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ABSTRACT

This review of literature on children's learning focuses on the following seven subject areas: (1) Infant learning, particularly studies of conditioning and individual differences in infants, (2) New perspectives on Piaget, reviewing studies where conservation and transitive inferences have been taught to young children, (3) Language and attention, focusing on evidence against verbal mediation theory, including shift studies, (4) Observational learning, (5) Selective attention studies, which include developmental trends, irrelevant dimension experiments, and incidental learning research, (6) Perceptual learning, and (7) Memory. It is concluded that the following basic themes apply to all the research areas reviewed: the importance of attention, interest in extending the study of learning downward to younger ages, and attempts to improve performance to a greater degree than would occur without intervention. (DP)

RESEARCH ON CHILDREN'S LEARNING

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Research on Children's Learning

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After a somewhat lethargic period in the early 1960's, the study of children's learning recently has assumed a new vitality. As with any change in scientific effort, there are many reasons for this upsurge of interest. Two reasons, however, seem especially important to me. First, child psychologists became more interested in studying the characteristics of the human child and less concerned about evaluating the relevance of concepts from general learning theories. These theories had not been based on research with children and they proved to be of limited use for the discussion of children's learning. Research became much more fruitful when it dealt with variables that focussed on the child, such as the development of language, social experience, imitation, and the control of attention. Second, society began to demand more from child psychologists. New programs for infants and young children were begun whose goal was to provide more than custodial care. In order to plan productive experiences in Head-Start and day care programs it was necessary to know more about children's learning and cognitive development.

For reasons such as these, research with children has become a source of ideas that have both theoretical and practical significance. There is a long way to go before we have anything like a thorough theory of how children learn, but if the impetus of the past few years is maintained, this goal may be less remote than appeared to be the case only a few years ago.

This is not intended as an exhaustive review. Rather than attempt to cover the entire range of topics I have selected those that are currently receiving the greatest amount of attention. Even within these topics it has been necessary to be highly selective in the studies covered. Other sources may be consulted for more comprehensive discussions of the literature (Brackbill and Koltsova, 1967; Horowitz, 1968; Stevenson, 1970, 1972).

Infant learning. If we want to understand children's learning, to know what children can acquire through experience, we must go back to the first weeks of life. The work of such persons as Siqueland and Lipsitt (1966) has demonstrated that simple forms of learning, such as conditioning, can occur shortly after birth. Infants who are reinforced with a nutritive substance for turning the heads in one direction show an increased frequency of such head-turning. When a buzzer precedes the trials in which reinforcement is delivered, head turns increase, and when a tone precedes the trials in which no reinforcement will be delivered the frequency of head-turning following the tone decreases. When the conditions are reversed, and the tone signifies that reinforcement will follow, head turns increase following the tone and decrease following the buzzer. Operant conditioning, extinction, and conditioned discrimination thus can be demonstrated with infants as young as one to four days of age.

Some of the most interesting research in infant learning has dealt with infant vocalization. Rheingold, Gewirtz, and Ross (1959) demonstrated some time ago that the frequency of infant vocalization can be increased if the infant is reinforced for vocalization. This research has been carried further in studies such as that of Routh (1969), who asked whether it is possible to increase the frequency of certain types of vocalization. Specifically, he asked if it is possible to increase the frequency of consonants by selectively reinforcing only consonants, or the frequency of vowels by reinforcing only the production of vowels. Infants, two to seven months old, were assigned at random to groups in which (a) vocalization was reinforced in the manner of the Rheingold et al. study, (b) only consonants were reinforced, and (c) only vowels were reinforced. Reinforcement (the experimenter's smiling, making "tssk" sounds, and touching the baby's abdomen) was given for three days with three thirteen-minute sessions per day. Conditioning was found in all groups. For the group in which all vocalization was reinforced, the frequencies of vowels and consonants were about the same. More vowels than consonants were found when vowels were reinforced, and more consonants than vowels when only consonants were reinforced.

Studies such as these leave little question that the neurological development of the young human infant is sufficient to enable the contingencies between response and reinforcement to be registered in the infant's brain. We do not know how lasting these effects are, nor how future learning is influenced by these early types of experience. One aspect of these studies, however, should be emphasized. There are, from birth, great differences among individual children in their rate of learning. This has been shown most clearly by Papousek (1967) in a study with three-day-olds. A tone was sounded in the midline above the baby's head and if the baby turned his head to the left, milk was offered to him. If the baby did not turn his head, the assistant touched the left corner of his mouth with a nipple, and if this was ineffective in producing head-turning the baby's head was turned to the left and the nipple placed in his mouth. The baby then was allowed to drink a quantity of the milk. The procedure was repeated for ten trials each day until the baby spontaneously made five consecutive head-turns to the left at the sound of the tone in a single day. Some newborns met this criterion for learning within a week, but others required more than a month of training. All were normal infants and careful analysis of possible bases for these differences, such as birth history, sex, and time of year, uncovered no explanatory factor. The most reasonable interpretation is that human infants differ in their degree of neurological maturity and that these differences are critical in producing individual differences in learning.

Individual differences tend not to be discussed in textbooks on learning. In their search for general laws, experimental psychologists have preferred to ignore differences among individuals. In studying children, however, it is impossible to disregard these differences. However refined the sample of subjects in terms of chronological age, intellectual level, sex, and socioeconomic status, there tends to be large differences in rate of learning. There is no simple interpretation for such individual differences, for seemingly obvious factors such as level of intelligence prove to account for only a small portion of the variance. Rather than being a feature of learning that is ignored, future research with children may be expected to concentrate increasingly upon the interpretation of the differences among individuals in their learning ability.

New perspectives on Piaget. Among the most influential contemporary child psychologists is Jean Paiget. His theory and research on children's thinking have had a profound influence on both psychology and education. It appears from several recent studies, however, that some of his ideas require modification.

The significance of these studies can be appreciated if they are placed within the context of Piaget's thinking. Piaget is a stage theorist, who posits that the child must go through a series of stages, namely, the sensory-motor, preoperational, and concrete operational stages before he arrives at the stage of formal operations, where true hypothetico-deductive thought is possible. The child's thought is bound by the characteristics of the stage in which he is currently operating, and movement to the next stage is the result of both maturation and experience. For many years researchers tried unsuccessfully to demonstrate that this was not true. Many training studies, in which efforts were made, for example, to transform a nonconserving child into one who could demonstrate conservation, proved to be only minimally successful. Recently, however, several studies have indicated that children can be trained to demonstrate conservation even though they are at a stage in which conservation is not predicted.

Gelman (1969) has proposed that children may fail tests of conservation because of their inattention to the relevant attributes of a situation. The child's inability to understand that the amount of liquid does not change, that it is conserved, when it is poured into beakers of different size, shape, height, width, may be based on responses to irrelevant attributes rather than to the relevant attribute of quantity. That is, they judge quantity by height of a liquid in a glass, rather than taking both height and circumference into account. Gelman proceeded to train children with oddity problems in which they were forced to attend to the relevance of a particular dimension, such as number, even when number and space varied independently. Both specific and generalized transfer were found. Children who failed tests of conservation at the beginning of the study now performed successfully. Conservation tasks, therefore, may be as much tests of the child's ability to deploy attention as of the understanding of concepts. When taught how to attend to more than one attribute, even young children are capable of conserving in a way that was assumed to be possible only at a later stage of development.

Another example of the ability to train young children to perform successfully in tasks thought to be solvable only by older children is found in a recent study by Bryant and Trabasso (1971). In earlier studies preschool children had been found to perform poorly in tasks involving transitive relations; that is, tasks in which two relations are defined and the child must combine this information to respond correctly to a question involving a third relation (e.g. John is taller than Bill. Bill is taller than Bob. Who is taller, John or Bob?). Bryant and Trabasso assumed that one of the difficulties that preschool children face in attempting to solve such problems is that they fail to remember the first two relations, and therefore are incapable of reaching the correct solution. In their study, children were trained on the first two relations until each relation was thoroughly learned; only then was the question involving the third relation introduced. Four- and five-year-olds were able to demonstrate transitive inference with this procedure, a feat that should not have been possible, according to Piaget, until the children were much older.

Here, then, are two successful studies that produce results clearly in conflict with Piaget's notion of stages. It appears that young children have difficulty with certain types of problems, not because of inadequate thinking, but because of other characteristics such as poor control of attention and poor storage of information in memory. Procedures can be developed in which deficiencies of these types can be overcome and children can respond correctly. We may be misled, therefore, if we base our expectations of what children can do on a position that posits stages of cognitive development where children are assumed to be capable of only certain types of mental operations and constrained in their thinking by their stage of cognitive development. It seems, rather that their failure may be due to deficiencies in certain component processes, such as attention and memory, which may be alleviated through proper training.

Language and attention. Another aspect of Piaget's ideas has fared better in current research. Piaget proposes that symbolic life develops during the preschool period and the symbols are acquired through interaction with the world. The formation of symbols is aided by, but is not dependent upon, language. Language and thought develop during the preschool years in a parallel fashion according to Piaget; only later in the child's life will the two become closely interrelated. We can contrast this view with that of the verbal mediation theorists, who have proposed that the development of language during the preschool period provides the child with a means of mediating between external stimulus and response. As the child proceeds through the preschool period, words, the internal representations of environmental events, become capable of controlling response. There is no question that language may be of help in conceptualization, but can concepts be learned and used without the intervention of language? To the degree that this question can be answered in the affirmative, Piaget's position is supported. Evidence against the verbal mediation theory is supplied if children demonstrate the skillful application of concepts which they cannot describe in words or which they cannot identify from the words of other persons.

A study by Caron (1968) is illustrative of studies that have shown the independence of concepts and words. Three-year-olds do not know words to describe the concepts of roundness or angularity. Furthermore, it is extremely difficult for them, without prior training, to utilize these concepts. Caron sought to develop pretraining experiences that might lead these young children to employ the concepts correctly. Many sets of figures were constructed in which the differentiating attribute was the roundedness or pointedness of a portion of the figure. The figures were paired in a discrimination problem where correct choice was dependent upon the consistent selection of a figure that contained one of these characteristics. Some children had to pick the stimulus with a rounded portion consistently and others had to pick the stimulus with a pointed portion. For some of the children the figures were presented initially only in part. Rather than use the fully represented figure, only the portion of each figure that contained the distinctive attribute was visible. Very gradually the full figure was "faded" in. By making only the critical feature initially discernible, three-year-olds were able to learn the discrimination. They gave clear evidence of having used the concepts, but there was no indication that the concepts had been represented in language. The children could not tell the experimenter at the end of the study how they had solved the problem, nor could they pick out the "round" or "pointee" figures when they were directed to do so.

The same results were obtained with a different pretraining procedure. Other groups of children were asked to fit the stimulus figures into a hollow V. The figures with an angular portion fit into the V and the others did not. The child was to go through the stimuli, placing figures that fit into one pile and those that did not into another. When the children later were required to learn the discrimination task they were highly successful. Again, they could not give a verbal explanation of how they solved the problem, and were unable to identify the figures that possessed the attribute described by the adult.

From studies such as this we are led to conclude that children are capable of using concepts they cannot verbalize, but whose salience has been heightened through pretraining. In other words, if the child is given experience in attending to the relevant characteristics of the stimuli he may be able to utilize these characteristics in the formation of a concept that he is capable of using successfully but cannot describe.

The importance of attentional processes in learning has been emphasized in another line of research. A great deal of research on reversal and non-reversal shifts was undertaken to clarify the relation between language and learning. The studies were conducted with stimuli that differed in dimensions such as brightness, size, height, and form. In an initial problem the child was presented pairs of stimuli that differed in two dimensions, such as brightness and form. In an initial problem the child was presented pairs of stimuli that differed in two dimensions, such as brightness and form. One value on one of the dimensions was correct; the child was to ignore form for example, and choose one value of brightness consistently. After this problem was learned, a new problem was introduced. Either the same dimension, but a different value on the dimension, or one of the values on the second dimension was correct. For example, the child may have had "black" correct on the first problem and "while" correct on the second problem (reversal shift); or "black" may have been correct on the first problem and "square" correct on the second problem (nonreversal shift). Children who were capable of verbalizing the stimulus dimensions were predicted from the verbal mediation hypothesis to show better transfer from the first to the second problem when the same dimension was correct in both problems, and children who were incapable of verbalizing the dimensions were predicted to show better transfer when a different dimension was correct. (It is unnecessary here to discuss the bases of these predictions in detail.) The important point is that the theoretical predictions were not supported convincingly. It seems that one of the reasons was that the salience of the dimension for each child was not considered. For some children form may be a salient or dominant dimension; that is, it is the dimension to which they direct their attention most readily. For others, it may be brightness. We can see that when we present children with stimuli that differ in both form and brightness, different results may be obtained, depending upon whether the dimension that is correct also is the dimension that is most salient for the child. If we give a form problem to a child for whom brightness is a salient dimension we may judge him to be a poor learner. If, by chance, we had given him a problem involving the discrimination of differences in brightness rather than form,our conclusion would have been different. Performance in tasks such as reversal-nonreversal shifts turn out to be highly dependent upon whether the training and transfer problems assigned to a child are in accord with the dimensions that are salient for this individual child. Evidence for this has been presented in studies such as Mumbauer and Odom (1967), Tighe and Tighe (1966), and Smiley and Weir (1966).

Current research seems to indicate, therefore, that possessing words is not a necessary nor sufficient condition for responding to abstract problems. Such findings place us more in line with Piaget's thinking than with that of the verbal mediation theorists and others who have proposed that abstract thought is dependent upon the acquisition of language. If conditions are arranged so that the child's attention is drawn to the characteristics of the stimuli that underlie the concept, young "preverbal" children are capable of successful performance on problems involving the acquisition of a concept.

Observational learning. We sometimes act as if the only way children learn is through active instruction or some form of motoric involvement. We may be so involved in providing children with appropriate opportunities for learning that we fail to consider the many opportunities they provide themselves. If it somehow were possible to sort what children know into what they have been taught and what they have learned through observation, we probably would find that the preponderant amount of learning occurs through observation. Children constantly are observing activities and events in their environment and imitate what they have observed. Some have called this no-trial learning, learning that is displayed without prior evidence of active participation.

The report of the first year of Sesame Street (Ball and Bogatz, 1970) offers an interesting illustration of how effectively such learning occurs. A battery of 240 questions that dealt directly with the content of the program was constructed. Before the program went on the air, 1,124 preschool children, mostly from disadvantaged homes, were tested in five communities in the United States. Six months later 943 of these children were located for retesting. In addition to the data obtained from these tests, parents and teachers were interviewed about children's viewing of television and about their viewing of Sesame Street in particular. The children were divided into quartiles according to the amount of time they watched Sesame Street: Q_1, never or rarely; Q_2, two or three times a week; Q_3, four or five times a week; and Q_4, more than five times a week.

Several examples of the results can be given. Children in Q_1 increased their knowledge of the alphabet by an average of 1.5 letters over the six-month period. Children in Q_4 increased their knowledge, on the average, by 7.9 letters. Ability to sort objects by function, a more general cognitive task, improved ten points among Q_1 children and 43 points among Q_4 children. Ability to write one's own name (which was not taught specifically on Sesame Street) imporved by eight percent among Q_1 children and by 30 percent among Q_4 children. At the pretest, two percent of children in Q_1 and four percent of children in Q_4 knew the whole alphabet. By the end of six months nine percent in Q_1 and 55 percent in Q_4 knew the whole alphabet.

According to these data, and many others contained in the study, degree of improvement in performance depended upon how frequently the child viewed the program. The more often the child viewed Sesame Street each week, the greater the improvement. Unfortunately, the children who were most in need of the types of information conveyed in Sesame Street viewed the program least often. They were from the most disadvantaged homes and had the lowest mental ages and pre-test scores. Research during the second year of Sesame Street (Bogatz and Ball, 1971) has indicated, however, that techniques can be used to increase the amount of time these children view the program and, in turn, to increase their post-test scores on the test battery.

Another example from the literature on television indicates that substantive knowledge is not the only thing that can be acquired from viewing television. Stein and Friedrich (1972) have shown that the frequency of aggressive and pro-social behavior also may be influenced by viewing television programs. Preschool children were observed for a three-week period to obtain baseline information concerning the frequency with which they displayed aggressive and prosocial behavior. Following this, three times a week for four weeks, the children viewed one of three types of television programs: (a) cartoons containing a high incidence of violence and verbal aggression, (b) episodes from a program that included such themes as cooperation, sharing, sympathy, and affection, or (c) neutral programs about such things as farm life and nature. The results were somewhat complex, but two major findings can be discussed here. First, when the groups were split according to baseline frequencies of aggression, it was found that children who initially were high in aggression showed greater interpersonal aggression after viewing aggressive programs than after viewing neutral or prosocial programs. Children who were initially low in aggression did not respond differentially to the television conditions. Second, when the groups were separated according to socio-economic class, lower socio-economic class children showed a significant increase in prosocial interpersonal behavior after viewing prosocial programs, and remained stable or dropped slightly after viewing the neutral or aggressive programs. Inexplicably, higher socio-economic status children showed the greatest increase in prosocial interpersonal behavior after viewing aggressive programs, a moderate increase after viewing neutral programs, and a slight decrease after viewing prosocial programs.

Obviously, different children do not learn the same things through observation, but many studies have demonstrated significant changes in behavior after observing different types of materials. Even when children do not spontaneously display what they have learned through their behavior, they can, if offered an appropriate incentive, relate the content of what they have observed. It is hard to understand why interest in such an important avenue for learning has been delayed for so long, for it clearly is an effective and common means for acquiring new behavior and new information.

Selective attention. Young children seem to have difficulty determining what is relevant and what is irrelevant to a specified goal; they respond to many salient features in a restricted fashion. As the child grows older, he appears to sample the stimuli in his environment more broadly and becomes capable of attending selectively to those stimuli that have the greatest potential utility or value. What younger children acquire from their experiences, may, therefore, be decidedly different from what older children and adults respond to and learn. Preschool children are readily distracted from the central content of material by irrelevant details. Older children, on the other hand, are able to disregard irrelevant or incidental aspects of the materials and concentrate their attention on what is central and of critical importance. There are differences according to age not only in what children attend to, but also in how they attend.

One of the clearest illustrations of developmental changes in attentional processes is found in a study by Vurpillot (1968). Children were asked to make same-different judgments of complex stimuli (pairs of drawings of apartment windows containing different objects). The manner in which the children scanned the pictures was recorded by means of an eye camera. The optimal strategy, of course, would be to compare systematically each pair of windows, to make a "different" judgment when any pair contained different objects, and to make a "same" judgment only after every pair had been compared. Vurpillot reported that children younger than six never took into account the whole of the stimulus, but restricted their scanning to limited areas and made their judgments on the basis of a sample of the available information. Improvement was observed between the ages of six and nine. The older children were more systematic in their scanning, and used a broader sample of information before making a judgment.

We cannot assume, therefore, that developmental differences in performance on learning tasks are always a direct reflection of developmental differences in the learning process. Young children may be operating on the basis of information that is different from that obtained by older children, and their poor performance may be a result of their having an inadequate or unrepresentative sample of the characteristics of the situation.

Another indication of developmental changes in attentional processes is found in studies of the influence of irrelevant stimuli upon learning. We can use a study by Tighe and Tighe (1969), to illustrate this point. The Tighes constructed materials for a reversal shift problem in which there were zero, one, or two irrelevant dimensions. When there were no irrevelant dimensions, only two stimuli were necessary: a black square and a white square. During original learning, the child was reinforced for choosing the white square. After this problem was learned, the white square no longer was correct and choices of the black square were reinforced. This problem should be easy for five-year-olds, and it was--they learned to switch their response in an average of less than ten trials. When one irrelevant dimension was present it was necessary to have two pairs of stimuli: a black square and a white circle; a white square and a black circle. (In all examples only one of the possible combinations is presented.) The problem was exactly the same as the preceding problem; brightness was the relevant dimension. Learning this problem proved to be difficult; the number of trials to learn the reversal increased nearly three-fold over those required when no irrelevant dimension was present. Finally, when there were two irrelevant dimensions, four pairs of stimuli were necessary. The stimuli varied in brightness, form, and height. The addition of the second irrelevant dimension further increased the difficulty of learning the reversal shift; now the average number of trials required to reach criterion was over 40.

We know from other studies that the rate of learning by older children and adults would not have been greatly influenced by the presence of one or two irrelevant dimensions. When form and height were found not to be useful cues these dimensions would have been ignored. Does this mean that young children are unable to disregard the presence of irrelevant information, or simply that they fail to do so without help? To answer this question, the Tighes repeated the study with a comparable group of children who had received pretraining in judging whether the stimuli were the same as or different from a "standard" stimulus. The sole basis for making an appropriate judgment was the brightness of the stimulus. When given pretraining in which the salience of the relevant characteristic was emphasized in this manner, the children later performed much more successfully. There were no significant differences in number of trials required for learning the reversal shift as a function of the number of irrelevant dimensions. Left to their own, young children seem to be strongly influenced by the presence of irrelevant information. If it is demonstrated to them that certain cues are of no utility, however, they are capable of learning to restrict their attention to the relevant cues.

Some of the most interesting research related to developmental changes in attentional processes is found in studies of incidental learning. Ordinarily, we expect performance in learning tasks to improve with increasing chronological age. This would be in line with common sense and with most views about the learning process. In studies of incidental learning, however, performance increases up to a certain age and then begins to decline. This result has been found repeatedly and with different types of materials (Collins, 1970; Hale, Miller, and Stevenson, 1968; Hawkins, 1972; Maccoby and Hagen, 1965).

In most learning tasks we seek to determine how well a child can learn what we want him to learn. Incidental learning occurs when the child acquires information that is irrelevant to the central task as defined by the experimenter. In one type of incidental learning task (Hagen, 1967), the child is shown a set of cards on which there are drawings of common objects. On each card there may be, for example, a picture of an animal and a picture of a household object. The child is told that he should look carefully at the pictures of the animals, for the experimenter will turn the cards over and the child will be asked to locate the card depicting a particular animal. After this has been repeated several times and the child always has been asked to locate the animals, the procedure is changed. Instead of asking the child to locate the animals, the experimenter asks the child to locate the card bearing the picture of each household object. Two scores are obtained, the number of correct responses for the central materials (the materials the experimenter instructed the child to learn) and the number of correct responses for the incidental materials (the materials the child preseumably was to ignore). When the number of correct responses for content is plotted according to chronological age , there is a consistent improvemant in performance. Older children are more effective than younger children. However, the number of correct responses for incidental content shows an increase up to about age 12 or so, and then a decline.

The same types of results have been found when children are shown ordinary movies or television programs. The information is categorized into central and incidental content on the basis of consensus among adults. After viewing the the film children are asked questions about the central plot and about incidental details, such as "What was the color of the lady's dress?" or "How many pictures were on the walls of the living room?" Again, memory for central content increases with increasing chronological age. Memory for incidental content shows an increase up to early adolescence and then a decline.

A common interpretation of this finding is that young children are not capable, on their own, of directing their attention selectively. They are incapable of separating central and incidental aspects of a situation, and learn a good deal about both. From what we know at present, the ability to focus attention selectively is readily accomplished only after the ages of 11 or 12. These developmental trends may be altered, however, if the child is given prior experience in learning how he should direct his attention. Young children can attend selectively if the significance of the stimulus has been pointed out to them in earlier experience.

Perceptual learning. A new view of the learning process has been proposed recently by Eleanor Gibson in her book, Principles of Perceptual Learning and Development (1969). This book has aroused a great deal of interest, for its basic propositions differ from what is traditionally considered to be the American behaviorist position. Rather than being concerned with the relations between stimulus, response, and reinforcement, Gibson concentrates her analysis on the role of the stimulus in learning. Perceptual learning refers to "an increase in the ability to extract information from the environment, as a result of experience and practice with stimulation coming from it." It is "self-regulating, in the sense that modification occurs without the necessity of external reinforcement. It is stimulus-oriented, with a goal of extracting and reducing the information in stimulation. Discovery of distinctive features and structure in the world is fundamental in the achievement of this goal." (Gibson, 1969, p. 3,4). According to this position, then, external reinforcement is unessential to the learning process, for increasing clarity of the properties of the stimulus provides its own source of reinforcement. Nor does active response play a central role in learning. Once the distinctive features of the situation have been determined, the acquisition of differential motor responses to the various features may occur rapidly.

The Tighe and Tighe (1969) study, discussed earlier, is based upon the ideas proposed by Dr. Gibson. Children must learn the invariant characteristics of stimuli that differ in many dimensions and must classify stimuli according to their dimensions of difference rather than according to their absolute properties. The distinctive features of the stimuli may be learned through repetitive perceptual experience with the stimuli, such as occurs when the child is asked to judge whether the stimuli are the same as or different from a standard. Even though the experimenter offers the child no feedback concerning the correctness of his responses, there is improvement in the ability to make such judgments. Later, when the child is placed in a situation where a differential response must be made to one of the dimensions of the stimuli, this phase of the learning process can be accomplished in a small number of trials. Learning, therefore, is seen to proceed according to a number of stages: the child must attend to the attributes of the stimuli, he then must isolate the dimensions of similarity and difference, and finally, he must learn some form of motoric response to these dimensions. Although the position is new and requires further elaboration, it constitutes a significant departure from views that have long dominated thinking about the learning process.

Memory. Among the necessary components for successful learning is the ability to remember. We know that children have great difficulty in remembering series of numbers, letters, or words. As problems become more complicated, failure to remember, as we saw in the Bryant and Trabasso study, leads to ineffective performance. Children and even adults who are given materials to remember do not consistently employ the most efficient strategies for remembering, such as clustering materials, rehearsing, or developing mnemonic devices. Once told how they can be more efficient, however, they are likely to adopt such techniques.

We have a great deal to learn about the development of memory, but recent studies have provided some basic information. Two types of memory have been discussed. Short-term memory refers to retention of information for brief, temporary periods of time. The content of short-term memory may or may not be transferred to long-term more permanent memory. It is commonly believed that one of the conditions that facilitates transfer of information from short-term to long-term storage is rehearsal, a process which young children fail to do.

In the typical short-term memory study, each card in a series is exposed briefly and then turned over. After all cards have been viewed, the child is shown cards, identical to the cards in the array, and is asked to point to their mates. Young children typically do not show primacy effects, while older children and adults do. That is, for young children, memory for the cards initially displayed is not above that for later cards in the series; they tend to remember best what they have just seen. It is assumed that the better retention of the initial cards is due to the tendency of older subjects to rehearse (Hagen and Kingsley, 1968). Kingsley and Hagen (1969), have shown how the performance of young children can be improved if they also rehearse the names of the stimuli after they have been presented. The children were required to continue to verbalize the names of all preceding items as each new item was introduced. By requiring rehearsal, the memory deficits of the young children were alleviated.

Memory also can be improved through imagery; that is, through attempts to develop a mental image of the materials that are to be remembered. Although young children are capable of utilizing imagery, they do not ordinarily adopt this technique on their own. Among the many studies demonstrating the usefulness of imagery in improving retention, is a recent report by Wolff and Levin (1972). Children in kindergarten and third grade were asked to remember a series of paired-associates. Sixteen pairs of stimuli were formed by combining 32 common children's toys. The children were trained in one of four conditions: (a) they were shown the pairs and told to remember which toys went together, (b) they were instructed to form a mental image of the toys in each pair "playing together", (c) they were instructed to manipulate the toys in a manner described by the experimenter, or (d) they were instructed to devise a means of having the toys in each pair play together. After one presentation of each of the pairs, memory for the pairs was tested in a random order. One toy in each pair was presented and the child was asked which toy went with it. Active manipulation of the stimulus pairs resulted in better memory whether the manipulation was initiated by the experimenter or by the child. At grade 3, instructions to form images of the toys were as effective as actual manipulation; all three conditions were more effective than simple instructions to remember the pairs. Thus, somewhere around the ages of 8 and 9 years, children develop the ability to use mental images and this ability is of help in remembering. At the age of five, memory is improved by manipulation of objects, but instructions to form mental images are ineffective. These findings are, of course, closely in line with the ideas of Piaget concerning the role of concrete operations in the mental life of the young child.

In an interesting second experiment, Wolff and Levin showed kindergarten and first graders the pairs of toys and told them either (a) to move the toys into a toy house where the toys could not be seen and to imagine the toys playing together, or (b) to engage in overt, but still unseen, manipulation of the toys in the house. When later tested for their memory of which toys went together, children who had engaged in manipulation without seeing the toys received higher scores than children who were told to imagine the toys playing together.

It is apparent, therefore, that children by the third grade are capable of benefitting from instructions to form mental images of objects, and before that time manipulation of the objects produces heightened retention. Thus, while different effects may be observed at different ages, the formation of images can be of help in improving young children's memory.

Conclusions. The preceding discussion is by no means an exhaustive statement about current research in children's learning. The various groups of studies, however, do provide examples of what I think have been the most significant developments in the field. Perhaps the most notable omission has been the failure to discuss behavior modification. This is not because the field is inactive. The extraordinary vitality of the field has come from repeated success in the application of reinforcement principles to a vast variety of problem behaviors, however, rather than from the introduction of new theoretical principles. Furthermore, this research is more widely known and excellent reviews of the literature are available (i.e., Bandura, 1969).

From this discussion, one may discern several recurring themes. First, it is obvious that the role of attentional processes has become one of the most vigorously pursued topics in the study of children's learning. A few years ago, it would have been difficult to find studies in which the term "attention" was used. Interest in the topic is indicative of the close relations that now exist between the study of children's learning and of cognitive development. One of the main criticisms of earlier studies of children's learning has been that the studies dealt with what many considered to be trivial forms of learning. On the other hand, studies of cognitive development have been criticised because of a failure to be concerned with how children come to acquire concepts and other complex cognitive processes. A mutual interest in the acquisition of complex behavior by both groups of researchers is bound to lead to a healthier state of affairs.

A second major characteristic of this research is the interest in extending the study of learning downward. The studies deal primarily with young children and the interest extends even into the study of learning during the earliest days of infancy. Interest in early learning is due, in part, to the very rapid changes that occur during these years. It is the period in which the child is learning language, is developing greater self-sufficiency, and in which socialization practices are introduced. All of these have a potentially profound effect on the learning process. We may hope that learning by older children and adolescents will be explored more thoroughly in later studies, and current research with young children may prove to be important in laying the groundwork for such studies.

Third, there are repeated examples of attempts to improve performance over that which would occur without intervention. This interest has not been dictated so much by an interest in practical application as it has by the results of careful analyses of the various aspects of the learning process. Learning has been found to be dependent upon a number of related processes. It appears that children perform less effectively than they could because they fail to use effective strategies for remembering, learning, and solving problems. Clearly, their performance can be improved if they are taught how to define a problem, how to ignore irrelevant information, how to formulate hypotheses, and how to rely on past experience in checking out what has proved to be effective. Left to their own, all of this takes a good deal of time. With help, mastery of such techniques may prove to be an important contribution to their learning and cognitive development.

We are at an interesting stage. The field abounds with suggestions and examples of how this information could be used productively in the day-to-day teaching of children. We are beginning to develop, it seems to me, a sound scientific basis for education. It will be interesting to see how effectively some of these ideas can be tested in practical situations.

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