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The Use of Function in Infant Concept Acquisition

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Abstract

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The use of function for concept formation in 5 and 8 month old infants was studied in an experiment employing a conceptual adaptation of the standard habituation paradigm. A total of 64 male and female infants were shown videoptaped presentations which involved changes in form and functional attributes of selected stimuli. The stimuli consisted of striped figures which could vary in form (shmoo-shaped or H-shaped) and function (side-to-side movements or up-down movements). During habituation, all infants were shown multi-exemplars of a specific figure performing a single movement pattern; the figures varied only in color. During test trials, the infants were shown (1) a change only in form, (2) a change only in movement, (3) a change in movement contrasted with a change in form, or (4) a change in movement contrasted with a combined movement/form change. Total visual fixation times to the various changes in stimuli presented during test trials were compared. The results provide partial, but not conclusive, support for the hypothesis that function serves as the central core for concept acquisition in infancy at both 5 and 8 months of age. The results do not, however, point to a developmental age trend towards either increased or decreased use of functional attributes for concept acquisition.

Table of Contents

Chapter 1

Introduction

Having ascertained that infants are indeed capable of many types of perceptual discriminations, many infant researchers have shifted their attention and are currently addressing the issue of hierarchical organization, integration, and storage of information gained from these early perceptual experiences. Cohen (1979) suggests that this shift to cognitive concerns will help answer important questions about the early development of information processing. What type of information is stored in memory and how is it encoded? What developmental shifts are evident in the processing of information? What function do age and experience play in the organization of information? It is plausible that discovering the nature of information processing in the infant by answering these and other similar questions may provide the necessary foundation for unraveling the complexities of later cognitive development.

Concept acquisition is one area under the broad umbrella of cognitive functioning in infancy that has captured research attention. Cohen (1979) and Caron and Caron (1981) both suggest that infants at a very early age may develop the ability to extract invariant properties from objects and events and form concepts based on these distinctive features. If, for example, the infant is shown a variety of differing stimuli that all share a certain common defining dimension, the infant will be able to recognize that they belong to the same category or concept based on this similiarity. Thus, a cup, bottle, and glass all belong to the category of containers for drinking. Similarly, a car, tricycle, and wagon belong to the category of vehicles with wheels. The infant must thus recognize that specific features of objects and events remain constant across a rich, complex, and rapidly changing environment.

Despite concurrence that concept formation undoubtedly develops its roots in infancy, knowledge regarding the emergence and development of concepts in the very young child is incomplete. As the present time, many questions remain unanswered regarding the basis for early concept acquisition and enrichment. The research in this study will address itself to one such area of unresolved controversy surrounding concept formation: Does function serve as the essential core for concept acquisition in the infant?

Before further definition and discussion of this specific problem, let us digress temporarily to discuss briefly what constitutes a concept, what types of concepts exist, and what developmental trends are evident in early concept formation.

Concept Definition

The precise definition of a concept, with its accompanying theoretical implications, has been a continuing controversy in the psychological literature. At a very basic theoretical level, the structuralists have opposed the functionalists. The structuralists, including Piaget (1952), contend that concepts are internal entities. As such, they are "individually constructed in accordance with a child's level of structural development" (Zimmerman, 1979, p. 58) and emerge in a set, maturational sequence. Thus, the impact that experience has on the child is indirect.

In contrast to this, the functionalists suggest that concepts do indeed derive directly from one's experience with the environment. One of the earliest functional theories is that which was put forth by Locke in 1924, later to be termed abstraction theory by Cassirer (1953). According to this theory, the child will abstract common features from a number of diverse objects or events and will draw these commonalities together to form concepts. Concept formation is therefore dependent upon the ability to transfer that which one has learned about familiar stimuli to novel stimuli which share specific common characteristics. Thus, the child's ability to form concepts is limited to those environmental stimuli to which the child is exposed.

In more recent times, Zimmerman (1979) has developed a modified functional definition of concepts which states: "concepts are defined by the discrimination of the degree of relevance of common attributes of stimuli or their surrounding context" (p. 62). Using this definition for the basis of his modern functional approach, Zimmerman addresses many of the current controversial issues surrounding concept definition and incorporates these into his postulates. Zimmerman first concurs with the basic premise in Lockean theory that a concept is defined in terms of common attributes among stimuli. However, he then broadens the definition of common attributes to include not only those perceptual features directly attached to the stimulus but also those features more tangentially related, including common setting, common use, and common user. Zimmerman also contends that all stimuli are not equally important in defining a concept but rather the relevance of each stimulus can be placed at some point along a continuous scale. He suggests that some stimuli are more prototypic than others for concept definition. For example, the attribute "catches mice" may be more prototypic of the concept "cat" than the attribute "has fur." Another issue confronted by Zimmerman is that of the single-versus-multiple exemplar controversy of concept definition. Proponents of the single exemplar definition believe that one exemplar is all that is needed for concept formation to occur. The opposing stance is formed on the belief that multiple exemplars are needed before the concept develops meaning for the individual. Zimmerman consolidates both positions by suggesting that it is possible to abstract specific attributes from an initial encounter with a stimulus, thus forming a concept, but that encounters with multiple exemplars will change the relevance assigned to an attribute, enhancing and more clearly defining concepts and allowing for better adaptation to the environment.

James Gibson (1950, 1966) and Eleanor Gibson (1969) also adopt the functionalist's point of view that environmental exposure is essential for concept acquisition. They contend that during early development, the infant learns to detect the invariant relational properties of objects from the continually changing array of perceptual features. The Gibsons do not envision major changes in perceptual processes during development, such as those set forth in Piagetian stage theory, but rather see this development as a continuous process (E. Gibson, 1969). This continuous process is characterized by the "progressive increase in the specificity of discrimination to stimulus information" (E. Gibson, 1969, p. 450). The Gibsons stress that the child must learn to differentiate distinctive features, patterns, and relationships from an environment rich in information. It is through the reciprocal mechanisms of abstraction (focusing on the invariant stimuli) and filtering (ignoring the variant stimuli) that concept acquisition occurs. The Gibsons note that theirs is a theory of differentiation, not a theory of enrichment. The child does not need to supplement the stimulation already available in vast abundance in the environment but must instead extract progressively more exact information for perceptual learning to occur.

Although the historically and currently espoused views of concept definition discussed above do not by any means exhaust all possible points of view, they do allow one to appreciate the various issues surrounding concept definition and the complexity such discussion entails. Certainly both structuralists and functionalists would agree that concept acquisition serves an obvious adaptative function for the individual. To quote Nelson, the use of concepts "is an economical way of dealing with the environment" (1976, p. 442). By organizing the objects and events in one's surroundings into concepts, the individual will be able to recognize recurring themes in the various experiences encountered. This recognition will enable the individual to form predictions about the world at large. If the individual can make correct predictions about recurring experiences, less time will be spent processing redundant information and more time will be spent attending to any novel elements in a familiar experience that warrant attention. Thus, organizing the events and objects in one's surroundings into concepts reduces the complexity of the environment and allows one to focus on new and more interesting phenomena in one's world and function in a more efficient manner.

Types of Concepts

In addition to defining concepts, one may also categorize them. There are three types of concepts generally alluded to: perceptual, relational, and functional. It is doubtful to this author that the three are in all respects mutually exclusive but perhaps instead share a degree of overlap. For the sake of clarity, however, let us look at each as a separate entity.

Perceptual Concepts

Concepts formed on perceptual features would be based on knowledge of such attributes as color, shape, size, and internal configuration. Among these attributes, Ruff (1980) stresses the structure of the object without which, she suggests, recognition of an object would be impossible. By structure, Ruff refers to the object's surface and edges and their relationship to one another. Ruff believes that the invariant structural qualities of an object, essential for its immediate recognition and presumably for later concept acquisition, are extracted through continuous visual change in the object. This visual change, including occlusions and perspective transformations, occurs when either the object moves against its own background or when the observer moves in reference to the object. Thus, motion plays an important role in providing perceptual information regarding the structural features of objects.

Along similar lines, Cohen and Strauss (cited in Cohen, 1979) collected test data on 5 month old infants which suggested that form was retained in memory longer than color, size, or orientation. They familiarized the infants to a three-dimensional styrofoam figure. They then tested for recognition, using the same figure and one that differed in shape, size, color, or orientation. When tested immediately after familiarization, the infants recognized all four dimensions. When tested 10 minutes later, they could recognize only the familiar form and the familiar color. After 24 hours, only form was retained in memory. Cohen and Strauss concluded from these results that form was either a more salient dimension or was processed more deeply because of its importance.

Some researchers point to color and size as infrequently perceptual features for concept formation (Nelson, 1979; Ruff, 1980). However, these features can, according to Nelson (1979) serve a useful function in distinguishing between individual objects assumed under the same concept.

Relational Concepts

The second class of concepts to be addressed are those based on relational features. In contrast to the perceptual concepts, which are based on the presence or absence of easily observed common features, the relational concepts are more abstract in nature. They are based on the relationship between sets of attributes rather than on single attributes. Zimmerman (1979) uses the relational concept of "people who can lift their own weight." In this rather complex example, it is not simply knowledge of an individual's weight or knowledge of the amount of weight one can lift but rather the combined knowledge of the two factors that must be taken into account before judging whether or not a specific individual rightfully belongs to the concept class. Certainly a myriad of other examples of relational concepts abound in everyday life that are less complex. For example, recognition of a tune, composed of a set series of notes, that remains constant despite raising or lowering the pitch is a more simplistic example of a relational concept.

Albert and Rose Caron (1981) stress the wide variety of relational concepts which apparently develop quite early in life including concepts based on spatial, temporal, actional, and causal features. They have recently presented evidence of the ability of young infants to classify stimuli on the basis of various relational properties. Problems such as above-below, same-different are typical of the types of relational concepts presented to the infants in their laboratory.

Functional Concepts

The last class of concepts, which form the focus of this study, are those of a functional basis. A strong proponent of the importance of function in early concept acquisition is Nelson (1973, 1976, 1977, 1979). Her proposed functional core model of concept formation is based on the assumption that there are two basic and distinct types of information that one can extract from the environment: functional features and perceptual features. The functional features are the dynamic, active, experiential components of objects that comprise the essential core for concept acquisition. This includes the uses of an object, the actions of an object, and the actions imposed by others upon the object . . . i.e., what an object does and what can be done to it. For example, one may view a cup as an object for drinking, a ball for bouncing, or a tricycle for riding. In contrast, the perceptual features play a secondary role in concept formation as previously noted.

They are of a more static nature and include such characteristics as shape, contour, and internal configurations of an object as well as less frequently used dimensions of size and color (1976). This is not to say that knowledge gained from perceptual features goes unused. To the contrary, Nelson suggests that the perceptual features are attached to the conceptual core and serve to "distinguish members of one concept from another and to distinguish among the concept members themselves" (Nelson, 1976, p. 433). For example, one can use the perceptual feature of "roundness" to help identify objects that share the common function of rolling. Similarly, one can use identifying perceptual features to differentiate small balls from big balls within the functional category of objects that roll.

Thus, the child first forms a concept by noting the invariant functional actions and relations that form the core of the concept. To these are added the identifying perceptual features. The identifying features may change to some degree each time the child is exposed to another exemplar of the concept but the underlying essential functional base will remain unaltered. This knowledge of function will permit the child to identify new instances of the concept when exposed to the new potential concept members. Correct identification of new concept members allows the child to predict future actions and changes in such objects; such predictability would presumably allow the child greater control over his environment.

Nelson's original basis for the functional core model was her observations of early language acquisition in children (1979). She noted that early expressive language generally consisted of a small set of words for objects that move or change in some way. She found that "the one outstanding general characteristic of the early words is their reference to objects and events that are perceived in dynamic relationships; that is actions, sounds, transformations--in short, variation of all kinds" (1976, p. 423). To step backwards developmentally and explore concept formation at a preverbal level, Nelson (1979) then tested her functional core model on 8 and 10 month old infants. They hypothesized that infants would pay more attention to a change in the function of an object than a change in form. If the essential core of the infant's concept is based on functional, dynamic properties of an object, then the infant should associate a certain function with a particular object ("hypothesis of functional specificity," 1979, p. 54). If there was then a change in the function of that particular object, the infant would be forced to alter his/her basic functional concept core, incorporating or integrating the new functional information with the old. It was hypothesized that this would require increased attention on the part of the infant. If there was a change in form rather than function, however, the infant could simply add the new perceptually identifying features to the old functional core. This, it was assumed, would require less attention on the part of the infant.

To test this hypothesis, Nelson (1979) presented the infants with two mobiles, a red cross and a red scalloped circle. Each of these could be moved in either a circular path or a linear path on a motor-driven arm. The infant was seated in front of the mobile and observed the mobile for three 90 second trials. During the three trials, there was either (1) a change in movement with the same form, (2) a change in form with the same movement, (3) a change in both form and movement, or (4) no change in either form or movement. Using a habituation paradigm, the four groups were compared in terms of visual fixation time across the three trials. The results indicated that the movement change groups showed the greatest recovery . . . i.e., both 8 and 10 month old infants looked longest at a change in movement suggesting that they had to expand the functional specificity of the object and this required increased attention to integrate the new functional information with the previously acquired functional concept core. It is also of interest to note that the group experiencing only a movement, or functional, change not only recovered more than the form change group but also recovered more than the combined form-movement change group. Nelson proposes that the dual form-movement change creates a new event that is not in competition with the old one and therefore may not require altering of the original concept.

Nelson's results, however, are open for at least one alternative interpretation. Ruff (1980) points out that the infants may have preferred the old object performing a new motion because it allowed them to learn more about the perceptual structure, as well of the function, of an object that already was somewhat familiar to them.

Another earlier experiment by Nelson (1973) also merits discussion because of the information it provides about functional categorization by the young child. In this experiment, Nelson exposed 10-15 month old infants to 10 different objects which were laid out on a table in front of the child. Included in this array were (1) a rubber ball, (2) three objects judged by adults to be very similar in function to the rubber ball (ex.--a football that could be thrown), (3) three objects judged to be very similar in form to the ball (ex.--a round, smooth, heavy 8-ball), and (4) three objects judged dissimilar to the ball in both form and function (ex.--a square block). The infant was asked to give the experimenter the ball. After handing the experimenter the chosen object, the child was again requested to give the experimenter the ball. This same request was repeatedly given until the child had chosen five different "balls." The objects were then returned to the table and the child was given 10 minutes to play with all 10 objects. Following this period of active exploration and manipulation, the verbal request to give the experimenter the ball was again repeated five times. When comparing the initial five choices with the latter five choices, Nelson obtained interesting results supporting her functional hypothesis. On the initial test, both form and functional attributes were chosen with equal frequency. After play with the objects, during which time it is assumed that the child was able to discover more about the functional qualities of the objects, functional attributes were chosen with greater frequency. These results suggest that very young children are capable of categorizing on a functional basis and that function can become more potent than form after the opportunity to interact with potential class members arose. This study also provided early support for the now more readily accepted idea that the young child can categorize objects before naming them. Although all the children in this particular study understood the word "ball," many did not use the word actively in their vocabularies. Thus Nelson concluded that concept acquisition can occur before expressive linguistic abilities have developed sufficiently to demonstrate underlying knowledge on the part of the child. Certainly the bulk of research reviewed in this paper lends further support to this same hypothesis.

Concept Development

Strong empirical support for specific trends in early concept development has generally not yet emerged. It has become increasingly obvious that the infant does not spend the early months of life in a perceptual/cognitive void, but the exact types of developmental changes that occur during this period of life are less clear. The many controversial issues surrounding general human development have surfaced as well within the more specific area of infant concept development. One issue is the overly familiar nature-nurture issue, which has found some resolution in the organismic point of view. Because of the early ages involved in infant research, questions of innate versus learned behavior are fertile fields for exploration. Another major issue is that of continuity versus discontinuity, as articulated in Werner's (1957) orthogenetic principle that stresses the synthesis of two opposing trends: discontinuous differentiation and continuous hierarchic integration (Langer, 1970). Within the wide scope of the continuity versus discontinuity issue, questions arise concerning the cognitive structures underlying concept formation. This is one area in which there appears to be at least partial consensus among some researchers (Kagan, 1979; Nelson, 1977; Ruff, 1980) that concept formation evolves within a cognitive structure that evidences a developmental shift from the acquisition of experientially based concepts to more context-free, logically derived, relational concepts. Initially, the child forms event-based concepts. At this level, the child's concepts are very concrete and based on real world events occurring within a specific context. With some variation in definition, this has been referred to as an event structure (Nelson, 1977), episodic memory (Posner and Warren, 1972), or scripts (Schank and Abelson, 1977). All of these connote an event occurring within a spatial and temporal framework that has specific boundaries. For example, the child may recognize his father's car when it is parked in front of their house but may not recognize the same car when it is parked in a shopping center parking lot. As the child matures, his concepts will become more abstract and context-free. At this point, the individual begins to recognize the logical relationships between concepts, including "similarities and differences in attribute structures" (Nelson, 1977, p. 223). Nelson refers to this as categorical knowledge . . . "knowledge that groups concepts into hierarchical taxonomies defining superordinate, subordinate, and coordinate relations" (1977, p. 222). Kagan refers to a seemingly similar structure as the symbolic category, defining it as "an arbitrary representation of the shared dimensions of a set of events" (1979, p. 167). At this point in development, the child will recognize that daddy's car is a part of the larger category of motor vehicles but has specific invariant features that remain constant across a varying environmental background that allows one to identify it and differentiate it from other cars. Thus, the child will recognize that a 1976 orange Volkswagen with a dent in the right front fender is still daddy's car regardless of where it is parked. The development of such context-free concepts will depend, according to Ruff (1980), upon exposure to the invariant features of the concept in a variety of circumstances. Unless the child is exposed to the concept in multiple and differing situations, the child will not be able to extract all the essential invariant elements necessary for more highly efficient and rich concept formation involving the ongoing dual processes of differentiation and generalization.

Another general trend in concept development that has been fairly well documented is the shift from the processing of visual elements to the processing of total configurations in visual stimuli (Caron and Caron, 1980; Cohen, 1975). Prior to 3 months of age, the infant's attention appears to be captured by a single, or limited number of features of an object or pattern; thus perception is limited to the parts, not the whole. At this age, the infant is capable of processing high contrast angles and edges (Bower, 1966; Haith and Campos, 1977; Salapatek, 1975). For example, Salapatek and Kessen (1966) demonstrated that 1 and 2 month old infants will focus their attention on the high contrast edges of a black triangle on a white background. When comparing the performance of the 1 and 2 month old infants on this task, Salapatek and Miller (cited in Salapatek, 1975) found that the 1 month old infants tended to fixate on one specific feature--typically a vertex of the triangle--whereas the 2 month old infant's eye movements followed the overall high-contrast outline of the triangle. This suggests some developmental change even in these early months. From approximately 3-5 months of age, "simple dimensions such as colors and forms can be processed as units" (Cohen, 1979, p. 896) and these units can be defined relationally. For example, Schwartz (1975) demonstrated that 2-4 month old infants were able to process the relationship of line segments forming angles of various degrees and recognize constancy of angles despite orientation changes. Also at this stage, the infant can discriminate one configuration from another when both are made up of differing arrangements of the same elements (Caron and Caron, 1981; Cornell, 1975; Vurpillot, Ruel, and Castrec, 1977). Milewski (1979), for example, used his operant high-amplitude sucking technique to demonstrate that the infant as young as 3 months of age could discriminate differences in visual pattern arrangement. He found that the infants were capable of differentiating between three dots arranged in a vertical line and three dots placed in a triangular arrangement. He additionally provided evidence that the infant did not use contour density or position cues but rather detected pattern configuration as the perceptual invariant.

It is not until 5 months of age, however, that the infant can process total configurations made up of disparate items (Caron and Caron, 1980; Cohen, 1979). For example, a cross and a circle are seen as separate components until 5 months of age, at which time the two become encoded as a compound . . . cross within circle (Bower, 1966; Cornell and Strauss, 1973; Miller, 1972). Similarly, recognition of total human facial configuration does not appear until approximately 5 months of age (Caron, Caron, Caldwell, and Weiss, 1973). At 4 months of age, infants are unable to detect "faceness," the invariant configuration of eyes, nose, and mouth. At this age, the eyes are more salient than the nose and mouth, and the head outline is more prominent than the inner facial pattern. By 5 months of age, however, the facial features have become integrated and the infant is able to process total facial configuration as a separate entity.

This shift from the processing of components to the processing of configurations, coupled with the apparent shift from context-contained to context-free conceptualization are but two of the developmental changes thought to occur early in life. Certainly their impact on the types of concepts formed during infancy should be substantial. In order to determine that such specific developmental changes occur regarding concept formation, a new methodology has evolved during the past twenty years which allows us to examine the nature of conceptual organization in the infant. Needless to say, the infant's response repertoire is limited. Taping his responses required the development and use of an ingenious procedure: the habituation paradigm.

The Conceptual Habituation Paradigm

The habituation paradigm has been the tool of choice for most researchers studying concept acquisition in infancy. Habituation is generally defined as a response decrement resulting from the repeated presentation of a stimulus. As the stimulus becomes more familiar with repeated exposure, the orienting reaction to it grows weaker; this results in decreased attention to the stimulus and subsequent decreased responding to it. This decrease in attention is thought to reflect the acquisition of internal representation of the stimulus. The incoming stimuli are compared to the memory model of past stimuli; when the two match, attention is inhibited and habituation occurs. Thus habituation is probably suggestive of a primitive form of memory (Jeffrey and Cohen, 1971).

The research in this particular study will be based on a combination of two different habituation techniques: Fantz's (1964) paired comparison technique and McGurk's (1972) conceptual variation of the standard habituation paradigm. Both are based on Fantz's premise that the infant will demonstrate a visual novelty preference; when the infant is presented with a familiar and a novel stimulus, the infant will prefer to look at the novel stimulus. From this, one can infer that the infant has discriminated between the two stimuli.

Fantz's paired comparison technique involves an experimentally induced preference for novelty. The infant is repeatedly shown a single stimulus until the infant's decreased looking time implies that habituation has taken place. The infant is then simultaneously presented with the familiar stimulus and the novel stimulus. Increased looking time at the novel stimulus implies that the infant recognizes the difference between the two stimuli and prefers to watch the new, unfamiliar one.

McGurk's method is an adaptation of the standard habituation paradigm. Like Fantz's design, it also employs an experimentally induced novelty preference. Unlike Fantz's design, the stimuli shown during the habituation period are not identical. Using McGurk's technique, the infant is instead shown a variety of different stimuli that all belong to the same category or concept. The infant is repeatedly exposed to these same stimuli until the infant's decreased attention demonstrates that he has habituated to them. The infant is then tested with a new member of the same category and a non-member. If the infant's visual attention does not increase to the new concept member but does increase to the non-member, it is assumed that the infant has adequately remembered the concept and has been able to generalize his habituation to the new member while dishabituating to the unfamiliar non-member. Such a response would suggest that the infant has been able to detect the invariant features of a concept through repeated exposure to the multiple exemplars of that same concept. This ability to extract the common defining properties of objects and events across a changing array of perceptual features therefore indicates that the child is capable of forming concepts to organize input from the environment.

The results achieved using this modified habituation paradigm for the study of concept acquisition have been encouraging. To quote Caron and Caron, "these studies indicate that recognition of constancy across change is probably the rule rather than the exception in normal infant perception, and that it occurs quite early in life" (1981). Empirical evidence is accumulating showing that young infants are capable of responding to many types of invariant properties. A review of selected examples of research in this area, utilizing various combinations of both Fantz's and McGurk's methods of habituation, will serve to illustrate conceptualization in the young infant.

Let us first look at McGurk's (1972) experiment which employed the adapted habituation paradigm discussed above. McGurk's results provided strong evidence that infants as young as 6 months of age could recognize the invariant property of form constancy against changing orientations. His infants were first habituated to a simple stick figure that was either presented in a constant, static orientation or rotated in a changing orientation during the familiarization trials. During testing, all infants were then exposed to two additional stimuli, the familiar stick figure and a novel stick figure, both of which were presented in a completely new orientation. For those infants that saw the stick figure rotated to various positions during habituation, McGurk found little recovery to the same form in a new orientation but did find evidence of recovery when these same infants were exposed to the changed form in the new orientation. For those infants initially exposed to only a single, static orientation of the original stick figure during habituation trials, McGurk found equally increased looking time to both the familiar figure in the new orientation and the unfamiliar figure in the new orientation. These results suggest that by 6 months of age, infants can recognize the unchanging, invariant properties of form across changes in orientation. The infants could generalize their habituation across the various exemplars of the same category, forming a concept based on shape constancy.

Constancy across change has also been studied by Bornstein (1976, 1978, 1979) using color as the independent variable. He first established that 4 month old infants could discriminate changes in hue (1976, 1978). It was found that infants who were habituated to a single hue dishabituated to a novel color during test. Next, Bornstein (1979) habituated 4 month old infants to a variety of hues (blue, yellow, red, etc.) and found that these same infants generalized their habituation to a novel hue that was presented during test. Bornstein concluded from these results that the infants not only discriminated between various colors, but also demonstrated the higher level function of abstracting the invariant property of chromaticity per se.

Auditory stimuli have also been used to study concept formation (McCall and Melson, 1970; Horowitz, 1972). Chang and Trehub's study (1977) is of particular interest for the information it sheds on concept acquisition in the young infant. They hypothesized that the 5 month old infant would code auditory stimuli in terms of configurations or pattern instead of individual elements. In order to test whether or not such temporal relational coding does indeed occur, they first habituated their infants to a repeated six tone pattern. During test, the infants then heard either a transposed version of the standard pattern (raised or lowered from the standard) or a scrambled version of the transposed pattern. By using cardiac deceleration as the response measure, Chang and Trehub found that the infants who were exposed to the transformed pattern during test did not dishabituate whereas those exposed to the scrambled version did dishabituate. These results suggest that the 5 month old infant is capable of processing the relational information contained in a six tone pattern. The infants recognized the familiar pattern in the transposed version and found it similar to the standard. The scrambled version was found to be dissimilar and resulted in a novelty response.

Several visual habituation experiments have focused on the use of human faces to study concept acquisition in the infant. Cornell (1974) used Fantz's (1964) paired comparison technique to look at possible developmental differences in concept formation between 19 and 23 week old infants. In this study, the infants were habituated to a specific category of faces. They saw either (1) different faces that shared the common dimension of sex (multi-exemplars of male or female faces), (2) a single male and female face in varying poses, or (3) the same male or female face in the same pose. After a series of six habituation trials, all infants were then exposed to a paired comparison of the male and female face seen in condition 3. Cornell found that the 19 week old infants were unable to generalize their habituation under any of the three conditions. In contrast, the 23 week old infants were able to generalize their habituation under all three conditions, preferring the novelty of the opposite sex face to the familiar same sex face during testing. Thus, the older infant could categorize the faces by (1) invariant sex, (2) invariant facial configuration against changing orientation, or (3) invariant facial configuration with accompanying orientation constancy. These results suggest that the older infant has the capacity to categorize faces in varying ways, depending upon how the task was structured.

In 1976, Fagan expanded Cornell's (1974) work to further examine the infant's ability to form concepts based on the recognition of invariant facial features. He conducted a series of five paired comparison experiments using 29 week old infants. The first experiment was designed to focus on Fagan's concern that Cornell did not demonstrate that the infants could reliably discriminate between the various same-sex faces shown during familiarization and those shown during test . . . i.e., the subjects in Cornell's photographs were quite similar in appearance and could conceivably be mistaken for one another. To eliminate this problem, Fagan established experimentally that his infants could in fact discriminate between two particular male faces that were very dissimilar in appearance. Secondly, Fagan established that the infants could discriminate between facial poses (front, three-fourths, and profile) of either of these male figures. Thus he determined, unlike Cornell, that the infant in all probability could make these distinctions. He then utilized this information in his final three experiments which focused on invariant facial features. In the third experiment, he demonstrated that the infants could recognize the same male face in different poses (invariant facial configuration against changing orientation). In the fourth and fifth experiments, he demonstrated that 7 month old infants could abstract male and female characteristics and categorize faces based on these invariant sexual features.

In 1979, Cohen and Strauss conducted an experiment similar to Cornell's and Fagan's in concept but differing in design. Instead of using a set familiarization period, they used DeLoache's (1973) common proportional criteria of habituation to avoid confusing lack of habituation with lack of concept generalization. Like Fagan, they also were concerned that the subjects in Cornell's photographs were too similar in appearance and consequently chose to use photographs of human faces that were markedly different from one another. They habituated 18, 24, and 30 week old infants to (1) a particular orientation of a particular female face, (2) a particular female face in varying orientation, and (3) varying female faces in varying orientations. During the test phase, all infants saw one familiar female face and one novel female face, both with a new facial expression and in a new orientation not previously seen. Cohen and Strauss found that the

18 and 24 week old infants could not generalize their habituation but that the 30 week old infants could generalize their habituation to (1) varying orientations of the same face, and (2) varying female faces.

Thus, Cornell, Fagan, and Cohen and Strauss all appear to have demonstrated that the infant is "capable of abstracting or differentiating appropriate conceptual categories regarding the human face" (Cohen and Strauss, 1979, p. 422). Although the three studies yield fairly similar results, there is not total resolution about the age at which such concept acquisition evolves. At approximately 4 1/2 months of age, such facial conceptualization apparently is not a part of the infant's repertoire. By approximately 7 1/2 months of age, the infant appears to have mastered these concepts. It is less clear, however, what happens between these two ages. Cornell and Cohen and Strauss obtained conflicting results with the infant of approximately 6 months of age. It is possible that a transition period occurs between 4 and 7 months of age leading to the conceptualization of facial identity and sex. This would support the findings of Caron, Caron, Caldwell, and Weiss (1973) that the processing of total facial configuration appears at approximately 5 months of age.

Not only have researchers been attempting to delineate age-related changes in concept formation, but they have also begun to explore differences in concept acquisition between normal and abnormal infant populations (Fagan, Fantz, and Miranda, 1975; Miranda and Fantz, 1974; Miranda, 1976). The Carons (1980) focused on one specific high-risk population by comparing the performance of term and pre-term infants on problems requiring the abstraction of relational information.

Recognizing that the infant with neonatal complications is at risk for later cognitive dysfunction, the Carons hypothesized that later intellectual impairment may be preceded by early deficits in relational processing. As a preliminary investigation into this area, the Carons presented four problems involving relational concepts to term and preterm infants, ranging in age from 12 to 24 months.

The 12 month old infants were given a problem entitled face-nonface. Using McGurk's multiple exemplar habituation technique, the infants were first exposed to four line-drawn faces, each of which had eyes and noses composed of different geometric shapes (one with circular eyes and nose, one with triangular eyes and nose, etc.). Despite these differences in elements, all shared the common relational property of normal facial configuration, with eyes, nose, and mouth in proper alignment. After habituation to these four exemplars, the infant was then shown four new stimuli during test, all possessing eyes and noses of new geometric shapes not previously seen. Two were similar in configuration to those seen during habituation; the other two had distorted facial configurations in which the eyes, nose and mouth were not in normal alignment. The second problem given to 18 month old infants, focused on the relational concept of above-below. The habituation stimuli consisted of pictures of varying geometric shapes; in each picture, a smaller geometric object was always placed above a larger geometric object. In test, the infants saw new geometric shapes in both the old configuration and in a new configuration in which the objects were reversed with the large object placed above the small one. The third problem, given to 21 month old infants, addressed the concept of same-different. During habituation, the infants saw pairs of line drawn faces which were identical. During test, the infants were asked to differentiate between more sets of "twin" faces and sets of dissimilar faces. In the last problem, 24 month old infants were asked to abstract the invariant relational property of facial expression. During habituation, the infants saw four photographs of different females, all with a neutral expression. During test, the infants saw new females, exhibiting both neutral expressions and smiles. All four of these problems contained stimuli that could be encoded in terms of the absolute properties of their elements (ex.--shape, size, etc.) or in terms of the relationship between the elements (ex.--little above big). For example, let us look at the above-below problem. The infant can encode this problem in one of two ways. If the infant's looking time increases during test to the two new pictures of geometric shapes which are still in the same above-below configuration, it is assumed that the infant is encoding the absolute properties of the geometric elements. If, on the other hand, the infant's looking time increases more dramatically to the two pictures in which there is a new configuration (big above little) as well as new elements, then it is assumed that the infant has successfully encoded the relational configurational information contained in the stimuli.

To measure the type of encoding used, the Carons devised two visual scores: a configural discrimination score representing relational encoding and a component discrimination score representing element encoding. On three out of the four problems, the pre-term infants yielded significantly lower configuration discrimination scores than did the term infants (only neutral-smile did not reach significance). On component scores, the pre-term infants did not score significantly higher than the term infants, as predicted, but more pre-term infants did dishabituate to the change in components only than did full-term infants. These results suggest that the pre-term infants were able to discriminate changes in stimuli components but did not notice the change in overall configuration that the full-term infants observed.

Problem

In all of the forementioned studies, the habituation paradigm has proved an effective tool for studying early concept formation in the infant. Overall, the results of these same studies have shown that concept acquistion does appear to evolve at a very early age. However, our knowledge bank regarding the precise manner in which concepts are formed certainly is not yet complete. The present study is designed to focus on one aspect of conceptual organization for which research results are currently inconclusive: Does function serve as the essential core for concept acquisition in the infant? Nelson (1977, 1979), as previously noted, answers affirmatively to this question, arguing strongly for the primacy of function in early concept formation. Others (Kagan, 1979; Ruff, 1980) suggest that the answer may not be so simplistic. Ruff, for example, stresses instead the combined importance of form and function. The answer to this question is important not only for the light it sheds on basic concept formation in infancy per se, but also upon its applied significance. Intervention with high-risk infant populations is a common phenomenon in our society, based on the assumption that early intervention may reduce later cognitive dysfunction. If one were to determine the specific type of information most essential for early concept formation, this same type of information could be used for cognitive therapeutic intervention--or simply for encouraging healthy development in the normal infant.

A second question posed by this study is the following: Are there differences between 5 and 8 month old infants in terms of their use of functional properties for concept definition? In Nelson's 1979 study, it was found that both 8 and 10 month old infants spent more time processing functional changes than they did processing changes in form. The following study, which utilizes habituation techniques different from those employed by Nelson, will attempt to provide further evaluation for Nelson's contention that 8 month old infants use function as the primary basis for concept formation. Additionally, it will look at concept acquisition prior to 8 months of age. If indeed functional attributes are the primary core of early concepts, it is hypothesized that the 5 month old infant will also prefer to focus on function over form for concept formation. Previously cited research has demonstrated that by 5 months of age, the infant is capable of forming various types of relational concepts (Bornstein, 1976, 1979; Caron, Caron, Caldwell, and Weiss, 1973; Chang and Trehub, 1977; Milewski, 1979). If, in fact, function is the defining dimension for early concepts, simple functional concepts should also be emerging by 5 months of age. It is additionally possible that a developmental shift may occur between 5 and 8 months of age but at the present time there is no concrete evidence that such a shift does occur nor knowledge of the anticipated direction of that shift (form to function, or function to form).

The present series of four experiments were designed to address these two major questions by using the habituation paradigm to measure visual attention to videotaped presentations involving changes in both form and functional attributes of selected stimuli.

Chapter 2

Methods

Subjects

The final sample consisted of 64 healthy, full-term infants from predominantly white, middle class suburban families (mean parental education level of 17 years). These infants were divided into two groups: 32 5-month old infants (140-154 days of age) and 32 8-month old infants (231-245 days of age). There were equal numbers of 4 males and 4 females of each age in each of 4 experimental groups, for a total of 16 subjects per condition. Ten additional infants were tested but 6 were excluded from the study due to changes in state (fussing, crying, sleeping, etc.) and 4 were excluded due to experimenter error.

The majority of parents volunteered their infants in response to notices in local childbirth education newsletters; others volunteered after referral by their pediatricians. All infants had uneventful pre- and post-natal circumstances, with 5 minute Apgar scores ranging from 8-10. Gestational ages were 38-42 weeks; birth weights were greater than 2500 grams. The mother's condition prior to and during the time of delivery was essentially free of common risk factors; deliveries under general anesthesia and unplanned caesarian-section deliveries were eliminated from the study. Infants with obvious signs of prematurity (neurological immaturity, specific respiratory problems, etc.) and post-maturity (dry skin, long fingernails, aging placenta, etc.) were also excluded.

Apparatus

The infants were individually tested during their normal waking hours. They were seated on their parent's lap in a darkened 210 x 300 cm room, facing the center of a brown framing screen which was located 70 cm in front of them. There were two 28 x 21 cm windows cut out of the frame, each located 9 cm to the left or right of the center of the frame. Through the windows, the infants could watch the various videotape cassette presentations projected on two 29 cm colored videotape monitors located behind the cut-out windows. To the side of the infant was a large partitition which hid the examiner who monitored the recording apparatus, as well as the apparatus itself, from the infant's view. The recording apparatus consisted of two Sony Betamax video cassette recorders which were connected to the color monitors and also connected to a special purpose computer. Each trial on the videocassette was preceded by a 2,500 Hz tone and terminated by a 313 Hz tone. These tones respectively activated and deactivated the computer for recording purposes during each trial. A hand held device attached to the computer contained left and right push buttons for scoring the respective direction, and length of visual fixation during the various trials. Following the entire test session, the computer read-out provided total fixation time per position per trial.

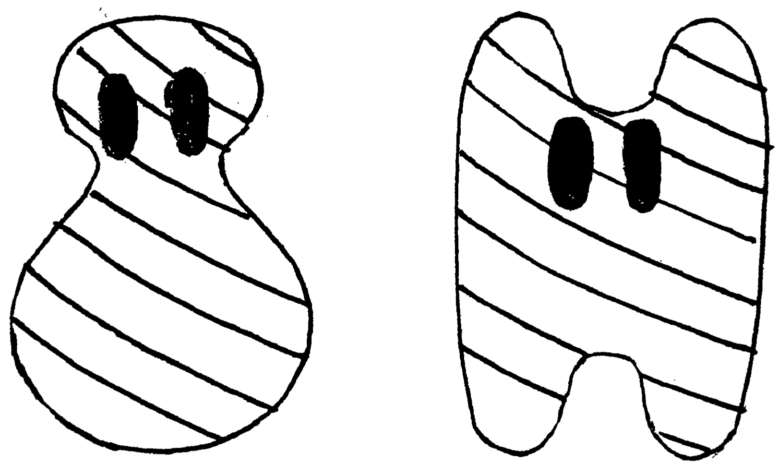
The infant's visual fixations were monitored by closed circuit television. A small 4 cm aperture was located directly between and 3 cm above the openings for the colored monitors. A closed circuit camera lens was placed in this opening, focusing on the infant's face. This facial image was carried to a monitor located behind the partition for viewing by the examiner. Fantz's corneal reflection technique was used to measure visual fixations which were recorded on the scoring device. On the monitor, the examiner determined if superimposition of the left or right videotaped stimuli over the pupils of the infants' eyes occurred, and if so, recorded this as a fixation on the computer. Each fixation was terminated when the infants looked away for at least .5 seconds. Inter-rater reliability for this procedure was established by having two examiners independently recording infant visual fixations on two separate computers. An agreement consisted of a difference of $\leq$ 1.5 seconds of total looking time to one screen over a single 10 second trial. A disagreement occurred when the recorded difference exceeded 1.5 seconds. Using the formula $\frac{\text{agreements} - \text{disagreements}}{\text{agreements} + \text{disagreements}}$, inter-rater reliability (over a total of 32 trials on two subjects) was calculated to be 84%.

Stimulus

The infants were shown colored videotapes of two-dimensional cardboard stimuli consisting of various combinations of shmoo-shaped figures and H-shaped figures (Figure 1). All of the figures had stripes and two large black eyes. They varied in color. One shmoo-shaped figure and one H-shaped figure had blue and yellow stripes; one of each had turquoise and orange stripes; another of each had purple and green stripes; and the final two had red and white stripes. The figures were capable of moving in one of two patterns, either bouncing slowly up and down in the same place or moving more rapidly with short hops from side to side. The figures, suspended from invisible strings,

Figure 1

Shmoo-shaped and H-shaped stimuli



moved against a plain light blue background.

Procedure

This series of four experiments theoretically replicates Nelson's 1979 form-function mobile study cited earlier. The methodology employed is different, however, drawing on a combination of Fantz's paired comparison technique (1964) and McGurk's (1972) conceptual adaptation of the standard habituation paradigm.

During each session, the infants saw the same videotape two times in succession with an approximately 2 minute interval between the two presentations. This repetition was deemed necessary after trial runs suggested that a single presentation of the tape provided viewing time which was insufficient for adequate information processing to take place. The videotape was approximately 2 minutes in duration and consisted of: (1) a warm up segment, (2) 6 segments constituting habituation trials, and (3) 2 test segments. Each of these segments was 10 seconds in duration. The intertrial interval between all segments was 3 seconds. The tone which signaled termination of the previous trial was delivered during the first .5 seconds of this interval. During the final .5 seconds of the interval, the tone signaling the start of a new trial was heard. During all 3 seconds, the infant saw only videotaped footage of the plain blue background.

Prior to the start of the test session, the parents were asked by the experimenter to refrain from talking to or interacting with their infant while the tape was being shown, except to comfort the infant if the child became upset. The parent then accompanied the infant to the testing room. When both were comfortably seated, the videotape presentation was shown.

For the warm-up segment, each infant saw a 10 second videotaped presentation of a rotating multi-colored cloth stuffed infant toy resembling a flower with a face in the center. The warm-up segment was presented simultaneously on both videotape monitors and served to orient the infant towards the two monitors.

Using McGurk's technique, the infants were then exposed to multi-exemplars of a specific movement paired with a specific shape during a series of 6 fixed habituation trials. Each habituation trial consisted of 10 seconds of videotaped footage showing either shmoo-shaped or H-shaped figures that varied in color repeatedly performing on one of the two movement patterns. The exemplars were presented on one of the two videotape monitors during the 6 habituation trials; their appearance on either the left or right screen was randomly ordered. In all, each infant saw three color variants (orange and turquoise, purple and green, and blue and yellow) of the same shaped figure performing the same movement (high slow bounces or quick side-to-side jumps) during habituation. Each colored form was seen a total of 2 times. The color of the six stimuli seen in succession on the two monitors was randomly ordered.

Fantz's paired comparison technique was used during test to measure selective visual attention to one of the two screens which were simultaneously running videotape footage. In the test sequence, the infants saw the familiar shmoo- or H-shaped figures observed during habituation but they were now composed of novel red and white stripes not previously seen. As such, they served as new exemplars for a variety of possible concepts formed during habituation. The specific combination of shapes and movement patterns seen during test depended upon the experimental condition and will be further elaborated upon below. During the two test segments, the left and right videotaped presentations were reversed to avoid position bias on the part of the infant. In all four experimental conditions, shapes and movement patterns were counterbalanced throughout habituation and test trials to prevent ordering effects.

Experimental Condition 1. The first experiment was conducted simply to ascertain that both 5 and 8 month old infants could in fact discriminate between the two different shapes of stimuli used throughout all of the experiments. The 16 infants participating in this particular experiment were first habituated to either multi-exemplars of shmoo-shaped or H-shaped figures using the method described above. During test, the infants saw a paired comparison of two red and white striped figures: the familiar shape seen during habituation versus the shape not previously seen. Both figures were performing the same movement pattern seen during the habituation trials. Total visual fixation time to the novel and familiar shapes, combined across the two test trials, were compared.

Experimental Condition 2. In the second experiment, 16 infants were asked to discriminate a change only in function, i.e. differentiate between the slow vertical bounces and the quick longitudinal jumps. Not only did this experiment seek to establish that both 5 and 8 month old infants could successfully discriminate between the two different movement patterns, but it also provided a basis against which to compare changes involving combinations of form and function seen in experimental conditions 3 and 4. In this experiment, the infants were again exposed to the same habituation series, involving multiple exemplar exposure to either shmoo-shaped or H-shaped figures repeatedly performing one of the two movement patterns. During test, these same infants saw the familiar figure, now with red and white stripes, on both screens. On one screen, the figure was performing the same movement pattern seen during habituation while the novel movement was seen on the other screen. Once again, visual fixation times to the novel and familiar stimuli were totaled over two test trials and compared.

Experimental Condition 3. In the third experiment, which was a critical test of Nelson's functional core hypothesis, the infant's visual fixation time to a change in shape was compared to visual fixation time to a change in function. It was hypothesized that looking time should be greater to the novel function than to the novel form. During habituation, a group of 16 infants saw the 6 trials of multicolored shmoo-shaped or H-shaped figures repeatedly performing one specific movement pattern. During test, the infants simultaneously saw a red and white striped shmoo-shaped figure and a red and white striped H-shaped figure on adjacent screens. On one screen, they saw the familiar shape seen during habituation, only it was now performing a new movement pattern. On the other screen, the infants saw the novel figure performing the familiar movement pattern seen during habituation. Once again, total looking time to the two stimuli across two test trials was compared.

Experimental Condition 4. An interesting question was posed by the fourth experiment: does the infant find a change only in function more captivating than a combined change in both form and function? Adopting Nelson's hypothesis, a new function attached to a familiar form should increase visual time more than a dual change in both form and function. When a new function is attached to an already familiar form, the infant is presumably forced to change the underlying functional base for concept formation. If, however, the infant is presented with a new form that performs a new function, the infant is able to simply create a new concept that is not in interference with the old one established during habituation; this should require less time than alteration of the original concept necessitated by a change only in function. To test this hypothesis, the 16 infants in experimental condition 4 were first habituated to the 6 trial series of the multi-exemplar shmoo- and H-shaped figures, repeatedly performing the same movement pattern. During test, the infants saw the familiar shape performing a novel movement pattern, coupled with a novel shape performing a novel movement pattern. If, for example, the infant saw shmoo-shaped figures bouncing up and down during habituation, the infant would then see a paired comparison of the red and white shmoo-shaped figure jumping laterally and the novel red and white H-shaped figure jumping laterally during test. As in the other experiments, total fixation times to the two stimuli seen during test were totaled across two test trials and compared.

Chapter 3

Results

Test Effects

The major dependent variable of interest in this study is the novelty preference score, computed as the total amount of fixation to the novel stimulus (N) on both test trials divided by overall looking to the novel and the familiar (F) stimulus combined on both trials, i.e., $\frac{N}{N+F}$ (Caron and Caron, 1981). This score was computed separately for the first session, second session, and both sessions combined within each experimental condition. A score value of 50% on this measure would indicate that the infant responded equally to the novel and familiar stimuli at test. If the value significantly exceeded 50%, the infant looked longer at the novel stimulus. A score significantly less than 50% would indicate that the familiar stimulus was preferred. In conditions 3 and 4, where both test stimuli were novel, the stimuli involving change in movement alone were arbitrarily designated novel, since Nelson would predict greater attention to this change.

An initial question of interest was whether infants in the various experimental conditions discriminated the novel stimulus. According to Nelson's theory, as noted, the infants should have demonstrated a strong novelty preference to changes in the function of objects (in this case, to changes in their movement) which force re-conceptualization of object meaning. Since inspection of the data revealed that there were no marked differences between sessions one and two, the novelty scores were totaled across both sessions for computational purposes. The mean combined novelty scores of Age x Sex x Condition subgroups are shown in Table I. To test for successful discrimination, separate *t*-tests were initially conducted for the deviation of the overall Condition means (bottom row of Table I) from a chance score of 50%. Of the four *t*-tests, one proved statistically significant, that for the Movement Change Condition (Condition 2)--$t(15)=2.01$, $p < .05$. In the Movement vs. Shape Condition (Condition 3), the mean approached significance ($t(15)=1.67$, $p < .10$). These data, combined with the absence of significant discrimination in the Shape Condition (Condition 1) are therefore consistent with Nelson's general position. Less consistent with her position is the lack of an effect in Condition 4 (Movement vs. Movement plus Shape), where stronger fixation of movement change alone at test would have been expected. It should also be noted that the major contribution to the Condition 3 effect came from the 5 month old infants ($t(7)=1.94$, $p < .05$), with the 8 month old infants responding just about at chance ($M=50.4$). In Condition 2, the 8 month old infants significantly discriminated the new movement pattern ($t(7)=2.10$, $p < .05$) but not the 5 month olds. No other subgroup or combined means were significantly discrepant from chance.

The previous analysis examined whether the various Condition and subgroup means deviated from chance value but did not tell us whether these means differed from one another. An initial question in this regard involved the comparison of Conditions 1 and 2 (Shape Change vs. Movement Change). An 2(Age) x 2(Sex) x 2(Condition) ANOVA restricted to these two Conditions yielded no significant main or interaction

Table I

Mean Combined Novelty Scores

Group	1(Shape)	2(Movement)	3(Movement vs. Shape)	4(Movement vs. Shape + Movement	Total
5 Months					
Male	54.60 (7.12)[a]	55.55 (14.95)	60.70 (16.50)	51.88 (12.43)	55.68 (11.84)
Female	47.20 (9.13)	53.62 (8.18)	64.82 (22.96)	46.08 (6.49)	52.93 (12.00)
Total	50.90 (7.58)	54.58 (11.16)	62.76*(18.52)	48.98 (9.18)	54.30 (11.73)
8 Months					
Male	54.02 (8.97)	54.95 (6.51)	51.18 (9.85)	48.42 (1.70)	52.14 (6.68)
Female	45.00 (3.64)	52.95 (4.59)	49.52 (10.91)	48.48 (6.37)	48.99 (6.23)
Total	49.51 (6.37)	53.95*(5.22)	50.35 (9.62)	48.45 (4.32)	50.56 (6.35)
Overall					
Male	54.31 (7.50)	55.25 (10.68)	55.94 (12.59)	50.15 (8.21)	53.91 (9.46)
Female	46.10 (6.43)	53.28 (6.14)	57.17 (16.64)	47.28 (5.96)	50.96 (9.40)
Total	50.20 (6.75)	54.26*(8.42)	56.56 (14.25)	48.15 (6.93)	52.44 (9.36)

[a]standard deviations shown in parenthesis
*$p < .05$

effects (Table II), thus indicating that while change in movement alone was significantly discriminated from chance, it was not discriminated to a greater extent than change in shape alone. A comparable analysis restricted to Conditions 3 and 4 also yielded no significant effects, indicating that change in movement was not discriminated more strongly when it was contrasted with change in shape than when it was contrasted with change in movement plus shape (Table III).

It was also of interest to determine whether there were any differences in the novelty scores as a function of stimulus characteristics. To this end, an analysis of 2(Age) x 2(Sex) x 2(Shape), with shmoo-shaped figures and H-shaped figures constituting the two shape variables, was conducted for the novelty scores in Condition 1 (mean scores shown in Table IV; ANOVA shown in Table V). This ANOVA yielded no significant main or interaction effects, demonstrating that the infants did not respond differentially to the particular shapes. A comparable analysis of 2(Age) x 2(Sex) x 2(Types of Movement . . . side-to-side vs. up-down movements) within Condition 2 also produced no significant effects, indicating that the infants had not fixated the two movements differentially in this condition (mean scores shown in Table VI; ANOVA shown in Table VII). However, the same analysis for Condition 3 did yield a significant movement effect ($\underline{F}(1,8)=8.07$, $p < .05$) in favor of the side-to-side motion (mean scores shown in Table VIII; ANOVA shown in Table IX). No other effects were significant in this Condition. The discrepant findings, regarding movement preferences in Conditions 2 and 3, are difficult to

Table II

Analysis of Variance of Conditions 1 and 2

SV	df	SS	MS	F
Age	1	8.21	8.21	< 1.00
Sex	1	207.06	207.06	2.85
Condition	1	132.03	132.03	1.82
Age x Sex	1	1.44	1.44	< 1.00
Age x Condition	1	1.12	1.12	< 1.00
Sex x Condition	1	78.13	78.13	1.07
Age x Sex x Condition	1	1.21	1.21	< 1.00
Error	24	1774.50	72.69	

Table III

Analysis of Variance of Conditions 3 and 4

SV	df	SS	MS	F
Age	1	334.75	334.75	2.13
Sex	1	5.36	5.36	< 1.00
Condition	1	492.19	492.19	3.13
Age x Sex	1	.01	.01	< 1.00
Age x Condition	1	282.64	282.64	1.80
Sex x Condition	1	33.81	33.81	< 1.00
Age x Sex x Condition	1	67.58	67.58	< 1.00
Error	24	3770.85	157.12	

Table IV

Mean Novelty Scores in Condition 1

Group	Shape: Shmoo Figure	Shape: H-Shaped Figure	Total
5 Months			
Male	50.00	59.20	54.60
Female	42.85	51.55	47.20
Total	46.42	55.38	50.90
8 Months			
Male	51.25	56.80	54.02
Female	43.30	46.70	45.00
Total	47.28	51.75	49.51
Overall			
Male	50.62	58.00	54.31
Female	43.08	49.12	46.10
Total	46.85	53.56	50.20

Table V

Analysis of Variance of Condition 1

SV	df	SS	MS	F
Age	1	7.70	7.70	$<$ 1.00
Sex	1	269.78	269.78	4.49
Shape	1	180.20	180.20	3.00
Age x Sex	1	2.64	2.64	$<$ 1.00
Age x Shape	1	20.00	20.00	$<$ 1.00
Sex x Shape	1	1.77	1.77	$<$ 1.00
Age x Sex x Shape	1	.70	.70	$<$ 1.00
Error	8	480.32	60.04	

Table VI

Mean Novelty Scores in Condition 2

Group	Movement: Side-to-Side	Movement: Up-Down	Total
5 Months			
Males	65.00	46.10	55.55
Females	51.80	55.45	53.62
Total	58.40	50.78	54.59
8 Months			
Males	57.65	52.25	54.95
Females	52.75	53.15	52.95
Total	55.20	52.70	53.95
Overall			
Males	61.32	49.18	55.25
Females	52.28	54.30	53.29
Total	56.80	51.74	54.27

Table VII

Analysis of Variance of Condition 2

SV	df	SS	MS	F
Age	1	1.62	1.62	< 1.00
Sex	1	15.40	15.40	< 1.00
Movement	1	102.51	102.51	1.30
Age x Sex	1	.01	.01	< 1.00
Age x Movement	1	26.27	26.27	< 1.00
Sex x Movement	1	200.95	200.95	2.43
Age x Sex x Movement	1	70.10	70.10	< 1.00
Error	8	661.85	82.73	

Table VIII

Mean Novelty Scores in Condition 3

Group	Movement: Side-to-Side	Movement: Up-Down	Total
5 Months			
Males	70.10	51.30	60.70
Females	78.75	50.90	64.82
Total	74.42	51.10	62.76
8 Months			
Males	56.50	45.55	51.18
Females	58.80	45.55	51.18
Total	57.80	42.90	50.35
Overall			
Males	63.45	48.42	55.94
Females	68.45	45.58	57.17
Total	66.11	47.00	56.56

Table IX

Analysis of Variance of Condition 3

SV	df	SS	MS	F
Age	1	616.28	616.28	3.40
Sex	1	6.13	6.13	$<$ 1.00
Movement	1	1461.10	1461.10	8.07*
Age x Sex	1	33.35	33.35	$<$ 1.00
Age x Movement	1	71.10	71.10	$<$ 1.00
Sex x Movement	1	66.88	66.88	$<$ 1.00
Age x Sex x Movement	1	.64	.64	$<$ 1.00
Error	8	1447.64	180.96	

*$p < .05$

explain. Had the side-to-side movement preference predominated in both conditions, one would be forced to look closely at the issue of stimulus equivalence and the effect that this may have had on all test results. However, the counterbalancing of movement stimuli throughout the experiment, coupled with the inconclusive movement preference findings just discussed, should reduce concern over the impact of this factor on other test results. No analysis was conducted for Condition 4 because both test stimuli involved change in this Condition. However, an 2(Age x 2(Sex) ANOVA for Condition 4 yielded no significant effects due to age or sex (Table X).

Familiarization

To determine whether the infants had comparable exposure to the familiarization stimuli in the four conditions, an 2(Age) x 2(Sex) x 4(Condition) ANOVA was conducted for mean looking time across the six familiarization trials within each experimental session (Tables XI and XII). No main effects or interaction effects were statistically significant in either session 1 or session 2, indicating that the amount of looking time during familiarization was equivalent for Conditions, Age and Sex.

It was also of interest to determine whether there was evidence of habituation in either session, and whether its extent was comparable across Conditions. For this purpose, each infant's total fixation time on trials 5 and 6 was subtracted from total fixation time on trials 1 and 2, and this difference was computed as a percentage of total fixation on trials 1 and 2, $\left[\frac{F_{5,6} - F_{1,2}}{F_{1,2}}\right]$. An 2(Age) x 2(Sex)

Table X

Analysis of Variance of Condition 4

SV	df	SS	MS	F
Age	1	1.10	1.10	$<$ 1.00
Sex	1	33.06	33.06	$<$ 1.00
Age x Sex	1	34.23	34.23	$<$ 1.00
Error	12	723.49	60.29	

Table XI

Analysis of Variance of Mean Total Looking

during Session 1 Familiarization Trials

SV	df	SS	MS	F
Sex	1	2.19	2.19	1.78
Age	1	2.12	2.12	1.72
Condition	3	.12	.04	< 1.00
Sex x Age	1	2.16	2.16	1.76
Sex x Condition	3	3.16	1.05	< 1.00
Age x Condition	3	2.70	.90	< 1.00
Sex x Age x Condition	3	1.52	.51	< 1.00
Error	48	59.01	1.23	

Table XII

Analysis of Variance of Mean Total Looking during Session 2 Familiarization Trials

SV	df	SS	MS	F
Sex	1	.06	.06	< 1.00
Age	1	4.61	4.61	3.36
Condition	3	4.05	1.35	< 1.00
Sex x Age	1	2.15	2.15	1.57
Sex x Condition	3	5.13	1.71	1.25
Age x Condition	3	6.31	2.10	1.53
Age x Sex x Condition	3	2.18	.73	< 1.00
Error	48	65.92	1.37	

x 4(Condition) ANOVA was conducted for this score with a constant factor of 76.3 added, for each experimental session (mean scores shown in Tables XIII and XIV; ANOVAs shown in Table XV). No significant results were obtained for either session, suggesting that the percentage decrease in looking time was comparable across Age, Sex, and Condition in both sessions 1 and 2. These same scores were next used to evaluate the absolute extent to habituation in both sessions. The mean percentage of decrease in the first session (1.4%) and the second session (9.7%) were compared against a chance score of 0% in two separate _t_-tests. Of the two _t_-tests, only the results of the second session were significant ($t(63)=3.59$, $p < .0005$), indicating that habituation was evident in the second session but not in the first. This may suggest that two sessions were necessary before sufficient information processing had occurred to allow for decreased looking.

Table XIII

Mean Percentage of Decreased Looking Time

in Session 1

Group	Conditions: 1(Shape)	2(Movement)	3(Movement vs. Shape)	4(Movement vs. Movement+Shape)	Total
5 Months					
Males	71.75[a]	71.05	78.62	48.80	67.56
Females	91.70	81.78	69.42	79.35	80.56
Total	81.72	76.42	74.02	64.08	74.06
8 Months					
Males	87.40	91.28	77.80	69.48	81.49
Females	88.82	74.60	85.80	74.85	81.02
Total	88.11	82.94	81.80	72.16	81.25
Overall					
Males	79.58	81.16	78.21	59.14	74.52
Females	90.26	78.19	77.61	77.10	80.79
Total	84.92	79.67	77.91	68.12	77.66

[a]A constant factor of 76.3 was added to each score

Table XIV

Mean Percentage of Decreased Looking Time

in Session 2

Group	1(Shape)	2(Movement)	3(Movement vs. Shape)	4(Movement vs. Movement+Shape)	Total
	Conditions				
5 Months					
Males	87.00[a]	94.40	83.65	85.90	87.74
Females	77.48	90.02	91.58	88.65	86.93
Total	82.24	92.21	87.62	87.28	87.34
8 Months					
Males	83.40	94.75	89.42	61.85	82.36
Females	86.25	80.88	87.40	92.78	86.83
Total	84.82	87.82	88.41	77.32	84.59
Overall					
Males	85.20	94.58	86.54	73.88	85.05
Females	81.86	85.45	89.49	90.72	86.88
Total	83.53	90.02	88.02	82.30	85.96

[a]A constant factor of 76.3 was added to each score

Table XV

Analysis of Variance of Habituation Percentage Scores in Sessions 1 and 2

Session 1

SV	df	SS	MS	F
Age	1	828.00	828.00	2.07
Sex	1	628.75	628.75	1.57
Condition	3	2365.57	788.52	1.97
Age x Sex	1	726.30	726.30	1.82
Age x Condition	3	8.90	2.98	< 1.00
Sex x Condition	3	1155.58	385.20	< 1.00
Age x Sex x Condition	3	1297.21	432.40	1.02
Error	48	19188.73	399.77	

Session 2

SV	df	SS	MS	F
Age	1	120.72	120.72	< 1.00
Sex	1	53.81	53.81	< 1.00
Condition	3	640.34	213.45	< 1.00
Age x Sex	1	111.59	111.59	< 1.00
Age x Condition	3	384.03	128.01	< 1.00
Sex x Condition	3	1494.29	498.09	< 1.00
Age x Sex x Condition	3	1026.05	342.02	< 1.00
Error	48	25617.78	533.70	

Chapter 4

Discussion

Nelson's functional hypothesis, it will be recalled, stated that function serves as the central core for concept acquisition in infancy. According to Nelson, an infant should look longer at a change in function than a change in form because of the essential information it provides about the particular concept being formed. In this study, function was synonymous with movement and form was synonymous with stimulus shape. The test results suggest that partial support for Nelson's functional core hypothesis can be found in three of the overall novelty preference discrimination tests. First, the infants demonstrated discrimination of a novel movement pattern from a familiar movement pattern in Condition 2, suggesting that sufficient attention was paid to this variable to yield significant results. Secondly, attention to movement changes were also somewhat evident in the preference for a movement change, when contrasted with a shape change in Condition 3. This discrimination yielded strongly significant results for the 5 month old infants and overall results which approached significance. Finally, the curious finding that neither 5 nor 8 month old infants could discriminate simple shape change in Condition 1 provides possible support for Nelson's predicted preference for movement change. It is quite well established that infants by 5 months of age not only discriminate shapes (Cohen, DeLoache, and Strauss, 1979) but they can also recognize shape constancy across changing colors and orientations (Caron, Caron, and Carlson, 1979;

Schwartz, 1975). It is possible that the infants in this study were so engrossed in watching the dynamic movement patterns that they simply ignored shape changes and thus did not discriminate between shapes during test trials. Before any conclusions could be reached regarding shape discrimination, it would be necessary in future research to compare the infants' visual responses to static shape change with their visual responses to shape change when accompanied by movement to determine if movement does in fact overpower shape.

The lack of a significant overall "novelty" effect in the Movement vs. Movement plus Shape Condition (Condition 4) is not consistent with Nelson's theory. She predicted longer fixation to the moderately discrepant movement change rather than the maximally discrepant movement plus shape change. The former change, according to Nelson, would necessitate expansion of the concept formed during habituation while the latter change would not be in competition with the originally formed concept. The results in Condition 4 do not bear out this theory. Neither 5 or 8 month old infants demonstrated significantly increased looking to the movement change. It is possible that the infants in this study simply did not prefer the functional movement change as predicted by Nelson. It is alternately possible that the methodology employed in this study had an impact on test results in Condition 4. The stimulus changes in Condition 4 were more complex than those in the other three Conditions. It is plausible that sufficient encoding was not achieved during the test trials to allow time for preferred looking towards one specific stimuli. Further assessment of the methodological considerations will be addressed in subsequent discussion.

Although the absolute movement effects generally support Nelson's theory, with the exception just noted, the relative movement effects were not as strong as anticipated. Movement change was not discriminated to a greater extent than was shape change when Conditions 1 (Shape Change) and 2 (Movement Change) were compared with one another, nor was movement change more strongly discriminated against a shape change than against a movement plus shape change when compared in Conditions 3 (Movement vs. Shape) and 4 (Movement vs. Movement plus Shape).

Drawing together the evidence supporting and refuting Nelson's contention that infants prefer to focus on function over form for concept formation, one thus finds mixed results. The infants appeared to pay more attention to movement changes than shape changes when the two were compounded as stimuli in the first two conditions. There was additionally some evidence of a preference for a movement change when contrasted with a shape change in Condition 3. There was no evidence, however, that the infants found a functional change more captivating than a combined functional-form change as predicted by Nelson.

In addition to addressing Nelson's functional core hypothesis per se, this study also looked at possible age differences in the use of functional information for concept formation. The test results do not point to an obvious developmental trend in the use of function for conceptualization. It can only be concluded that functional properties appear as salient for 5 month old infants as they are for 8 month olds. It is also important to note that no indication of sex differences was found in any of the analyses. None of the forementioned ANOVAs yielded significant main or interaction effects for sex as a variable. This appears to suggest that male and female infants performed comparably throughout both the habituation trials and the test trials.

A number of methology factors could have distracted from the present findings and merit discussion. First, one might question whether or not the infants were sufficiently familiarized to the stimuli presented in trials 1-6. In contrast to the static pictures or slides usually presented as stimuli in this type of study, videotapes were used. Videotapes are, by their very nature, visually captivating for young infants. This became obvious during the familiarization trials. Although a statistically significant decrease in looking time did occur in the second session, the percentage of decreased looking (9.7%) was not as pronounced as one usually obtains with static stimuli. Two pieces of data, however, argue against the possibility of insufficient familiarization. First, the 8 month old infants did not habituate more strongly than the 5 months old infants although one would have expected them to process the stimuli more rapidly. Secondly, the test results in the second session were not greatly different from the results in the first session, which one would have expected if familiarization was inadequate. Together, these factors might suggest that the test results are not readily explainable by a possible lack of habituation.

The manner of presentation of stimuli is another methodological concern that could have attenuated test results. The infants grew accustomed to focusing their attention on a single stimulus during each habituation trial. They would see a moving figure on only the left or the right screen at any given time. During test, however, two complex, dynamically changing stimuli, which competed for the infant's attention, were projected simultaneously on the left and right screens. This examiner observed that the majority of infants gave many short, quick, darting looks to the dual stimuli presented during test. This pattern appeared to continue through both the test sessions. Perhaps the infants continued these quick left and right looks for fear of missing any further changes on either screen. On the other hand the complexity of simultaneous presentation of stimuli may have prevented the infant from having sufficient time to finish processing the essential information contained in the test stimuli before the end of the second session. It this were the case and the infants had not completed encoding and comparing all the information contained in the two test stimuli prior to the end of the second session, it is doubtful that they could have demonstrated a strong visual preference to one particular stimulus. This factor could have had an impact on test results in all four Conditions.

In future research utilizing this same paired comparison technique, it may be beneficial to present two stimuli simultaneously during each familiarization trial. This would allow the infant to gain familiarity with the format of simultaneous presentations prior to the test trials. Additionally, it might be advantageous to increase the length of each test trial to allow for more complete encoding of stimuli. Making these changes in the methodology could conceivably increase information processing and may allow for more meaningful responding on the infant's part to the questions posed by Nelson.

In summary, the results of this research provide some support for Nelson's contention that function is at the core of concept formation. The results, however, are not conclusive and are possibly confounded by methodological considerations as discussed. The results do not point to a developmental age trend towards either increased or decreased use of functional attributes for concept acquisition, but instead suggest that function is salient for both 5 and 8 month old infants.

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