DOCUMENT RESUME

ED 031 951 24 EM 007 377

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A Study of the Advantages and Disadvantages of Using Simplified Visual Presentations in Instructional Materials.

Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.

Bureau No-BR-7-E-144

Pub Date Jun 69

Grant-OEG-1-7-070144-5235

Note-70p.

EDRS Price MF-$0.50 HC-$3.60

Descriptors-*Children, Classroom Materials, *Cues, Educational Research, Instructional Improvement, Instructional Materials, Kindergarten Children, Perceptual Development, Pictorial Stimuli, Tachistoscopes, *Visual Discrimination, *Visual Learning, *Visual Perception, Visual Stimuli

Beginning with a survey of work previously done on the subject, this study attempts to learn more about how, and to what extent, children benefit from pictorial illustrations, with a view to improving instructional materials. Three areas were investigated with experiments using children from nursery schools and kindergarten to sixth grade. The first experiment probed the effect redundant clues have on the recognizability of an illustration, the second the relative values of realistic and abstract illustrations in the teaching of a concept, and the third the effect of age differences on the perception of pictures. The first experiment, in which the pictures were presented by means of a tachistoscope, led to the conclusion that a picture becomes more recognizable as more clues are furnished. In the second experiment, children taught the concept "one-half" by means of abstract materials did as well as those taught with illustrations of real objects: a four-year-old's idea of what is abstract is, apparently, not an adult's. The best learning was achieved when children were taught and tested with realistic materials. Children learned best when the illustrations suggested a kinetic situation. Perception increased with age. A great deal more research, though apt to be expensive, is recommended. (GO)

A STUDY OF THE ADVANTAGES AND DISADVANTAGES OF USING SIMPLIFIED VISUAL PRESENTATIONS IN INSTRUCTIONAL MATERIALS

Robert M. W. Travers–Principal Investigator

Final Report on Grant No. OEG-1-7-070144-5235
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Preface

Although the research reported here represents a relatively small project, many different individuals have contributed to it. Special mention must be made of the assistance given by Helen Carey on the studies reported in Chapters 2 and 4. Additional help on the study reported in the latter chapter was given by Thomas Feister. The study described in Chapter 3 was conducted largely by Victor Alvarado who, in addition to his research skills, showed great talent in winning the cooperation and friendship of nursery school children.

Grateful appreciation is expressed to the many in the Kalamazoo Public Schools who have provided help in connection with the project. These include Dr. Reed Hagen, Mrs. Marian Patton, Mr. Roderick Hill, Miss Suzanne Frazier, Mrs. Grace Potts and Miss Marilyn Richmond. The assistance given at all levels from the Office of the Superintendent to the classroom teacher could not have been better. In addition, the fine help of Dr. George Miller, principal of the Campus School is gratefully acknowledged.

Considerable help was provided in the artistic and photographic area by Mary Frances Fenton, without whose skills materials for the project would not have emerged as satisfactorily and smoothly as they did. Finally, a special word of thanks is due to Kathy Weaver for providing such patient secretarial services to the many individuals who liked to change their minds just when the typing was finished.

Robert M. W. Travers

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CHAPTER I

RESEARCH ON NONCODED VISUAL INFORMATION

Some Gross Characteristics of Pictures

Several reviews have already been undertaken of the scattered research on pictorial perception that has had a long history but very little concentrated effort to solve problems. These reviews include those by Dale and others (1949, 1950), Spaulding (1955), an anonymous review done under contract at the University of Illinois (1953), one by Ibison (1954), and one by Allen (1960). Little purpose would be served by providing just another summarization of the studies already undertaken. What will be attempted here will be a consideration of what these studies say in relation to what is known about perceptual development in general and the visual perceptual development in particular.

Many of the research reports in the area of studies of pictorial material point out that one of the difficulties of undertaking research in the area is that there are few recognized dimensions along which pictorial materials can be considered to vary. True, they can be black-and-white or colored, or large or small, but beyond that point the attributes of particular illustrations which distinguish them from other illustrations representing the same object are difficult to identify. One of the more significant analyses of pictorial material that has relevance for this problem has been provided by Gibson (1954).

Gibson derives his analysis from the work of C. W. Morris (1946) on theory of signs as Knowlton (1966) has more recently. Although Morris distinguishes between what he calls iconic signs, represented by pictures and images, and non-iconic signs, represented by words and other symbols, Gibson points out that both words and pictures have certain features in common. For Gibson, both pictures and words are stimuli produced by a person. These stimuli are specifically related to some object, place, or event, not present to another individual who perceives them. Such stimuli are referred to as surrogates. Both pictures and words are surrogates. Now Gibson makes the important point that since surrogates are always produced by one person and arouse perceptions in another, what they arouse will depend upon the clarity of the original producer's original perceptions.

A second point made by Gibson in his analysis is that surrogates vary all the way from those in which there is some physical correspondence between the surrogates and its referent to those in which there is no such correspondence. For example, a color photograph reflects a cone of light that has a direct physical relationship to a cone of light reflected by the original scene photographed, but a diagram or word does not have this direct relationship to a physical phenomenon.

Gibson points out that both picture surrogates and word surrogates may be vague and ambiguous, but for different reasons. The vagueness or ambiguity of pictures is of particular interest to us here and is referred to as lack of fidelity. A picture has these properties to the degree to which the sheaf of light reflected by these pictures and coming to a point where it is received by the eye fails to correspond in optical properties to the sheaf of light derived from the scene that the picture is designed to depict. In the case of pictures derived by a process other than the photographic, there is generally a considerable lack of fidelity. Often the artist introduces conventions which produce light effects which were completely absent from the original scene. The artist may also emphasize certain cues he believes help in object identification and omit other cues which he judges to be of much less importance. Surrogates, since they are produced by people, have certain built-in distortion which facilitate perception from the point of view of the person who produces them, but are not necessarily facilitating to others who attempt to interpret them. The greater the difference between those who produce the surrogates and those who are exposed to them, the greater may be expected to be the failure of the surrogate to produce a perception similar to that which the producer intended.

Knowlton (1966) has also based his analysis of pictorial material on the Morris analysis of communication but with some differences in the terms used and the directions in which more detailed analysis is introduced. In place of the term non-iconic signs, Knowlton prefers the term digital signs, a matter of no great consequence, but he does introduce a classification of pictures of some interest. Pictures fall into the threefold classification of realistic, analogical, or logical. The category of realistic needs no further explanation. The category "analogical" refers to pictures in which, not the phenomenon under consideration, but an analogy to the phenomenon, is presented. An example of the latter would be an illustration of the circulatory system in the body, but in which the heart was represented by a mechanical pump and in which the arteries and veins were represented by pipes. The third category of logical pictures is illustrated by the schematic of a circuit. Just what is the difference between a logical picture and an analogical picture is not entirely clear. A picture of a circuit represents the real circuit through an analogy in which wires and connections are represented by lines. Both the logical and analogical categories involve some special recoding of information before the information can be used effectively by the perceiver. Probably much recoding occurs through the use of the auditory verbal system.

The classification of realistic, analogical and logical, have only an indirect relationship to the fidelity-nonfidelity dimension of Gibson. Both the realistic and the analogical pictures can have both high and low fidelity.

The Dimensions of Pictures

Although much has been written about the use of pictorial materials in educational settings, the area still calls for extensive inquiry, largely because pictorial materials can vary along a great number of different dimensions, some of which are well identified and some of which remain quite obscure. One dimension already considered is that of fidelity or lack of fidelity. Pictures may also vary in the extent to which the object of central interest in the picture is presented in context or in isolation. Many books designed for children present pictures of animals, but the animal is not portrayed in its native surroundings, but other books present the same animals in their natural settings. The presence or absence of settings represents a dimension involving the amount of information presented and also a dimension related to the number of stimuli that may distract attention from the central object of interest. A picture of an object embedded in a ground presents a different visual task from a picture of an isolated object. The former calls upon the observer to differentiate the object from its setting, and sometimes to use the setting to determine attributes of the object such as size. Individuals apparently differ considerably in the extent to which they are influenced by the setting in the perception of an object. This effect is known as field dependency, and although it has been extensively studied, little has been learned about it in the context of instructional materials.

Another dimension along which pictorial material may vary is the extent to which the object of central interest is presented in detail. Pictures of people, for example, show extreme variations in this respect, varying from full color photographic representations to black and white cartoons that portray only the few edges the artist considers to be of crucial significance in identifying the character. What is presented may be presented with fidelity but little may be presented. A picture of a fruit or vegetable may vary from a black and white sketch to a full color representation. Still another dimension involves the extent to which a picture is what is called stylized. Stylized pictures represent pictures of low fidelity to use Gibson's term, but much more is also involved. Generally, they represent partially coded information that can be interpreted only by a person who knows the code. Adults are so familiar with the interpretation of pictures in this form that they do not even recognize them as coded. Cartoons represent one form of stylized pictorial representation, but there are other forms involving a much greater use of detail. For example, the typical comic in the newspaper shows another form of stylized representation. The essential feature of stylized representations is that certain conventions are adopted that determine the features to be represented. In cartoons, certain edges of the face are typically used for making the representations. Stylized pictures in elementary school readers use other features for presenting pictures of boys and girls, commonly features of particular significance in the perception of movement. Such stylized pictures have to be drawn by an artist who selects the features to be portrayed. Stylized pictures do deviate to some degree from being optically correct representations of the real world, but their usefulness lies more in the extent to which they represent directly the real world than in their symbolic value.

A large number of other dimensions of pictorial representations have been noted by research workers, including the extent to which a third dimension is presented, fidelity of color and degree of aesthetic value, but there are undoubtedly dimensions of consequence that have not yet been identified. Most educational research on pictorial materials has attempted to relate one or another of these dimensions to the amount of information acquired in an instructional context.

The Development of the Perception of a Picture

A central issue in understanding how individuals acquire information from pictures is that of how the perception of a picture develops when the person is first confronted with it -- which features tend to become figure and which ground, and which are noticed and which remain unnoticed. The manner in which the development of the perception of a picture occurs depends upon many factors, including that of age. Relatively little material on pictorial perception starts from such a viewpoint, though there is some information from related studies of the perception of ink-blot material and other semi-abstract visual presentations that has implications for the present review.

Ames and others (1953) undertook a study of how children, aged from 2 to 10 years, responded to the Rorschach Test Blots. Their results are probably far less clear than they present them in their writings and considerable scepticism must be expressed concerning their conclusions. They report, for example, that the responses of the very young children are "primarily global" (p. 199). However, the global responses of the youngest children in the study appear to be largely unrelated to the blot, and it seems much more likely that these young children were simply emitting nouns for which they receive some kind of reinforcement than that they are able to structure the material in the blot to provide an organized percept of the whole. Indeed, it may well be that the extraordinary complexity of the typical Rorschach blot may be beyond the structuring ability of most preschool children, let alone the 2 year-olds included in the Ames and others study. This same study did find that an increasing frequency of the tendency to identify details as the children grew older and then, later, a renewed tendency to identify the blot as a whole, but with these older children the "wholes" identified did bear some relationship to the blot. An interpretation of the data; which fits other facts, is that the younger children were not responding at all to the blot as is evident from the lack of correspondence of the noun emitted and the characteristics of the blot. This same interpretation would take the position that the first genuine percepts based on the blot are those involving details. Then, as the child grows older, genuine percepts involving the blot as a whole begin to appear.

In fairness to Ames and his associates, it must be said that the interpretation given here is not the one which they gave. The Ames article suggests that children first perceive on a global basis at the earliest ages, then they tend to perceive in terms of detail and then, once again, the perception of wholes emerges again. The latter interpretation is of very doubtful validity. It seems to this writer that the early wholistic responses probably had nothing to do with the material presented, and that perception proceeds from a perception of detail to a perception of larger and larger units.

Our interpretation of the Ames and others findings is consistent with a study of Elkind and others (1964). These latter research workers presented drawings in which both parts and wholes had well-defined meanings -- a feature not possessed by the Rorschach blots. The figures used included an arrangement of vegetables that looked like a fish, an arrangement of fruits that looked like a human figure, and two giraffes whose necks were curved together in such a way that the space between them formed a heart. Children aged 4 to 9 were presented with these figures and were asked to tell what they saw. The data showed that parts were perceived at an earlier age than wholes and that the parts had become integrated into the whole by the age of 9. A major difference between this study and the Ames and others study is that the parts and wholes in the Rorschach did not have a well-defined meaning, but those in the Elkind and Koegler study did.

The findings of the Elkind and others study and those of the Ames and others study, as it has been interpreted here, fit well with much of the information that is known about perception. Research has well established that as the child grows older his capability of handling complex stimuli increases as does his preference for complexity. The perception of a complex display, seen as a whole, is quite obviously a much more difficult task than the perception of a small component. For example, the identification of a boy in a picture is a much simpler task than the recognition of the fact that the boy is engaged in playing a game of baseball. More relationships have to be recognized when the parts are integrated into a whole than when a part is separately recognized. Another, and closely related conceptualization of the development of perception is provided by Piaget in many of his writings. Piaget postulated that the development of perception involves first what he calls decentering and the focussing of attention on highly specific aspects of the perceptual field.

Despite this rationale and the data presented which fit, all is not as simple and straightforward as it might seem. One suspects that much depends upon the recognizability of the parts and the recognizability of the whole. Suppose, for example, that the picture in which an arrangement of vegetables formed the outline of a fish might be redrawn so that the vegetables were scarcely recognizable, but the outline of the fish was very clear. Under such conditions one would expect that the parts would not be recognized by the younger children, but the outline of the fish might be. The picture could also be redrawn with the reversed emphasis and with a resulting facilitation of the recognition of the parts. This may well account for the results of Meili-Dworetzki (1956) who found that the whole was recognized at an earlier age than the parts.

Piaget (1956) has also pointed out that young children asked to reproduce a drawing tend to reproduce the outline with considerable accuracy, but the details within the drawing are not properly located, indicating that the child has a problem in space perception. This observation should not be taken to imply that the child sees a disordered world. The child probably sees the world much as the adult sees it, but he is not able to recognize the spatial order in the world and cannot utilize the information provided by the order. What one sees, what one recognizes, and what one can report, are not always the same.

Although the studies that have been considered indicate that children readily see wholes by the mid-elementary grades, one should be cautious in generalizing from the artificial materials used in experiments to more typical visual materials used in classrooms. The perception of the total organization and theme of a picture in an elementary school science textbook may be a much more complex task than seeing the outline of a fish formed by an arrangement of vegetables. An old study by Miller (1939) provides some support for this point of view.

Miller (1938) found that the teacher had to direct the children to the important items in the pictures if the latter were to be of value. One hundred children in the third grade reported seeing only a few of the total items in the six pictures selected from books used by third grade children. Items in the pictures were seen in isolation rather than parts of the unified whole. The children could describe correctly only 19.5 per cent of the main items of a picture -- the items which gave the picture its meaning. Each child was given as much time as he needed for looking at the pictures. No child mentioned any item not appearing in the picture. In the pictures some items were, what Miller called, "generalized" and these were the items that carried the theme of the picture. Miller reported that few saw the relations between the three or four generalized items which made the meaning of the picture clear, even though some children were given credit for recognizing the central theme of the picture. Most of the children saw the generalized items when they were brought to their attention but admitted that they had not thought about them before. The differences of ability to identify generalized items at different intelligence quotient levels were not statistically significant.

Another feature of particular interest comes out of the study of Ames and others which appears to be of significance for the design of illustrative material. This is the relatively late age at which the children give interpretations involving movements. Apparently such interpretations involve relatively complex processes that the younger children in the study were unable to undertake.

Now the importance of movement responses in the understanding of informative illustrative material must be regarded as crucial. Suppose a picture shows Galileo performing his classic experiment dropping weights of different size from the top of the tower of Pisa. The weights are shown a few feet below the edge of the tower from which they have been dropped. A child who has to interpret such a picture must interpret the weights as falling; that is to say, as just having left Galileo's hands and as moving towards the ground. The picture itself does not provide any visual experience of motion, but motion must be imposed upon it by the interpreter. Most pictures, if they are to be informative, have to be viewed as a state of affairs that has emerged from some previous events, and a state of affairs that is leading up to and producing some new events. Even a picture in a first grade reader showing a child running after a dog which is dragging a leash behind him requires the viewer of the picture to see it as a scene in a sequence of moving scenes. However, a few pictures do not require the introduction of the concept of motion in order to understand them. For example, a picture of a crystal, or of an amoeba, may do no more than present structural elements which can be readily understood without resorting to a concept of motion and change, but such pictures are relatively rare. Most pictures in books for children in school require that interpretations be given in terms of a moving sequence of events.

Since motion and change are difficult to present in a still two-dimensional picture, artists have introduced various conventions to represent motion. A common convention is to draw lines behind a moving object as if to represent something analogous to the wake of a ship. The age at which children do actually learn or can learn to interpret such conventions still remains to be determined.

Attention Value of Particular Features of Pictures

Attention is a problem that has long been studied by the industrial psychologist interested in designing advertising displays to catch the eye of the public but such studies have little relevance for education. For this reason it seems preferable to begin with an examination of psychological studies of conditions under which living creatures orient themselves towards or avoid particular parts of their environment. Many years ago a series of studies was initiated which found that a wide range of living creatures showed a tendency to avoid those parts of the visual environment that had been recently viewed and to choose those parts of the visual environment that had not been seen before or not been seen recently. Many experiments have shown a similar finding with human subjects.

From this general line of experimentation another finding emerged; namely, that there is generally a preference for viewing complex rather than simple visual displays. Such a preference is shown at a very early age. This does not mean that more is learned from a complex display than a simple display, but only that the complex are viewed longer. For example, Thomas (1965) presented two groups of young children with a series of displays that varied in complexity and measured the amount of time that the infants fixated each. One group of children was aged 2 to 14 weeks and the other group 15 to 26 weeks. Even the younger of the two groups of infants tended to avoid fixating the simplest of the three displays. Of the other two, one resembled a human face and the other was a checker pattern. There was no particular tendency for the infants to choose the human face pattern rather than the other pattern. One might reasonably expect that the level of complexity preferred would not necessarily be the maximum level among the visual displays presented, since extreme complexity would represent a state of chaos. Presumably there is an optimum level of complexity insofar as preference is concerned. Vitz (1966) put forward this hypothesis and collected some data to check it. He did find some support for his position.

The theoretical position that has been considered is also reflected in some direct studies of children's preferences for pictorial material.

French (1952) studied children's preference for pictures of varied complexity. He studied groups of six and seven year-old children (N=142) and eleven year-old children (N=554) of varied socioeconomic levels. He used thirteen paired pictures with each pair containing a simple and a complex picture, and found an increase in preference for complexity with age. The six and seven year-old children preferred the simple pictures made up of clear-cut, unbroken, unaccented line drawings showing the outlines of flat, two-dimensional, familiar objects. On the other hand, the eleven year-old children preferred the sketchy, irregular, complex pictures. The latter illustrations contained suggestions of objects rather than carefully well-defined representations. Such illustrations were probably perceptually complex and, in terms of information theory, may well have a high information content in contrast to French's simpler pictures. First grade children consistently preferred simple pictures. French hypothesized that such selections seem to be guided by the type of pictorial pattern that they have explored in their own art work. He found almost complete similarity between boys' and girls' responses except for a slight and statistically insignificant tendency (no levels indicated) for girls to prefer the more simple illustrations.

The preference for complexity shown by children in the older age groups and by adults is also related to the increased capacity to handle perceptual complexity that comes with age. The preference that the younger children show for the simpler representation is undoubtedly partly due to the fact that they are unable to structure the more complex representations. One is tempted to hypothesize that a child prefers the most complex presentation that he is able to organize perceptually. A similar interpretation of the findings comes from scientists interested in the application of information theory to problems of perception. Those who have embraced the latter viewpoint commonly view the human not only as an information analysis system, but also as a system that requires a continuous input of information to maintain a homostatic balance. From such a viewpoint, the viewer chooses to examine displays that provide an optimum input of information or displays that come nearest to satisfying the information input requirements.

The research considered in this section has relevance for the designing of illustrations that will attract and hold attention. It says nothing about how to design illustrations so that useful information can be extracted from them. It also provides no knowledge concerning the extent to which attracting attention to a picture also attracts attention to related reading material.

Brief mention must be made at this point of the numerous studies undertaken in the first half of the century on the value of illustrations for stimulating reading behavior on the part of purchasers of magazines. The Illinois study of the use of pictures and graphs (1952) cites several studies of this problem which show that magazine articles are more often read if they are illustrated than if they are not. One may well doubt whether these studies have any implications for the design of classroom materials. The purchaser of a magazine may well select to read those articles in which the pictures reflect some event of interest to him. The pictures enable the reader to make a choice of what he will read and what he will ignore. Illustrations in textbooks do not generally provide a basis for selecting what to read and what to ignore. Hence, the mere fact that illustrations increase the probability that a magazine article will be read cannot be taken to imply that children will be more likely to read books if they are illustrated.

Certain other features have also been established as having attention value in the sense that viewers tend to prefer looking at pictures incorporating these features than looking at pictures that do not have them. For example, Spaulding (1956) studied the responses to pictures of illiterate or semiliterates in Costa Rica and Mexico. The pictures were prepared in three forms, realistic line drawings, woodcuts, and what he called stylized illustrations. The latter, presumably, had the lowest fidelity, to use Gibson's term. The test procedure required the individual respondent to examine each picture and tell what he saw. The responses of the poorly educated adults were very much like that of children in the United States and showed a marked tendency to fixate on a particular detail that was often of trivial significance. Of special interest in the present connection was the finding that these adults showed substantial preference for the realistic rendering, perhaps because they had difficulty in structuring the versions of the pictures built in terms of a set of conventions accepted by the artist. The perception of the artist in producing the pictorial surrogate was almost certainly different from the perception of the subjects to whom it was shown. A similar finding was reported for Puerto Rican children in a study by Rodriguez Bou (1950). Rodriguez Bou presented children in the second, fourth and sixth grade, (Total N=2,492) with pictures presenting the same scene but which differed in fidelity. The children showed a marked tendency to prefer the most realistic of the pictures.

Preference for realism, that is to say high fidelity to use Gibson's excellent term, also appears to extend to some degree to the matter of color. The latter problem was investigated by Rudisill (1952) who prepared illustrations some of which were realistically colored and some of which involved very unrealistic coloring. Some were also uncolored. The children not only preferred the realistically colored pictures, but they also preferred the uncolored illustrations to the unrealistically colored ones. Rudisill also found that the preference for realistic presentations increased with age. However, the conclusions quite obviously need some qualification. Commercial producers of color film for amateur photography long ago discovered that the public has a preference to buy film which tends to present colors more saturated than those that are found in nature. Attempts to sell color film that provides strictly realistic colors have been unsuccessful.

The Use of Pictorial Material in Content Learning

The central problem in the whole area of the design of pictures for instructional purposes is one which has hardly been touched upon. This is the problem of identifying the features of pictures that result in the effective communication of information. An attack on this problem requires that a careful analysis be made first of the features of pictures that result in the enhancement of learning. Most research on this problem has failed to begin with a theoretical analysis of the problem.

Studies designed to detect the effect of illustrations on the amount learned from books generally look for some overall increment and do little to analyze the reasons for any increment found. In the article by

Dale (1952) in the Encyclopedia of Educational Research studies are cited which have yielded significant positive increments as a result of the use of illustrations, but other studies are also cited in which no such increment was produced. The typical design of such studies is to prepare two sets of instructional materials consisting of a printed text with accompanying pictures in one version to an absence of pictures in the other. Since the studies have used a great range of instructional materials, uniformity of results could hardly be expected. In some of the studies cited by Dale the pictures were merely illustrations added to reading material and these illustrations were not designed to add information over and above that presented in the text. In other studies, the illustrations presented information to the reader that could not be readily presented through print. Illustrations in textbooks can serve many different functions and the particular function served by illustrations in the materials used by a study are not typically identified in the published report.

The most systematic account of the relationship of illustrations and printed material in instructional settings has been provided by Smith (1960). The following list of the functions of printed materials is derived to a considerable extent from Smith's analysis even though it does not use his particular terminology.

1. Incentive-motivational functions. These functions of pictorial material have already been discussed in a previous section of this chapter in which it was pointed out that certain features such as complexity, lack of recent previous exposure, as well as the more obvious factors of color, brightness, and so forth, determine the tendency to attend to

or approach particular parts of the environment. Smith also adds the factor of aesthetic quality which, he suggests may be influential in producing approach tendencies towards reading material. The studies of industrial psychologists in the advertising field as well as other studies cited in this chapter give substantial support for Smith's position. However, Vernon who attempted to identify an effect of this kind could find no evidence for it.

2. Information-giving functions. a. A picture may provide information not readily codified in words. Most strange plants and animals are not readily described through the use of words, though the taxonomist, who has a specialized and technical vocabulary, can give excellent descriptions which other biologists can understand. The scientist has special skill in coding information in his particular area into words, but less sophisticated groups can comprehend the same materials only through direct observation or through pictures. In this connection one must point out that there is some evidence that pictures representing events or materials remote from the viewer's background may be readily misinterpreted. This fact comes out clearly in a study by Spaulding (1956) in which pictorial material together with simple written material was prepared for teaching newly literate adults in Latin America. Spaulding concluded that (p. 45) "An illustration as such has no educative value, and may even be a detracting influence, if the drawing content has not been presented in terms of the past experience of the intended audience." Perhaps more important still is the viewer's skill, derived from past experience, that permits him to code the visual

information in words.

b. A picture may present information that is partly codified in words in the accompanying text. This arrangement wherein the picture and the verbal material present redundant information has been referred to in media literature as the one medium reinforcing the other medium. This use of the term reinforcement is entirely different from the usage of the same term as it occurs in the literature of operant conditioning. Reading about a phenomenon and also being presented with a pictorial representation of the same phenomenon is allegedly like having two separate learning trials. This argument is just attractive speculation for there is no evidence, as far as the present writer knows, to support the position on which it is based. There are excellent opportunities for experimentation in this area, though studies would probably be best undertaken with contrived material rather than with material available for instructional purposes.

A well-known example of instructional materials involving pictures that are partially codified in verbal terms is represented by illustrated foreign language instruction books. Such a text shows, for example, a man entering his house and the text says (in the foreign language) "The man is entering his house." Although the picture is a static representation, the viewer must see motion if he is to use it as a cue for interpreting the text. It is of no use for him to see a man standing on one leg in the middle of the frontdoor for such a perception would be valueless in interpreting the text. What he has to see is a man entering the front door, that is to say a man in action. Since studies already cited suggest that the interpretation of motion in pictures develops relatively late, illustrations requiring such a perception should probably not be used at the lower grade levels.

c. Pictorial material may provide new experiences and new information that the learner has not previously encountered. The text may then provide a means whereby the visual material becomes translated into a verbal code. A child shown, for the first time, a picture of the inside of a power station may be bewildered by the mass of gadgetry. However, once he is told that here is the generator that makes the electricity and here are the master switches that switch the electricity to the power lines, and so forth, he then has a vocabulary that will help him to identify components of the display, and second, a code which permits him to talk about and perhaps more readily remember what he has seen.

d. Pictorial material may be such that, until it is recoded into verbal form, the information provided is virtually useless. Any picture that explains by analogy is of this character. A picture of an arrangement of pipes and a pump representing the circulatory system of the human body, already referred to, is meaningless unless the perceiver says to himself that the pump represents the heart and the pipes represent the arteries and veins. In contrast, if the pipes were really meant to represent pipes and if the pump really represented a mechanical pump, and not the heart, then the information might be used directly without a recoding into verbal terms. Knowlton (1966), in his article on pictures, refers to pictorial material of this kind but does not point out the importance of recoding in the use of such information. Iconic material can clearly be used either directly or is utilizeable only after recoding.

One presumes that the latter generally involves learning at a much more sophisticated level than does the latter.

e. Pictorial material may provide a link between verbally represented generalizations and the world of phenomenal experience. Some such link would appear to be necessary if the generalizations are to be effectively applied. Overing and Travers (1966, 1967) conducted an experiment in which the principle of refraction was taught to children in the upper elementary grades. The study showed that quite abstract materials could be used successfully for instruction provided that they were preceded with a discussion of a concrete situation in which the principle of refraction was applied.

Some Final Comments

The review of the literature reveals an area of research of enormous complexity in which the main difficulty of beginning research has been in identifying the problems that can be profitably explored. The type of research that compares textbook material presented with and without illustrations involves analysis of the problem at the crudest level and a much more sophisticated analysis would appear to be necessary if research is to have useful outcomes. A hopeful sign is that, in recent years, the analysis of the problems of the area has moved forward to a point where it is beginning to provide a sound basis for research. The analysis of the functions of pictorial materials by Smith is particularly notable in this respect since it provides a basis for a whole program of research. It is surprising that such a program has not emerged as a result of Smith's excellent thinking on the topic. At a more theoretical level, the contribution of Gibson also provides some of the analytic thinking that has to precede a sound research program. The contributions of the developmental psychologists have also demonstrated ways of analyzing responses to pictorial materials that should be of great help to future research workers in the area. What is needed, quite obviously, is an extended program of research to explore what appears to be the major variables involved in the design of pictures for instructional purposes. One reason for the lack of research in this area is the difficulty involved in organizing a team of research workers, artists and photographers needed for the production of experimental materials. Such teams are not only difficult to assemble but are expensive to maintain.

The studies that follow represent a series of probes designed to provide some information at points where a more extensive exploration would be profitable. They represent a follow-through of ideas already suggested and generally attempt to produce experimental evidence for particular theoretical positions concerning the perception of pictorial material.

CHAPTER 2

THE EFFECT OF REDUNDANT CUES ON RECOGNIZABILITY

One important source of variation in pictorial materials is the extent to which they involve redundant cues. Consider, for example, the range of illustrations in textbooks used in the elementary grades. Such illustrations vary from those involving full-color photographic reproductions to very sketchy so-called stylized pictures in which the main edges of the object portrayed are represented by a few bold lines. The tendency has been to use the stylized versions at the lower elementary grades largely because they are cheap to prepare and reproduce and generally involve only the crudest color-printing techniques. In technical terms one can consider the full range of illustrative material as representing a continuum involving, at one end, pictures providing maximum cues for recognition, and at the other end pictures involving minimal cues for recognition. One can argue that the simpler pictures may facilitate picture recognition in the young children for two reasons. One is that these children have a more limited capacity than the older children for handling information and, hence, the simpler illustrations do not flood them with large quantities of information. Another argument is that visual perception involves an information-reduction process in which greater emphasis is given to boundaries of objects than to shading within the objects. Since the simplified illustrations of the stylized type also give greater emphasis to boundaries they may well facilitate recognition, particularly at the younger age levels where this factor may combine with the child's inability to handle large quantities of information. The argument is that, by presenting the younger children with those cues that they can be most readily perceived, and by avoiding overloading them with information, recognition should be facilitated. Older children, on the other hand, who have a greater information handling capacity would be more readily able to recognize an object in a picture if it were to be presented in full detail.

Method

General Procedure of the Study

The study involved the preparation of pictures of common objects at three different levels of details. Each picture was presented to each subject by means of a tachistoscope and the subject was asked to attempt to identify the object presented in the picture. The duration of the exposure was adjusted in an initial trial run so that subjects had approximately a 50 per cent chance of identifying the object. By means of this technique, data could be collected showing the relationship between recognizability and the level of detail at which objects were portrayed for both children and adults.

Materials

Considerable difficulty was experienced in the development of materials for presentation. Since our interest was in the perception of common objects that every child had encountered on numerous occasions, this limited the range of objects from which a choice could be made. The following criteria were adopted in the selection of objects:

1. The objects should be common objects, highly familiar to every child in the population studied. It is obvious that the use of relatively unfamiliar objects would introduce individual differences that would, in turn, produce inflated error variances.

2. The objects must be such that they could be readily identified from their contour. Since one problem to be studied was whether

young children would identify objects in terms of contour rather than other details, it was essential that contour alone should provide identifiability.

3. The objects should also be such that interior detail should also have value in the process of identification. The reader may note that many objects have virtually no interior details that improve identifiability. For example, a portable television is identified largely in terms of the contour of the front of the picture tube and not in terms of detail within the area of the screen. Indeed, the television screen itself is a blank, detail-free, area when no picture is being shown.

The preparation of the materials, once a set of objects had been decided upon, also presented a series of problems. A first idea was to derive from catalogs, magazines, and other sources, photographs of the common objects. From these photographs two versions with a reduced amount of detail were prepared, using black ink on a white background. In this way three representations of each object were prepared. The simplest involved only the contour of the object with as few additional lines as were necessary to make it recognizable. The second version involved the inclusion of the major details within the contour. For example, on the second version of the picture of a shoe, details were included pertaining to the shoe laces. In the third version, shading was introduced to provide a three-dimensional effect. In the early series of materials the third version was a photograph since such a reproduction included shading. However, it soon became evident in the trial runs with the materials that the shaded version had such entirely different properties from the black-and-white line versions that the three drawings in each version could not be considered to lie along a dimension. The low contrast of a photograph was confounded with the presentation of a large quantity of detail. The photographs tended to blend readily with the white field presented before and after the picture and hence provided a reduced visibility compared with the black-and-white line drawing versions.

In order to overcome this defect in the materials, the decision was made to have all drawings prepared by an artist and with all drawings prepared in jet black India ink on a white background. The artist was also instructed to provide only an outline of the object in the first picture and to draw only those boundaries that were necessary for identifying the object. In the second drawing details were to be added, and those details that presented major boundaries within the object. The third drawing was to include all the material in the second drawing but was also to include shading to enhance the three dimensional appearance of the object. The shading was produced by the use of overlays which also consisted of jet black lines and these, when installed, appear on a white background. Large areas of black on specific drawings were avoided so that an object would not become readily identified by the presence of such an area.

The objects represented were an airplane, a bed, a bird, a chair, a car, a gun, a horse, a household iron, a locomotive, a man, a telephone and a shoe. The drawings of the objects were photographically reduced so that they could be framed in an area 2 inches by 2 inches. The resulting drawings presented the objects on different scales since, for example, the drawing of the gun was about the same size as the drawing of a locomotive. Such differences in the scale of the drawing are probably inconsequential since the tachistoscopic form of presentation eliminates most distance cues. The size of the image on the retina cannot be used as a cue in the identification of the object unless cues pertaining to distance are also present.

Equipment

The drawings were presented by means of a Gerbrands 2-field tachistoscope. The subject looked into the equipment and saw a uniform field of white light 4 inches by 6 inches in size and surrounded by a black field. The subject was told to watch the center of the field. When the subject was ready to be exposed for a very short time to the stimulus picture, he pressed a switch that had the effect of turning off the pre-exposure field, turning on the field presenting the picture for 6 milliseconds, turning off the field presenting the picture, and turning on the pre-exposure field again. The switching of the fields was controlled by means of a set of electronic timers that was sufficiently well-synchronized to eliminate any flicker effect. The brightness of the fields was measured by means of a Spectra Brightness Spot Meter, Model UB, and was 4 ft-L.

Procedure

Subjects were instructed concerning the nature of the task. They were told they would see a picture of a common object presented very briefly and that they would have to name the object.

Subjects were seated in a dimly lit room and were instructed to look into the tachistoscope when the experimenter said that everything was ready. They were also instructed to push the switch that triggered the tachistoscope. The latter procedure has been found to be superior to that in which the experimenter triggers the equipment.

Subjects were given one trial with a card before beginning the experimental series. The latter consisted of three presentations of each object at each level of detail. Hence, there were 108 presentations which required about 25 minutes.

Subjects

Subjects were 10 students (5 boys, 5 girls) from a second grade class and 8 students (4 boys, 4 girls) from a fourth grade class at Waylee Elementary School in Portage, Michigan. Thirty-one subjects were derived from undergraduate psychology courses at Western Michigan University. The second grade children had an average age of 7 years 11 months and the fourth grade pupils averaged 10 years 0 months.

Results

Responses for each subject were recorded as either right or wrong. With one exception, the exposure and the drawings were such that the subjects slowly learned to recognize them. The exception was the second grade group presented with the picture of the gun. This group was virtually not able to identify this object under the conditions of the experiment and hence no useful data could be obtained from the presentation of the cards showing this object. For this reason, only the data from the remaining 11 objects are included in the tables for the second grade group. The assumption was made that the second grade group was not sufficiently familiar with the gun to make it comparable to the other objects.

Table 1 shows the mean percentage of drawings correctly identified at each level. The data clearly show that as the number of cues is increased by adding detail to a drawing identifiability increases. Also, the addition of interior detail adds about as much to recognizability as does shading which has the function of providing the illusion of depth. The phenomenon is not related to age for the second grade children show about the same increment as do the adults. There is no evidence from the data that children in the lower elementary grades are more dependent upon cues derived from the outline than are adults.

Table 2 provided the means and standard deviations for the number of correct recognitions for each level of detail used in the drawings. The analyses of variance that follow are based on the data presented in Table 2.

Table 3 provides analyses of variance testing the significance of the main effect, namely, number of cues provided. For all three groups the effect is significant at least at the 5 per cent level of confidence.

Table 1

Percentage of Drawings Recognized

at Each Level of Detail

	Level 1	Level 2	Level 3
Grade 2 (N=12)	40.39	50.24	62.88
Grade 4 (N=8)	62.89	70.14	89.22
Adult (N=31)	39.69	48.56	64.42

Table 2

Means and Standard Deviations for Scores

for Number of Correct Recognitions

at Each Level of Detail

	Level 1		Level 2		Level 3	
	M	SD	M	SD	M	SD
Grade 2 (N=12) (11 pictures)	13.33	6.60	16.58	7.15	20.75	7.74
Grade 4 (N=8) (12 pictures)	22.64	5.26	25.25	5.46	32.12	3.91
Adult (N=31) (12 pictures)	14.29	7.35	17.48	7.85	23.19	7.48

Table 3

Analyses of Variance for Testing the Significance of the Effect of Detail on Recognizability

Second Grade

	SS	df	MS	F
Between Subjects	1,524.9	11		
Within Subjects				
Between Levels of Complexity	331.7	2	165.9	20.6 ($p<.001$)
Residual	176.9	22	8.0	

Fourth Grade

	SS	df	MS	F
Between Subjects	454.7	7		
Within Subjects				
Between Levels of Complexity	385.1	2	192.5	4.85 ($p<.05$)
Residual	555.8	14	39.7	

Adult

	SS	df	MS	F
Between Subjects	4,763.7	30		
Within Subjects				
Between Levels of Complexity	1,261.3	2	630.7	43.1 ($p<.001$)
Residual	878.3	60	14.6	

Discussion

The data have shown that the recognizability of a picture is related to the number of cues present. No evidence could be found supporting the hypothesis that the younger children might be more dependent than the adult on cues related to contour. Indeed, recognizability appears to be very much the same for the children as for the adults. The second grade children and the adults were comparable in their ability to recognize pictorial presentations, except in the case of the one set of pictures of the six shooter that the younger children failed to identify at all, but the fourth graders performed at a slightly higher level than either of the other groups. The significance of latter difference was not tested by means of any statistical test, since it was unexpected and would have been uninterpretable were it found to be significant.

The data support the position that the recognition processes of children in the second grade are closely similar to those of the adult, so long as highly familiar objects are involved. Differences in the perception of pictures between children and adults must probably be sought at age levels lower than those considered in this study. The data of the study suggest in most cases that insofar as illustrations involve familiar objects, the judgments of adults concerning the clarity and recognizability of particular illustrations may well be a sound basis for including them in textbooks. However, one must also point to the fact that the second graders did have difficulty in recognizing one of the objects although the adults had no difficulty in recognizing this object even when only the drawing with minimum cues was presented.

The problems of perceptually structuring unfamiliar materials is a different and much more complex one from that considered here. The adult probably has a more useful repertoire of responses for structuring unfamiliar visual pictorial materials than does the child in the lower elementary grades, who would probably be working at a disadvantage in the perception of such materials. The perception of unfamiliar materials is a difficult problem to explore.

No evidence could be found to support the position that the younger children gain an advantage by being provided with simpler pictures since these do not overload their information capacity. Even with the youngest children in this study, the addition of cues did not produce any symptoms of information overload. On the contrary, the addition of information facilitated perceptual structuring.

CHAPTER 3

RELATIVE VALUE OF REALISTIC AND ABSTRACT ILLUSTRATIONS FOR DEVELOPING A CONCEPT IN NURSERY SCHOOL CHILDREN

Another exploration involved a direct study of the utility of concrete and abstract pictorial materials for teaching young children a simple concept. Although the literature on nursery school education is filled with admonitions to use familiar and concrete materials for instructional purposes, no studies could be found to provide direct support for this position. Considerable indirect evidence is available in such studies as those undertaken in Piaget's laboratory, but a direct test of this principle of teaching seems to be lacking. Perhaps research workers have believed the proposition to be so undeniably true that no experimental test of its validity seemed necessary.

In the study described here, nursery school children were taught the concept of a half by one of two teaching procedures. One procedure involved presenting the child with pictures of fruits and baked goods. Some of the pictures showed the edible object cut in half, but on the others the subject was cut in such a way that one of the pieces was clearly very much larger than the other. The objects in this learning sequence were presented in fairly natural colors in natural sizes on colored backgrounds. The second procedure involved the use of abstract shapes such as squares, triangles, ovals, and so forth, also presented in bright colors on colored backgrounds. In both training programs the range of colors and the size of the objects, either real or abstract, were approximately the same, since color and size might be factors related to learning. Children were trained either on the realistic or the abstract materials.

After training, children were tested for their understanding of the concept. The test consisted of ten pictures of objects and ten pictures of abstract forms, also presented in bright colors. Five of the objects and five of the abstract forms were cut in half and the five of each were cut with one part very much larger than the other part.

Thus training was carried out with either concrete or abstract materials and testing was undertaken with both kinds of material. The design of the experiment permitted a determination of the extent to which training with one kind of material is transferred to situations involving other kinds of material.

From one point of view a more desirable design would have involved testing the children, with the same test, before and after training. This procedure was not used for two reasons. First, a preliminary trial showed that the children lost interest when both a pre- and post-test was used and could not be kept in the testing situation long enough to complete the post-test. Second, the children were not able to score above a chance basis on the pre-test. For these reasons only the post-test was used, but a very quick check was made during the actual study of the children's knowledge of the concept by beginning the procedure by handing the child a scrap of paper with the instructions "Give me a half of it." The typical response was for the child to tear off a small corner. The children, except for a few knowledgeable children who were eliminated, understood the concept of a half to mean any fraction. What the children were taught in the study was that the concept meant a particular fraction.

Method

Materials

The two sets of materials involved in training were mounted on colored construction paper generally about 9 inches by 14 inches in size. The items in each series are described as follows:

Realistic Material	Abstract Material
1. cake (cut in half)	*1. triangle (cut in half)
*2. corn (cut in half)	2. circle (cut in half)
*3. apple (cut in half)	3. triangle (cut in half)
4. hot dog (whole)	4. square (whole)
5. orange (whole)	5. oval (whole)
6. doughnut (cut in half)	*6. oval (cut in half)
*7. lemon (cut in half)	*7. oblong with rounded corners (cut in half)
8. corn (whole)	8. square with concave sides (whole)
*9. grapefruit (cut in half)	*9. elipse (cut in half)

On some of the cards the object or shape was shown in its whole form and also cut in two pieces. The latter are marked with an asterisk. On the other items the object or form was shown only with it cut in some way.

Testing materials, used immediately following the testing session were similar, but all subjects were tested with both abstract and realistic objects. Each card in the 20-item test series consisted of a picture of either a real object or an abstract form, with ten of each of these in the series. Five of each of the abstract and the realistic representations were cut in half and the others were cut in two but with one portion much larger than the other portion. The items were presented in a random order.

No picture in the testing series was identical with any picture in the training series though some of the objects and forms were similar. Thus although the realistic training series and the testing series both contained a picture of a lemon, the object was shown cut in half in the one series, but cut in pieces of different size in the other. A cream pie was shown in the one series and a fruit pie in the other. In some cases the objects involved differed. An onion, for example appeared only in the testing series.

Subjects

Subjects were 100 pupils derived from nursery school classes in Kalamazoo, Michigan. The children covered a wide range of socioeconomic levels, but a majority came from middle-class neighborhoods.

Instructions to subjects

The experimenter spent several hours distributed over two or more days with the children before data collection began. After the children had become familiar with his presence, the teacher arranged for each child to be taken aside in a separate room to "play a game." The child was given the following instructions:

"I am going to show you some pictures. With these pictures I am going to teach you what a HALF means. Can you say that word?

"If I had a whole cake all to myself and you came to see me, I would want you to have as much cake as I have. So I would cut my cake right down the middle and have two pieces. They would look exactly the same and we would have the same amount of cake. Your piece would be called a HALF and my piece would be called a HALF. We would each have HALF a cake.

"Remember now, when I cut something in HALF, that means that I cut it into two pieces that are just the same."

Subjects were shown each picture for about ten seconds during which they were told:

"This picture is (not) cut in half. This is (not) a half. This is (not) a half."

During the testing series the subject was asked whether each picture was or was not cut in half. All responses were recorded as they occurred. No feedback was provided during the testing session. Separate scores were determined for both the realistic and the abstract materials.

Results

The design is that of a repeated measures experiment with two conditions of training, either with realistic or abstract materials, and two achievement measures on each subject -- one measure involving realistic materials and the other abstract materials. The means and the standard deviations summarizing the results are shown in Table 4 which assumes a 2 x 2 form. A particularly interesting feature of the table is that there is a negligible difference between the two training conditions for the means are almost identical. A much larger difference exists between testing conditions for performance with the realistic materials appears to be slightly better than on the abstract.

An analysis of variance of the data is shown in Table 5. The difference between training conditions is negligible as is evident from Table 4. A particularly interesting finding is that, although it makes no difference whether the realistic or abstract materials are used for training purposes, it does make a difference on testing. Children find

Table 4

Means and Standard Deviations for the Two Training Conditions and Two Conditions of Testing

	Realistic Testing Materials B		Abstract Testing Materials B'		Total Achievement Score	
	M	SD	M	SD	M	SD
Realistic Training Materials A	7.40	1.91	6.28	1.83	13.68	3.42
Abstract Training Materials A'	7.10	1.92	6.70	2.05	13.80	3.70

Table 5

Analysis of Variance of Data on Training Conditions and Testing Conditions

	df	SS	MS	F	p
Between Subjects	99	621.62			
Training Conditions	1	0.18	0.18	.03	ns
Subjects within groups	98	621.44	6.34		
Within Subjects	100	143.00			
Testing Conditions	1	28.88	28.88	26.50	<.01
Testing x Training	1	6.48	6.48	5.94	<.05
Testing x Subjects within groups	98	107.64	1.10		

it easier to demonstrate their knowledge of the concept when realistic testing materials are provided. There is also a significant interaction effect brought about mainly by the fact that the best learning is manifested when both the training and the testing materials are realistic. The data in Table 4 suggest the hypothesis that realistic training materials do not provide skills which transfer well to the handling of abstract materials, but that training with abstract materials provides skills that transfer well to the handling of realistic materials. This is another way of interpreting the significant interaction effect.

Discussion

The findings do not conform closely with the pedagogical doctrine that instruction is best undertaken with realistic materials. Indeed, the type of training material used made no overall difference. This finding may be a result of the fact that what we defined as abstract material may not be viewed as abstract by the children. This came out clearly in the case of some of our subjects who talked about the abstract shapes as meaningful things. For example, on being shown the triangle, one child said "That is a house." A child might call the circle a ball and the oval an egg. The children studied demonstrated a substantial knowledge of form, and had obviously abstracted particular forms as attributes of the objects they had observed in their environment. One of the features of being raised in what is called a "carpentered" environment is that it is filled with a wide range of geometrical forms with which a child acquires a familiarity at an early age. In such an environment, the child probably recognizes many geometric forms long before he is able to name them. Children who live in primitive cultures have more difficulty in responding to common geometric form because their environment does not provide them with related experiences. Why particular object attributes become recognized and others remain unrecognized is not well understood at this time. The central point to be stressed is that the teacher or other adult may be a very poor judge of what is or is not abstract material, that is to say material that does or does not represent quite closely some object in the environment.

A second finding of interest is that the children excell when tested with realistic materials, but do not excell on overall performance when trained with realistic materials. Training should probably take place with a diversity of materials if testing is to take place also with a diversity of materials. The use of only realistic materials for training purposes is efficient if the child is to apply his knowledge only to realistic materials similar to those on which training has taken place. Training with a diversity of materials would have advantages in training a child to cope with a world which presented a diversity of problems in which the knowledge acquired was to be applied.

The basic issues in the selection of pictorial materials for training purposes is to obtain materials that are not only closely similar to those they are likely to be encountered but also to provide training with maximum transferability to new and unexpected types of materials. Both of these selection criteria cannot be satisfied at the same time. The one calls for specificity and the other for diversity.

CHAPTER 4

AGE DIFFERENCES IN THE PERCEPTION OF PICTURES

In a previously cited study by Ames and others (1953) some evidence was provided to support the position that younger children tend to structure a selected detail in a complex presentation and typically do not show any sign of responding to the remainder of the display. The latter study used Rorschach ink blots and a search was made of the literature in an attempt to locate a parallel study using drawings or photographs to determine whether a similar phenomenon could be identified with such materials. No such study could be located and, hence, one was planned as a part of the project.

The general plan of the study was to obtain a series of color 5" x 7" photographs of common but fairly complex scenes and to prepare a black-and-white version of each of these pictures. The color version and the black-and-white versions were to be the same in size and presented the same scene. Some difficulty was encountered in meeting this requirement since it involved making a black-and-white negative from a color slide and then making both color and black-and-white prints of comparable sizes that presented objects on the same scale. The density of the pictures also had to be about the same.

The pictures were presented to a subject by means of a tachistoscope.

Method

Materials

The materials consisted of photographs showing the following scenes:

1. A farm scene with a bailing machine in the foreground and farm workers performing various tasks on it.

2. A country scene with a wooded slope in the foreground sloping down to a valley with a lake.

3. Three children modeling clay in a schoolroom.

4. A suburban street scene with a large colonial house in the center and a number of persons walking.

5. A backyard scene with many persons standing and talking and with children and toys in the foreground.

6. A living room scene with an elderly lady reading a book at the center and many articles of furniture in the room.

Equipment

The pictures were presented to the subject by means of a Gerbrands 2-field tachistoscope. Subjects looked into the tachistoscope and saw a field lit as uniformly as the equipment permitted and with an intensity of 2.0 foot lamberts near the center. On pressing a switch, the picture appeared for 0.25 seconds. The white field and the picture were at a distance of 23 inches from the eyes of the subject. The picture had a luminosity near the center of the field that varied from 1.6 to 2.0 foot lamberts. All measures of luminosity were made with a Spectra Brightness Spot Meter, Model UB.

Subjects

Subjects were 12 pupils from each of the grades of nursery school, kindergarten, first grade, third grade, and sixth grade from the University Campus Elementary School at Western Michigan University.

Procedure

The general nature of the experiment was described to the subject who was also told that each picture would be presented ten times for a quarter of a second, and that after each presentation he was to tell what he had seen. The subject was given one trial with a colored picture that was not later used in the experimental trials. The subject was shown each one of the pictures for 10 separate trials, and after each trial the description of the picture given by the subject was recorded.

Each subject was exposed to three black-and-white and three colored pictures. The pictures that were black-and-white with one subject were colorea for the next subject. The pictures were in a different random order for each of the 12 subjects at a particular grade level. The same 12 orders were used at each grade level.

Subjects controlled the switch that caused the picture to flash on for 0.25 sec.

Scoring of Protocols

The records of the 60 children were scored by examining the responses to a particular picture of a sixth grade child, then the responses to the same picture of a fifth grade child and so forth down the grades. Responses to the same picture were then scored for another child beginning at the nursery school and working up to the sixth grade. Through this process of working up and down the grade levels any scorer tendency to change the scoring system with the passage of time was distributed over all grade levels. Frequencies were determined for each one of the following categories:

1. Number of separate objects identified correctly
2. Number of separate objects named but not present
3. Number of instances of motion correctly identified
4. Number of instances of motion named but not present
5. Number of themes correctly mentioned
6. Number of themes mentioned that did not seem to be represented by the picture
7. Number of repetitions
8. Number of references to color

The one category which needs further definition is that of theme. A theme is identified when a person is reported as doing something (as when a person is described as conversing with another or as being at a party, or modeling clay,) or when a scene is described as a place where something might happen (as when a subject says that the place shown in the picture would be a good place for a picnic or a farming area). A theme generally goes beyond the data and requires fairly complex perceptual structuring.

Time requirements on the project did not permit a complete and independent rescoring of all protocols, but a spot check indicated very high reliability of the procedure. Experience with scoring this class of data indicates that high reliability is readily achieved.

Results

Table 6 shows the mean ages of the boys and girls at each of the grade levels. The educational system is such that at least 90 per cent in each group fall within an age range of a year.

Table 7 shows the frequency for each of the scoring categories by grade and divided according to whether the picture was black-and-white or colored. The frequencies for black-and-white and colored generally follow each other very closely, but there is one very important difference. A careful examination of Table 7 shows that the proportion of errors tends to be larger for the black-and-white than for the colored. This is particularly noticeable in the case of the more difficult perceptual tasks such as that involving motion and that involving the production of themes. That this tendency is, almost certainly, more than a fiction can be demonstrated statistically. The latter involves the preparation

Table 6

Mean Age and Distribution By Sex of

Subjects at Each Age Level

Grade	Mean Age Yrs.	Boys - N	Girls - N
6th	10.88	5	7
3rd	7.79	6	6
1st	6.02	6	6
Kind.	4.81	7	5
Nurs.	4.07	6	6

Table 7

Frequency of Responses in Various Categories to All Pictures Classified According to Whether the Responses are Correct or Incorrect and Whether the Pictures were Colored or Black-and-White

Grade		OBJECTS Correct	OBJECTS Incorrect	MOTION Correct	MOTION Incorrect	THEMES Correct	THEMES Incorrect	Repititions	Color
6th	B&W	406	86	30	21	28	8	275	49
	Color	404	89	30	14	34	6	274	66
3rd	B&W	262	137	18	21	20	23	323	25
	Color	275	131	31	14	30	18	356	61
1st	B&W	215	114	17	44	10	18	184	19
	Color	219	109	21	30	17	12	186	47
Kind.	B&W	119	53	6	42	1	7	328	7
	Color	119	55	8	34	5	6	384	9
Nurs.	B&W	85	39	4	19	2	5	303	2
	Color	79	44	2	17	5	3	279	5

of 2 x 2 frequency tables showing the number of correct and incorrect responses to colored and black-and-white pictures taken separately. A 2 x 2 table of this kind can be prepared for the three main categories of objects, motion, and themes, using the frequencies provided in Table 7. These three tables show the phenomenon under discussion very clearly. For each one of the 2 x 2 tables a value for chi square can be computed in order to test our hypothesis. In the case of the frequencies for objects, the value for chi square is virtually zero, indicating that the presence of color has no effect on the frequency with which objects are perceived correctly. In contrast, the frequencies for both motion and themes show a strong effect of color on correctness of recognition. The tables for these categories yield values of chi square of 6.34 and 7.60 respectively. The former is virtually at the .01 level of significance and the latter substantially beyond that level. It seems clear that color makes a substantial contribution to the accuracy of perception and, to some extent, even influences the number of events correctly perceived in the areas of motion and theme. However, object identification, as such, is not influenced by the presence or absence of color.

The main trend in Table 7 is obviously the greatly increased number of responses with age, except in the case of the number of repetitions. It is also evident that some of the very young children tended to repeat the same response again and again to each one of the pictures. A much more significant aspect of the trend in each category can be obtained by studying, not total number of responses, but the number of responses per object mentioned correctly. The data in the latter form are presented in Table 8, but with the responses to all pictures combined.

Table 8

Frequency in Each Category Divided by the Total Number of Objects Correctly Identified at That Particular Grade Level

Grade	OBJECTS Correct	OBJECTS Incorrect	MOTION Correct	MOTION Incorrect	THEMES Correct	THEMES Incorrect	Repititions	Color
6th		.21	.07	.04	.07	.01	.67	.14
3rd		.49	.09	.13	.09	.07	1.26	.16
1st		.51	.08	.17	.06	.06	.85	.15
Kind.		.45	.05	.15	.02	.02	2.99	.06
Nurs.		.50	.03	.10	.04	.04	3.55	.04

Several trends are noticeable in Table 8. One is that the tendency to repeat responses shows a sharp decline. The latter parallels a change with age in the approach shown to the development of the perception of a picture. The youngest children tended to identify a single object in a picture and remain fixated on that object. The older children expanded their perception of the picture with each new presentation.

The perception of motion and themes appears to show a slight trend in development with age, but this trend is much less striking than the trend in the number of repetitions. Even the youngest children seem capable of showing some perceptual responses reflecting movement and some theme response, but their responses tend to be typically object identification responses. Incorrect responses do not show any clear age trend.

Discussion

The present study provides a certain parallel with the Ames et al. (1953) study in which the development of perception of Rorschach materials was studied with children of different ages. An essential difference between the study reported here and the Rorschach study lies in the fact that this study used materials providing unambiguous representations of real situations.

This study, like the Rorschach study, showed that the preschool child generally becomes preoccupied with specific details to which he continues to direct his attention. An additional point in common is that the perception of motion is one of the more difficult representations to perceive. Among nursery school children this is one of the rarer kinds of perceptions in comparison to perceptions of specific static objects.

We did not find, as Ames and her associates found, an increase in accuracy with age, but this difference between the studies may be a result of the differences in materials used. Ours was a quite familiar task, but the interpretation of the Rorschach materials is a highly novel task for young children.

A number of other findings, unrelated to those in the study by Ames et al., are of considerable interest. First there is the matter that color has been demonstrated to facilitate the veridical perception of a picture. In most previous studies of color, little evidence has been found to support the commonly held idea that color facilitates perception. The evidence here demonstrates quite clearly that color may facilitate the complex perception of common visual materials. This is probably the first evidence supporting the use of color in textbook illustrations. Most previous research has come out with the conclusion that color is useful only when the color has significance, as in teaching children the names of different fruits and what they look like.

Another finding of interest is that the young children seemed unable to shake themselves loose from the particular aspect of the picture which they managed to structure on their initial perception. One presumes that the initial perception involves a sampling procedure and that the particular object identified represents the sample of stimuli taken from the vast array presented. In the case of the older children, each presentation of the picture would seem to involve the subject receiving a new sample of information, but the younger children tend to keep on receiving the same sample and, hence, name the same object time after time. Some of the older subjects would sometimes say after the presentation of a picture "I did not see anything new that time," implying that the information sampled was the same as that on previous occasions. The differences that accompany age, in this respect, can be understood in terms of stimulus sampling theory and differences in the sampling process at each age level.

CHAPTER 5

CONCLUSIONS, IMPLICATIONS, AND NEXT STEPS

The studies presented lead to three main conclusions. The first is that the recognizability of a picture is related to the number of cues provided. The greater the number of cues the greater is the ease with which it is recognized. Perhaps this finding suggests a reason for the commonly found preference for realistic rather than stylized pictures. The latter generally provide fewer cues than the former and, hence, are less readily recognized. Individuals generally prefer to work with situations in which clear perceptions can be readily achieved. Realistic pictures provide a high degree of redundancy of cues and are, for this reason, more easily handled by the perceiver. Redundancy of cues appears to provide considerable advantages to the percipient.

Although knowledge in the area under discussion fits together extremely well, it does not seem to have been either considered or applied by those who prepare illustrations for school materials. Nursery school representations of animals are still typically sketched in rough outline form, when they should probably be highly realistic. Books read to children in kindergarten commonly use a form of illustration similar to the cartoon. The first grade reader typically shows stylized forms of illustrations, perhaps because these are consistent with a cheap form of printing. Realistic pictorial representations are rarely found in the educational materials for the age levels at which such presentations would appear to have particular value.

Related to this problem is the matter of the relative educational value of realistic pictures and the actual three-dimensional objects they represent. These two forms of materials do not provide the same information, except perhaps where the actual object is presented from only one viewing position and is seen with only one eye. When the latter restriction is removed, as it is in practically all educational settings, then the three dimensional display provides information that is not available in the corresponding picture.

A second finding of some interest is derived in the second of the three studies. The finding is that, within the framework of the experimental design, the nursery children taught the concept of a half using abstract materials performed about as well as those trained with materials representing real objects. Perhaps what has been learned from this finding is that what one judges to be abstract for a child four years of age may not be abstract at all. For such a child, a round shape may represent a plate, a square may represent a table, and so forth. However, the best training effect was found when the child was trained with realistic materials and then was tested with realistic materials. The old adage that learning should focus on the concrete rather than on the abstract receives some weak support, but what is concrete and what is abstract for a four year-old is not entirely clear.

A third and interesting finding that emerges from the final study in the series is that the more complex perceptual functions, such as the perception of movement or the perception of a theme, is greatly facilitated through the use of color. What this suggests is that redundancy of information, although shown in other studies to facilitate perception at a simple level, becomes particularly important when complex perceptual processes are involved. The perception of movement or a theme generally requires the subject to respond to a greater number of cues than does mere object identification. This leads to the hypothesis that needs to be tested in a subsequent study that stylized pictures, since then tend to provide only minimal cues, might provide a situation in which young children could not readily perceive either motion or a theme, but that realistic pictures, designed to provide a great amount of redundancy of information might well provide an optimum situation for these complex perceptions to occur.

In studying illustrative materials in children's textbooks during the course of the project, the investigators have been impressed with the fact that a very large percentage of illustrations designed to inform can do so only if the percipient sees them as representing an ongoing scene. Illustrations of the anatomy and morphology of organisms are notable exceptions to this, but the illustration typically has instructional significance only if the learner perceives it as representing an ongoing situation. The learner has to understand what happened before the moment shown in the picture, in order to understand the picture, and he also has to know what is going to happen next. The simplest case of this kind is the perception of movement. The latter can be recognized only by a percipient who appreciates that the picture tells him about what has just happened and what is going to happen next.

The cues that are involved in the perception of motion and change need to be identified, and this may form the focus of subsequent research. The cues fall into two categories. First, there are contrived conventions such as drawing a wake to a moving object such as a ball. The usefulness of such cues needs to be studied, particularly with young children who may well have not yet learned the conventions involved. Second, there are cues derived from the physical form of the picture which, in some way, provides a sensory impression similar to that produced by actual motion and change. For example, stationary objects probably provide a much more precise and well-defined retinal image than do moving objects which provide what may be described as a smeared image in the retina. Thus in portraying a person running, the artist may show the foot in contact with the ground as a clearly drawn object, but the foot that is moving rapidly forward may be drawn as if it were smeared. Another way of indicating change is to draw a situation that cannot remain static. For example, consider an illustration of Galileo who has just released the weights from the top of the Tower of Pisa. It is clear to the viewer that the weights cannot remain suspended in mid air. If the scene is to continue, then something has to happen. Many situations in illustrations are impossible as static representations and, hence, have to be interpreted as a part of an ongoing event.

A final comment needs to be made on the overwhelming size of the problems that have been sketchily studied in the course of this very limited study. The present writer is convinced that the kind of knowledge needed, that will lead to the improved design of illustrations, cannot be derived from a project built on one or more small grants. What is needed here is a concentrated attack by teams of psychologists, illustrators and photographers. Such an enterprise will be expensive, but it will almost certainly lead to great improvement in the design of pictorial materials for instructional purposes. A large scale project of the latter kind might best start out in quite a small way and expand as researchable problems are slowly identified. When the present project was initiated, the writer was hard-up to find areas where research on illustrations could be readily undertaken, but after working for sixteen months in the area the number of identified research problems has not become very large. There is even some basis now for conducting analytic studies of illustrations at present used in school materials, for even our present limited knowledge is sufficient for identifying some of the very common deficiencies that such illustrations manifest. There might even be virtue in interviewing some highly competent illustrators to find out how they think they go about communicating highly dynamic situations through a static picture. Such interviews might be valuable in suggesting what problems of pictorial communication might be explored profitably.

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