DESIGN OF LEARNING ENVIRONMENTS FOR INFANTS

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This paper describes a product-design program intended to enhance infant learning through appropriate environmental modifications. A data system was designed to allow translation of information about infant behavior into non-technical language. Seven thousand still photographs of infants were obtained to provide visual documentation of the principal behaviors referred to in the data system. Textual information and still photographs were then combined to develop a series of maps showing the progress of behavior development in infants. A series of three-dimensional materials was designed for inclusion in the immediate physical environment of infants under one year of age. Three-dimensional materials were tested and modified until they successfully elicited and sustained a broad range of exploratory behaviors. In addition to increasing opportunities for infant learning, competent play materials allow infant caretakers to understand more fully the behaviors infants are capable of, and the environmental conditions which elicit and sustain these behaviors.

Introduction

The first year of life is characterized by major and fast-moving changes in physical growth and behavior. Body weight triples by the end of the first year, and brain weight doubles within the first six months. Reflex grasping gives way to voluntary reaching, holding, and careful manipulation and examination of small objects held between the extended fingers. Visual discrimination of light and dark proceeds to discrimination of complex visual patterns, including human faces. Body movements proceed from the ability to thrust arms and legs and lift the head and chest through turning, crawling and creeping, sitting, standing, and walking. The ability to discriminate loud sounds proceeds to accurate discrimination of most of the soft sounds that are recurrent in the environment, including complex patterns of adult speech. Vocalization proceeds from crying through mastery of most of the vowel and consonant sounds of spoken language and the emergence of an early vocabulary of names (Illingworth & Illingworth, 1972).

The most prominent activity of the awake infant is exploration of the physical and social environment (Haliday, 1968; Welker, 1961). Although exploratory and play behaviors do not have to be taught, their appearance does depend upon an appropriately supporting social environment and the availability of meaningful information (Ainsworth & Bell, 1970; Caldwell, 1971; Hartley, et al., 1971; Herron & Sutton-Smith, 1971; Lowenfeld, 1967; McLellan, 1970; Millar, 1971; Piaget, 1962; Piers, 1972; Reichardt, 1969; Rutter, 1972; Schaefer, 1970; Weikert & Lambie, 1970; Winnicott, 1971). These generalizations hold true throughout the human life cycle -- but they assume a particular character and significance in infancy.

Human infants, like the young of many species, become attached to one or more principal adult caretakers during the first year of life. This process of attachment is facilitated by visual contact, smiling, crying, grasping, and other close physical contact (Ainsworth & Bell, 1970). When the attachment process occurs in a normal way, infants become increasingly bolder and more far-ranging in exploring the surrounding physical environment (Rheingold & Eckerman, 1970). These explorations are facilitated by behaviors that help infants relate to objects. These behaviors grow in number and complexity throughout the first year of life (Uzgiris, 1967).

During the first three months, infants relate to objects through visual inspection, holding, and mouthing. Hitting and shaking movements are common during the next three months. During the same time, infants show more sustained and careful visual examination of objects. From six to nine months, dropping and throwing are common as well as complex movements of the hands and fingers, including pulling, tearing, sliding, squeezing, rubbing, and pushing. During the last three months of the first year of life, many behaviors appear in imitation of adult models, usually accompanied by the social reinforcement of adult vocalization, smiling, and physical contact. It is at this age that children will

imitate the movements of rolling a car on a flat surface or placing a string of beads around the neck or over the wrist. Increasing sensitivity to social reinforcement is further demonstrated by naming objects and showing them to others (Uzgiris, 1967).

As these behaviors first emerge, they are applied rather indiscriminately to a wide range of objects. As time passes, each behavior is used in a more selective way and becomes combined with other behaviors in a manner appropriate to the exploration of specific objects (Uzgiris, 1967).

The infant's explorations are facilitated by the vocalizations, smiles, direct physical contact, and other reinforcing behaviors of caretakers. It is in the context of these social influences that new ways of relating to objects begin to appear toward the end of the first year (Gordon, 1970; Honig & Lally, 1972; Uzgiris, 1967). A small truck, previously shaken, thrown, and dropped, will now be rolled along a flat surface in direct imitation of the behavior of an adult. In the same way, a string of beads will now be placed around the wrist or neck as a bracelet or necklace.

The availability of objects appropriate to the sequential exploratory behaviors of infants may play an important role in the development of the organization of thinking and understanding -- such as the understanding of cause and effect relationships, and object permanence (Sutton-Smith, 1973; Watson & Ramey, 1972; Uzgiris, 1967). How can our understanding of infant behavior be used to design more competent infant learning environments? This is the question that will engage us through most of the discussion to follow.

Problem

Information about infant behavior is dispersed through the technical literatures of many specialty fields, principally Developmental Psychology, Early Childhood Education, and Pediatrics. Each of these fields makes use of a number of separate technical languages to describe human behavior development. Review of these technical literatures is additionally complicated by the frequent intermingling of complex theories with simple observations. As a result, it is difficult to survey and inventory the existing high-quality information about human behavior development. This is true even for experts in one of the principal fields concerned with the study of human behavior. The difficulty is far greater for the environmental designer who has not been trained in the behavioral sciences.

The availability of good bibliographies and libraries does not really solve our problem. These resources are of real value to the student of environmental design. They are of far less value to the design practitioner. Enormous amounts of time are required to review complex technical literatures, and it is unrealistic to expect that such time is available to practicing designers. Even when it is possible to review complex technical literatures in the behavioral sciences, the

designer is often still quite uncertain how the information reviewed might best be incorporated in the design decision making process. Most designers have not had the opportunity to obtain practical experience in the direct observation of human behavior under appropriate supervision, but a full appreciation of the topography of human behavior is not possible without such practical training.

Thus far, we have limited ourselves to a consideration of problems that surround the incorporation of information about behavior into the design decision making process (Derman, 1973; Lindheim, et al., 1972; Royal College of Art, n.d.). However, comparable problems surround the assessment of the effectiveness of the designer's efforts. Once we have inventoried the existing high-quality information about human behavior development; coupled that information with the development of skills in the direct observation of the behavior of infants; and translated the whole of this education into a series of design statements, how do we know whether we have made a constructive contribution to the lives of infants and their caretakers?

Current Environmental Design Practices

The design, production, and distribution of play materials constitute a major industry. In 1973 retail toy sales in the United States equalled $4.2 billion (TOYS, 1974). Each year, approximately five thousand new toy products appear in the United States. In spite of this enormous amount of design activity, relatively little information about the behavior of infants and children directly influences the design of play materials. Many pieces of play material perform quite well in spite of this because they have evolved over long periods of time and have been tested by many people in a great variety of settings. No single designer is responsible for making blocks or sand-water tables available to young children. Individual designers occasionally make valuable modifications in these materials. But these materials are abundant because they have been found to be so interesting to young children. We are describing an evolutionary process of vernacular design in which broad support develops for the use of certain kinds of play materials because they work so well. In addition, cultures maintain some constancy in the design of play materials as a means of introducing new generations to traditional styles of play behavior. Nesting eggs are available in the Soviet Union, shadow puppets in Indonesia, and brightly-painted wooden horses in Sweden as they have been for generations (Fraser, 1972). Deliberate efforts at innovation in the design of play materials can be found in contemporary cultures that are characterized by a deep appreciation of design quality. Many contemporary play materials from Scandinavia and England demonstrate ingenious use of structure and materials and achieve a high level of esthetic achievement.

During the past five years there has been increased interest in toy product safety. The Toy Manufacturers of America has been drafting voluntary toy product safety guidelines (Safety standard for toys, 1974), and the Consumer Product Safety Commission has been gathering information

from hospitals throughout the country about product-related injuries, including toys (Banned products; NEISS News). Offending products have been identified and recalled, and new and improved product safety codes have been written and made available to manufacturers. This represents admirable progress in the improvement of safety standards for toy product design and manufacture, and is a most welcome supplement to the efforts to improve the esthetic quality of play materials. But what can be said about the value of play materials in the lives of children and their caretakers? Is it possible through appropriate use of information from the behavioral sciences to design play materials that increase opportunities for learning? Most manufacturers of play materials make minimal if any investment in behavioral research either as part of the initial design effort, or as part of the process by which the products are evaluated. Even the best contemporary catalogs of play materials provide the reader with very little information about the different ways in which play materials can be used, or what these materials can be expected to contribute to the experience of children.

Environmental Analysis and Environmental Design

Our efforts to design play materials are organized around an interest in supporting processes of normal behavior development in infants. To this end we require that each piece of play/learning material attract the attention and sustain the interest of large numbers of infants. We attempt to elicit and support as many behavioral responses as possible, and look for evidence that the materials continue to be of interest and use over long periods of time. Hazards to safety are minimized, and a simplicity of design is sought in order that caretakers might better understand the characteristics of the materials that are responsible for the interest shown by infants. In addition, simplicity in design can encourage innovation and improvisation in the use of materials by both infants and their caretakers.

We begin the design process by surveying the technical literature on behavior development in infancy. We have designed a specialized information system to make this easier, and that system has been described in some detail previously [Chase, et. al., 1973; Chase, in press (a); Chase, in press (b)]. In brief, we have developed a specialized library of approximately 1,500 books, 2,000 journals, and 6,500 documents covering the following major categories: child care, growth and development, pediatrics, developmental psychology, early childhood education, play, toys and materials, and environmental design. As the literature in the library is reviewed, modules of information that have relevance for the design of play/learning materials are recorded on 5 x 8 filing cards that are coded for specific behaviors and the age range for which the information on the card is relevant. The information modules are written in non-technical language as much as possible.

The specialized data system was designed to overcome some of the problems discussed earlier in this paper concerning the utilization of information from the behavioral sciences in the design process. Only high-quality

information is transferred from the technical literature to cards. Statements on the cards are written in non-technical language. It is easy to search through the cards according to the age ranges and behaviors relevant to the designer's problem.

We do not restrict our information about infant behavior to the review of the technical literature about behavior development (Figure 1). In addition, we have carefully studied three-dimensional materials utilized by pediatricians and psychologists to assess the developmental progress of infants. We have developed a library of play materials in widespread use. Lists of materials recommended by parents, teachers, and other caretakers have been carefully studied and have been complemented by the ideas generated by our own research staff. Information about infant behavior is then used to generate a preliminary plan for an object intended to elicit and facilitate specific behaviors. This early prototype is subjected to technical merit reviews by project staff members and consultants, and the prototype is revised as a function of criticisms received. The revised prototype is then evaluated with infants in a variety of home and institutional settings. The ways in which infants and their caretakers respond to the materials is documented through the use of questionnaires, videotape, and still photography. These field evaluations suggest additional revisions, and these revisions lead to additional field evaluations (Figure 1). When, at last, the prototype is performing according to intent, information is developed about the ways in which it might best be used so that caretakers who know nothing about design can quickly orient themselves to the material and determine whether they feel it is of interest to them and to their infants.

We convey this information by using clusters of photographs showing different infants playing with the same piece of material. The infants are grouped according to age. The result is a set of models of ways in which the material might be used by an individual caretaker, and ways in which infants might respond. There is no rigid single plan for use, neither is there any rigid set of expectations about how an infant should respond. This manner of providing information allows caretakers considerable latitude in deciding how to use a piece of material.

A survey of some of the play/learning materials that we have designed provides a clearer view of the way in which information about infant behavior has influenced our design work.

1. Red Ring

Red rings about 5 to 6 inches in diameter have been used for many years to test infant behavior development. Infants even a few weeks of age will follow the ring with their eyes as it moves slowly by them. At later ages they will reach for the ring and grasp it with one hand; manipulate the ring with both hands; manipulate the ring and the string

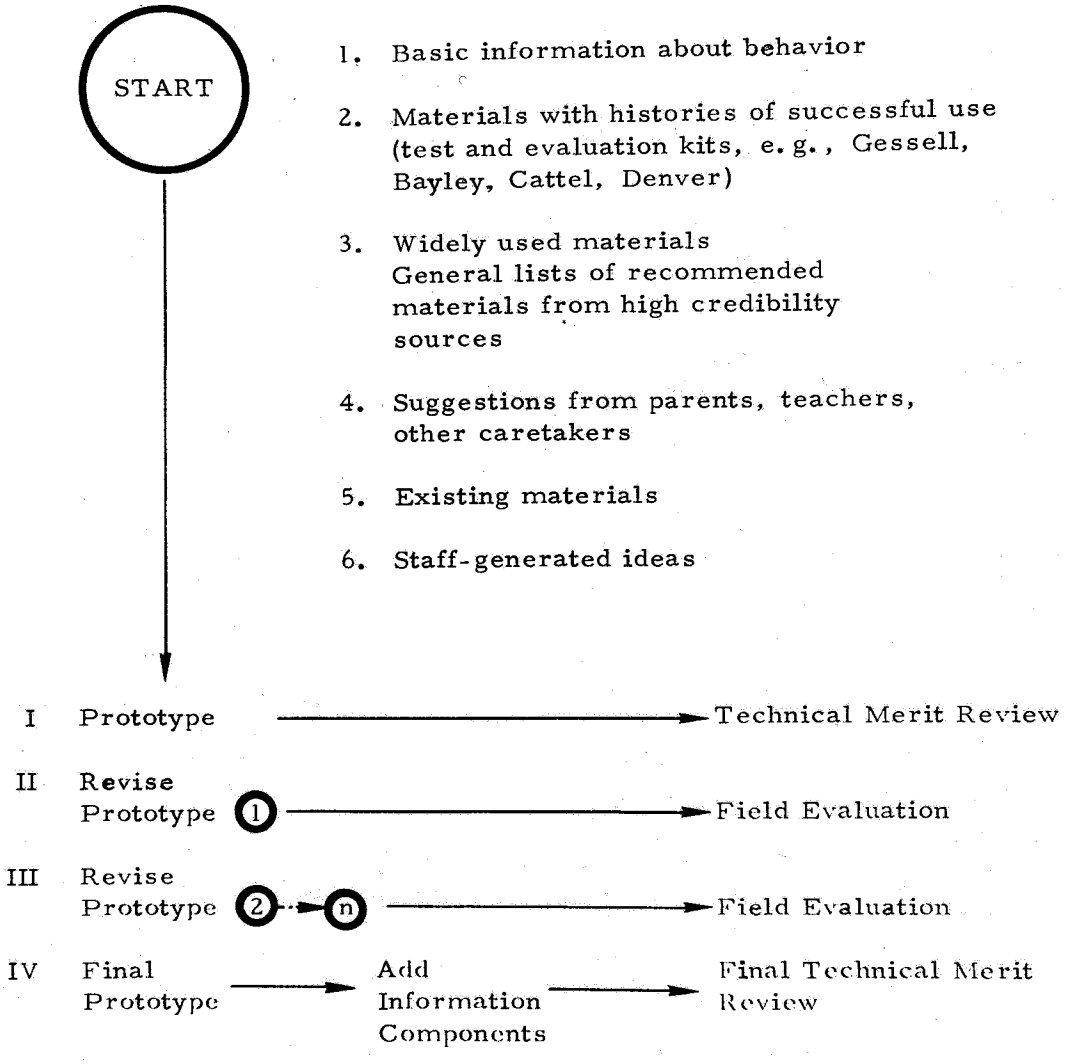


Figure 1. Flow chart of procedures used in the design of infant play/learning materials.

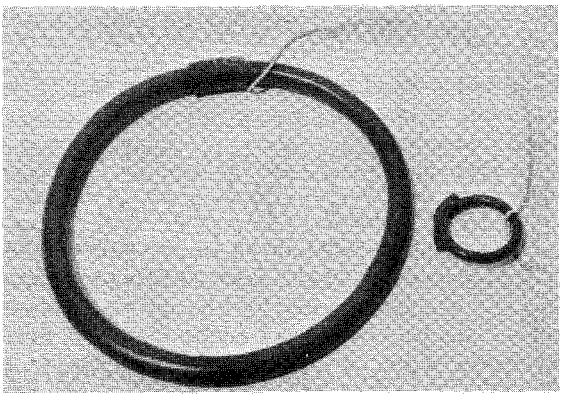


Figure 2. Ring made of red vinyl tubing, with elastic cord attached.

with finely coordinated movements of the fingers; and retrieve the ring by pulling on the string. We have introduced a number of modifications to the rigid plastic and wooden rings which increase the amount and variety of behavior shown by infants. Our ring is made of flexible red vinyl tubing with an elastic cord attached (Figure 2). The pulling, tearing, rubbing, squeezing, and pushing movements of fingers and hands that are so prominent after six months result in different responses from the material. This is a direct function of the flexibility of the material. As a result, infants demonstrate a wider range of behaviors over longer periods of time than we observe in the case of rigid rings of comparable size, shape, and color.

2. Stick and Rings

The stick and rings shown in Figure 3 represent a simple modification of a ring toss set. The stick and rings are made of light-weight, semi-rigid plastic. These materials are examined by increasingly deliberate and coordinated movements of eyes and hands. They are mouthed, shaken, banged, thrown, and dropped. We deliberately designed the stick without a permanently-attached base so that caretakers would be encouraged to hold the stick and demonstrate ways in which the stick and the rings might be related. For example, the caretakers might demonstrate how the rings can be placed over the

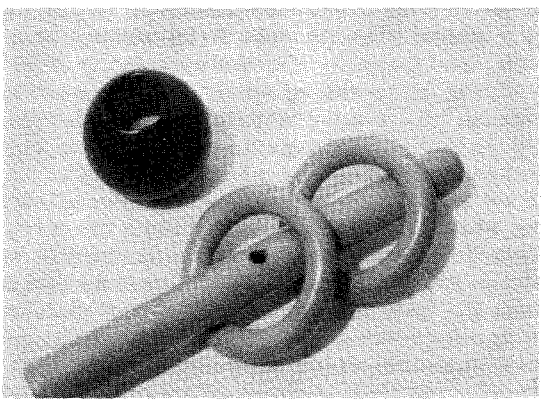


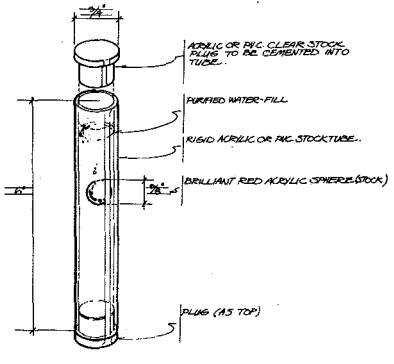
Figure 3. Stick and rings. The round object in the upper left is a weighted sphere that may be used to hold the stick in an upright position.

stick or how the stick might be used to spin the rings on the floor. These are behaviors that are very unlikely to occur as a result of an infant's individual exploratory behavior. However, toward the end of the first year of life, these behaviors will be imitated when appropriate models are provided. In this case we were not simply thinking about the behavior of the infant, but the behavior of the caretakers upon whom the infant is so dependent. The materials were designed to bias the socio-physical environment in a way that would encourage the acquisition of new behaviors. We finally did add a base for the stick, but the base is a weighted, rounded sphere with a hole that allows the infant to stack the rings on the stick without adult support.

3. Tracking Tube

During the early months of life, infants look for prolonged periods of time at lights, simple patterns with high-contrast edge features, and slowly moving objects. If objects are moved past the infant's eyes too rapidly, visual pursuit is not possible, and the infant loses interest in those objects very quickly. We designed a piece of

material that would allow caretakers to learn more about the visual tracking behavior of infants while, at the same time, providing infants with additional features of the visual environment of interest to them. We started by filling a clear plastic tube with water, inserting colored plastic objects, and capping the ends of the tubes (Figure 4). When this tube is gently tipped, the plastic objects move slowly from one end to another because their movement is impeded by the water through which they are passing. We experimented with a variety of sizes of tubing and sizes and colors of plastic objects. A single red plastic sphere of at least 3/8 inch diameter proved to be highly effective in eliciting visual attention and visual tracking from infants even a few weeks of age. The red color contrasts with the light colors of walls and ceilings. Most caretakers quickly learned how to position and tip the tube so that the infant would notice and follow the slowly moving red ball. The prolonged attention demonstrated by infants was an obvious source of satisfaction to caretakers as evidenced by smiling and vocalization. At later ages infants can manipulate the tracking tube independently and thereby control the movement of the ball they are inspecting. The addition of opaque rubber balls at each end of the tube permits the object



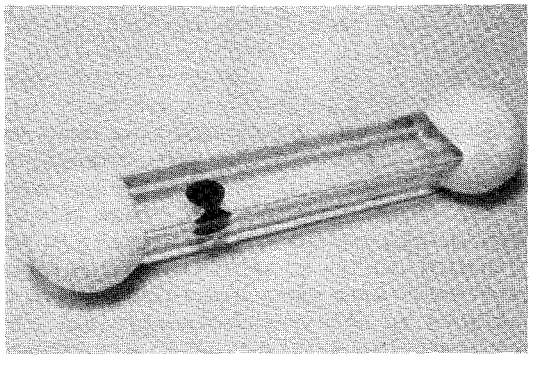


Figure 4. Visual tracking tube. The body of the tube is made of translucent plastic filled with water. The wall varies in thickness so that reflected and magnified images of the red ball in the water-filled center are obtained by manipulation of the tube. The round ends are opaque allowing the red ball to "disappear" and "reappear" as the tube is tilted.

to be rolled, banged, and dropped (Figure 4). In addition, this modification allows the red ball to disappear and reappear as the tube is tipped. Some psychologists feel that this capability promotes the learning of the concept of object permanence. Provision of a non-uniform wall thickness for the tube allows reflected and magnified images of the red ball to be produced by manipulation of the tube. This feature provides additional reinforcement of close inspection with eyes and hands.

4. Mylar Discs

The full range of hand and finger movements that infants are capable of can only be observed if flexible materials requiring little power for manipulation are readily available. Most of the so-called "clutch balls" sold for use by infants do not have these properties, and are of relatively little interest and use to infants under six months of age. Sheets of paper, plastic, and rubber do have these properties, and we have examined the way in which infants of varying ages play with a wide variety of such materials. We found that sheets of materials with rubber-like qualities did not elicit the range of hand and finger movements that can be obtained when sheets of paper are used. It occurred to us that the sounds made by handling paper might play an important role in maintaining the infant's behavior. We therefore experimented with a variety of paper materials that varied in their sound-making qualities. Materials that produce sharp, clear sounds were handled in more ways and for longer periods of time than comparable materials that produce less distinct and more muted sounds. Infants engage in visual inspection of many of the materials they manipulate and it seemed to us that materials with reflective qualities in addition to sound-making qualities were manipulated for the longest periods of time. These observations and inferences led us to select metallized mylar discs for the purpose of eliciting and sustaining prolonged episodes of arm, hand and finger movements involving pulling, rubbing, squeezing, pushing, patting, and so forth. They can be easily deformed by infants, and each change in shape is associated with complex reflection patterns of light, and sharp "crinkly" sounds. This appears to be an ideal combination of properties. The result is more sustained use by infants than any other paper-like material we have studied.

5. Kits of Play/Learning Materials for Infants

Many of the play/learning materials we have designed for infants are, like the cases described above, quite simple in form. Utilization of information about infant behavior coupled with the direct observation of the ways in which infants make use of prototype materials allow considerable economy in design. Materials designed in this way are more effective in eliciting behavior from infants, and they are generally easier to manufacture as well. Most infant caretakers are impressed by the way in which a carefully-designed piece of material can engage the attention and sustained exploration of infants. The simplicity of

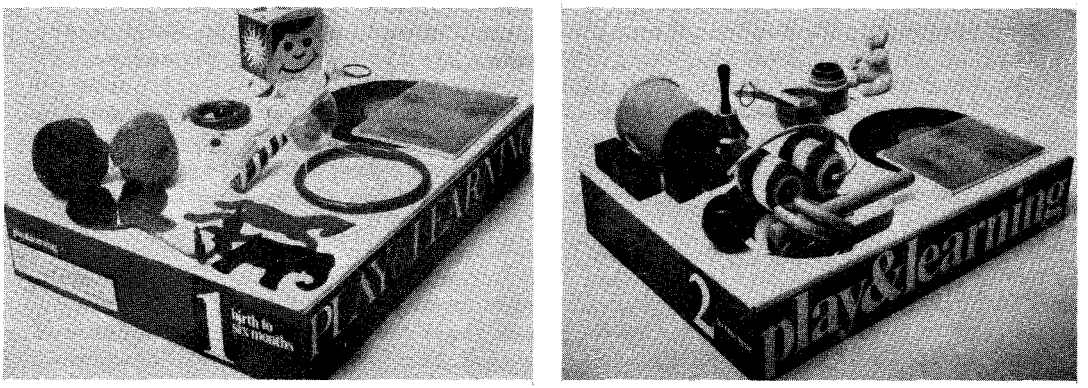


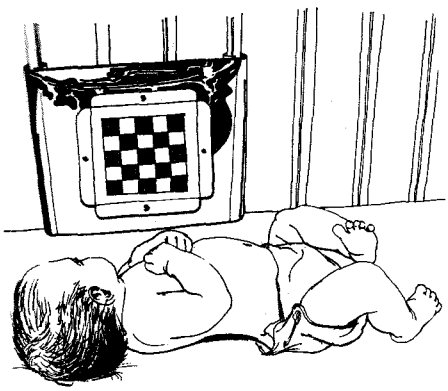
Figure 5. Kits of play materials for infants under one year of age. Accompanying records and books provide information about ways in which the materials might best be used.

the materials allows them to draw their own inferences about the properties of the physical environment that are of most interest to infants. However, they often need an introduction to the ways in which materials might best be used. The simplicity of our materials seems to make this requirement even more urgent. For this reason, we have grouped individual pieces of infant play/learning materials into kits also containing records and books that orient caretakers to the ways in which these materials might be used most effectively with infants of varying ages (Figure 5).

6. Soft-cube and Visual Display System

This case will be somewhat more detailed than those we have already reviewed. It will also allow a clearer view of the way in which information from the technical literature on infant behavior and information derived from the use of prototypes dictate continuing changes in the form of designed play/learning materials.

There is a very sizable literature concerning the properties of the visual environment that are of interest to young infants. Infants as young as a few weeks of age will stare intensively at simple patterns with high-contrast features, like black and white checkerboard and bullseye patterns (Frantz & Nervis, 1967). This observation has been made by many investigators, and we have been able to confirm it quite regularly also. We have made this kind of visual experience available to large numbers of infants by designing a simple piece of hardware that allows visual patterns to be attached to the crib side (Figure 6). The visual pattern cards which can be attached to the crib-side frame were designed in pairs so that they could be easily joined to form a cube. At two to three months, infants are looking straight up



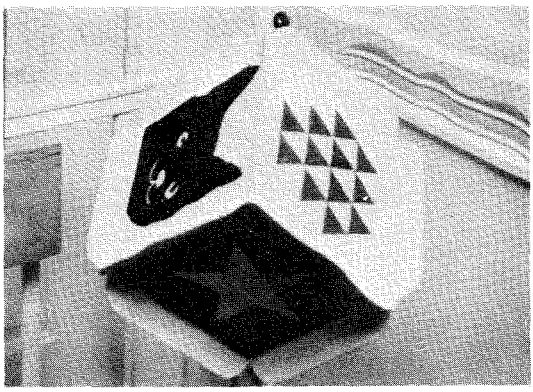


Figure 6. The drawing to the left shows a three-week old infant looking at a black and white checkerboard pattern. The visual pattern card is snapped onto a plastic frame with scrolled edges that allow easy attachment to vertical crib rails. High-contrast edge features are also found in the visual patterns screened on the side panels of the fabric-covered cube suspended over the crib in the right-hand photograph. Flaps are available on each edge so that infants can easily grasp the cube. An elastic cord is used to suspend the cube from the crib clamp so that hand contact will produce movement of the cube.

at the ceiling a good deal of the time. The visual-display cube should be suspended above the crib at that time. This not only results in information of visual interest located where it is most likely to be observed--it is also an addition to the physical environment that facilitates visually-directed arm and hand contact (White & Held, 1967, White et al., 1967). We suspend our visual-display cube by an elastic cord so that hand contact results in movement of the cube. This proves to be a powerful way to increase the extent of visually-directed contact, including reaching and grasping. A flap was provided around each edge of the cube to make it easier to grasp. We used a variety of paper materials in our early experiments with visual display panels and cubes. They did not stand up well under continued use, and the sharp edges of the cube constituted a safety hazard. We therefore decided to make the cube by covering a block of foam with fabric (Figure 6). A clamp was designed to allow the cube to be suspended above the crib, and a bell was added to the center of the foam block so that when infants touch the cube it would not only move, but make a sound as well. The graphic designs on each surface of the cube were revised to include more colors and some representational forms without losing simplicity of pattern and high-contrast edge features. We found that infants a few months of age had difficulty manipulating a cube as large as the ones that were most enjoyable to infants five months and older. We therefore decided to make a small cube (about 3 inches on each side) (Figure 7) as well as a large cube (approximately 6 inches on each side). The important

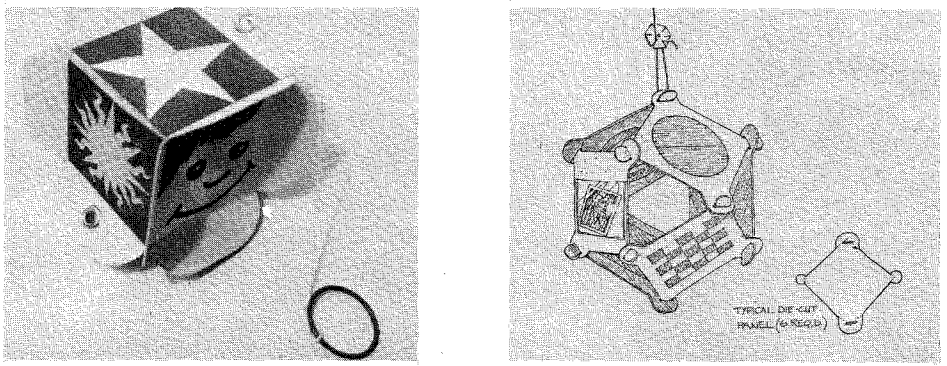


Figure 7. A smaller version of the fabric-covered foam cube is shown in the photograph to the left. Simple patterns with high-contrast edge features are screened on each panel. This block is small enough and light enough to be manipulable by infants a few months of age. Simple visual patterns with high-contrast edge features have been incorporated in the die-cut plastic-paper mobile shown on the right.

visual properties of the cubes have been incorporated into a lower-cost, die-cut version made out of plastic-coated paper (Figure 7). The original crib-side panels have been revised. We now have three frames that are easily attached to the side of the crib. One is made of metallized mylar, the other has a vinyl pocket into which visual-pattern cards can be placed, and the third has a vinyl pocket that holds a variety of textured materials.

We have described some of our work on the design of visual display panels and cubes for infants in previous publications [Chase, et al., 1973; Chase, in press (a); Chase, in press (b)]. These efforts have spanned a five year period, and it is interesting to see how the continued flow of information that comes to us through reading about visual perception in infants and use of our prototypes by infants and caretakers produce a continuous flow of ideas about new and better ways of designing these play/learning materials.

7. Space Frames

This case contrasts sharply with the last. It involves behaviors that we know far less about and designed materials that are in a much more preliminary state than the visual display system materials. This case began with observations on the ways in which structures help infants to pull themselves to a standing position and to walk before they are able to stand and walk by themselves. Many such materials are available commercially, but we were interested in designing something

simpler and more versatile. At one stage in our work we observed the way in which a nine and one-half month old infant made use of a square frame made of two-foot lengths of plastic pipe (Figure 8). This particular structure was too light to give adequate support, and the infant stepped on the frame in ways that often interfered with walking. Nonetheless, it generated considerable interest. The infant explored it in a great variety of ways and seemed to relate to the space defined by the structure as well as the physical components of the structure itself. The infant spent a good deal of time within the frame, even when he was not manipulating the frame itself, and he seemed to relate to objects near the frame without abandoning his physical commitment to the space defined by the frame. Although these observations are limited to a single infant, they are provocative nonetheless, and encouraged us to amplify our efforts to design space-frame systems that could be tested with larger numbers of infants and young children (Figures 9 and 10).

Infant Learning and the Nature of Early Experience

Learning environments for infants reflect the understanding and sensitivity of caretakers and societies. Infant care and education programs must be able to influence the behavior of caretakers before they can influence the behavior of infants. Infant caretakers can function more competently if they know the basic facts about how human behavior changes over time; those aspects of the social and physical environment that attract the infant's attention and interest; and the ways in which infants communicate attention, interest, and need. These issues focus our attention on caretaker education, and the crucial role of information in the caretaker education process [Chase, in press (b); Honig & Lally, 1972].

We have examined the kinds and amount of information about infant behavior presently available to caretakers in much the same way as we have studied the play/learning materials that are presently available for infants, and we have designed new ways of transmitting information about infant development in the same way that we have experimented with new ways of designing play/learning materials. We have used still photographs to illustrate several hundred facts about infant development during the first year of life [Chase, in press (a)]. Clusters of photographs with brief caption texts are arranged on a map four feet long and three feet high. Separate horizontal portions are assigned to each of the following topics: "seeing," "hearing and language," "making sounds and language," "moving," and "touching and holding." In addition, there are two portions assigned to more complex behaviors and groups of behaviors: "things babies do," and "play." Looking at the map from left to right along any of these horizontal portions reveals the way in which the behaviors in that section change as the infant matures. The map has been designed with a great many features intended to promote an interactive relationship with caretakers. There are many places for parents to place photographs

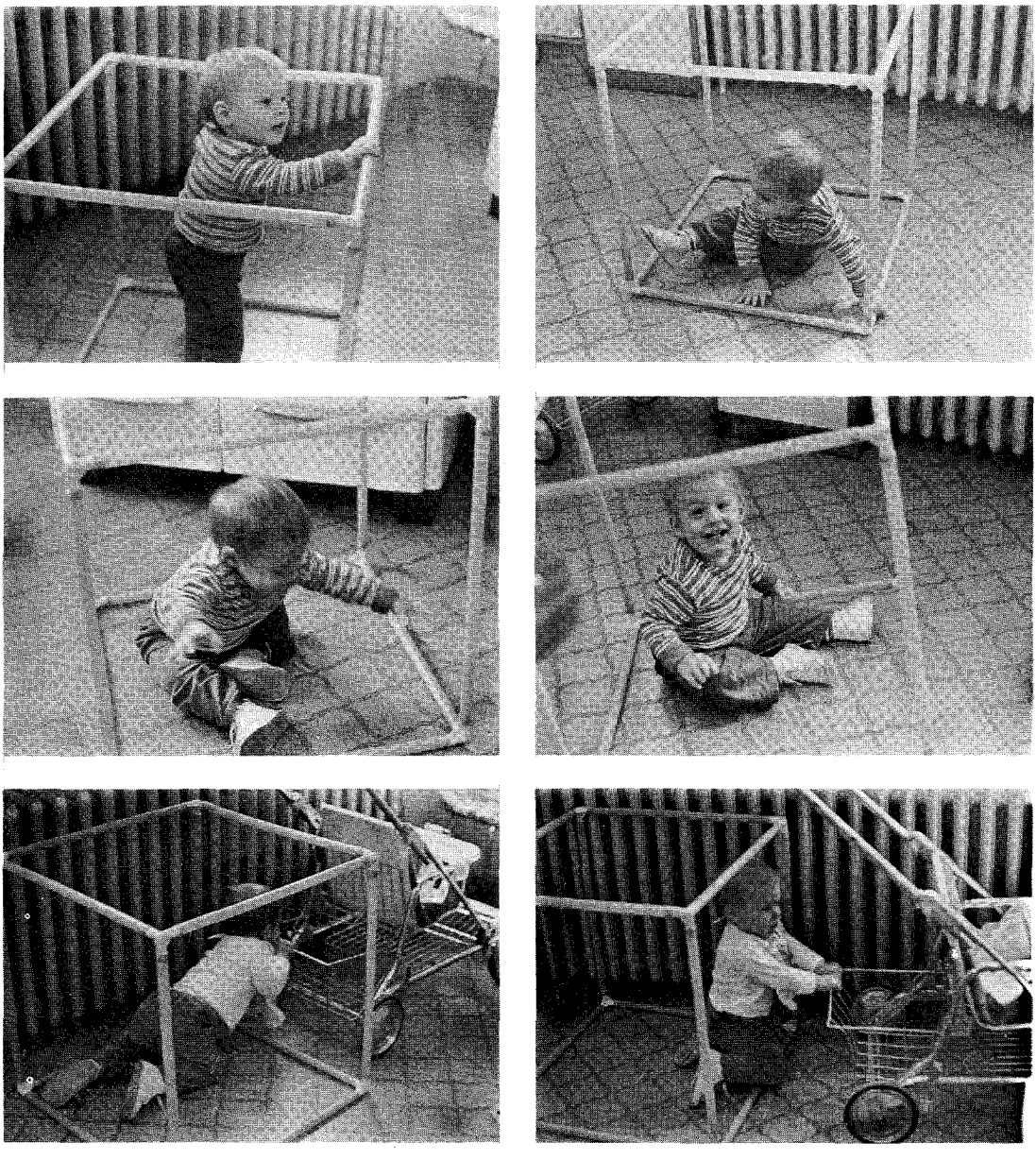


Figure 8. These photographs show the behavior of a nine and one-half month old male infant in a two foot cube made of plastic pipe.

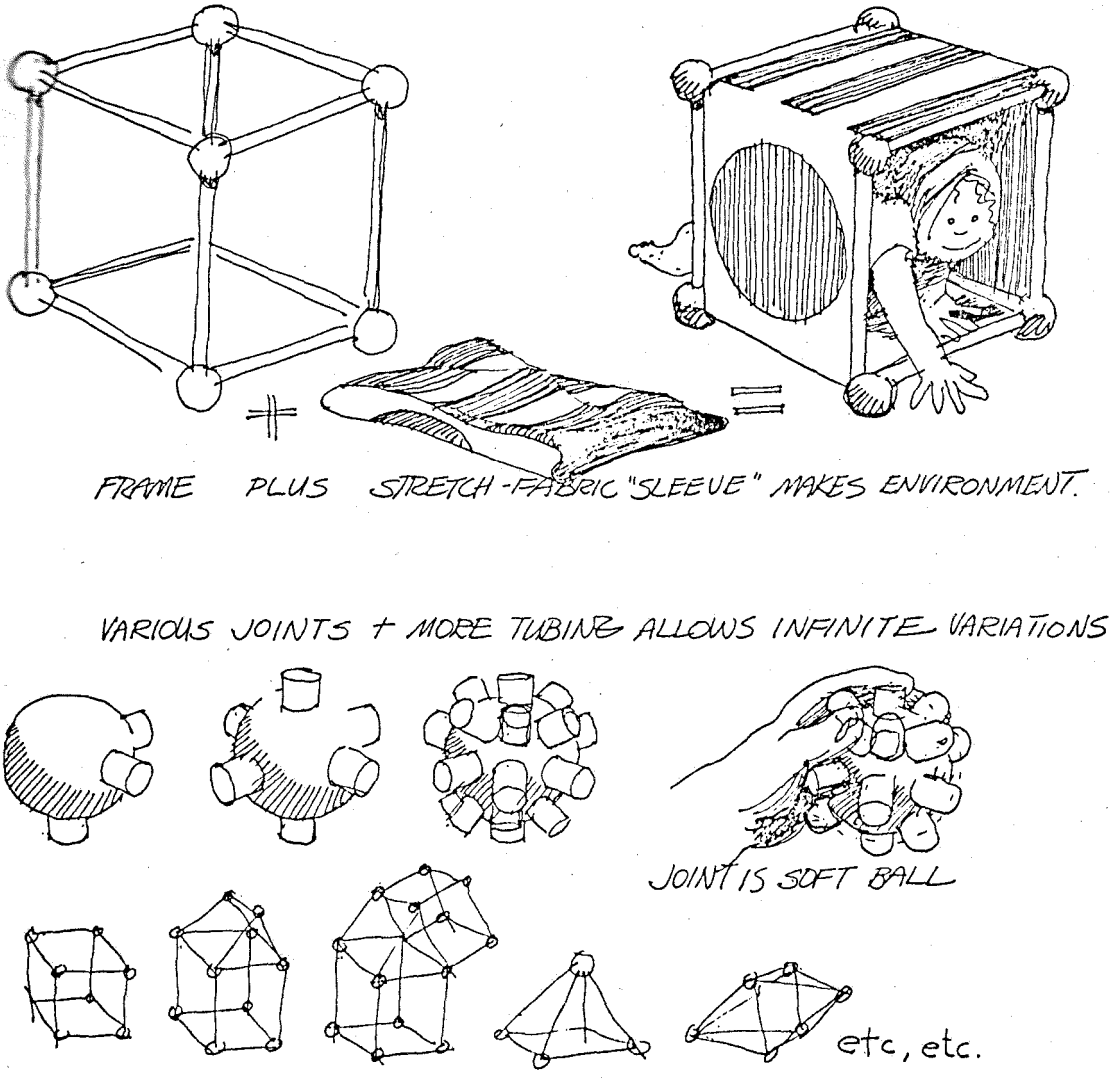


Figure 9. Design studies for space-frame play systems utilizing rods and joints.

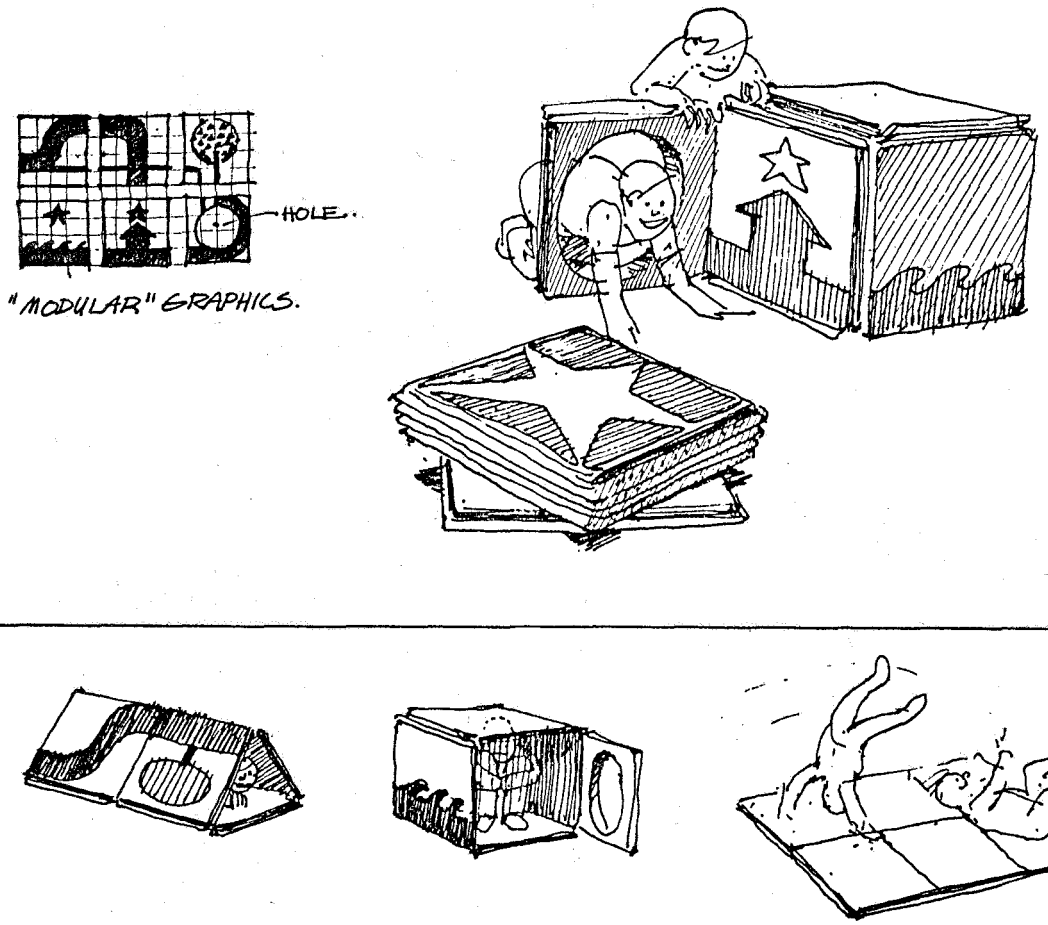


Figure 10. Design studies for space-frame play systems utilizing fabric-covered foam panels.

that they have taken of their own infant. Each statement about behavior development is followed by a space which can be used to record the calendar date or chronological age when an infant showed the behavior illustrated. There are places to record the specific reactions of an infant to common sounds in the environment, as well as observed patterns of vocalization. There are also places for observations about temperament and style of behavior as well as the specific behaviors that have been observed. These design features allow parents and other caretakers to construct a profile of the emerging behavior patterns of an infant, within the context of a broad framework of information about major aspects of infant behavior development.

Our efforts to design play/learning materials for infants and maps of information about infant behavior for use by caretakers have been guided by an interest in optimizing opportunities for infants and their caretakers to share experiences that support learning and the development of broadly competent repertoires of behavior. We do not provide an infant education curriculum with specific behavioral objectives and specific plans for achieving those objectives. We feel that such planning must be individualized -- not only because infants differ so much in behavior and temperament, but also because each infant lives within a set of social groups that has its own customs and values, many of which profoundly influence caretaking practices. Urie Bronfenbrenner has written in detail about the many ways in which cooperation is encouraged in Russian children (Bronfenbrenner, 1970). He observed that collective play is emphasized not only through group games, but through the use of special toys designed to require the cooperative efforts of two or three children to make them work. Learning environments designed to support cooperative behavior were prominently incorporated in the Familistère, an ambitious Nineteenth Century French communal society designed by Jean Godin and influenced by the theories of Charles Fourier (Benevold, 1971). Figure 11 shows the Familistère infant nursery, with its rows of cots, infant benches, and concentric railings that allow groups of infants to pull themselves to a standing position and walk with adequate support (Benevold, 1971).

It would be easy for us to think that exciting scientific discoveries about learning in infancy (Baer & Wright, 1974; Stone, et al., 1973) have moved us to develop our strong interests in opportunities for learning in infancy. In some measure, this is no doubt true. However, it seems to us that we must look to broader aspects of the evolution of our culture to understand the steady growth in interest of parents and scientists in human development (Ariès, 1962; Carnegie Commission on Higher Education, 1973; Chase, et al., 1974; Hutchins, 1969; Parke, 1973; Rossi, 1971).

The first public kindergarten in the United States was opened in St. Louis in 1873. The Day Nurseries that began to multiply in the United States during the last decades of the 19th Century were developed to provide assistance to infants and young children who could not be adequately accommodated in their home environments because of the social dislocations and instability caused by rapid industrialization, urbanization, and immigration. However, the early decades of the 20th Century brought with them a growth in optimism about opportunities for learning afforded by the early years of life. Serious research on early learning by American workers has developed within the last fifty years through the efforts of groups such as the Bureau of Educational Experiments, the predecessor of the Bank Street College of Education (Winsor, 1973). The same fifty years have witnessed an effort to bring educational opportunity to every young person in this country on a scale unprecedented in the history of Western Civilization. Optimism about human improvement and perfectability and interest in

Figure 11. The infant nursery of a 19th Century French cooperative society based on the theories of Charles Fourier. The double set of railings allow infants to pull themselves to a standing position and walk without additional help.

probing the limits of human learning capacity are powerful forces in our culture (Carnegie Commission on Higher Education, 1973; Chase, et al., 1974; Hutchins, 1969).

Public education programs have broadened their patterns of exploration, and efforts to make educational opportunities available to ever larger numbers of people have been accompanied by an appreciation of the fact that much important learning takes place outside of schools (Chase, et al., 1974). Against this background, it is not surprising to find that the progressive search for new ways to optimize opportunities for learning has led to a careful scrutiny of the earliest years of life. The arguments for infant education are, in a sense, the very same arguments that are used to support any program of education. An infant shows as much evidence of interest in the environment as older children do. One simply has to know the ways in which infants communicate their interest. The behavior of infants is dramatically altered by changes in the environment -- but one needs to know which changes have consequences for behavior, and which do not, and how these relationships change as the infant matures. As this understanding grows, it becomes possible to design environments for infants that elicit attention, engage interest, support exploration, and contribute to the development of competent behavior.

Implications for Environmental Design Methods, Research, and Education

Our work on the design of play/learning materials for infants has required a review of literature in Psychology, Education, and Medicine as well as the development of a specialized information system. The behavioral sciences do not constitute a single, coherent, well-ordered body of information. However, the many fields of investigation that comprise the behavioral sciences contain a great deal of information relevant to design decision making. Although our data system is modest in proportion and specialized in character, we feel that it represents an approach that offers promise for the field of environmental design. It is easy to conceive of cumulative, specialized data banks containing information about human behavior that has been selected and formatted in ways that allow easy retrieval according to the requirements of specific environmental design problems.

In our case, we found an abundance of information about the behavior of infants, and much of it was relevant to the design of play/learning materials. The way in which this information was applied to design decision making was determined not only by the character of the information but also by the character of the group making use of the information. Our group contained members with specialty training in Pediatrics, Developmental Psychology, Early Childhood Education, and Design. We have had the opportunity to work together for six years, and have had criticisms and suggestions from a great many parents and professional workers. In addition, we have had the opportunity to work with a great many infants. The selection and use of information about human behavior in environmental design is facilitated by task-oriented group efforts.

It seems to us that much environmental design research, practice, and education will involve teams of individuals with different training and skills, united by common interests and purposes. However, such groups require specific problems in order to achieve clearly-focused efforts, and tangible results of efforts in order to sustain interest. The growth of knowledge about behavior-environment interaction requires the rigorous evaluation of the tangible products of the environmental designer's efforts. The growth of experimental methods for the performance evaluation of designed environments will, of all the things we have discussed, have the most far-reaching consequences for the way in which environmental designers will work and be trained. When environmental design is undertaken with clear anticipation of critical, quantitative assessment of the performance of the designed environment, all aspects of the work effort are influenced in a constructive way. Problems are formulated more clearly, existing information is scrutinized more closely, decisions are made more deliberately, and they are executed more carefully. For these reasons, we recommend sequential test and evaluation of design decisions throughout the design process. A few infants making use of an early prototype of a new piece of play/learning material give quick indication of the design decisions that are faulty and the design decisions that show promise. These preliminary discriminations of design merit do not require large populations of subjects and elaborate research procedures. However, if we wish to know the consequences of a particular early experience for later behavior, the necessary research might be enormously complex (Kagan & Klein, 1973; Sutton-Smith, 1973; White & Held, 1967). Environmental designers need sophisticated understanding of the strategies and tactics of behavioral research. This knowledge should go beyond a familiarity with existing methods to include an understanding of the indications for using one or another method at different points in the environmental design process.

Growth in understanding strategies and tactics of research seems to us a necessary antecedent to the maturation of theory in the field of environmental design. We stand in need of far more experience in environmental design problem solving before it will be possible to know what kinds of knowledge about human behavior will help us most in our efforts to design new environments, and how this information might best be organized, stored, retrieved, and supplemented. The increasingly effective application of such knowledge to environmental design practice will, in time, define those high-level generalizations that constitute effective theory.

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Footnote

Many of the ideas discussed in this paper are now being put to a practical test through a contract for the development of play/learning materials for infants between the authors and the Childcraft Education Corporation.