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ABSTRACT

The aim of this report was to provide teachers of preschool and early elementary school children with a brief summary of current psychological research and theory concerned with the development of cognitive skills in young children. Psychological research often provides a basis for procedures teachers use in the classroom. Each chapter of the report begins with a digest of recommendations which summarizes major psychological findings and their practical implications. The digest is intended to serve as a quick reference guide and an introduction to topics explained in more detail in the narrative section which follows. Narrative sections present discussion of psychological research on attention and discrimination, memory, language, and logical thinking in children. Research findings are presented and explained, and specific examples are given which explain in detail how the psychological findings might be used in the classroom. Extensive reference sections at the end of each chapter document sources of information for further study. (Author/BRT)

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Cognitive Development in Young Children

A Report for Teachers

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Preface

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Any literature survey requires many hours of tracking down and sifting through potentially relevant books and journal articles. We are grateful to Christy Crowley for her diligent assistance in this task.

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Chapter 1

Introduction

The aim of this report is to provide teachers of preschool and early elementary school children with a brief summary of current psychological research and theory concerned with the development of cognitive skills in young children. Psychological research often provides a basis for procedures teachers use in the classroom. When psychologists have suggested that young children think and learn in certain ways, educators have tried to apply these ideas to the practical problems of education. It is difficult, however, for individual teachers to keep up with the latest developments in psychological research.

Since the primary concern of teachers is the application of research, the report is designed to relate research findings to practical issues. The reader should be aware, though, that the sources reviewed have been primarily the professional journals in psychology. Only a small sample of educational literature has been surveyed, primarily to provide some examples of practices that appear to be consistent with psychological research. These examples should give the reader an idea of how the principles which are discussed might be applied.

The report is limited to a relatively narrow aspect of young children's development. Areas of equal importance, which are intimately related to cognitive development, have not been covered. Many of these--such as the effect of anxiety on learning, individual differences in motivation to learn, and the effect of reward and punishment on learning -- are discussed, however, in a companion report, "The Social Development of Young Children: A Report for Teachers." The two reports were prepared as a joint project and share similar goals and formats. The reader is encouraged to use them together.

Organization of the Report

Each chapter of the report is divided into three main sections. First is a digest of recommendations which summarizes major psychological findings and their practical implications. The digest is intended to serve as a quick reference guide and an introduction to topics explained in more detail in the narrative section which follows. The reader may wish to review the digest again after completing the narrative discussion. It is also keyed to the Chapter references, so it can be used to locate sources for further reading on a particular question.

The central section of each chapter is a narrative discussion of psychological research on attention and discrimination, memory, language, or logical thinking in children. In this section, research findings are presented and explained, and specific examples are given which explain in detail how the psychological findings can be applied to the classroom.

The extensive references section at the end of each chapter documents sources of information and offers the reader a guide for further study. Citations in the chapter narrative are keyed to the references by number. References particularly useful to teachers are marked with an asterisk.

Basic Research and Practical Implications: A Note of Caution

Summarizing research in psychology can be a risky undertaking. What seems "true" at one point in time often becomes "false" when new information becomes available or when new theories change the interpretation of old findings. Teachers are understandably wary of changing fads in educational practice--fads which often grow out of psychologists' changing conceptions concerning the "truth" about child development. The preparation of this report has been guided by a desire to preserve a cautious and moderate perspective on new research and theories, in order to minimize the dangers of premature application of incompletely tested psychological conclusions.

Substantial problems arise in any attempt to formulate practical suggestions for professionals in one discipline based on research findings from another discipline. Throughout this report, recommendations for teachers have been derived from (1) logical extensions of experimental findings, (2) translations of experimental training procedures, and (3) educational programs which have employed techniques consistent with the psychological findings.

All of the recommendations make sense from a psychological perspective, but some may prove unworkable in the classroom, or less effective than procedures a teacher is already using. Teachers may develop some sense of the evidence concerning the effectiveness of a procedure by consulting the middle column of the Master Chart. The authors' principal criteria for including a recommendation were, first, whether it followed logically from the psychological research findings, and, second, whether it seemed to be a "safe" procedure, whatever its ultimate effectiveness might prove to be. Recommended practices have been selected to supplement procedures most teachers are already using.

An important point to remember in any attempt to apply psychological findings to real life problems is that psychological research most often deals with groups of people and with probability statements about their behavior. If a certain procedure is, on the average, more effective than another, it is recommended. It is quite possible, however, that individual children or teachers will work better with a procedure that is, on the average, less effective. Teachers must ultimately be the judges of what works best for them and their students.

It is hoped that this report will serve to stimulate teachers to a reconsideration of what is happening in their classrooms, and that it will offer some insights into why some strategies tend to fail and others are consistently successful. It is easier to remember to use a technique if one understands why the technique is important. Awareness of current psychological thinking about young children can, we hope, help teachers make better decisions about classroom procedures.

Chapter 2

Attention and Discrimination

Digest of Recommendations

Suggested Teaching Techniques	Rationale	Selected References
1. Schedule lessons requiring sustained attention after preschoolers have had a period of vigorous activity.	Three- and 4-year olds may attend better to a quiet activity after a session of outdoor play than after another quiet activity.	Hawn, Holt and Homberg, 1973.
2. Try teaching "impulsive" elementary school children to talk to themselves as they work. Big Bird has demonstrated this technique on "Sesame Street."	Impulsive 8-year-olds became slower and more accurate in their work after learning to use "self-control" speech while working out a problem.	Meichenbaum and Goodman, 1971
3. Design lessons so that the information presented is neither completely strange nor completely familiar, but just at the edge of the children's experience and ability to comprehend. Prepare children gradually for unusual experiences or difficult ideas.	Children are likely to attend to and remain interested in activities or materials that are somewhat new but partially comprehensible.	Kagan, 1972; Piaget, 1951

Suggested Teaching Techniques	Rationale	Selected References
4. Give children practice in searching, both in active search games and in perceptual search activities such as looking for small details in complex pictures.	Young children, preschoolers in particular, typically have difficulty in planning and carrying out a systematic search. Thus, they often fail to see the information they need to make a discrimination. Children's ability to search improves with age and practice.	Bruner, Olver and Greenfield, 1966; Pick and Pick, 1970 Zaporozhets, 1965; Nodine and Lang, 1971
5. Try to avoid cluttering learning situations with unnecessary information, particularly when working with preschoolers.	Young children have very limited ability to focus their attention on important information and ignore the rest. Extraneous comments from the teacher may interfere with preschoolers' learning.	Miller and LeBlanc, 1973; Pick, Christy and Frankel, 1972; Schell, 1971

Suggested Teaching Techniques	Rationale	Selected Reference
6. When children have difficulty making a particular type of discrimination, help them by:	Repeated exposure to a set of forms or sounds, active involvement, learning distinctive features, and learning names all improve young children's ability to identify and discriminate among items in the set.	Flavell, 1970; Pick and Pick, 197; Wolff, 1972
a. Providing repeated opportunities for exposure to, and active involvement with, the items to be discriminated;		
b. creating learning situations which will highlight the "distinctive features" that differentiate similar items such as the letter forms "m" and "n" or "b" and "d";		
c. teaching them to use names for the items to be discriminated.		

What Is Attention? How Can The Teacher Tell If Children Are "Paying Attention"?

The basis for young children's learning is in the interaction between their current understanding and the new information they take in through their senses--what they see, hear, touch or feel their own bodies doing. Learning depends not on children's total environment, but on their effective environment. They learn only from information they have attended to.

> Alison, aged 3, regularly chooses not to participate in preschool "music time," but spends this time playing alone in another area of the room. Nonetheless, Alison's mother comments on the many new songs, learned at school, which she sings at home.[1]

Attention is the process of "tuning in" to sensory information. Without some degree of attention, information cannot become part of the child's effective environment and the child cannot learn from it. In real life situations, as well as in psychological experiments (29, 30, 48) children tend to be judged as attending or not depending on their physical appearance. If children look directly at the teacher, it is assumed that they are paying attention. Appearance is often a good indicator of attention, but it can be very misleading. Children often pay attention to sounds without coming close or even looking toward their source. Visual attention is easier to relate to external appearance, since children cannot see something without looking toward it. They sometimes, however, stare intently at a picture, book, or demonstration without actually attending, in a mental sense, to the information before their eyes.

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1. Phyllis Haas, Personal Communication, October, 1974.

An alternate approach to the measurement of attention is to determine if the child responds appropriately to the information that was supposed to be "getting in" Young Alison, in the above example, must have been paying attention to the songs because she was able to sing them. If a child can do something correctly, the teacher can usually assume that the child has been attentive. If the child has not learned, inattention may have been the reason, but the learning process could also have been disrupted by many other factors.

Because it is difficult for teachers to be sure that children are attending to information they need to learn, it is often useful to try to structure learning situations so that children's attention is naturally drawn to the important elements

What Factors Determine the Focus and Duration of a Young Child's Attention?

Teachers can develop some ability to predict the focus and duration of their children's attention by considering five general factors which jointly determine attention:

1. *Children attend to information they can discriminate.*---Children cannot, of course, pay attention to things they cannot see or hear. The physiological sensory capacity of young children's hearing and vision is generally about as good as adults' (62). A particular child who is habitually inattentive, however, may have a visual or hearing impairment. Even children with no handicap may occasionally have difficulty discriminating relevant cues. When many children are clustered around the teacher, for example, those on the outside of the group may be unable to see or hear, and give up trying.

2. *Children are more attentive at some times than at others, and some children are generally more attentive than other children.*---No one is equally alert and attentive at all times. Small individuals have periods when they are sleepy, over-excited, or distressed and thus find it difficult to pay attention. Although the teacher may be unable to adapt to each child's "good" and "bad" times, classroom schedules can

be manipulated to take advantage of predictable fluctuations in the group's ability to attend to particular types of activity. In one study of 4 preschoolers, the children were more attentive in a "group time" when this quiet activity followed active outdoor play than when it was preceded by another quiet activity (24). Children who walk to school or play outside before class starts may be ready for quiet work first thing in the morning as well as after outdoor play periods later in the day.

As children grow older, they tend to study problems longer before making decisions; they become less "impulsive" and more "reflective" (23,29,32,41,42). Children who respond slowly tend to be more accurate, at least in those situations in which snap judgments are penalized (23, 51). In one study a group of unusually impulsive 8-year-olds were taught to talk to themselves while solving problems. The children listened to a teacher demonstrate the technique and were encouraged to imitate the teacher's behavior. The muttering they were taught to do emphasized the requirements of the task, the need to work slowly and carefully, and to correct errors rather than giving up:

> Okay, what is it I have to do? You want me to copy the picture with different lines. I have to go slow and be careful. Okay, draw the line down, down, good; then to the right, that's it; now down some more and to the left....That's okay. Just erase the line carefully.... Good. Even if I make an error I can go slowly and carefully....[2]

"Sesame Street's" Big Bird has used this technique in some episodes of the educational television series.

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2. Meichenbaum, D. H. "The Nature and Modification of Impulsive Children: Training Children to Talk to Themselves" Research Report No. 23, 1971, Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada, 18. Reprinted with permission.

3. *The odds that a child will attend to a particular stimulus are influenced by its physical qualities and the background against which it occurs.*---Loud noises or big pictures are more likely to be noticed than soft sounds or small pictures. Large and brightly colored educational materials have built-in advantages over those that are small and dull. The background or context within which a stimulus occurs may, however, reverse this pattern--in a mass of large pictures, a single small one will stand out and receive attention because it is different. Children will "tune out" stimuli that are repeated again and again, even if they are intense, originally interesting events (48). In the long run, then, there is no advantage to the teacher in speaking more loudly than necessary, since the initial attention value of a loud voice is quickly exhausted (as is the teacher).

More intense sights and sounds have a natural advantage in capturing a child's attention, but what kinds of events are most likely to both catch and hold the young child's interest? Psychologists have labored greatly in the search for a set of general rules that would describe the physical characteristics of visual materials most likely to interest young children. The question is an important one, since there are many classroom situations in which a teacher would like to choose pictures or displays that children will like and study intently. There is some evidence that children will spend more time looking at complex, irregular pictures than at simple, regular ones but this is not always the case (34, 48, 60, 62). Children's interest varies with the particular set of choices offered, with the measure of interest used and with the individual child's personality or aesthetic taste (34). Since psychologists can offer no simple rules for what kinds of pictures children will like, teachers who use their own experience as a guide for choosing materials are probably taking the wisest course.

4. *Attention is determined, to a considerable extent, by the meaning or learned associations which an event has acquired.* Many events which are, in themselves, of little interest, become great attention-getters because a child has learned to associate these events with important experiences. Events can acquire meanings for even the smallest infant (26, 53). Children's lives are filled with innumerable situations in which events become signals for, or associated with, other events and are thus invariably attended to. For example, babies who are hungry may stop crying when they hear mother approaching because the sound of her footsteps signals that food will soon be there. Young children pay close attention when their own names are called. Children in school learn that a particular shift in the teacher's tone of voice means "stop fooling around or there will be trouble." As children learn to read, abstract visual patterns are transformed into letters and words, components of meaningful messages.

As children grow and learn, meanings are attached not only to whole events, but also to particular aspects of events (17, 59, 61, 62). Children learn what parts of an event contain important information, and what parts can safely be ignored. Children who are learning to read, for example, learn that the form of the letters is important, but that their color and overall size are insignificant (60). In music lessons, children may learn to attend to the pitch and duration of each tone. Learning where to look and how to listen for important information increases the efficiency of children's ability to discriminate among, and make sense of, the events they encounter.

5. *Attention is determined by the way an event fits with a child's existing understanding of the world.*---According to Piaget's theory of cognitive development and Jerome Kagan's extension of that theory, children tend to pay the most attention to events which are slightly different from what is familiar and expected (29, 30, 54). With age and experience in looking and listening, every child builds up expectations of how things should be. Human faces, for instance, are expected to have certain

features in a standard arrangement, and 2- or 3-year-olds will stare intently at distorted faces (13, 29, 30, 38).

Young children often stare intently at anything unusual, anything they can't quite understand from their past experience (29, 61). Sometimes a moderately discrepant event arouses delight as well as interest, as when, for instance, a friendly dog invades the classroom. If a new experience is totally unrelated to what the child has previously known, the child may ignore or avoid the experience, as an adult nonscientist would "tune out" a technical lecture on nuclear physics. Sometimes children will be frightened of experiences which are a bit too strange for them to understand:

> The young 3-year-olds at their group table had mixed reactions to a hand puppet of a dog used for helping the children increase and focus their attention. All of them focused directly on it, three of them with smiles. Tammy and Timmy did not want to touch it. They pulled back their hands and shrieked. The following day when the puppet was used at the next table, another 3-year-old, Paula, responded in a similar way.[3]

If Tammy, Tommy and Paula had had no idea at all of what the puppet was, they would probably have ignored it rather than being frightened. They seem, however, to have understood enough to know that a moving, disembodied animal head was not "normal" but not enough to know that it was a safe toy. When children react in this way to a strange experience, the teacher can help them gradually to understand the experience so that it will no longer be frightening. A sequence of activities suggested to help

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3. Weikart, D. P., McClelland, D., Smith, S. A., Kluge, J., Hudson, A., and Taylor, C. The Cognitive Curriculum. Ypsilanti, Michigan: High/Scope Educational Research Foundation, 1970. Reprinted with permission.

children understand the nature of the dog puppet involved lessons on the child's own body and its parts, the body parts of a doll which is not real, making and manipulating puppets, and becoming familiar with both real and toy dogs (70).

With every advance in understanding, attention patterns shift as another set of experiences becomes comprehensible, familiar, and perhaps even boring. At a given time, for a given child, the most interesting experiences are those which are moderately discrepant from what he or she already understands. According to cognitive theory (20, 30, 54, 55) children will be naturally drawn to these mind-stretching experiences, and will attend to them without any external rewards or threats. In large classes it is, unfortunately, difficult to devise group programs to keep pace with the different comprehension and interest levels of the children.

The discrepancy between a child's understanding and that required by a new event is not the only cognitive factor determining attention. Between the ages of 1 and 3, children seem to increase in the length of time they will attend to puzzling materials such as distorted faces and figures (29). On the basis of the discrepancy principle alone, one would expect children to grow less attentive to these stimuli as they grow older and develop more complete understanding. The results can be explained if one considers that as children mature they develop increasing ability to generate hypotheses about unusual experiences. They continue to look at or listen to puzzling events while they try out alternative explanations. In looking at a picture of a three-headed man, for instance, children might think to themselves that the picture "really" represents three men standing behind one another with heads tilted at different angles, that it truly is a three-headed man, that two of the heads are false, etc. Older and brighter children can think of more ways to explain puzzling experiences, and so pay attention for a longer time (29).

The classroom teacher who must cope with children who seem to attend to the wrong things, or not at all, might consider the problem in the context of the five

determinants of attention presented above. Perhaps the children are inattentive for one or several of the following reasons, which have been derived from theory and research on attention:

1. The children might not be able to see or hear what is happening.
2. A lesson requiring close and sustained attention may be scheduled at the wrong time of day.
3. Teaching materials may not be attractive (in size, color, or design, for instance) to that group of children.
4. Particular experiences may have no meaning for the children, or the children may not have learned which aspect of an event carries the important information.
5. Events may be too familiar or, more likely, too novel and incomprehensible. Even if the experience is perfectly chosen to stretch the limits of children's understanding, their attention may be limited by their inability to consider the new experience in a variety of ways.

How Does Children's Ability to Focus Their Attention Change with Age?

> David, aged 3, has lost his hat. It is in plain view on top of a table, but he does not see it immediately. The teacher suggests that he look for it and he makes a vigorous effort, running about the room, moving his eyes in every direction. After a few seconds of unsystematic wandering, he gives up and asks for help.

1. *Young children have relatively little ability to plan and carry out a search for useful information.*---Between the ages of 3 and 7, children change dramatically in their ability to conduct a search. Three-year-old David's difficulties in searching for his hat are paralleled by the difficulty he would have in searching for a particular feature of a picture or design. Comprehending a complex visual pattern requires more than a single glance. To learn what is in the pattern, children must

move their eyes purposefully to scan its various parts. Studies in which children have been asked to identify, match, or discriminate among objects have found that older children are slower and more accurate in their judgments (1, 62, 73). They are also more efficient in their search; they act as if they know where to look for critical information (49). Given a concealed object to identify by touch, 6- or 7-year-olds trace its outline with their hands, but 3- or 4-year-olds grasp it in their palm without systematic manipulation (73). In trying to discriminate a shape visually, older children will follow the outline of the figure with their eyes, while younger children let their gaze wander about somewhat haphazardly (73). With more experience (usually between ages 7 and 9) children also learn when to stop attending. Younger children continue to search a pattern long after contacting the information necessary to solve a problem, but older children stop searching as soon as they find the answer (6, 62).

To some extent, improvements in search skills probably reflect children's learning, discussed in the previous section, of what aspects of an event are likely to be important. In complex situations, however, there is also the influence of developmental changes in children's ability to plan and regulate their behavior. Older children are capable of forming and carrying out a search strategy that scans the most likely spots first, covers the remaining alternatives, and ceases when no more information is necessary (62).

2. As children grow older, they become increasingly able to "tune out" irrelevant information.---Preschoolers' attention is captured by any intense, recognizable, or puzzling stimulus element. If something is naturally intriguing, they are not able to ignore it on command (27, 51). For this reason, young children are often said to be "distractable." A voice from the playground may intrude on what the teacher is saying; the sight of another child's interesting activity can draw attention away from the assigned project. Preschoolers tend to notice bits and pieces of everything

they are exposed to while older children and adults become very efficient at attending only to those elements which are relevant in a particular situation. Young children, then, often do not distinguish between what they need to know and that which is incidental, and their learning of important information may be reduced because they attend to and learn a little bit of everything (22, 36, 39, 61).

Preschoolers are not, however, totally unable to control their attention. Over time, they do learn how to attend in standard situations which occur often enough to provide the opportunity to learn appropriate habits (17). They may sometimes attend and learn better if instructed to remember specific things (72). They are also quite able to block out monotonous and uninteresting distractions such as the noise of a typewriter (68).

3. Young children have difficulty attending simultaneously to several aspects of a situation.---Somewhat contrary to the increase with age in children's ability to focus attention, is the corresponding increase with age in children's ability to "decenter" and consider several aspects of a problem simultaneously. There is no actual conflict, however, in saying that children's attention becomes more focused with age and that it also becomes less "centered," since these strategies relate to different aspects of perception. As children grow older, they learn to focus on important information, but they also learn that certain situations require simultaneous attention to more than one factor.

Until about age 8, children are likely to say that a tall, thin glass contains "more to drink" than a short fat glass even though the latter contains the same or even a greater quantity. They center their attention on one dimension, the height of the liquid, and ignore its width (7, 50, 56). This behavior, is, depending on the theoretical viewpoint one adopts, perhaps more of a logical than an attention problem (15, 56). Whatever the reason, young children tend to notice that particular aspect of a problem which is most obvious and to try to solve it without

attending to and considering other factors. Centering on a single dimension may be an important determinant of young children's tendency to make quick impulsive judgments on perceptual problems. They don't attend to and weigh all the evidence (32).

4. Teachers can use several approaches in adapting educational experiences to young children's limited ability to plan, focus, and decenter their attention.---One technique that may prove useful in the long run is to give children practice in searching. Children can play at finding things both in active search games such as hide and seek and in "perceptual" search activities such as identifying by touch objects hidden in a paper bag, finding "hidden" objects in a picture, or looking at a set of similar drawings to determine which are identical and which differ in some detail.

When the teacher's immediate objective is not to improve children's search skills but to ensure their attention, the best approach is probably to devote substantial effort to structuring the situation so that attention is naturally drawn to appropriate features of the experience. Extraneous comments (43) and other distractions should be avoided. Visual materials should not be cluttered with extra information which the child must ignore. It is quite possible, for instance, that materials which are color-coded to "help" a child learn to discriminate differences in number or length may actually complicate the problem by distracting the child from the critical dimension (64). Piaget (58) has suggested that the color coding of Cuisenaire rods may sometimes make it more, rather than less, difficult for children to learn the number and length relationships which the materials are designed to teach. Piaget's prediction, derived from his theory of knowledge, is that color coding should be minimally distracting when the rods are actively manipulated by the children themselves (the way they were designed to be used). The colors should be more confusing when the rods are used for demonstrations by the teacher, with the children watching but not participating.

How Does Sensory Discrimination Improve With Age?

In one sense children's discrimination abilities are extremely good from birt onward.--Even young infants show signs that they are capable of discriminating am different shapes and patterns, colors, and sounds (10, 12, 31, 33, 40, 44, 45, 46, 48, 62, 67). Children's sensory systems change slightly as they mature, but these physiological changes have very little impact on perceptual capacity (62).

Preschoolers are even able to perform discrimination tasks which require the integration of information from different senses--sight and hearing, for instance, or sight and touch. At one time, psychologists thought that young children were unable to integrate information from the different senses and proposed that the development of this ability might serve as a useful predictor of "reading readiness" (3, 47). Convincing evidence now exists to show that sensory integration ability is present from infancy and that tasks requiring sensory integration (e.g. matching a sound with a written symbol) are not necessarily particularly difficult for young children (2, 5, 8, 20, 28, 35).

In another sense, however, children's discrimination abilities get much better as they grow older.--Everyday discrimination problems usually require much more tha the sensory capacity to detect a difference between two events. Discrimination in the broad sense, or perception, is a process which draws on all of the child's intellectual skills and previous experience. This is particularly true when children must discriminate quickly or when the sensory information is incomplete, ambiguous, or buried in a mass of extraneous information (6, 16, 36, 19, 61, 62). As children grow older they attend more efficiently, remember better, acquire language and develop more mature logical reasoning skills. All of these changes help a child make faster and more accurate discriminations. The importance of age changes in attending skills has already been discussed. A brief introduction to other related processes will balance this description of the development of discrimination abilities.

One of the most important age changes in discrimination ability is improvement in the ability to discriminate and work with information that is presented over time, rather than all at once. The development of this ability to make perceptual comparisons of new information with older, remembered information may be responsible for age improvements in children's ability to solve problems such as hearing some sounds and then matching the sounds to written symbols (20, 28, 35).

The development of language also has considerable impact on children's discrimination abilities. Learning names for particular classes of experience forces the child to isolate and attend to the distinctive features which identify one group (e.g. dogs) and distinguish that group from other similar groups (e.g. cats or horses). It is generally easier for both children and adults to identify and remember experiences for which they know a name (14, 62).

Certain kinds of discrimination problems are actually problems in logic as much as sensory detection. Learning to discriminate "left" from "right", for instance, involves understanding an abstract logical relationship (see Chapter 5). Young children are capable of making extremely fine sensory discriminations but often falter when asked to make a judgment which requires reasoning beyond their years.

Points to Remember

If a child with normal sensory capabilities has trouble with a particular discrimination, there can be several possible reasons for the difficulty. Teachers should remember that they can only observe a child use a discrimination, that is, make a response which is the result of a chain of information processing. What comes out is not always a perfect indicator of what went in. Careful analysis of the child's behavior might indicate, for instance, that the child attended to the wrong aspect of the situation, or that the child did not know the appropriate name for the event. Children's "mistakes" are rarely random, and the sensitive teacher can often learn a great deal about a child's thinking from trying to imagine why a child has made a particular response. Often a child attends to aspects of a situation which an adult would not have considered important.

2. If children seem unable to pay attention to an activity it may be that they don't have sufficient understanding of what's happening to fit the new experience into the context of that which they already understand. If a group of children are restless and inattentive it might be best to change to a different activity and begin again another day with a simpler presentation.

3. Young children do not always attend to those aspects of a situation which seem important to an adult. They need to learn which dimensions of a situation are critical and which are unimportant or irrelevant. Sometimes a lesson may be easier for young children, preschoolers especially, if the teacher takes care to eliminate extraneous, and potentially confusing information. In teaching preschoolers to identify different shapes, for instance, it might be best to start with a set of forms that are all the same color and size, and then work gradually up to tasks in which the children must focus on shape while ignoring color or size differences (43, 64).

4. If children have difficulty making certain types of discriminations--language sounds or letter shapes, for instance--they may need more exposure to those sounds or shapes, coupled with activities that direct their attention to the distinctive features that differentiate the items and illustrate the meaningfulness of the difference. Tracing, sorting and matching tasks are among the activities a teacher might choose to help children learn new discriminations.

There is no evidence that children from any particular home background are generally deficient in ability to make perceptual discriminations, but some children may not have had much practice in making specific types of discriminations that are important in school. Many preschool and compensatory education programs provide descriptions of curriculums for helping children to learn important discriminations (11, 66, 70).

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Chapter 3

Memory

Digest of Recommendations

Suggested Teaching Techniques	Rationale	Selected References
1. Recreate experiences in words or pictures so that children can recognize material from past activities. Photographs of a field trip or special project will help children remember what they did. Showing children the illustrations from a story will help them retell the story.	Young children have excellent perceptual recognition memory. Preschoolers are almost as accurate as adults in recognizing things they have seen before.	Berch and Evans, 1973; Brown and Scott, 1971; Fajnsztejn-Pollack, 1973; Hoving, Morin and Kronick, 1970; Perlmutter and Myers, 1974
2. Present new information in small doses: the younger the children, the smaller the dose. Add more only after the first has been well learned.	Young children have very limited short-term memory capacity and can absorb only a few items of new information at one time.	Miller, 1956; Farnham-Diggory, 1972; Goodnow, 1972

Suggested Teaching Techniques	Rationale	Selected References
3. Repeat information as needed until children remember it well. One correct answer doesn't necessarily indicate enduring memory. Repetition can take the form of presenting the same information in a variety of different contexts.	Children remember better if information is presented more than once. Repetition is helpful even when the same idea is presented in several different forms. Children who partially understand an idea are likely to maintain interest until they have fully mastered it. Repetition is a form of play for young children.	Brown and Scott, 1971; Hoving, Coates, Bertucci, and Riccio, 1972; McCarson and Daves, 1972. (See Chapter 2.)
4. Permit children to become actively involved with the information they are to remember. Whenever possible give them the opportunity to touch or manipulate materials.	Memory is often increased by active involvement in the form of activities such as touching or manipulating objects to be remembered.	Balling and Myers, 1971; Blank and Frank, 1971; Wolff, 1972; Wolff, Levin, and Longobardi, 1972.
5. Make sure children know the correct names for things. When working with preschoolers it is especially important to have them repeat the names <u>out loud</u> while learning.	Labeling aloud helps young children to remember. Elementary school children may do this spontaneously and silently, but preschoolers need to be encouraged to label aloud.	Flavell, Beach and Chinsky, 1966; Kingsley and Hagen, 1969; Locke and Fehr, 1970

Suggested Teaching Techniques	Rationale	Selected References
6. Plan a series of lessons around the same theme; try to relate new learning to experiences which are already familiar and comprehensible to children.	Information that is organized, familiar, and comprehensible is easier to remember.	Horowitz, Lampel, and Takanishi, 1969; Rossi and Wittrock, 1971; Hall and Halperin, 1972
7. Plan problems so as not to demand too much of young children's short-term memory. Young children can sometimes handle more advanced logical problems if the problems don't require much memory. Preschoolers, for instance, do better at sorting tasks when they have only a few items to sort. Elementary school children may do better if problems are written down than if they have to remember the problem information while they are trying to work out a solution.	"Memory aids" such as writing down the terms of a problem, help elementary school children to solve problems that would be beyond them if they were given orally.	See Chapter 5, Balling and Meyers, 1971; Roodin and Gruen, 1970.

Suggested Teaching Techniques	Rationale	Selected References
8. Teach children to <u>try</u> to remember. Children remember better when they are taught to use tricks such as saying things over and over to themselves, (verbal rehearsal) writing things down, or using pictorial "notes" to help themselves remember things. Preschoolers, for instance, might participate in setting up pictures or diagrams to show where various toys are stored. Elementary school children could make drawings of a display they have created, and use those drawings to set up the display on another day.	By about age 6, children spontaneously begin to use memory strategies such as verbal rehearsal. When preschoolers are taught these strategies they often remember better.	Corsini, Pick, and Flavell, 1971; Ryan, Hegion and Flavell, 1970; Kingsley and Hagen, 1969.
9. Techniques which help memory are appropriate even when children appear able to get by without this help.	Children as old as 8 frequently remember better if given the aids suggested in this digest.	Hagen, 1971; Farnham-Diggory, 1972; Goodnow, 1972

How Does Memory Work?

Memory makes it possible for children to profit from experience. The processes involved in this important ability are internal, and judgments about them must, therefore, be made on the basis of overt responses that demonstrate memory.

There are two direct ways in which children can show that they remember something that has happened in the past. Children can recognize whether or not an event is familiar. A recognition response is usually a simple yes or no. Alternatively, children can recreate the information they remember. When an experience is recreated in words (i.e., children repeat, label, or describe what has happened) the response is called recall. When nonverbal means are used to recreate an event (as when children make copies of a design they have seen or hum a tune they have heard before) the response is called reconstruction. Memory can also be measured indirectly, by observing the extent to which the solution of a logical or practical problem reflects reliance on remembered information.

There are two types of memory. Long-term memory (LTM) is the process whereby enduring records of experience are stored. Once information is stored in LTM it is probably there for a lifetime, but it may be "forgotten" because it has somehow gotte "lost" in the LTM filing system or because its retrieval has been blocked by interference from other learning. Experiences which fit well with what children know already, and with what they will learn in the future, will be more systematically filed and thus be easier to recall. Sometimes experiences seem to be stored as sensory images of what actually happened; at other times memory records are symbolic or verbal translations of experience.

The other process is short-term memory (STM) which is a temporary store for incoming information and for information called up from LTM for present use. STM can hold only a very limited amount of information at one time. In adults, the limit

is about 7±2 "chunks" of information (33). Seven chunks of information might be 7 unrelated 1-digit numbers or 7 randomly selected words. "Benevolent providence gave us short-term memory just long enough to hold a telephone number--and failed to predict area codes" (49). Information is held in STM for a few seconds or until one's attention is diverted elsewhere. Whatever is not transferred to LTM is then forgotten. Adults help themselves hold information in STM by repeating the information over and over until it is used and no longer needed, or until it has been permanently stored in LTM.

Organization of information facilitates the use of both short- and long-term memory. In LTM, organization permits efficient filing and ultimate retrieval of information. In STM, organization increases the information-holding capacity of the store as isolated chunks of information are collected into a few larger chunks. The number "1776" is, for example, much easier to remember than most other 4-digit numbers because it can be chunked, coded and stored as "date of the American Revolution" rather than as four separate numerical items. More detailed discussions of the memory process can be found in Information Processing in Children, edited by Sylvia Farnham-Diggory and in Volume 14 (1971) of the Journal Human Development.

In the pages that follow, it will become evident that young children's memory performance shows patterns of strengths and weaknesses which depend on such factors as the type of response by which memory is measured (recognition, recall, or reconstruction), the meaningfulness and organization of the material to be remembered, the way information is coded for storage, and the demands placed on the child's very limited short term memory capacity. An understanding of how memory functions in young children can give teachers the opportunity to improve the chances that what is taught will not be forgotten.

How is Young Children's Memory Different From Adult Memory?

Memory is not an automatic "mindless" process, but "a special case of intelligent activity, applied to reconstruction of the past...." (34). The maturity of children's reasoning skills and the scope of their knowledge affect how well they will be able to remember. This is particularly true when memory tasks require focusing on select samples of important information, organizing material into systematic units or translating experience into efficient codes. A general rule is that the older the children the better will be their memory skills. Performance on recall and reconstruction tasks has been shown to be better in children who are older, brighter, or more familiar with the type of information to be remembered (15, 17, 27, 28, 29, 30, 42, 45).

One exception to the general pattern of increasing memory skills with increasing age is the performance of young children in tasks of recognition memory.---Children as young as 3 years old are amazingly accurate in their ability to recognize which of a large set of objects or pictures they have seen before and which are new. Young children perform almost as well as adults, even when there is a delay of days or weeks between the time they first saw the material and the time of the test for recognition (4, 6, 10, 25, 35). Recognition of perceptual images may tap more elementary skills than are required for other types of memory tasks.

Young children have a very limited capacity for short term memory.---They process few elements of new information at a time, and the few that are retained for a second or two are likely to be lost before they can be used. In the standard digit-span memory task adults can recall 7±2 chunks of information but preschool children can cope with no more than 2 or 3 chunks, 5-year-olds with about 4 chunks, and 6 to 7-year-olds with 5 chunks (11). Other investigators, using different tasks, give slightly different estimates of young children's STM ability. All agree, however, that this ability increases as children mature (16, 18, 19, 47).

Limitations of STM affect not only children's ability to memorize, but the ability to follow instructions and to use remembered information to solve logical problems. Young children tend to solve complicated problems better if they are given "memory aids" so that they don't need to remember all the problem components, or steps to solution, while working out the answer (2, 42, 50). Older children and adults routinely use aids to help their memory. For example, they write down complicated problems which contain too much information to remember all at once. Children have much greater need for this kind of help.

The use of strategies for remembering is one of the major factors which distinguishes memory in preschoolers from that of older children.---Before age 5 or 6, children don't seem to plan to remember. Under some circumstances they remember better if told that they should try to remember (56), but in most research situations preschoolers don't remember any better when told to do so than when no such instructions are given (1, 13).

When adults or older children know they will have to remember something, they use a variety of strategies to help themselves. If the information is originally verbal or can be readily labelled, adults and school-age children tend automatically to say the name to themselves. The labels are then "rehearsed", silently or aloud, until the time for recall. Preschoolers sometimes spontaneously label information as it is presented but they do not always do so. This is due in part to the fact that they are less likely than adults to know the appropriate names (13, 27). Preschoolers may know labels yet not use them, and even when they both know and use labels they don't complete the strategy by rehearsing the labels during the delay interval (15, 27). Preschoolers and kindergarteners can be taught to label and rehearse out loud and they usually remember better when using these techniques (15, 26). Asking preschoolers to label or rehearse silently does not seem to help them much (26).

When a memory task calls for recognition or nonverbal recreation rather than for recall, there are nonverbal strategies which help adults and older children remember. One approach is to concentrate on a perceptual image of the information, keeping the picture "in mind" after it has been removed. In one study, 4-year-olds were able to recognize three-dimensional nonsense shapes better when they were instructed to visualize the shapes than when they received no such instructions (32). In other studies, however, instructions to form images have not been particularly helpful to very young children although this strategy can be used effectively by elementary school children (38, 40).

Adults often make notes of things they must remember. Written outlines, diagrams and patterns are useful ways of preserving enough of a body of information so that it can be reproduced when called for. Preschoolers typically do not use such strategies, even when it would be very simple to do so and the notetaking devices are supplied. Young children can sometimes be taught to take and use pictorial notes, but they are frequently so inefficient that their products are useless. The age at which children can learn effective notetaking skills probably varies with the complexity of the task (8, 44).

Teachers might wish to introduce the idea of notetaking as part of beginning instruction in reading and writing. In the context of the "language experience" method of reading instruction the teacher can demonstrate how a written record serves as a valuable reminder of past experience.

Memory reflects children's general cognitive capacities in several ways.--The relationship between memory and tested general intelligence has been mentioned. There are also specific relationships between performance on recall and reconstruction tasks and maturity of the logical ability to deal with such conceptual problems as the interrelationships among classes (46), seriation (9, 12, 36), and spatial relationships (36).

The development of logical understanding sometimes has very surprising effects on memory. Kindergarteners, for instance, have been shown a set of sticks arranged in a "staircase" series of increasing length. When asked to draw the arrangement immediately after they have seen it, the children often made incorrect reproductions. Several months later, with no additional exposure to the arrangement, these children were asked again to draw the sticks. The children often drew better series after a long delay than they made on their first attempt. Children's memory for a single experience changes and may improve over time as they develop more mature understanding of what they should have seen (9, 12, 36).

When Do Children Remember Well?

Up to this point, the emphasis has been on how the memory of young children differs from that of older children and adults. It should be clear, however, that procedures which are useful in helping adults or older children are also useful in helping young children remember. Indeed, these techniques may be especially important to use with young children because of the limitations of their memory ability.

Children remember a set of information better if it is familiar, meaningful, and contains some internal organization. (21, 22, 23, 43, 44).---Since recall is an intelligent process which reflects mental organization, any procedure that helps children organize new information will also help them remember.

Young children often remember better when they have been actively involved with the material to be remembered.---This involvement might be naming or talking about the material (5), or touching, tracing, or manipulating it (2, 52, 53). One great advantage of real objects as teaching materials is that they permit this kind of involvement.

Young children remember better if they have more than one exposure to the material. (6, 24, 28).---Repetition does not have to be in the form of a drill in which

exactly the same information is presented over and over again in the same way. Indeed, children are better able to learn the name of a conceptual category, such as "fruit" if they are given many different examples of items in the category (apple, banana, peach, etc.) than if they are given a few examples which are repeated many times (28). Children remember pictures better if, weeks after the initial learning, the picture names are used in a story (24).

Young children remember better if they are interested in and pay attention to the information (see Chapter 2).---Many of the procedures which facilitate memory may be effective, to at least some degree, because they increase children's attention to the task.

Points to Remember

There are a number of strategies teachers can use to help children overcome the limitations of their ability to remember:

1. Since young children have excellent ability to recognize visual information even after long delays, teachers can use familiar objects and pictures to help children remember. Because recognition tasks are easy for preschoolers, they can be used to build confidence and interest. For instance, the child who cannot retell a story without help will probably recognize the illustrations and will be able to use them as cues for organ- recall of the story. Teachers can also build on children's recognition memory by beginning new lessons or activities with a summary of earlier, related activities. The children will probably be able to participate in this review by recalling some details.
2. Because young children retain relatively few items of new information, teachers should make sure that each small set of information has been thoroughly learned before presenting additional information. Inexperienced

teachers are often tempted to present too much information too fast. A preschool lesson on shape concepts, for instance, may procede well so long as the teacher restricts the discussion to "circle" and "square" but collapses when "triangle" is prematurely added to the set. If children have been "overloaded" with new information a lesson may be impossible to salvage and is best put off to another time.

3. Repetition is often necessary for young children to learn. A child who has learned a new lesson well enough to give a correct answer once or twice, may need considerably more exposure before the memory is secure. When children need repetition, they do not find it boring, but the dangers of boredom can be minimized by presenting the information in a variety of ways.
4. Young children remember better when they can get actively involved with new information by talking about, touching, tracing, or manipulating it. Since real experiences permit more involvement than pictures do, they may be better remembered.
5. Children remember better when they can give a name to an experience. They may do this spontaneously, but the teacher can help by making sure that the children know and use appropriate names, particularly when new experiences or concepts are involved.
6. Information that fits together and makes sense is easier to remember. This point has several implications: (a) A series of lessons should have an internal structure. Several lessons planned around a central theme will be remembered better because the children will be able to relate one day's learning to the next. (b) Lessons should be related to things the children already know from their experience both in and outside school. When the learning involves words and experiences the child knows and understands, memory should be better. (c) Some ideas are difficult to present in any

way that makes sense to young children. If a particular lesson seems to be unusually difficult for the children to remember, the teacher might try to analyze the ideas in the lessons and reconsider the appropriateness of the lesson for that age group (see Chapter 5).

7. Teachers should take the limits of young children's short term memory into account when planning problems. Sometimes a problem can be redesigned so that it has fewer terms or steps. Problems for elementary school children may be easier if they are written down than if they are given orally.
8. Children can be taught to try to remember. About age 6, children begin to do this on their own, but both elementary and preschool children can probably benefit from instruction in memory strategies such as repeating lessons over and over (verbal rehearsal) and using physical clues to prompt memory. Even children who are too young to write may be able to get the idea of "taking notes" through tasks such as making drawings of the arrangement of objects on a table, then using the drawing to recreate the arrangement at some later time.

Precise age ranges have been omitted from the recommendations in this chapter because, in addition to individual differences in children's memory development, there are great differences in children's performance depending on the exact nature of the materials and procedures used in a memory task. Teaching procedures, such as repetition, active involvement, and labelling, which are vital to helping preschoolers remember, are also important to older children. Even if children of a certain age can learn or remember "the hard way" they may still benefit from teaching strategies which make memory easier.

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Chapter 4

Language

Digest of Recommendations

Suggested Teaching Techniques	Rationale	Selected References
1. Give young children ample opportunities to play and talk with one another and with adults.	Learning language involves talking as well as listening. Children talk a great deal when playing among themselves. Some children will talk fluently to their peers, but not to adults.	Garvey and Hogan, 1973; Labov, 1970b; Mueller, 1972
2. Create situations in which children want and need to formulate clear and complete verbal messages. When they have difficulty with this task, help them by asking probing questions--What else did it look like?" "What did you do then?"--and by providing examples of good messages.	Children provide more complete verbal information when they know the listener really needs this information. Children who are initially poor at these games can improve with help and practice. Children tend to imitate the speech style of their teachers.	Flavell, 1967; Gleason, 1972; Peterson, Danner, and Flavell, 1972

Suggested Teaching Techniques	Rationale	Selected References
3. Do not assume that young children understand and use words in terms of their adult meaning. Children may have a very limited understanding of words such as "more, on, before, etc. and they need extended exposure to such words in many different contexts before they fully understand their meaning.	Young children often understand only part of a word's full adult meaning. Children may mask the limits of their verbal comprehension by guessing meaning from the situation in which a word is used. Varied methods for teaching "cognitive code" vocabulary words have been used successfully in innovative educational programs.	Cazden, 1972; Clark, 1973b; Thomson, 1972; Weikart, Rogers, Adcock and McClelland, 1970; White, Day, Freeman, Hantman, and Messenger, 1973
4. Don't nag children about their grammar. Attempts to teach mature grammar to young children are fruitless and may alienate children.	Children's grammar reflects a consistent, developing system which will mature without specific teaching. Children will imitate the speech patterns of teachers and friends they admire.	Brown, 1973; Dale, 1970; Smothergill, Olson, and Moore, 1971.
5. Don't try to convert the grammar and pronunciation of children who speak Nonstandard English to Standard English.	Pressure won't work at this age. Children can understand and read Standard English without speaking it. Nonstandard English is perfectly adequate as a tool for thinking and communication.	Burling, 1973; Hall and Freedle, 1974; Labov, 1969; Labov, 1970a,b

Suggested Teaching Techniques	Rationale	Selected References
6. In teaching reading to all children, and particularly to children who speak Nonstandard English, emphasize comprehension rather than Standard English phonetics. Adapt spelling and reading phonetics lessons to the pronunciation used by the children in the class.	Emphasis on Standard English phonetic reading may lead to anxiety and failure. The ultimate goal of reading instruction is the training of individuals who can understand what they read. Pronunciation, or phonics, is an intermediate step which can be handled in any dialect.	Burling, 1973; Goodman, 1974; Labov, 1970a,b; Smith, 1974
7. Don't assume that low-income children are "nonverbal" or that they lack the verbal skills necessary for thinking.	Language helps children think but it is not a necessary tool for logical reasoning. Children from low-income families perform quite well on some measures of verbal ability. Verbal ability in Nonstandard English is just as sufficient for thinking as ability to use Standard English. The language children reveal in talking to a teacher may be only a fraction of their true competence.	Cazden, 1972; Genshaft and Hirt, 1974; Labov, 1970b; Shriner and Miner, 1968; Spence, 1973

How Can Teachers Encourage Children to Talk?

Children learn to talk well (and, perhaps, gain a good foundation for writing well) by getting extensive experience in talking.---Listening to a teacher is only part of language learning. To master a growing vocabulary and develop increasingly mature ways of putting words together, children need to talk as well as listen (8, 18).

Everyone likes to talk to people who talk back. In a classroom situation, teachers are inevitably drawn to the most verbal children, with the result that quiet and inarticulate children become relatively more so as the school year progresses and the teacher devotes more and more time to conversation with the children who probably need it least. One advantage of highly structured language drill programs (such as DISTAR) is that they do insure that all children get at least some experience in talking with the teacher (8, 9).

Certain teacher-child situations are better suited than others for getting the child to talk. As a start, the teacher can become a better listener by sitting or stooping to meet children at their eye level. Many children are turned off by teachers who ask questions which are not real requests for information, but tests of knowledge. When a teacher holds up an object and asks, "What is this?" he or she is asking a "test" question. The children know that the teacher does need that information, but is testing their knowledge. Some children love such challenges; others avoid them with "I dunno" (38). Children seem to talk best in situations where they can talk with a teacher and answer questions that are real questions in situations that are interesting to both the child and the teacher (9). "For example, rather than asking a child what he had for breakfast, a teacher might say to whomever is near and will listen 'There are so many good things to eat for breakfast. I like orange juice. I wonder if everybody likes orange juice'" (58, p. 23).

The teacher's responses to children's speech are important in several ways. When teachers are interested in what children say and refrain from turning a conversation into a grammar lesson, children are likely to talk more in the future. The teacher's language also serves as a model for children to imitate in their own speech. In one research study preschoolers' speech reflected their teachers' speech style after a few weeks of exposure to a particular style (56).

Some children do not talk well in the presence of a teacher, despite great efforts to engage the children's interest and put them at ease. Some of these children come from backgrouns where it is not acceptable to speak at length to adults. These children may, however, speak very well when they are given the opportunity to talk to other children (37, 38). Speaking to their equals or to even younger children, children may unleash their full verbal powers. Preschoolers talk to each other a great deal when playing together in pairs (25, 47). In one research study of this situation, one or the other of the children spoke, on the average, once every 9 seconds (47). In another study, in which the children were previously acquainted, the rate was one utterance every 4.6 seconds (25).

The quantity and quality of children's speech may vary with the types of activity in which they are involved. There is some evidence, for instance, that preschoolers talk to each other more while playing house than while playing with blocks or working on a craft project (18). Such data should, however, be interpreted with caution. Almost any group activity can stimulate conversation if the teacher has this goal in mind and provides materials or ideas that will facilitate discussion and cooperation (58).

How Can Teachers Help Children Use Language for Effective Communication?

Most children's speech is intended to communicate a message, even though the actual communication may be rather inefficient. There are times, however, when children say things which are not intended for any listener. A child who is involved in

a project might make remarks such as "That's a good one," or, "Now I have to put one over here." Adults, of course, also mumble to themselves, but children are more likely than adults to use "egocentric speech" when other people are present, and to speak aloud rather than muttering or silently speaking the words.

Young children's egocentric speech is not an undesirable thing. It is a normal and useful early stage of development which may be involved in the development of thinking and self control (17, 18, 61). It accounts, moreover, for a relatively small proportion of children's speech, even at the preschool level. Most children's utterances have a clear communicative intent and are successful in eliciting some response from the listener (25, 47).

Even though young children's speech is not frequently egocentric in intent, it may be egocentric, or inadequate, in that it fails to provide all the information needed by the listener.

Teacher (seeing Jimmy looking dejected): What's the matter?

Jimmy: I can't find it.

Teacher: What can't you find?

Jimmy: The big one.

(Phyllis Haas)

Much of what the child says can be understood only if the listener can see what the child sees, or remembers the past event the child is trying to describe. Preschool speech relies heavily on tone of voice, pointing and the use of indefinite pronouns. The three-year old will say "What is it?" to a listener in the next room who could not possibly know what "it" is (35). Learning to use language well involves development of an ability to appreciate the needs of the listener, and to provide complete

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4. Phyllis Haas, Personal Communication, October, 1974.

verbal information. The need for such a skill becomes particularly critical when the child begins to communicate in writing. The gestures and intonations which amplify the message of oral language cannot be incorporated into written language.

To a great extent, children fail to communicate clearly because they do not understand what the listener needs to know and what they must say to provide that information. Young children produce their best efforts when the needs of the listener are dramatic and obvious--when, for instance, the child is asked to describe a set of materials so that a blindfolded listener can perform some task. Even when children perceive the listener's needs they may, however, give less than adequate information, particularly if the ideas to be communicated are complex (22, 42).

There are a number of strategies which teachers can use to help preschoolers and early elementary school children communicate better. Several curriculum packages, borrowing from research methodology, suggest structured "communication games" in which a child must convey information to another player who cannot see what is being talked about (1). Two children might, for instance, sit at a table on which a screen has been placed to block their view of each other and of each other's sections of the table. Each has an assortment of shapes with which to make a design. The children take turns as speaker and listener. The speaker makes a design with the shapes and then tries to describe the design so that the listener can make an exact copy.

Children (aged 4) who are initially poor at these games become competent talkers after a few weeks of training in playing the game with an adult who asks leading questions and provides a good example of how the game should be played (28). One child initially tried to identify a picture for another "blind" child by saying, "People are sitting next to each other." Compare this performance with the child's description of the same picture after 4 weeks of training: "The M & M is under the picture with a cat and a mother who's holding the cat, and telling her baby to pat it, I guess."

Communication skills can also be taught in the course of everyday classroom activities. Children can, for instance, be asked to convey oral messages to a teacher or child in another room, or to describe an ongoing activity to someone who has just joined the group. Adult listeners or bystanders can help the young messen er by probing for any information the child has omitted.

The kind of help children need to improve their communication attempts depends on their age. Seven- or 8-year-olds will improve an inadequate message in response to vague hints from the listener such as "I don't understand." Preschoolers need more detailed help in the form of specific questions such as "What else does it look like?' 'What color is it?" or, "What did you do next?" (22, 49). Children of any age profit from the combined experience of trying their own communications, and listening to teachers' examples of clear and complete messages.

How Do Children Learn the Meanings of New Words?

Learning the full adult meaning of words is a complex process which is not complete until children are well into the elementary school years. The task is difficult because the meanings of many words require abstract reasoning and familiarity with conventions of language use.

An adult might, for instance, look at a person and judging from gray hair, stooped posture, or other cues, reason that the person could be described as "old." In choosing this word the adult is relying on knowledge that these perceptual cues are fairly reliable signs that a large number of years have passed since a person's birth. The adult's word choice might also reflect the specific context of the remark. An "old" graduate student, for instance, might be considerably less stooped and gray than an "old" professor.

Young children's word usage sometimes reveals their lack of mastery of the subtleties which govern adult usage. Preschoolers, for instance, call a human figure

"older" if it is larger than a comparison figure, even though other cues such as dress and body proportion clearly contradict this usage (34, 41). Young children are also prone to use words in inappropriate contexts and occasionally amuse adults by making statements such as "There's only a small piece of cake but its middle-aged" (18). Adult language is frequently of little help to children who are in the process of sorting out the rules for using a particular word. The preschool child who confuses "older" with bigger is showing the influence of listening to adults who use "big" as a synonym for "old," "grown-up" or "mature". The adult who uses "big" this way knows that "big" does not always imply "old", but young children are less aware of the full meanings of the words and can therefore be tricked into errors of usage.

Despite occasional errors of usage in children's speech, it is often difficult to tell when a child's understanding of word meaning differs from an adult's. Young children have usually mastered some aspect of a word's meaning. This incomplete understanding may often serve children sufficiently well most of the time, but children with incomplete understanding can have difficulty when the teacher's use of words and their own interpretation don't coincide. Many psychological research techniques have been designed specifically to lead children into errors in word comprehension or use, and thus reveal the limits of understanding which might not surface consistently in real-life situations (19, 20, 43, 44).

"More" and "less", for example, are among the words which are imperfectly understood in the preschool years. Children aged 3 or 4 seem to understand that "more" and "less" are related to the dimension of quantity, but have not yet sorted out the difference between "more", "less", and "the same amount." "More" seems to be understood earlier than "less" and there is a period when the child seems to think that "less" is "more" (19).

Children are often able to respond correctly to verbal directions even when they are not paying attention or are unable to understand what is said. Children (and

adults in similar circumstances) do what they think the speaker wants, judging from the circumstances. If a teacher says, "Put the crayons ------ the box," the young child, seeing a box at hand, will put the crayons inside the box and probably be correct. Children below the age of 3 will often put an object inside a container even if the direction is to place the object under or on the container. If, on the other hand, the child faces a table or other large object with a flat surface on which things can be put, the child will assume that the direction is to put the crayon on the table (13). In a familiar situation, children often act more on the basis of past experience with what is expected than by following verbal instructions. This tendency is more pronounced, of course, if the child cannot understand what the teacher is saying. This guessing is not undesirable--it is, in part, the way children learn new word meanings and grammatical patterns. Teachers should, however, be careful in assuming that children understand a word because they appear to comprehend the word in a particular situation. A word is not fully understood until the child has sorted out the features which distinguish it from other similar words and understands the word's meaning in the full range of situations to which it might be applied.

One way in which the understanding of words improves with age is from a limited understanding of the word in a specific context only ("on" applies to things with surfaces but not containers) to a broader, more flexible understanding (12, 13). Teachers who know the limits of children's understanding can talk with the children in ways they can understand. Knowing where a child "is" also permits the teacher to present words in ways that will help expand the child's understanding to more mature levels.

Most early childhood programs stress the learning of particular sets of vocabulary words which will ultimately be useful in learning situations. Many of these words deal with relationships of quantity, space, and time, or with dimensions of

objects. The "cognitive code" vocabulary of many preschool programs includes words such as color and shape names, more, less, big (bigger, biggest), small (smaller, smallest), between, behind, on top of, beside, before, after, etc., (1, 8, 62, 63, 71).. These words are involved in the directions or description that accompany many early learning situations and it makes sense to ensure that children learn them.

The "cognitive code" words are often difficult for the child to learn because they express ideas which require the child to attend to an unchanging feature or relationship (red, bigger, on top of) which must be separated from the individual situation in which the word is used. The child must learn that all sorts of objects can be red, that there are a whole range of colors that can all be called red, that a thing which is bigger than a breadbox may not be bigger than a house (18). Since learning these word meanings involves a gradual sorting out of properties, the child's learning is best facilitated by the opportunity to encounter new words in a variety of situations, both verbal and practical. The child needs to deal with more and less, for instance, in cases of discrete, countable quantities and of continuous, fluid quantity. The child needs to learn that if one thing is more, then another is less, or that sometimes both are the same. The child also needs to hear words used in a variety of sentence contexts so that their meaning can be appropriately separated from the context. For instance, the child who hears sentences such as, "Before you close the door turn out the lights" has to learn the meaning of "before" in the difficult language context where the order of the words is different from the order of the sentence meaning.

Having a child hear or say a word in a single, repeated situation will not help the child learn the full meaning of the word in the range of situations to which it must ultimately be applied. A better way for children to learn the meanings of new words is suggested by Carolyn Thomson of the University of Kansas:[5]

> When one is planning a "language experience" it is easy to narrow the activity to materials that are specifically designed for the acquisition of specific language skills. This may be very appropriate. However, language is an activity that invades every portion of the preschool program and therefore, a teacher is providing language experiences in each activity and in each portion of the day in which she is responsible for interaction with children. Thus, while a teacher may plan an activity to enable children to acquire a certain skill, she might also look for a variety of ways and times throughout the day when acquisition of this skill can be emphasized. For example: suppose a teacher plans a specific game where she cues children to place cereals in different positions on an object--an activity to teach the comprehension of prepositions. She might consider other times during the day to emphasize preposition comprehension: clean-up time when she might tell children where to place materials or ask children where they placed them; washing hands before snacks when she might ask children who is in front of Billy, behind Jane, beside Joe, etc.....

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5. Thomson, C. Skills for Young Children. Department of Human Development, University of Kansas, 1972, 134-135. Reprinted with permission.

Should Teachers Try to "Improve" Young Children's Grammar?

Child: Nobody don't like me.

Teacher: No, say "Nobody likes me."

Child: Nobody don't like me (8 repetitions of this dialogue)

Teacher: No. Now listen carefully; say "Nobody likes me."

Child: Oh! Nobody don't likes me![6]

Every teacher or parent has tried to do something about a child's persistent errors in speaking and has been frustrated by the child's failure to respond to direct preaching about grammar. Adults can sometimes produce changes by providing a model of correct speech and rephrasing the child's utterances into adult form, but this technique produces immediate results only if the child is ready to imitate the change. Otherwise, the benefits of speaking correctly to children are to be seen only over a period of weeks, months, or years. The child in the example above was ready to adopt the Standard English rule which calls for "s" to be added to a verb in the third person singular. The child was not, however, ready to abandon use of the double negative (45).

Children's grammar is difficult to change because it is not simply bad speaking or a mishmash of random errors. Children talk the way they do because they have their own grammar, which makes perfect sense to them--it just happens to be slightly different from adult grammar (18). The differences between child and adult grammar tend to be particularly noticeable when children make errors such as:

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6. McNeill, D. "Developmental Psycholinguistics." The Genesis of Language, F. Smith and G. A. Miller, Eds. Cambridge, Mass.: M.I.T. Press, 1966, 69.

"Nobody don't like me."	Double negative; lack of subject-verb agreement
"She holded them loosely."	Overgeneralization of "ed", past tense ending
"All the childrens came."	Overgeneralization of "s"; plural ending
"Why you don't come?"	Failure to change word order in forming question
"Her did it."	Wrong case of pronoun

When children make these errors it does not necessarily mean that they are reproducing the kind of language they have heard at home or at school. They are merely speaking in an immature system of their own, and their speech will change in time. The young child's grammar is, at any stage, a reflection of the child's best current guess about the structure of his or her native language. The "guesses" are constantly changed and improved as the child matures (6, 18).

There is little reliable information on how teachers and parents might help a child's grammatical development to progress, but it does seem that giving children a chance to talk a lot themselves, and to hear adult speech, is the natural and perhaps the only way for development to proceed. Adults sometimes like to repeat what children say in an expanded and corrected form. This is a natural tendency which may be helpful in the long run. Children should not, however, be required to rephrase their own statements. As in the example above, expecting children to imitate grammar too far from their own levels leads to repeated failures and frustration for both teachers and children (8, 18, 45).

An additional problem for teachers in schools where children speak a variety of nonstandard dialects is the need to be aware that dialect speakers may use grammatical forms which appear similar to immature forms of Standard English, but which are actually based on mature rules of Nonstandard English. The double negative, for

instance, is, in Black English vernacular as well as many foreign languages, a perfectly legitimate, rule-governed form (36). Children who speak Nonstandard English are not speaking a grammatically immature or deficient language. Children's grammar must be evaluated in terms of the language or dialect they are acquiring (18).

Can teachers "improve" young children's grammar? In general, time will take care of the problem. Given ample opportunities to speak, and to hear adult language, children will eventually master mature forms of their native language. A strategy of "benign neglect" is as appropriate for children whose grammar reflects a developing form of Nonstandard English as for children whose native dialect is Standard English (7).

How Can Teachers Work Effectively With Children Who Speak Nonstandard English?

A large number of American children come to school speaking languages other than the Standard English which is officially and socially acceptable in white middle-class society. Some are from homes where a foreign language, such as Spanish, is spoken. Others speak regional or racial dialects which are varieties of English, but which are different enough from the standard to cause problems of communication and social prejudice. This report will focus on the group of dialects known as Black English because these dialects have been studied more extensively than other nonstandard forms, and because some form of Black English vernacular is the language of a large proportion of school children.

The Black English vernacular spoken by many inner-city children differs from Standard English in its vocabulary, its pronunciation, and its grammar (38). Vocabulary differences present relatively little difficulty in the classroom. Children learn to use certain words and not others when talking to teachers. Teachers learn to comprehend the children's special vocabulary. The differences between Black and Standard English in rules for pronunciation and rules for grammar do often lead to problems in school (37, 38). The differences between the dialects

in underlying linguistic rules are relatively minor but the resulting differences in word sounds and sentence structure can lead to considerable mutual misunderstanding between the teacher who speaks Standard English and the child who speaks Black English vernacular.

One problem for the child who speaks any nonstandard dialect is the prejudice that some teachers may feel against someone whose speech does not conform to standard. The child's language may be classified as "retarded" or "restricted" and the child may be thought to be stupid. This prejudice is completely unreasonable. There is no evidence that any language is, as a whole, "better" or more complex than any other language (40). In comparing two systems, such as Black English and Standard English, one typically finds that one language makes elaborate distinctions in one area, the other in different areas. In Black English vernacular there is a distinction, for example, between an activity occurring a single time and a habitual or repeated activity. "He working" means that he is working right now, while "He be working" means "He usually works," or, perhaps "He has a steady job" (36). Any language can be used well or badly for communication. In evaluating communication skill it is often necessary to overcome prejudices about style to focus on the meaning of the message.

Simply eliminating social prejudice against Nonstandard English would not erase the difficulties inherent in maintaining a school system for children from a diversity of linguistic backgrounds. Because the various dialects of English are much more similar than they are different, educational programs have in the past tended to rely completely on materials which are appropriate for speakers of Standard English without considering the complexities which certain activities might raise in a classroom where some or all of the children speak varieties of Nonstandard English. Consider, for instance, the lessons which are often used to

acquaint children with English spelling and sound patterns. Children are often asked to find sets of words which rhyme with one another. Teachers whose classes include children who rhyme ~~pour and mere~~ with sew cannot make rhyming into a useful lesson unless they work from the pronunciation rules the children are using as well as the rules in textbooks of Standard English (7).

There is no reason why children who speak Nonstandard English should not be able to pronounce words their own way, and also learn to write using standard spelling. English spelling is a difficult erratic system regardless of the dialect used to pronounce it, and all children are faced with the task of learning many spellings by memorizing individual words and special patterns. Teachers who are sensitive to children's pronunciation, and who try to teach spelling by using the children's pronunciation rules rather than imposing their own are likely to have much greater success than teachers who lack this flexibility (7, 37, 38).

Dialect differences in grammar and pronunciation can also create confusion in the teaching of reading. For example, speakers of Black English vernacular may sometimes employ an optional pronunciation rule which calls for the deletion of final consonant sounds. When this rule is used, passed and past are indistinguishable from pass, and rowed and road sound identical to row (37, 38). Such pronunciation patterns may make it difficult for teachers to determine whether or not children are picking up and understanding the past action message in the -ed ending of regular Standard English verbs. If a child's pronunciation does not reliably distinguish present from past tense forms, the teacher may need to use some ingenuity in checking the child's comprehension. One way to make sure that a child understands the past tense is to listen for the child's pronunciation of a verb such as read, which has different present and past tense pronunciations in both Standard and Black English. By noting whether a child pronounces read with a short or a long vowel sound, the teacher can determine whether children are

correctly interpreting other nonpronounced past tense markers in the same sentence. In the following sentences, for example, comprehension of -ed past tense forms can be checked by listening for the child's pronunciation of read in sentences (d), (e) and (f), and comparing it with the present and past tense forms used in sentences (a), (b), and (c).[7]

(a) Last month I read five books.

(b) Tom read all the time.

(c) Now I read and write better than Alfred does.

(d) When I passed by, I read the posters.

(e) When I liked a story, I read every word.

(f) I looked for trouble when I read the news.

Children should be able to learn to read Standard English without ever using Standard English grammar or pronunciation in their own speech. This is fortunate, since the available evidence indicates that efforts to drill Standard English usage into young dialect speakers are as futile as efforts to force mature Standard English on young children who are native speakers of that dialect (7, 37, 38).

Speaking and understanding language are somewhat different processes, and black inner-city children do develop the ability to comprehend Standard English at the same rate as white inner-city children do (31). Black children also remember Standard English sentences as well as white children do (26).

Insistence on Standard English pronunciation and grammar may be one source of the reading problems so prevalent among inner-city children. Children who develop anxiety about their inability to "sound out" words according to alien pronunciation rules may eventually stop trying to read (29).

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7. Labov, W. Language in the Inner City, Chapter 1. Philadelphia, Penna.: University of Pennsylvania Press, 1972.

There are a number of strategies suitable for teaching reading to all children, which have particular relevance for children who speak Nonstandard English. Teachers might wish to consider the following:

1. Emphasizing the importance of reading and writing as communication tools. Children can, for instance, be given "important" messages to decipher, such as "The snack is in the closet." (29)
2. Using reading materials that reflect the patterns of the children's own speech, such as dialect literature or the children's original compositions (7, 37, 38, 55).
3. Stressing reading for comprehension rather than Standard English phonetic pronunciation. The traditional practice of "reading aloud" for the teacher can be supplemented by activities such as silent reading followed by group discussion of the material, or individual work on comprehension exercises such as connecting words and pictures (7, 55).
4. Encouraging, rather than discouraging, children's attempts to guess words from context. Guessing from context is a common practice among fluent adult readers. The practice may be particularly helpful to children who, because of Nonstandard pronunciation, find "sounding out" particularly difficult (55).
5. Adapting phonics instruction to the pronunciation used by the children being taught (7, 37, 38).

This discussion of Black English is intended only as a brief introduction to the issues involved in designing educational programs for our multi-dialectical culture. Psychologists and linguists have made extensive studies of dialect differences and of the nature of language itself. These studies have provided detailed information to help teachers understand how dialects differ, what these

differences mean, and how school experiences can be adapted to cope with these differences. Even teachers who are themselves bidialectical speakers of Nonstandard and Standard English can profit by learning how the dialects are related and why the old-fashioned rules of "proper" language are largely nonsense. Particularly concise and comprehensible treatments of this subject are available in English in Black and White, by Robbins Burling (New York: Holt, Rinehart and Winston, 1973) and The Study of Nonstandard English, by William Labov (Champaign, Illinois: National Council of Teachers of English, 1970). A more comprehensive treatment of Labov's work is presented in Language in the Inner City (Philadelphia, Penna. University of Pennsylvania Press, 1972).

Is Language Training an Effective Way To Improve Children's Ability To Think?

> Identity statements were reviewed by using various objects placed in a can, e.g., a car, a cup, a plate. I took an object out and gave the identity statement: "This is a....." The children were asked to repeat this statement in unison. Then I asked questions about the object. For a car I might ask, "Is this a ball?" and they would respond, "No, this is not a ball."[10]

A number of popular preschool programs, the best-known being Bereiter and Engelmann's DISTAR program, place heavy emphasis on language drill as a way of teaching a child to talk "better" and to think better (48). In their original conception, these programs were based on a set of related assumptions:

1. The ability to use language is critical for logical thinking.
2. Preschool children from low-income backgrounds have inadequate language skills and are therefore poorly equipped for thinking.
3. Language skills, and consequently thinking, can be improved by concentrated drill in stereotyped patterns of response.

These assumptions are discussed below:

Is the ability to use language critical for logical thinking?---This question is by far the most complex of the three. The answer depends on precisely how one looks at the question. The acquisition of language does influence and enhance the child's thinking in a number of ways. When a child is able to link up understanding of a situation with the use of the right language, the child has achieved a high level of control over that situation.

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10. Weikart, D: P., McClelland, D., Hiatt, L., Mainwaring, S., and Weathers, T. The Language Training Curriculum. Ypsilanti, Michigan: High/Scope Educational Research Foundation, 1970. Reprinted with permission.

In learning a name for an object, a child is forced to attend to the features of the object which most reliably distinguish it from other objects with different names. Once a child has learned names for sets of things, the similarity among things with the same name (e.g. trees) will be more apparent, and the difference between things with different names (e.g. trees vs telephone poles) will be more obvious. Learning language therefore, helps the child to perceive experiences in adult ways (27, 50).

The child who has learned names for the dimensions and relationships of objects is perhaps better equipped to solve problems on the basis of classes and relations rather than individual instances. For instance, the child who knows the word "bigger" and learns to solve one problem by always choosing the "bigger" thing is likely to apply the same verbal rule to similar problems. The child may sometimes achieve the same results without using language, but language is certainly no hindrance (15, 16, 33, 57).

Learning language, and learning to use language, also expands the potential of the child's memory. The ways in which language can help children remember are discussed in Chapter 3.

Another way in which the acquisition of language might influence thought has received little research attention and must remain as speculation. Learning language may itself be the most impressive intellectual feat accomplished by the young child. In the first few years of life, usually without any formal instruction, children learn an enormous set of words and sounds, and a complex system of grammatical rules. The "push" given to the child's thought processes by the demands of language learning may well carry over to other areas of cognition.

In discussing the relationship between language and thought, psychologists often stress the limits of language influences on the young child's behavior and argue that not until age 5 or 7 does the child use language for thinking.

Nonetheless, preschool children can and do act and think in many ways that rely on their verbal skills. They can, within limits, follow verbal directions, communicate verbally to others, absorb ideas from verbal presentations, and do creative thinking on a purely verbal level. One preschooler, for example, asked her mother why pigs were not milked. Her mother replied, that "they have little ones to feed." The child countered that statement with the argument "So do cows have calves--try again Mommy." (4) This child is demonstrating an ability, which all young children show at some time or another, to think logically in a situation where the "problem" and "solution" are entirely verbal. The difference between young children and adults or older children is not in presence or absence of the ability to use language for thinking, but in the range of situations in which this ability can be applied and in the efficiency of its application (4).

Learning language does expand the possibilities of the child's thinking, but it may be more accurage to emphasize that language reflects the child's intellectual growth (54). In many situations, a child's nonverbal understanding precedes and surpasses the ability to use the relevant language. Four- and five-year-olds, for example, understand the concept "big" correctly even though they confuse the word "big" with "tall" (43).

Developing language helps children think, and developing new ways of thinking helps children learn language. Young children who have been virtually without language are, however, less handicapped in their thought processes than one might expect from the discussion above. Deaf preschoolers who have not yet learned sign language are able to cope fairly well with tests of logical reasoning ability (24, 57). Language helps children think, but it is not an absolute necessity.

Do young children from low-income backgrounds lack sufficient language skills for logical thinking?---If language does help children think better, even to a limited extent, children with serious language deficiencies might be expected to have difficulty thinking and learning. Psychologists and educators have therefore wondered whether the academic difficulties common among children from low-income families might be traced to deficiencies in this group's language development.

The degree to which low-income children appear to be linguistically deprived depends to a great extent on how their language skills are measured.

During the 1960's estimates of the language skills of children from low-income families suggested that these children suffered from massive language deficiencies, massive enough, perhaps, to be a source of problems in thinking (2, 48). These early estimates were, however, made by researchers who had no understanding of the nature of dialect differences and who judged children's "deprivation" largely in terms of the degree to which their language failed to conform to middle class speech patterns. These early estimates also failed to allow for the tendency of many low-income children to become suddenly "nonverbal" when tested by a strange adult (7, 38).

More recently, psychologists and educators have pointed out that most "nonverbal" children speak fluent, complex, and effective language when among themselves or away from school. In addition, the language skills of children who speak Nonstandard English are much more impressive if their language is evaluated by its own rules, the only sensible measure (7, 8, 38).

One way of testing children's language competence is to give them nonsense words and sentences to comprehend or manipulate. Performance on this kind of test reflects children's comprehension of the grammatical structure of language. Several studies using this type of measure have found no racial or social class differences in children's performance (39, 52).

Thus it appears that there is no massive deficit in the language competence of poor children. They may sometimes have particular difficulty in performing some of the language tasks which are required in school, and may need some extra help in specific areas such as mastering the "cognitive code" vocabulary (9, 28). There is no evidence, however, that these children suffer from the general lack of a "thinking language."

Will language drill help a child to think better?---Language drill programs have been popular because they have frequently been successful in producing relatively large, fairly enduring gains in school performance and test scores (48, 64). This success could be taken as support for the philosophy that language drill trains good thinking. There are other facets of the programs, such as the high degree of teacher-child contact and the training of skills which will make the child popular with his teachers, that might account for the results. Indeed, a general pattern in the compensatory education literature is the finding that programs with specific goals, a detailed curriculum plan, high teacher-pupil ratios, extensive teacher-child interaction, and enthusiastic staff are successful no matter what the particular flavor of the approach (64).

Children in language drill programs do learn how to speak confidently and how to answer teachers' questions in acceptable form. The system can be defended for its accomplishments, but, as the previous sections have shown, there is little reason to think that the success of language drill programs can be attributed to improvement in thinking by learning a limited set of words and expressions in a rigid, repetitive format.

Points to Remember

The preceding discussion of language development can be summarized into a few general principles with direct relevance to classroom procedures:

1. Children get useful language practice by talking and listening to one another.
2. Children talk when they want to communicate, and know that the listener wants to hear what they have to say.
3. Young children often have difficulty formulating clear and complete messages which can be understood without reliance on nonverbal cues. Practice, with helpful suggestions and examples provided by the teacher, can improve their performance.
4. Children's grammar is a logically consistent, developing system which will mature in time without specific teaching.
5. Children learn new word meanings by a long, slow process of experience with words in a variety of practical situations and sentence contexts. Some words require considerable logical sophistication to be fully understood.
6. The language of children who speak Nonstandard English is perfectly adequate for communication and for thinking. Children can learn to read and understand Standard English without learning to speak that dialect.
7. The problems which low-income children sometimes have in school cannot be traced to lack of a "thinking language."

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Chapter 5

Logical Thinking

Digest of Recommendations

Suggested Teaching Techniques	Rationale	Selected References
1. Give young children varied opportunities to exercise their developing understanding of basic logical principles through activities such as a. putting things into logical groups on the basis of common properties such as form, color, function, number or abstract qualities (e.g. living vs. nonliving) b. putting things into serial order (stacking rings, graduated sticks) and establishing relationships between two such series (e.g. dolls and beds of varied sizes) c. transforming materials and observing how their perceptual properties can be changed back and forth without altering the essential quantity, e.g. rolling and squashing playdough, bending and straightening wire.	Until age 7 (give or take 2 years) children's thinking is characterized by an inability to comprehend such general logical principles as classification, seriation, and the conservation of quantity during perceptual transformations. Understanding is thought to develop from active manipulation of materials and observation of the changes that occur.	Baldwin, 1967; Bruner, Olver, and Greenfield, 1966; Lloyd, 1971; Lovell, 1971c; Piaget, 1971; Sigel, 1972

Suggested Teaching Techniques	Rationale	Selected References
2. Try teaching children a "rote" skill, such as counting, or identifying Euclidean shapes, even if they do not yet understand the system they are using. This teaching should include opportunities for children to use manipulable materials to work out problems on their own.	Children attain conservation of number after learning how to count, add and subtract. Practice in manipulating quantities may help conservation to develop. Programs have been developed which provide a sequence of number learning activities consistent with the psychological evidence on how basic number skills are acquired. Preschool children can learn to identify common Euclidean shapes (e.g., circles, triangles, squares)	Cousins and Abravanel, 1971; Denney, 1972b; Piaget, 1971; Resnick, Wang, and Kaplan, 1973; Winer, 1968; Wohlwill, 1960.
3. When teaching computational or measurement skills to young elementary school children, give them practice in all types of situations (e.g. measuring with different units, averaging numbers of different magnitudes) in which they will be expected to use the skill.	Young children tend to learn these skills in terms of specific instances, and learning is not likely to generalize spontaneously to new situations.	Lovell, 1971a,b,c

Suggested Teaching Techniques	Rationale	Selected References
4. Give children opportunities to analyze space in terms of its topological properties (e.g. holes and boundaries).	Young children seem to be naturally attentive to these properties of space. This may be the only kind of spatial understanding that preschool children can handle well.	Laurendeau and Pinard, 1970; Piaget and Inhelder, 1956; Sauvy and Sauvy, 1974
5. Give young children extensive practice in discriminating and using projective space relationships, especially right and left.	Young children's understanding of space and spatial relationships is limited by their logical immaturity. Projective spatial relations (e.g., left-right) and measurement are particularly difficult. Left-right distinctions are more difficult than front-back and up-down. Children learn to coordinate spatial relations between objects years after they learn spatial features of single objects. Practice helps children learn spatial distinctions.	Asso and Wyke, 1971; Elkind, 1961; Goodnow, 1972; Harris, 1972; Strayer and Ames, 1972

Suggested Teaching Techniques	Rationale	Selected References
6. Give young children practice in predicting how spatial arrangements might look from different viewpoints.	This skill typically develops during the early elementary school years without formal teaching. Young children act as if they know the view from different locations must vary, but they can't predict just how it varies.	Fishbein, Lewis and Kuffer, 1972; Laurendeau and Pinard, 1970; Selman, 1971; Shantz and Watson, 1971
7. Supplement teaching of computational formulas for measurement (e.g., area = length x width) with experiences that demonstrate the concrete logic of the process (e.g., adding small units of standard area)	Children who have learned the standard formulas and techniques of measurement may not understand the logic or be able to generalize their skills to new units or situations. A certain degree of intellectual maturity is necessary for children to understand this process.	Lovell, 1971b,c

How Does Children's Thinking Change Between Age 3 and Age 8?

This chapter introduces important principles of Jean Piaget's theory of the development of children's thinking. A general discussion of the theory and its relevance to the classroom is followed by a review of two specific educational topics; how children learn to understand numbers and how they learn to understand space. The topics illustrate how age changes in children's general patterns of thinking affect their ability to learn specific skills.

The central argument of Piaget's theory of cognitive development is that older children do not simply know more than younger children, but think in qualitatively different ways. The rate at which thinking skills develop varies among children and among cultures, but all children are said to go through the same sequence of stages. Piaget categorizes preschool age children as "preoperational," that is, prelogical. Their thinking is dominated by perceptual processes--by what seems to be rather than by what logically must be. Preoperational children have not mastered the systems of logical operations which characterize the thinking of older children.

The shift from preoperational to operational (logical) thinking is a gradual process which begins, roughly, at about age 5 or 6 and continues until about age 9. Throughout this period and beyond, children gain the ability to apply their logic systems to an ever-increasing range of situations (3, 48, 49, 50). The transition from preoperational to operational thinking can be described in terms of the mastery of three types of logical problems: classification, seriation, and conservation.

Classification is the process of grouping events in terms of their similarities (within classes) and differences (between classes).---The child who takes a pile of red and blue blocks and sorts them into one pile of red and one pile of blue is classifying the blocks. Classification is most important as a mental operation, a way of thinking. Since mental operations cannot be observed directly, however, children's ability to classify is usually measured by observing how they group real objects or pictures.

Preschool children can often form reasonably adequate, if not perfect, groups of objects on the basis of a single common attribute (i.e., form or color or function). They tend not to be able to classify things in more than one way at a time. Rarely will they produce classification hierarchies such as the one diagramed in Figure 1 below. Specific teaching methods and practice can improve young children's classification performance (17, 26, 59).

Teachers who are concerned with evaluating children's classification ability should be aware that, for preschoolers in particular, success in classification tends to vary with the number of items in the task, the familiarity of the materials, the dimensions defining possible classification arrangements, the task instructions, and, for some children, whether real objects or pictures are used (8, 10, 16, 17, 33, 59, 65).

The ability to group objects in multiple, hierarchical classes (as in Figure 1) is one of several signs that the child has developed a working understanding of the logic of classification. Age estimates vary by several years, depending on factors such as those mentioned above, but full competence in a classification task such as the one in Figure 1 may not come until the child is 7 or 8 years old. Between the ages of 5 and 7 children are prone to inconsistencies such as the size-color reversal shown in the lower left corner of Figure 1.

Insert Figure 1 about here

Understanding of the relations among classes is, according to Piaget (3, 50), a necessary precondition for the development of understanding of a number of important ideas. The class inclusion relation is evident in the hierarchical scheme of Figure 1--the superordinate class "all rectangles" includes subgroups of rectangles of different sizes and colors. Similar relationships exist in many aspects of mature thinking. Understanding the class inclusion principle permits the child to

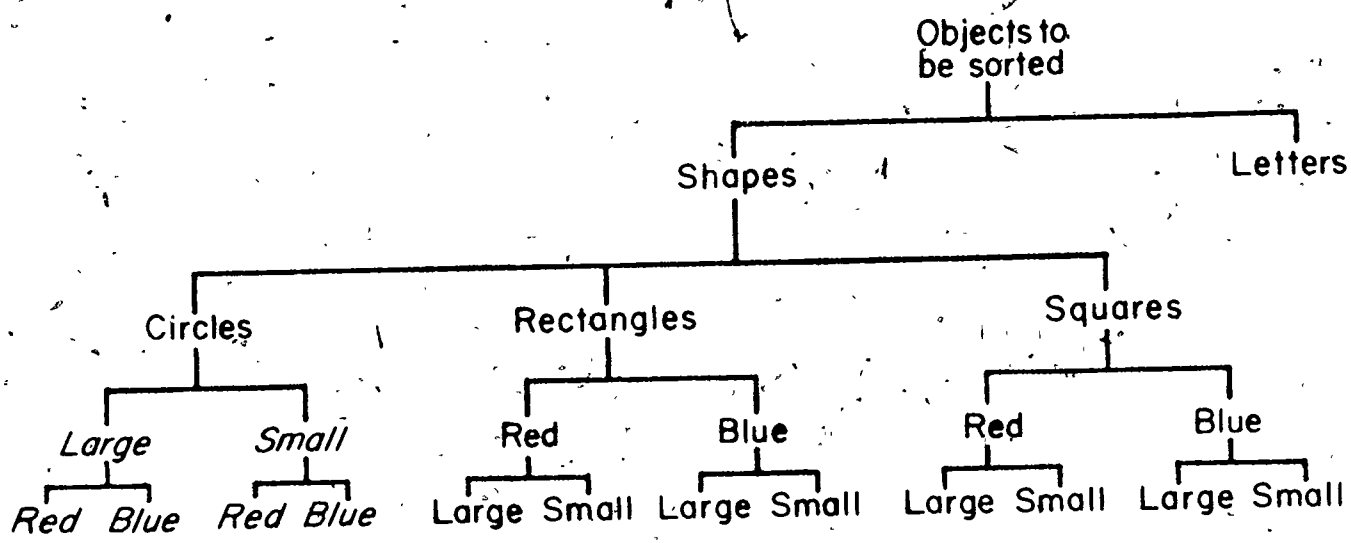

Figure 1

understand, for instance, that things can have more than one name. "Mother" is a member of the general class "women". A person who lives in Philadelphia is also a resident of Pennsylvania.

The class inclusion principle is also basic to understanding numbers and simple arithmetic. Children may be able to memorize addition and subtraction "facts" but they do not fully understand what they are doing until they have mastered the underlying logic that the number of items in a superordinate class (e.g., 10) is the sum of the numbers in the possible subordinate classes (e.g., 10 + 0, or 9 + 1, or 8 + 2, etc.). One aspect of this understanding is the principle of reversibility--children who understand the reversibility of the class inclusion operation should have no difficulty switching back and forth between addition (8 + 2 = 10) and subtraction (10 - 8 = 2) procedures because they realize that one operation reverses, or cancels out, the other.[11]

Seriation, the ability to order events in terms of differences on a single dimension, is another basic intellectual skill which distinguishes preoperational from concrete operational children.---Even 3-year-olds can put things in order in terms of perceptual properties such as size. They are delighted with "seriation" toys such as stacking rings and nested boxes and easily put them in order after a period of trial and error (39, 40). The older child's logical understanding of seriation (as opposed to the preschooler's perceptual understanding) requires mastery of the logical operation of transitivity. This is the principle that if A is larger than B and B is larger than C, then A must be larger than C. Understanding transitivity makes it possible for children to put things in order without directly trying out all the comparisons.

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[11] Readers interested in a more complete discussion of classification logic, mathematics and reasoning may wish to read How Children Learn Mathematics, by Richard Copeland (12).

Estimates of the age at which children master transitivity and seriation vary with the task used to measure the ability and with the type of response (correct performance or correct explanation) required to "pass" the test. Some estimates indicate mastery of transitivity at age 5 or 6, others at 7 or 8 (6, 38, 62). Although the tasks used to assess seriation differ, they all involve materials and procedures which make it difficult for the child to be successful by using perceptual cues alone.

Many logical and mathematical problems are based on the principle of seriation. The number system, for instance, can be described in terms of seriation as well as class inclusion (5, 12, 38, 40, 52). If one conceives of numerals as an ordered progression on a number line, relations among them can be accounted for in terms of serial properties.

Children who have mastered seriation should have no difficulty in establishing the correspondence between the progression of sets of increasing quantities and the numeral "names" for these sets. With this understanding, children logically conclude that if 4 is more than 3, and 5 is more than 4, then 5 must be more than 3. Furthermore, mastery of the reversibility of serial relations permits children to reverse these relations to conclude that 3 must be less than 5. Children who do not fully understand seriation might answer such questions correctly with small, familiar numerals representing easily countable quantities, but they are likely to be stumped by more difficult questions such as the following:

Adult: Which is more, 29 or 30?

Child: 30

Adult: Which is more, 30 or 33?

Child: 33

Adult: Which is more, 33 or 29?

Child: I want to go home now.

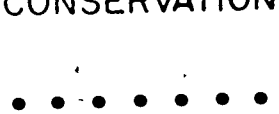
The principle of conservation of quantity is basic to adult logic.---It seems obvious that the number of buttons in a row is unchanged if they are spread far apart or bunched together. A wire that is bent has the same length as it had when it was straight; the distance between two tables is not changed by placing a chair in the intervening space; the quantity of liquid in a tall, narrow glass is not altered when that liquid is poured into a shorter, wider glass. The invariance of quantity in the face of such perceptual changes is not, however, apparent to young children. Preoperational children do not realize that perceptual changes in one dimension (height of liquid in a glass, the space between buttons) are compensated for by changes in other dimensions (the circumference of the liquid, the total space covered by the buttons) or that the changes are reversible (the liquid can be poured back, nothing has been added or taken away). Since young children's judgments of quantity are perceptual rather than logical, they do not have concepts of quantity independent of misleading perceptual cues.

Insert Conservation Figure about here

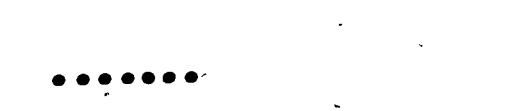
Preschoolers are not readily convinced that one large cookie is as desirable as two small ones, or that the juice in a short, wide glass is really as fair a share as the juice rising higher in a neighbor's taller but narrower glass. In situations such as these, preschool children seem to "center" their attention on a particularly compelling aspect of the perceptual situation such as the height of juice in the glass (14, 44, 48, 51). Explanations from the teacher are unlikely to change the child's judgment.

Starting at about age 5, and continuing through the elementary school years, the child gradually acquires conservation of various quantity concepts. Number is usually mastered first, followed by length and distance. The conservation of mass,

CONSERVATION OF NUMBER



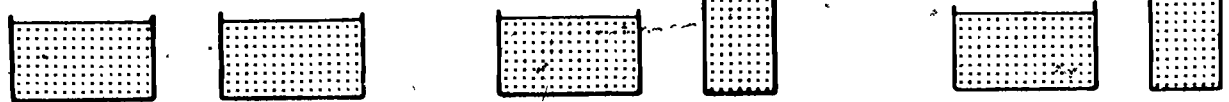
The child is shown 2 equal arrangements of candies and asked if they are the same or if one has "more to eat".



One array is rearranged and the child again is asked whether one now has more or whether both are the same.

Figure 2a

CONSERVATION OF LIQUID



Two containers are filled to levels which the child agrees represent equal amounts.

The contents of one container are poured (while the child watches) into a container of a different shape.

The child is asked whether they are the same or whether one has "more to drink".

Figure 2b

liquid quantity, weight and volume come later; many 8-year-olds, for instance, might fail the conservation of liquid task illustrated in Figure 2 (7, 21, 23, 42).

Small differences in the way conservation tasks are administered (such as eliminating the requirement for a verbal explanation, or reducing the number of objects in a number conservation task) can have big effects on how well children will perform (28, 45, 69). Children often make correct conservation judgments before they are able to explain their decisions. Children who are at the transitional stage for a particular type of conservation are also likely to make "conserving" predictions about the perceptual effect which will result from an action such as pouring a liquid into a narrower glass, but fall back to a nonconservation judgment when they see the results of that operation before them (7, 14, 35, 48).

Conservation, like classification and seriation, is a basic logical operation which children must master before they can fully understand a number of the logical and mathematical concepts taught in the early school years. Until children understand conservation of number, for instance, they cannot really comprehend the meaning of the numeral "3", much less the meaning of 2 + 3 = 5. Similarly, conservation of length is prerequisite for understanding measurement. Nonconserving children may be able to do these tasks, after a fashion, but they do not understand what they are doing in the way an older child or adult would. To measure the circumference of a finger, for instance, an adult would hold a string firmly around the finger, mark it, then straighten the string out against a ruler to determine its length and, therefore, the circumference of the finger. The young child who does not understand that the length of a string is the same whether it is in a circle or lying straight has difficulty accepting the validity of this technique.

Children who have not yet mastered conservation still benefit from practice in manipulations, such as counting, arithmetic, and measuring, but they will not fully understand these operations until they begin to conserve. Conservation of number

follows the acquisition of basic computational skill (31, 67, 68, 69). Practice in learning the correspondence between quantities and numerals probably also helps children to reach understanding of conservation. That understanding can then open a new perspective on the computation process.

When confronted with evidence that young children think in different ways than older children do, the teacher's natural desire is to find a way of teaching those young children to think "better."---There is evidence that this can be done. Young children can be taught to classify, to seriate, or to conserve at levels considerably beyond what would be expected of their age group (26, 27, 59, 62). The greatest amount of research effort has been devoted to developing techniques for teaching young children to make mature judgments in the various conservation problems. A number of these training procedures have significantly changed children's judgments on the specific problem used for training and, in some cases, have also increased the likelihood of children's making conservation judgments on other types of problems (27, 28, 46, 58). In general, children do not learn conservation responses by listening to lectures (31, 53) but do learn when they can be active and responsive and when their attention is repeatedly drawn to the relevant dimensions of the situation (27, 28, 58, 63). Children also learn to make conservation judgments by working and debating with small groups of classmates who already understand the principle (43).

Despite evidence that children can, with intensive training, be taught to demonstrate more mature logic, teachers who are considering trying such specific training in their own classrooms might first consider several basic points derived from Piaget's theory and from experimental studies of children's thinking:

1. Children's thinking matures without formal teaching. Even children who have never been to school eventually develop operational thinking. The experiences critical for its development must, then, be available in children's normal daily activities. The rate of development may, however, vary with the kinds of experience and "push" offered by the child's environment (9, 29, 37, 40).
2. Children learn best when they are ready to learn. Children whose minds have developed to the point of generating new ways of thinking make the transition easily, while children who are not ready may learn only after prolonged effort (29).
3. Teaching children to solve one type of logical problem does not result in a general leap in cognitive maturity. Teaching classification, for instance, helps children to classify, but it doesn't accelerate the development of conservation, seriation, or English grammar (1).
4. The most important difference between children of high and low ability may be not in how fast they progress through the developmental sequence but in the breadth and flexibility of their understanding at each stage. It may, therefore, be more important for teachers to stress activities which promote thorough, diversified mastery of reasoning at (or only slightly beyond) the child's existing level rather than to push toward a new level (40).

Activities involving classification, seriation or conservation do have a place in the preschool or early elementary school classroom. As children play at putting things in groups or series, or at pounding a mass of playdough into various shapes, they gain valuable experience which facilitates the gradual maturation of their thinking. There is an important difference, however, between giving children opportunities to experiment to expand their thinking and attempting to make children think the way adults do. The teacher who sorts objects into an adult classification system and then tries to communicate the logic of that system to a group of young

children misses Piaget's point. Children can be brainwashed into parroting that all small blue things should go together, or that two glasses hold the same amount of water, but this kind of activity will probably have little long-term value. Standard tests of logical understanding can be helpful when used as diagnostic aids for assessing children's level of understanding but such tests should not be used as teaching devices so that children learn only circumscribed patterns of responses defined by the tests (1, 24, 49).

How Do Children Develop An Understanding of Numbers?

Previous sections of this chapter have presented evidence that the concept of number and the understanding of relationships among numbers are not part of the thinking of most preschool children. To truly comprehend numbers, children need a certain degree of general intellectual maturity. Very young children can, however, acquire a number of basic skills in dealing with quantity and number which are useful in themselves and which may help them in the long-term development of more complete understanding.

The two number skills most often taught preschoolers are counting and learning number names. These apparently simple tasks actually present quite a challenge to the young child:

> Anne, aged 3-1/2, is beginning to learn how to count. She can correctly give the number of objects in any set containing up to five items. When asked to count six or seven things, she falters. Anne seems to be unsure of which numerals follow five, although she knows the sequence up to five without hesitation.

Many young children can recite names of numbers in serial order without being able to use these names to count objects. The ability to recite a string of numbers is only one step in learning to count. The child must also acquire the ability to pair each numeral with the "marking off" of an object. When 2- or 3-year-olds "count," they often chant a series of number names in one tempo and point to the objects

counted in a completely different tempo, so that saying "2,3,4" may correspond to the touching of only one object, or vice versa.

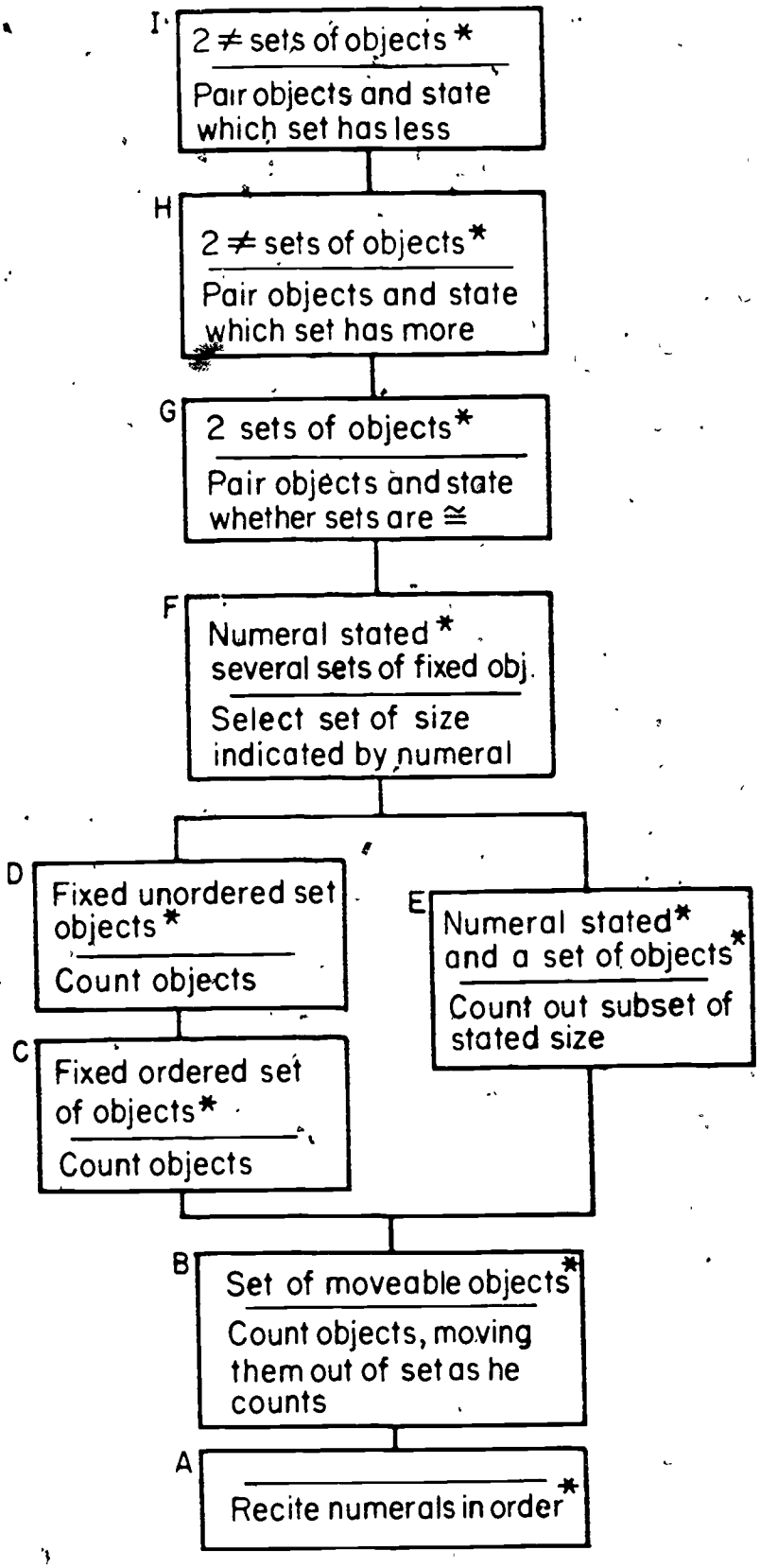
Counting is easiest if each object can be somehow set aside as it is counted. Under these conditions the child has less trouble determining which items have already been counted and which remain. Errors of repetition or omission are less likely (52, 60). Counting is somewhat more difficult if the child cannot move each object as it is counted. In this case children must pick a starting point and count off objects in a systematic serial order, keeping track of where they have been. Counting a fixed set is still more difficult if the objects are not lined up but scattered about so that the starting place and serial order for counting must be created by the child. Children seem to handle this problem by first grouping the objects into a visually ordered arrangement and then proceeding to count (52).

The preschool child learning to count can simultaneously be acquiring the ability to recognize and use written number symbols which will be needed when arithmetic problems shift from use of actual sets of objects to symbolic representations of those sets. Figure 3 outlines possible training sequences for counting and learning to use numerals. These sequences were derived from Piaget's theory and from research on the natural order in which children acquire counting skills.

Insert Figure 3 about here

The training program outlined in Figure 3 suggests teaching numbers up to 5 before attempting to work with larger numbers. This suggestion is based on the research finding that children normally acquire a range of skills (counting, addition and subtraction) with numbers up to five before beginning to master the same set of skills with larger numbers (64). Perhaps this reflects the limits of the young child's short term memory.

COUNTING ONE-TO-ONE CORRESPONDENCE



*(to 5)

Figure 3a

NUMERALS TO 5

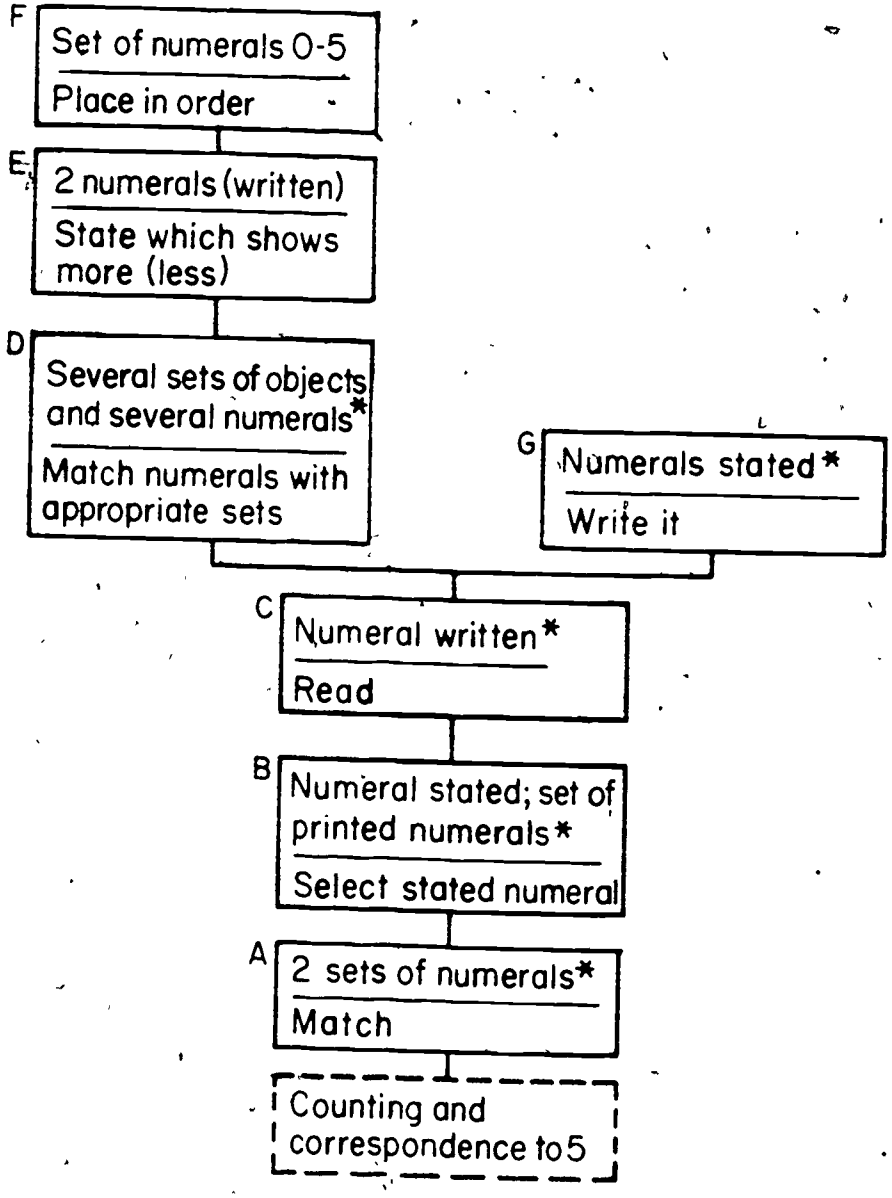


Figure 3b

Preschool children who have learned to count still have a great deal to learn about numbers. They have not yet acquired a concept of number, an understanding of the basic properties of the number system. The limits of preschoolers' comprehension are apparent when they are asked to do something unexpected, such as starting to count from three onwards, or to say what number comes before five (34).

Children must learn to understand two complementary aspects of the number systems; the ordinal, serial nature of numbers and their cardinal or "manyness" aspect (5). The understanding of the ordinal nature of numbers is closely tied to general understanding of seriation; understanding the cardinal use of numbers is tied to understanding classification. There are a number of learning tasks, derived from Piaget's theory, which have been designed to help children learn both aspects of number and the realtion between the two (12, 38, 40).

Development of an understanding of the number system is slow to reach completion. In general, children seem to learn a particular skill, such as counting or addition, some time before they acquire a conceptual understanding of the operations associated with that skill. For instance, the preschool child who can count with great facility has not yet achieved conservation of number and will not be at all distressed by the contradiction of counting two sets of objects, reaching the same total for each set, yet judging that one set contains "more" when it is spread out so that it covers more space (60). Many of the general principles of the number system, such as the idea of averaging, or the effects of combining odd and even numbers, seem to be gradually mastered between the ages of 8 and 11. Before age 8, the child is likely to master an operation in a specific instance without seeing the generality of the rule (38). Teachers should not assume, therefore, that young children who appear to understand an operation in a specific instance are being perverse if they fail to apply the operation in a new instance.

One major contribution of psychological research to mathematical education has been the demonstration that young children need to learn mathematics through extensive experience with the manipulation of real objects, forms and pictures.[12] Symbols such as written numerals or addition and subtraction signs become meaningful after children have acquired a conceptual, logical understanding of the symbols (49).

How Do Young Children Develop an Understanding of Space and Spatial Relationships?

This section concerns the child's ability to understand and use spatial information. The distinction between basic perceptual capacities and understanding is important to keep in mind, for young children perceive many things without understanding them in the systematic way required to use the perceptual information.

There are several logical systems into which space and spatial relations can be divided.---Piaget (50) has argued that children's first intuitive understanding of space is in terms of its topological properties.

> In topology, the only properties described are those that would not change if the space were stretched or distorted. For this reason it is sometimes called a rubber-sheet geometry. Distances and angles and shapes are not preserved in distorted space. If three points, A, B, and C, on a straight line were drawn on a sheet of rubber with B between A and C, and the rubber was then stretched, we could easily change the distance between A and B and C. We could distort the rubber so that the line was no longer straight. But, no matter how we stretched the rubber (provided we did not tear it) we could not put C between A and B on the line connecting them. If two regions sharing a common boundary were marked out on the rubber sheet, no stretching could separate those

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12. Lovell's Growth of Understanding in Mathematics: Kindergarten Through Grade 3 (40) offers a useful catalogue of commonly available materials which can be used for teaching mathematics.

> regions, although we might make the boundary much shorter or longer than it was. Thus, properties like neighboringness and betweenness are said to be topological, because they do not change by stretching or other kinds of deformation of space.[13]

Although this system seems rather strange to adults, its properties describe a number of characteristics of young children's dealings with space.

Learning the system of projective space seems to be one of the most difficult tasks of the early years. This system involves relationships of distance (e.g., near and far) and direction (e.g., right and left). Children must learn to coordinate their own egocentric (self-centered) points of view with other systems of reference. They must also learn a complex verbal system to label their understanding of these relationships. The difficulties are such that children's ability to use the projective system is not fully adequate until age 6, 7, or even later.

Interdependent with the projective system is the Euclidean system of analyzing space. This system emphasizes distinctions such as the differences between lines and curves and quantitative features such as numbers of angles and lengths of sides. The Euclidean system is familiar to most adults since it is the basis for the measurement and computation skills traditionally taught in school--the definition of a parallelogram for instance, or the formula for computing the circumference of a circle. Young children pick up the basic features of this system in preschool or early school experiences. They can learn to distinguish among and label such forms as triangles, squares, circles, and ellipses. It is not until well into the elementary school years, however, that they understand more advanced Euclidean problems such as the measurement of space and distance.

The development of children's understanding of topological, projective, and Euclidean space is described in more detail on the following pages.

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13. Baldwin, A. Theories of Child Development. New York: John Wiley and Sons, 1967, 95.

There is evidence that preschool children are very sensitive to certain topological properties.---In some circumstances, young children act as if they are coping with topological "laws" but not with the laws of the projective-Euclidean systems. Consider, for example, the performance of children asked to place a row of miniature lampposts so that they make a straight line between two miniature houses. Preschool children (up to about age 5) have great difficulty making a straight line without perceptual guidance from a nearby table edge. The children's constructions seem to reflect a "pull" to the "neighborhood" (a topological feature) of nearby edges or the endpoint houses. Examples of young children's productions in this situation are given in Figure 4.

Insert Figure 4 about here

Another task used to test children's sensitivity to topological properties requires the child to recognize or match shapes varying in either topological or Euclidean features. Children's judgments indicate attention to topological features such as the presence or absence of holes, as well as to certain Euclidean properties, such as whether an edge is straight or curved. Preschoolers make matching judgments on Euclidean properties if the shapes used are familiar ones such as circles and squares (13, 19, 36). When the shapes are less familiar children are more likely to match them according to their topological properties. If a child is attending to "holes," for instance, an elliptical "doughnut" would be matched with a straight-edged, rectangular doughnut rather than with a plain ellipse.

Children's ability to utilize projective-Euclidean features of spatial problems varies with the exact nature of the task, and, perhaps, with their educational experience (13, 20). It does seem, however, that young children can deal well with concepts such as continuity, boundaries and holes. Whether this competence has anything to do with topology as a formal geometrical system is unknown. What matters

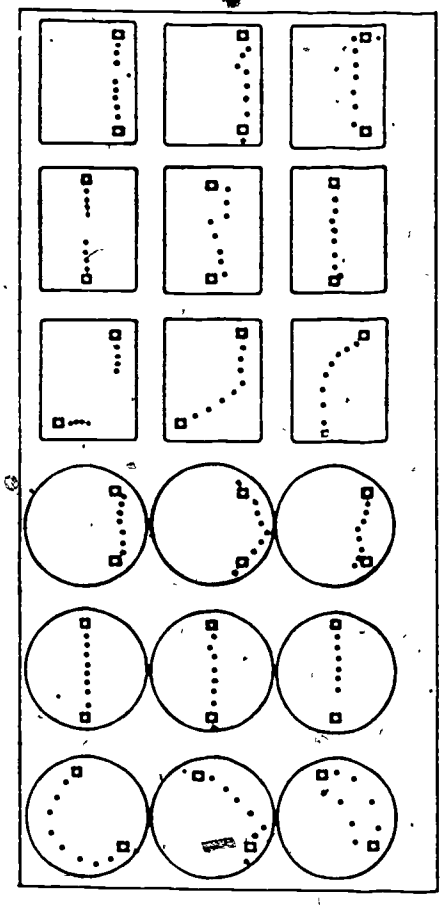

Figure 4

to the teacher is that consideration of topological properties provides a realm of educational experiences with which very young children can stretch their minds and have encouraging successful experience in handling spatial problems. Topological principles can be used as the basis for an endless variety of games and puzzles for both preschool and elementary school children.[14] Preschoolers, for instance, can study the nature of holes during sand or water play with funnels, cups, and sieves. The teacher might help the children discover which objects permit the sand or water to flow through and which do not. Older children can be introduced to the idea of continuity by creating and solving pencil mazes.

Both formal research and informal observation confirm the theoretical argument (50) that the system of projective spatial relationships is a major challenge to the young child.---In part the problem is a matter of attention habits, but the development of logical capacity and semantic comprehension also play a part in the child's eventual mastery (at age 6, 7, or later) of this system. Since several different cognitive skills are involved in different situations in which understanding of projective space is put to the test, the child's success or failure depends on specific features of the situation and the array of skills demanded to solve the problem.

Object orientations and relations among objects. A 3-year-old is quite capable of indicating that a picture of an upside-down house is "wrong" (41). Young children don't, however, regard orientation as a significant cue when asked whether one picture is "the same" as another. Things of different shapes, sizes or colors are considered to be different, but pictures in different orientations are usually considered to be the "same thing" (41). Since the identity of any real object is, indeed, constant despite its apparent orientation the child's tendency to ignore orientation is quite reasonable.

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14. A fascinating selection of such games is provided by Jean and Simmone Sauvy in "The Child's Discovery of Space" (54).

Children's ability to use orientation in their drawing or writing is even weaker than their ability to attend to orientation when making a discrimination (2, 61). A normal 6 1/2-year-old, who never reads from right to left and who usually writes correctly, may occasionally "lapse" and produce constructions such as "yaJ oT" in addressing a note to a friend. There is evidence that giving children specific training in using orientation cues to make a discrimination will generalize to produce improvement in their writing as well (61).

One source of difficulty in young children's writing may be their tendency to write in accordance with a few set habits or "rules." They seem, more often than not, to try to start at the top of a form, move from left to right, and use a continuous stroke. Persistence in these habits can lead the child who should "know better" into production of forms such as "И" for "N" (30).

Of all the concepts associated with object orientation and the relations among objects, left and right cause young children the greatest difficulty. The left-right distinction is harder than front-back or up-down distinctions (32). By second grade, children have excellent command of up-down and front-back but still are confused about left-right when asked questions such as "Is the pencil to the left or to the right of the matches?" Perhaps left and right are more difficult because nature has not provided human beings with a natural perceptual reference system for learning these concepts. Gravity provides us with a natural "down" and the structure of our bodies and visual orientation helps clarify the front-back distinction, but left and right have to be learned without perceptual help (11).

Children first master left and right in relation to parts of their own bodies. Most 5- or 6-year-olds can make these identifications correctly (22, 32). Identifying the left and right body parts of another person is much more difficult, particularly if the person is sitting face-to-face with the child. This skill is not sure until age 7 or 8 (22). More difficult still is coordination of positional

relations among a set of objects. According to Piaget, children first learn "left and right" as properties of particular objects, starting with their own bodies, and later come to understand the system of left and right relations among objects. To fully understand, children must not only be able to determine that the pencil is "to the left of the matches," but must also be aware that the pencil (in the middle of the set of objects) is also "to the right of the keys" (32).

Since an understanding of projective space concepts is so important to the basic skills of reading and writing, and because this understanding is normally slow to develop, teachers should be diligent in teaching and reteaching use of these concepts. The specificity of the contexts in which they are first understood suggests, in addition, that teaching should emphasize a large number of possible contexts. In particular, children who have mastered "left-side" and "right-side" as properties of particular objects may still need practice in "left" and "right" relations.

Children's difficulties in understanding projective space are particularly apparent when they are asked to judge how a spatial arrangement would differ when seen from different points of view. One task frequently used to assess children's ability to coordinate visual perspectives involves a miniature landscape with mountains or other large obstructions which can block off certain objects, such as some miniature animals, from the view of a doll placed at a particular point on the tableau. Young children are rarely able to give an accurate assessment of what the doll sees, and may respond as if they were assuming that the doll's perspective were the same as their own. The argument has been made that young children's performance on such tasks reflects their egocentric thinking (36, 50).

Recent evidence indicates, however, that children as young as 3 or 4 can sometimes make perspective predictions correctly if the task is simple enough. Three-year-olds, for instance, are able to rotate a turntable holding several animals to the correct position when asked by an adult, standing at various positions around

the table, to "Show me the side of the moose" (56). Furthermore, the errors which young children make on perspective tasks are not always egocentric errors. Overall errors decrease as children get older, but specifically egocentric errors do not invariably decrease and may sometimes increase, perhaps as a transitional stage preceding full mastery of the task (25).

Since the extent and nature of children's errors varies with the specific nature of the perspective task, it seems reasonable to propose that young children are indeed aware that things look different from different points of view, that their own perspective is not the only one possible. When tasks are complicated, however, they have difficulty imagining or expressing what the proper point of view should be, and may suggest their own viewpoint, knowing it is wrong, in their desire to provide some reasonable answer (25, 36, 55, 56).

Children's performance on perspective tasks shows patterns similar to their performance on another purported test of egocentrism, the "blind listener" communication task discussed in Chapter 4. In both cases children seem to know that their own perspective or knowledge is not universal, that others may see things differently or need different information. In both cases, young children perform much better when the task is extremely simple. In communication tasks, training procedures which show children what the needs of the listener are and how they can tailor their speaking to those needs have led to improved performance. Similar strategies might be effective in teaching children to predict how things look from different perspectives. It is possible to create situations in which children must respond from the viewpoint of another child sitting opposite or at right angles to them. The children can compare what they see, and the teacher can help them analyze and predict the view from different perspectives.

Another great challenge for young children is understanding the quantitative measurement of space and distance.---Measurement, as a rote skill, is fairly easy for young children to learn. If all that they are required to do is line up the end of a ruler with the end of an object and read off the ruler mark corresponding to the other end of the object, 5- or 6-year-olds can often succeed. Psychological research indicates, however, that children this young will probably not have mastered the concepts underlying the measurement process. If the task is changed slightly so that they cannot rely on rote-learned skill, their competence falters. True understanding of measurement requires, according to Piaget's theory, the ability to use several logical operations (39, 40).

In essence, measurement of distance or space depends on the division of the length or area into standard units. These arbitrary standard units (such as inches, centimeters, wquare feet, or acres), can then be summed to give the total extent or expanse of the space in question. Thus, one logical operation the child must master is class inclusion--the addition of several parts to form a whole.

Understanding transitivity and seriation is also essential to the use of standard units of measure and to any comparison of length, size, weight, etc. If one melon weighs less than a pound and another weighs more than a pound, the second must be heavier even if there is no balance available for comparing their weights directly.

Measurement also depends on the attainment of conservation. Meaningful measurement of length is not possible, for instance, if children do not yet understand that the length of a stretched-out paper clip is the same as its length when coiled. Similarly, children's attempts to measure distance are likely to be affected by their inability to understand that the distance between two objects is not changed by placing additional objects between the first two (39, 40).

Piaget stresses that comprehension of measurement requires that the child understand the nature of seriation and transitivity, the conservation of number, length and distance, and the class inclusion principle. These logical operations are thought not to emerge until the elementary school years, beginning at about age 6 or 7. The child would not, therefore, be expected to understand measurement until age 7 or later--perhaps much later. There is some evidence to support this prediction.

In one study, a few children showed mastery of length measurement at age 6, but the majority did not succeed until age 8 or later. The measurement task required the children to judge which of a pair of multi-angled lines was longer, using a 2" piece of cardboard as a standard unit of length (35).

The results of another study of measurement (30) indicate that some children who appear to know how to measure do not actually understand what they are doing. The 8-10-year-old children in this study had all learned, according to their teachers, to measure area by the usual procedure of multiplying length by width. The children were given eight right-angle triangles, each measuring 2" by 4". They were to use these triangles to compare the areas of an 8" by 8" square and a 4" by 16" rectangle. The task was a hard one, since the children had only enough triangles to cover half of the total area of each figure. Children who started out using the triangle units appropriately were often stumped when they ran out of triangles. No child below age 8 and only half of the 8-year-olds figured out the correct procedure of using the triangle tiles to block off as much as possible, noting the boundary of the area covered, then re-using the tiles to measure the area remaining. Furthermore, many children who were able to compare two areas using this technique were still not able to use a small card as a unit of measure to calculate the area of a figure. These children had learned to compute areas in inches, but did not under-

stand that areas could also be in other units, such as "blue cards." Lovell (39, 50) suggests that teachers supplement instruction in the length-by-width method of area computation with experience in measuring area by adding units of standard area.

Points to Remember

Awareness of the child's competencies and how they develop provides teachers with a framework for maximizing the efficiency of instruction by scheduling learning experiences at the age when most children are best able to profit by them. This awareness also provides teachers with a sense of what problems and misunderstandings might be expected in presenting material to children of a given age. Furthermore, teachers who know what kinds of understanding a child is capable of can ensure that their teaching makes maximum use of that capacity.

Teaching which takes into account the child's existing level of understanding, and which is geared to stretch that understanding has great power to capture the child's interest. Children pay attention to, and willingly become involved in activities which are "moderately novel" to them. In today's schools, this possibility may provide the single greatest reason for adapting teaching to the best available understanding of cognitive development.

This chapter's discussion of young children's thinking can be summarized in a few basic points which have direct implications for teaching:

1. Children's logical thinking matures without specific teaching, but the rate of development and the depth of their understanding may possibly be enhanced by varied, low-key experiences which offer opportunities to practice and expand classification, seriation, and conservation skills.
2. Young children can sometimes benefit from memorizing facts and procedures, such as addition or measurement, even though they are too young to understand all the implications of what they are doing. This practice may facilitate ultimate understanding, which takes time to develop.

3. Even simple number skills such as counting, represent a major challenge to preschool children and should be taught slowly, with the difficulty of the task gradually increased.
4. Young children master skills, such as arithmetic computation or measurement, in the specific forms which they have been taught and are not likely to spontaneously generalize a procedure to new types of problems.
5. Since young children tend to be naturally aware of the topological features of space, this system offers a useful approach for building confidence and establishing habits of thinking about spatial problems.
6. Young children need prolonged, repeated practice in mastering projective spatial relationships, particularly right and left. Distinctions such as right-left and front-back are mastered first as features of the child's own body, then as properties of other objects, and finally as properties of the relations among objects.
7. Young children often have difficulty coordinating perspectives and predicting how things will look from viewpoints other than their own. Their skill in such tasks may improve with practice in simple situations.
8. Children who have been taught computational procedures for measuring space do not necessarily understand the general principles behind what they are doing.

There are a number of books and materials listed in the references which provide a wealth of ideas for translating basic cognitive theory into methods and procedures for mathematics and science teaching. For general background, readers may wish to consult Lovell's The Growth of Understanding in Mathematics: Kindergarten through Grade 3 (40); or Piagetian Cognitive-Development Research and Mathematical Education, edited by Rosskopf, Steffe and Taback (1, 4, 20, 38, 39, 60) or, Copeland's How Children Learn Mathematics (12). Specific curriculum ideas may also be found in Sauvy and Sauvy's The Child's Discovery of Space (54), in the Nuffield Guides

published by John Wiley and Sons (66), and in the materials developed in experimental early education projects such as the program directed by Lauren Resnick (52).

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Chapter 6

Summary: How Children Change and Learn

This report has focused on changes which occur as children grow older: when they are ready to learn, how they learn, and what they know. Knowing the cognitive skills children are likely to have can help teachers create opportunities to exercise those skills and apply them as they are needed. Knowing what kinds of experiences are likely to foster the emergence of new skills may help teachers choose classroom activities which are likely to have long-term beneficial effects on children's cognitive competence. Knowing the probable limits of young children's capacities permits teachers to devise learning situations which stretch but do not overburden those capacities.

Reviewing the report as a whole, one can draw a number of general conclusions about the nature of young children's minds and the ways in which teachers can help them grow:

1. Young children naturally seek out experiences which help them expand their understanding. A teaching program which is adapted to children's developing cognitive abilities will capitalize on this built-in desire to learn.
2. Young children have limited ability to control their attention, and may need help in discovering what aspects of a situation are important. They may also profit from the teacher's efforts to reduce extraneous, distracting elements in the learning situation.
3. Young children have limited ability to recall newly learned information. Lessons for young children should be designed to present information in small doses which can be repeated until the information is securely remembered.
4. Although young children can and do learn by quietly watching and listening, many ideas and skills are best learned when children have opportunities for

active involvement--for touching, talking, and testing things on their own. Such involvement enhances children's attention, memory, and ultimate understanding. One advantage of using concrete materials in the classroom is that these materials can be used to encourage children's active involvement in learning.

5. Young children's verbal fluency, communication effectiveness, and understanding of new words can be enhanced by providing opportunities for children to practice their language skills and to observe how adults use language. Efforts to modify young children's grammar by direct teaching are, however, ill-advised. Opportunities to hear and use language will eventually be reflected in children's grammar as well as in their other language skills.

6. Children can benefit from learning skills even though they are not yet mature enough to understand all of the logic underlying what they are doing. Learning is slow and situation specific when skills such as counting are taught to very young children, but practicing these elementary skills may help children in their gradual development of understanding of the logic related to each skill.

7. Children learn what they are taught, but both the psychological and the educational literature provide ample evidence that there are no known magic activities for producing generally "intelligent" children. Children can be taught to speak well, master mathematical computation skills, classify, and demonstrate understanding of mathematical logic. None of these gains, however, shows impressive generalization to other cognitive areas which have not been stressed (1, 2). This is undoubtedly one reason why no early education program has been found to be consistently and generally superior to other programs (3).

8. The best test of any teaching strategy is the children's interest and their success in learning.

The application of psychological knowledge is not likely to make the teacher's job an easy one. The evidence is consistent in indicating how very difficult it is to teach effectively. An analysis of the research literature suggests that teachers should be constantly aware of each child's existing level of understanding; that every child should be given opportunities for active involvement with the learning process, using an abundance of attractive materials; and that children will do unusually well only on those tasks to which considerable classroom time has been devoted. Teachers are asked to apply these findings to their activities in classrooms which are likely to be overcrowded and underequipped, and to groups of children whose individual abilities and interests will probably be tremendously varied. It is the very difficulty of the task of teaching effectively with inadequate support systems that makes it so important for teachers to learn all they can about the nature of young children and of their learning processes. The authors hope that this report has increased teachers' understanding in ways that can be translated into successful classroom experiences.

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Legends for Illustrations

Figure 1: Diagram of a Free Classification Problem[i]

[i] Lovell, K: The Growth of Understanding in Mathematics: Kindergarten Through Grade 3. New York: Holt, Rinehart and Winston, 1971, 8. Reprinted with permission.

Figure 2: Examples of Tests for Conservation of Number and Conservation of Liquid Quantity

Figure 3: Suggested Sequences for Teaching Counting and Numeral Names[ii]

(Note to copy preparers: The two sequences should be printed side by side on the same page or on facing pages.)

The diagrams should be read from bottom to top. The upper half of each block indicates the situation presented to the child, while the lower half describes what the child is expected to do.

[ii] Resnick, L. B., Wang, M. C. and Kaplan, J. "Task Analysis in Curriculum Design: A Hierarchically Sequenced Introductory Mathematics Curriculum." Journal of Applied Behavior Analysis, 1973, 6, 679-710. Reprinted with permission.

Figure 4: Samples of Young Children's Attempts to Construct a Straight Line Between Two Points[iii]

[iii] Laurendeau, M. and Pinard, A. The Development of the Concept of Space in the Child. New York: International Universities Press, 1970, 146. Reprinted with permission.