letters was 5 hours 11
minutes. As demonstrated in all the previous studies conducted by Staats with individual children, the time taken to learn successive letters was less and less as the training proceeded. The training of the lower case letters in conjunction with the upper case letters previously learned, was very rapid.

In the studies collected by Chall (1967) and mentioned in Chapter II, knowledge of the names of the alphabet letters was shown to be a good predictor of later reading skill. The justification for alphabet training as a prerequisite to reading in S-R terms is that the letters are the smallest stimuli in reading which must be separately discriminated. Until the child can discriminate (respond separately to) the alphabet letters, he will be unable to respond differentially to similar words such as "pen" and "pan". Of course adult readers respond to much larger groups of letters but this skill is built from the initial discrimination ability. As only one of these children had been taught any letter names at home, the training given them in this skill could facilitate their early reading.

Reading Concept Formation Results

Child 6, Child 9, Child 10 and Child 11 took part in this experiment. As shown in Figure 9, the children took many trials, an average of 109, to reach the third criterion on their first learning of Set 1. But the average number of trials to learn Set 2 for the first time was
Fig. 9. Reading concept formation.
only 24.5. There were minor fluctuations only in the number of trials to learn Sets 3, 4, 5, and 6 for the first time. Almost all of the learning to learn in this task therefore took place in the first set, the completion of which was an arduous task for the children. Figure 10 shows the gradual acquisition of Set 1 to the first criterion and the faster acquisition of Set 2 for a typical subject, Child 10. Table IX gives the analysis of variance and Table X the trend analysis of the first learning of Sets 1 to 6 by the four children. The figures confirm what seems obvious in the graph, a significant difference between sets and a significant linear and quadratic trend.

Only one of the four children, Child 6, completed the whole experiment, but all the children were tested with the tests of the generalization of the concept in the last week of the second semester. Child 9 was absent for the last test. Table XI gives the new syllable taught and the tests of generalization given to the children. An "X" indicates that the new syllable was learned and the generalization test was passed with an unprompted correct response on the first presentation of the previously unseen syllables.

The four children were successful in most of the first generalization, that of applying already known initial consonants to a newly learned ending "ab". This verifies the previous findings (Staats, 1968, pp. 309-315) in
Fig. 10. Acquisition of set 1 and set 2 for Child 10 to first criterion. (Vertical lines indicate end of sessions).
# TABLE IX. ANALYSIS OF VARIANCE OF LEARNING OF FIRST SIX SETS OF READING CONCEPT FORMATION TASK

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>3</td>
<td>1,309.61</td>
<td>2.98</td>
</tr>
<tr>
<td>Within Subjects</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sets</td>
<td>5</td>
<td>4,682.70</td>
<td>10.66**</td>
</tr>
<tr>
<td>Residual</td>
<td>15</td>
<td>439.45</td>
<td></td>
</tr>
</tbody>
</table>

**p < .01

# TABLE X. TREND ANALYSIS OF FIRST SIX SETS OF READING CONCEPT FORMATION TASK

<table>
<thead>
<tr>
<th>Trend</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>25.00**</td>
</tr>
<tr>
<td>Quadratic</td>
<td>19.75**</td>
</tr>
</tbody>
</table>

**p < .01
### TABLE XI. GENERALIZATION TEST IN READING CONCEPT FORMATION TASK

<table>
<thead>
<tr>
<th>Child</th>
<th>New Syllable</th>
<th>Generalization Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cab</td>
<td>rab</td>
</tr>
<tr>
<td>6</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>11</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Child</th>
<th>New Syllable</th>
<th>Generalization Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ax</td>
<td>max</td>
</tr>
<tr>
<td>6</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Child</th>
<th>New Syllable</th>
<th>Generalization Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bad</td>
<td>bag</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>X</td>
<td>-</td>
</tr>
</tbody>
</table>
the first test of this type of concept formation reading learning. The second generalization was made by three of the children but only once by Child 9. The third generalization, that of adding previously learned endings to a newly learned initial consonant, "b", was accomplished only by the boy who had completed the experiment, Child 6.

In this task the way the children learned the sound correspondence of a letter or groups of letters was investigated. These results indicate that the initial consonants were discriminated early in the training and were probably the major part of what was learned in the first set. When a new ending was taught, the children were quickly able to prefix the known initial consonants to it. The learning of the "a + consonant" endings was more gradual and was not accomplished by children 10 and 11 at the stage of training they had reached, but was accomplished by Child 6 who had completed the procedure.

That the "a + consonant" ending concepts took longer to form may have been due to the experimental arrangement. If the first set had been, "cad, cam, cap, can, cag, cat"; the discrimination of the endings might have been acquired first. This needs to be investigated empirically.

This task was not designed to demonstrate an ideal way of teaching syllables. The method of presentation controlled the number of times each stimulus was seen. A method of presentation more like that used for the alphabet
training, that is, each syllable learned to criterion before the next was presented, may have resulted in faster acquisition of the syllables and of the concepts, but this also would have to be tested empirically.

There was no indication in this task that the words which had the most meaning for the children were learned most quickly.
CHAPTER VII
NUMBER TRAINING RESULTS

Pretest
The children's number status, that is, each child's repertoire of counting response sequence before the beginning of the training was as follows:

TABLE XII. COUNTING STATUS

<table>
<thead>
<tr>
<th>Child</th>
<th>Status</th>
<th>Child</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>7</td>
<td>6*</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>9</td>
<td>14*</td>
</tr>
<tr>
<td>5</td>
<td>4*</td>
<td>10</td>
<td>13*</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>11</td>
<td>10*</td>
</tr>
</tbody>
</table>

The number in the counting chain is starred if the chain was functional, that is, if the child could count objects to this number. Non-starring of the number indicates that the child could say the verbal chain but not count objects. These children had a range of initial counting ability from 0 to 14.

Number Labeling
Most of the children could already label 1 and 2. The two children who had no number labeling responses were trained to a one versus two discrimination. The training then went on to the counting procedure directly, although the previous findings have included the labeling of three
stimuli also (Staats, 1968).

Counting

The children were given an average of 238.4 trials in 22.66 sessions of counting training up to the point where the verbal chain was extended. The training established a functional counting chain of at least 5 for those children whose original status was less than this. The training also consolidated the verbal chains and object counting behavior of those with a higher original status.

The variability of the original counting status of these children complicated the analysis of the counting acquisition in this study. Staats (1968) has shown, with children whose initial counting status was virtually zero, acquisition curves which demonstrate a gradual reduction in the number of trials to criterion for successive numbers taught. Child 1 and Child 3 in this study, who had an original status of 0 and 3 respectively, both had this type of acquisition curve which closely resembles the curves obtained with alphabet acquisition in this same study (see Figure 11). Children 9, 10 and 11 averaged 11 sessions of consolidation of their already established chains. The remainder of the children needed few trials of counting 1 and 2 objects, more for counting 3 and 4 objects and progressively fewer trials for counting the succeeding numbers.

All of the children learned or consolidated previous
Fig. 11. Trials taken for counting numbers.
learning of functional counting to 10. This was accomplished rapidly for all except Child 1 and Child 3. Child 3 spoke so slowly that prompting of the successive members of the chain broke down. The trainer speeded up her responding by requiring her to count as he dropped marbles. This technique is also recommended by Stern (1949). Once the chain was speeded up, Child 3 acquired additional numbers much more rapidly, and was finally making faster progress at learning to read numbers than any of the other children. Child 1, already mentioned as the slowest learner in the alphabet task, began counting from a zero baseline. He learned to count functionally to 10.

The Verbal Number Chain Extension Hypothesis

In previous work with his own two children Staats advanced their counting repertoires purely by training additional verbal counting sequences. This experimental-naturalistic finding thus served as the hypothesis for a more formal test in the present project. That is, when a child has been trained to count objects to 5 or more, it was hypothesized that his verbal counting chain could be extended without giving further object counting practice, and the child would then be able to use this extended chain to count objects. This hypothesis was confirmed.

The test was given to nine children whose initial functional counting chains varied between 5 and 14. The range of the extension of the verbal counting sequence for
each child is shown in Table XIII.

**TABLE XIII. RANGE OF VERBAL COUNTING SEQUENCE EXTENSION**

<table>
<thead>
<tr>
<th>Child</th>
<th>Range of Extension</th>
<th>Child</th>
<th>Range of Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10-13</td>
<td>8</td>
<td>5-12</td>
</tr>
<tr>
<td>4</td>
<td>5-11</td>
<td>9</td>
<td>14-20</td>
</tr>
<tr>
<td>5</td>
<td>7-11</td>
<td>10</td>
<td>14-20</td>
</tr>
<tr>
<td>6</td>
<td>10-15</td>
<td>11</td>
<td>14-20</td>
</tr>
<tr>
<td>7</td>
<td>9-15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When the verbal extension training was completed, a number of objects equal to the limit number of the new verbal chain were presented to the child to count. In every case the objects were counted without error on the first presentation.

This test showed that even if a chain of only 5 was established as functional, it was possible to extend it verbally and find that the new chain was also functional. Very few adults have counted objects to 5,000, but few would doubt that they could do this if it were required of them. That the functional counting concept is formed on a very short chain indicates that time may be saved from practising counting objects beyond the first few numbers.

**Reading number Results**

Table XIV presents the response data of the children
<table>
<thead>
<tr>
<th>Child</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Trials</td>
<td>1325</td>
<td>912</td>
<td>1774</td>
<td>1375</td>
<td>833</td>
<td>1036</td>
<td>2222</td>
</tr>
<tr>
<td>Total Trials to Criteria</td>
<td>651</td>
<td>494</td>
<td>870</td>
<td>636</td>
<td>481</td>
<td>687</td>
<td>1474</td>
</tr>
<tr>
<td>Total Time in Minutes</td>
<td>260</td>
<td>155</td>
<td>310</td>
<td>246</td>
<td>166</td>
<td>210</td>
<td>359</td>
</tr>
<tr>
<td>% of Prompts and Errors</td>
<td>30.4</td>
<td>30.7</td>
<td>34.9</td>
<td>32.8</td>
<td>13.1</td>
<td>24.0</td>
<td>29.9</td>
</tr>
<tr>
<td>Rate: Trials per Minute</td>
<td>5.09</td>
<td>5.88</td>
<td>5.72</td>
<td>5.59</td>
<td>5.02</td>
<td>4.93</td>
<td>6.19</td>
</tr>
</tbody>
</table>
during the number reading training. The total trials classification includes other than actual learning trials on the numbers; it includes interspersed material such as pictures, at the onset of the training, and previously learned numbers as the training progressed. The total number of trials to criterion is the sum of the number of trials on the numbers up to and including the last prompted trial on each number. These are therefore the actual training trials.

The seven children who completed learning to read the numerals 1 - 10, took an average total number of 1,354 trials to learn these numbers. Of these an average of 756 were criterion trials. The average time taken was 4 hours 3 minutes. Child 11 took many more trials than the other children to complete this task although she recorded the highest posttest I.Q. score in the group, 135 on the Stanford-Binet Scale.

There was interference from previous learning in this task. The children knew the names of the numbers through the counting training and therefore had an associated hierarchy of responses available. Reading numerals is a necessary skill for the future handling of numbers, but this skill does not logically follow from counting. Written numbers in the preschool child's experience are usually nominal numbers: T.V. channel numbers, car registration numbers and telephone numbers.
It is interesting to ponder the influence of television and the constant exposure to T.V. channel numbers. In this study the children required many trials to learn to read numbers 6, 7 and 8. None of these numbers are used for identification by local television channels, whereas 2, 4 and 9 are so used and many fewer trials were required for the children to learn them.

Addition Results

Figure 12 shows the records of the three children who worked through the addition sets twice. The record shows a gradual decrease in the number of trials to learn each set but this was not an even drop from set to set. The analysis of variance (see Table XV) shows that the difference between groups was significant at .05. A trend analysis gave an F for the linear component of 18.87 which is significant at better than .01. The relearning of the sets took less trials than the initial learning of the sets. The function of decreasing number of trials required to learn successive sets is therefore evident in this data as well, although it is very probable that the sets are not of equal difficulty in this task.

Table XVI indicates which of the addition concept formation tests were passed by the children. The children all passed the "1 and 5 are 6" test, but Child 6 passed no others. Child 8 passed the first three tests but missed the "4 and 5 are 9" test in both cases. Child 10 passed
Fig. 12. Trials to learn addition sets.
<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>2</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sets</td>
<td>6</td>
<td>152.11</td>
<td>3.92*</td>
</tr>
<tr>
<td>Residual</td>
<td>12</td>
<td>38.79</td>
<td></td>
</tr>
<tr>
<td>F Linear Trend</td>
<td>18.87**</td>
<td>**p &lt; .01</td>
<td>*p &lt; .05</td>
</tr>
</tbody>
</table>
## TABLE XVI. ADDITION CONCEPT

### FORMATION TESTS

<table>
<thead>
<tr>
<th>Test</th>
<th>Child</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 5 are 6</td>
<td>1st trial</td>
<td>pass</td>
<td>pass</td>
<td>pass</td>
</tr>
<tr>
<td></td>
<td>2nd trial</td>
<td>pass</td>
<td>pass</td>
<td>pass</td>
</tr>
<tr>
<td>2 and 5 are 7</td>
<td>1st trial</td>
<td>fail</td>
<td>pass</td>
<td>fail</td>
</tr>
<tr>
<td></td>
<td>2nd trial</td>
<td>fail</td>
<td>pass</td>
<td>pass</td>
</tr>
<tr>
<td>3 and 5 are 8</td>
<td>1st trial</td>
<td>fail</td>
<td>pass</td>
<td>fail</td>
</tr>
<tr>
<td></td>
<td>2nd trial</td>
<td>fail</td>
<td>pass</td>
<td>pass</td>
</tr>
<tr>
<td>4 and 5 are 9</td>
<td>1st trial</td>
<td>fail</td>
<td>fail</td>
<td>pass</td>
</tr>
<tr>
<td></td>
<td>2nd trial</td>
<td>—</td>
<td>fail</td>
<td>—</td>
</tr>
</tbody>
</table>
the "1 and 5 are 6" test, but missed the following two. During the learning of Set 4, however, he discovered that he could add on his fingers. From that time on his number of trials to criterion dropped (although his calculations took him some time) and he gave correct responses to all the concept trials. It can be concluded that while it was possible for the children to gain the addition concept while learning addition sets verbally, it was not inevitable.

The concept to be formed in the addition task required that the child combined the counting function with the labeling function of numbers. The step taken in this study between the separate counting and reading tasks and functional addition is probably too great for most children. The model for the verbal number chain extension could be followed. The children could first be trained to add with practical materials (counters or Cuisenaire rods). After this a verbal addition task like that presented in this study could be trained. It may be that addition, like the verbal number chain, need only be made functional with a few combinations for the concept to generalize to further combinations learned verbally.
CHAPTER IX
CONCLUSIONS

This study gave further support for the efficacy of the reinforcement system and the procedures used for training young children in cognitive tasks designed by Staats (1968). It was shown that it was possible to isolate the early skills essential for the learning of cognitive skills such as reading and number and to train average four-year-old children in these skills when their attention and work behaviors were maintained by adequate reinforcement. Procedures and materials suggested by work in previous experimental-longitudinal studies by Staats were evaluated and hypotheses suggested on the basis of work with single subjects were tested.

Learning Set

In all the parts in this study where the children began learning from a zero baseline, as well as in previous studies by Staats of similar learning tasks, a significant learning to learn effect was in evidence. As the children progressed through a series of similar learning items, they took fewer and fewer trials to learn items to criterion. The significant linear and quadratic trends in the alphabet reading, reading concept and addition tasks demonstrate this function in the present case, not only verifying the learning to learn effect previously found
in the reading, writing and number concept areas of cognitive learning, but also establishing the statistical reliability of the effect.

This phenomenon looks very similar to learning set as described by Harlow (1959), but there are differences. Harlow's subjects did not learn each problem to criterion but were given only six or eight trials on each problem. In this study each part of a task was learned to criterion before the next part was presented. In Harlow's studies the response was the same simple movement in each case, while in this study a separate response had to be learned to each stimulus. Learning set researchers have found that simple discriminations, such as were given monkeys, were too easy for normal children (Koch and Meyer). It may be that the more complex responses, such as were called for in this study, allowed the gradual acquisition of a learning set to be more adequately demonstrated in children.

To the extent that learning to learn is like learning set, it would be interesting to examine whether the relative permanency exhibited by learning set is also true of learning to learn effects. As the skills the children learned in this study were reinforced in their homes and by their playfellows, and there was likelihood that most of the children would continue to practise the skills, a test of retention of the learning propensity for these
tasks, six months after training had ceased, would prove little.

Learning set has appeared to have been problem specific. How much transfer should be expected from the tasks in which the children were trained in this study? Some of the learning was of attention skills. The children were reinforced for attending to particular types of stimuli, instructions and letters and numbers. It is reasonable to expect that this at least may be transferred to other life situations. The training of these attention behaviors should facilitate school learning for these children.

Analysis

The reduction of the data to individual graphs of the several dependent variables proved useful. Although the most regular functions were obvious in the number of trials taken, the time variable showed itself most sensitive to certain stimulus changes such as the change of trainer for the four children learning alphabet.

Where the children started from virtual zero in a task the acquisition curves were quite similar and means were obviously representative. Whenever regularity was apparent in the graphs, an analysis of variance of the repeated measures confirmed the significance of the regularity. This was true in the case of the alphabet reading, the reading concept formation and the addition learning.
In these three sections, also, the trend analyses confirmed the significance of the learning to learn phenomenon.

The analyses presented have not exhausted the possibilities of getting information from this data. One interesting and legitimate question which could be asked is what effect, if any, breaks in the training had on the learning rate. What was the effect of the two-day breaks each weekend and of the longer vacation breaks or the periods when the children were absent for sickness. Some method for comparing performance before and after gaps in training could be devised.
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