76-22,474

FARMER, Val Gene, 1940-
INFANT COGNITION DURING THE SECOND YEAR
OF LIFE AS INDEXED BY VISUAL ATTENTION
AND EXPRESSIVE BEHAVIOR.

The University of Arizona, Ph.D., 1976
Psychology, general

Xerox University Microfilms, Ann Arbor, Michigan 48106

INFANT COGNITION DURING THE SECOND YEAR OF LIFE AS INDEXED BY VISUAL ATTENTION AND EXPRESSIVE BEHAVIOR

by

Val Gene Farmer

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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THE UNIVERSITY OF ARIZONA

GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my direction by Val Gene Farmer

entitled Infant Cognition During the Second Year of Life As Indexed by Visual Attention and Expressive Behavior

be accepted as fulfilling the dissertation requirement of the degree of Doctor of Philosophy

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ACKNOWLEDGMENTS

The author expresses appreciation to the members of his dissertation committee for their support, helpfulness, and constructive criticism. A special word of gratitude is due to Dr. Eric Gelber whose guidance was instrumental in bringing this research to fruition. Jim Reed, Joe Stevens, Linda Traher and other students gave generously of their time and were invaluable in their assistance.

Thanks are also due to the policy board, staff, and parents at the El Rio-Santa Cruz Neighborhood Health Center for their gracious participation in this project. Drs. George Comerci and Helen Johnson at The University of Arizona Medical School Pediatrics Department were unflagging in their support and cooperation. Their trust and friendliness made this project a very pleasurable experience. Pat Till and Willie Dreier, under the auspices of the Pediatrics Department, were talented contributors to this research. Thanks go to John Gaines and Harland Carey for their patience and great skill in reducing the vast array of data to meaningful levels.

Lastly, my wife Darlene, took an active role as an experimenter in addition to steady support of this endeavor.

She is the unsung heroine in back of the research and of its author.

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ABSTRACT

The focus of this dissertation was to examine infant visual and expressive responses to stimuli transformed along dimensions that disconfirm basic cognitive expectancies. Infant reactions to violations of expectancy were postulated to index the presence and relative strength of cognitive structures pertaining to the transformed event. Age, sex, environmental background, and various types of transformations were examined in relationship to infant surprise, fixation, crying, and tracking behaviors.

A longitudinal sample of 46 infants, tested at 11 and 18 months of age, was obtained from a low income and ethnic minority area of Tucson. Mothers of 43 of the 46 infants were observed at home and subsequently rated high or low risk as to the quality of their relationships with their infants.

The infants were brought to a television studio at the University of Arizona Medical School and exposed to a series of six expectancy violating events following habituation trials with the pretransformed stimuli. A pulley system that transported objects behind a center screen was used for transformations of color, size, form, and location.

A discrepant doll and alteration of the experimenter's facial appearance were also used in the test sequence. Infant reactions were videotaped and data were gathered using recording and rating techniques.

Results showed a significant increase in surprise behavior from pretest to posttest on the form, location, and disguise transformations as well as an overall increase in surprise on all six transformations. Females were significantly more surprised than males at posttest. Low risk infants tended to be more surprised at pretest while posttest data were inconclusive. Differential patterning of responses to person permanence and object permanence transformations at each age level were apparent with respect to surprise behavior and helped to clarify the weak results of the risk data at posttest.

Findings on fixation recovery suggest an inverted U function of fixation to the transformations at posttest. The relationship of fixation recovery to surprise, tracking, crying, risk and sex support the view that shorter looking may be a developmentally appropriate avoidance response when strong expectancies are violated. Contrary to expectation, habituation rate did not vary with age in this study nor did it associate strongly with other indices of infant cognition. However, tracking behavior at pretest proved to be a sensitive measure and correlated meaningfully with other cognitive variables at pretest and posttest. Additional inferences are made regarding the meanings of response systems based on longitudinal intercorrelations and the simultaneous association and configuration of the responses themselves.

There are both theoretical and practical implications derived from this study. There is empirical support for the notion that the developing infant experiences surprise when his cognitive structures are unexpectedly violated. The simultaneous measurement of several response systems in a short term longitudinal study helped to define the meaning and validity of the response systems in question. These various responses can be used to assess a preverbal infant's level of cognitive development. In addition to assessment of developmental status, information can be obtained regarding the emergence and development of particular cognitive structures. Admittedly, the procedures and measurement techniques used in this study need to be refined and standardized to permit systematic investigation of infant cognition.

INTRODUCTION

This study examines a broad spectrum of preverbal infant behavior following exposure to expectancy-violating events. These responses include visual fixation time, orienting responses, habituation rate, facial expressions, and responses denoting surprise.

Specifically, the research deals with young infants from varying child-rearing backgrounds and at two different ages. Among the questions being raised are the following: 1) What are the relationships between age, environmental background and sex on the one hand, and the infants' visual and expressive behavior following a series of events that systematically violate his expectancies on the other? 2) What are the interrelationships of these responses and their relative stability or continuity over time? 3) How do these responses differ when the discrepancy or rule-violating experience is varied along specific dimensions (size, color, form)? 4) Is this methodology useful in discovering the acquisition and strength of concepts and as a potential means of cognitive assessment?

The distribution of attention in infancy is proving to be a useful indicator of perceptual and cognitive processes (Kagan, 1972). The deployment of attention to certain images is felt to reflect differential acquisition of cognitive structures pertaining to those images. Studies of visual attention are focusing on specific dimensions that are known to affect fixation time, i.e., novelty, complexity, discrepancy and anomaly. The findings of the current research in each of these areas will be considered, with special emphasis on those studies dealing with anomaly or violation of expectancy.

Complexity

Studies of complexity attempt to define the physical attributes of various stimuli that affect infant attention. Complexity has been shown to be related to visual attention (Berlyne, 1958a, 1958b; McCall and Kagan, 1967; and Moffett, 1969); and a developmental progression in preference for complexity has been found in numerous studies (e.g., Brennan, Ames and Moore, 1966; Greenberg and O'Donnell, 1972; and Karmel, 1969). McCall (1971) reviews the relevant studies and summarizes the general finding that infants after 2 to 3 months tend to look longer at irregular patterns. The data suggest that as the infant matures, he maximally attends to stimuli possessing more and more contour. McCall also suggests a common finding that preference for complexity levels off between 5 and 9 months. Recent studies also relate the rate of infant habituation to preference for complexity (Brown, 1974; Greenberg, O'Donnell and Crawford, 1973).

The latter study (Greenberg, O'Donnell and Crawford, 1973) found that 11-week-old infants who habituated less rapidly looked longer at the more complex patterns in a complexity test while the former study (Brown, 1974) found that 8-week-old infants showed significantly less habituation to a 8 x 8 checkerboard pattern than to either a 2 x 2 or 24 x 24 pattern.

Novelty and Familiarity

A second line of inquiry on infant visual attention centers on differential response to novel and familiar stimuli. There is substantial evidence that fixation time gradually declines as a consequence of repeated exposure to the same stimulus (habituation paradigm) and recovers (dishabituation) upon presentation of a new stimulus (Lewis and Goldberg, 1969; Jeffery and Cohen, 1971). Habituation is generally regarded as a process during which the repeated presentation of the stimulus leads to the formation of an internal representation or schema of the external stimulus. The primary assumption is that the magnitude of recovery is assumed to reflect the extent to which novel and familiar events have been discriminated.

Numerous studies manipulate the amount of familiarity through an habituation procedure (Caron and Caron, 1969; Fagan, 1970; Fantz, 1964; Pancratz and Cohen, 1970; Saayman, Ames, and Moffett, 1964). A general finding is that after

3 months of age, infants look longer at the novel stimuli than at the familiar stimuli. Various subject and stimulus variables have been manipulated to learn about early cognitive and memory development. Common experimental procedures include long term familiarization in the home (Greenberg, Uzgiris, and Hunt, 1970; Weizmann, Cohen, and Pratt, 1971) and brief in-the-laboratory familiarization (McCall and Melson, 1969; Pancratz and Cohen, 1970).

Both successive exposure and simultaneous exposure (or paired-comparison) methods have been used to assess visual preference. The latter method suffers the drawback of confounding increasing interest in the novel stimulus and decreasing interest in the familiar stimulus. Stimuli have also been presented without prior familiarization in visual preference studies (Wilcox, 1969; Kagan et al., 1966; Fantz and Nevis, 1967). The interpretation of long fixation times is ambiguous in these studies since other stimulus dimensions that sustain infant attention are not subjected to experimental control.

Violation of Expectancy and Discrepancy

Piaget (1952) and others (Berlyne, 1960; Dember and Earl, 1957; Fiske and Maddi, 1961; Miller, Galanter and Pribram, 1958; Hebb, 1946; Hunt, 1961) have proposed conflict models of cognitive development. They suggest that change or development in cognitive structure occurs when cognitive equilibrium is disrupted by a conflict between information already stored in the central nervous system and the incoming information. Sokolov (1963) proposed a neuronal model of attention that was also based on the degree of conflict between the stored model and incoming stimuli. Piaget and Inhelder (1969) elaborate notions of "accommodation" and "assimilation" in describing changes in cognitive development. Accommodation refers to change in existing schemata while assimilation refers to storage of coding of these changes. It is felt that stimulus inputs of limited discrepancy can be accommodated to central schemata. With large discrepancies, either the subject presumably cannot see his preceding schema in the new stimulus or the discrepancy instigates a fear or withdrawal response.

As to the schemata or cognitive structures themselves, Bart and Smith (1974) offer a definition. A cognitive structure is felt to contain elements and processes and a set of rules ascribed to the elements.

> Elements are the input and output of the cognitive structure and are those entities that are attended to, thought of, and cognized . . . Processes are the representational actions performed on the elements; they are defined in terms of the elements they act on and the elements they produce . . . Rules provide axiomatic laws for the classification of cognitive structure (Bart and Smith, 1974, p. 164).

Bourne (1974) identifies a structure as being a group of relevant attributes or features forming a relationship based on some rule of combination. The universe of objects, events, processes and states of affairs is divided into positive and negative instances where stimuli are either consistent or inconsistent with existing structure. Change in cognitive structure involves (a) identification of additional attributes that conform to a given relationship or (b) the generation of a relationship that combines relevant and known attributes. Restle (1974) suggests these cognitive structures are hierarchically ordered in their ability to incorporate information and the depth of processing corresponds to the generality and size of the cognitive structure involved.

Bruner, Wallach and Galanter (1959) state:

> . . . learning and problem-solving may be more probably viewed as identification of temporally or spatially extended patterns . . . and that the process of learning or problem solving can be viewed as the development of means for isolating such regularities from the flow of irrelevant events that originate either in the environment, in the organism, or are produced by the organism's response to the environment (p. 206).

Cognitive structures with the greatest generality are those that reflect lawful phenomena and invariances in the natural environment. Certain events are viewed as always occurring, others as never occurring, and some always occur in invariant combination.

In order to assess how cognitive structures are formed, an experimental procedure has been developed that demonstrates utility. Stimuli are presented that violate a rule that combines attributes of a given cognitive structure and the weight of the violation is observed in the organism's responses. The stimulus is transformed along a key dimension that previously held it in combination with other stimuli.

The prestimulus experience of the organism with both the familiar and transformed stimulus is critical in determining the degree of responsiveness.

Charlesworth (1969) points out that events are misexpected rather than unexpected because of the organism's prior history of learning and associating signals that precede the stimulus event with the event itself. The recognition and integration of these signals create specific expectancies about forthcoming events. When an expectation is created about a forthcoming event and a stimulus fails to confirm this expectancy, the event is misexpected rather than unexpected.

Labels such as incongruity, violation of a rule, discrepancy, misexpected outcome, and violation of expectancy have been used by various researchers in describing their procedures when expectancies are disconfirmed. These studies can be divided into two groups based on the amount of preexperimental familiarization with stimuli or class of stimulus events.

The first group of experiments are those where the stimuli are arbitrarily selected and are equivalent in their ability to recruit attention. Using the habituation paradigm, the organism is subjected to experimental familiarization with one stimulus, then exposed to a variant of that stimulus that has been transformed along specific dimensions of a discrepancy continuum. These studies will be reviewed as a unit and will be referred to as "discrepancy" studies. The second series of experiments are those in which the stimuli are not equivalent in their power to recruit attention because of preexperimental familiarization. Typically, the transformation of these stimuli involve disconfirmation of expectancies developed over time through the organism's interaction with his environment. Studies so designed are referred to as "violation of expectancy" studies.

Discrepancy Studies

McCall and Melson (1969) have proposed that attention to novel stimuli is an inverted U function of the degree of discrepancy between a novel and a previously exposed stimulus. Specifically, low or high degrees of discrepancy will be less likely to recruit the attention of an infant than a moderate degree of discrepancy. This hypothesis reflects two factors. Attention increases with increasing amounts of information. As stimulus information becomes difficult to process and integrate by existing cognitive structures, attention will decrease. A number of studies have systematically varied transformations along a discrepancy continuum (Caron et al., 1973; Cornell, 1975;

Gyr et al., 1974; McCall, 1973; McCall and Kagan, 1967; McCall and Kagan, 1970; McCall and Melson, 1969; McCall et al., 1973; Super et al., 1972; Parry, 1973; and Welch, 1974). Two studies have reported findings suggesting that two-dimensional discrepancy between novel and familiar stimuli elicit more attention than a one-dimensional difference (Cohen, Gelber and Lazar, 1971; Saayman, Ames and Moffett, 1964).

Overall, the evidence for a complete inverted U function of magnitude of discrepancy is weak. Results have been equivocal at best in support of the theory. Both long term and short term habituation patterns have been used with often contradictory results. Thomas (1971) points out the lack of a theoretical basis for selection of the amount of discrepancy sufficient to produce the downturn in the response curve. Post hoc, many studies mention the fact that they may not have used stimuli to cover a sufficient range of discrepancy. In addition to the problem of having to make an a priori determination of ordered discrepancy, a second problem involves the likelihood that experimentally induced expectations may not be strong enough to qualify as extreme discrepancies. The transformation of arbitrary stimuli and combinational rules following relatively short term familiarization seem unlikely to produce the extreme discrepancies sufficient to produce the downturn in the response curve. This may be particularly true when downturn represents fear or avoidance behavior.

Violation of Expectancy Studies

One of the invariant experiences associated with infancy is repeated exposure to human faces and forms. The experimental comparison for visual preference to various configurations of schematic, scrambled and sculptured faces simulate the experimental in-the-home habituation paradigm. Presumably, the internal representation of the human face involves gradual differentiation of individual distinctive features and their interrelationships. Presentation of a transformed face or form elicits sustained fixation that varies with the saliency of the transformation and the cognitive structures available to the subject.

Systematic assessments of the relative attention value of facial configuration have been accomplished by Fantz (1966); Kagan et al. (1966); Fantz and Nevis (1967); Koopman and Ames (1968); Haaf and Bell (1964); Lewis (1969); and Wilcox (1969). The strategy most commonly used is a comparison of facial representations with stimuli composed of rearrangement of these same elements. The infant's response to orientation of faces has also been studied by Watson (1966); McGurk (1970); Fagan (1972); and Harris and Allen (1974).

A consistent finding is that the ability to discriminate different faces does not appear until after 5½ months of age (Fagan, 1972; Caron et al., 1973, using an habituation paradigm). Various features are discriminated earlier and assume gradients of salience and combinations, however, the invariant configuration of eyes, nose, and mouth is not perceptually organized as immutable characteristics. Assuming the infant has a cognitive structure of "faceness," a violation of the rule that combines the attributes should exert control over infant attention. This should also apply to other early cognitive structures such as human form.

Kagan (1971) in a longitudinal study of 180 infants, assessed responsiveness to altered human faces and form at 4, 8, 13 and 27 months. Transformations included scrambled three-dimensional faces, asymetrical arrangements of human form (12 inch doll), and incongruous transformations of human form (animal head on human doll and visa versa, three-headed human doll). Major dependent variables included fixation time, vocalization, cardiac deceleration, and smiling. He found virtually no relationship between attentiveness or vocalization at 4 or 8 months and attentiveness or speech in the same child at 27 months. Moderate stability of these reactions were found in comparing the behavior at 13 months and 27 months. There was a positive relationship for females and social class and fixation time between 13 and 27 months ($r = .20$ and $.31$). The females who had the largest vocabulary at 27 months had the largest increases in fixation time. This was also associated with middle class social background.

As a result of this study and many other supporting studies, Kagan (1972) summarizes data to suggest a new cognitive process emerges after 8 months of age. This presumed process is labeled "activation of hypotheses" to describe an active process of comparing incoming stimuli with existing cognitive structure in an attempt to accommodate the discrepant event into a form with which he is familiar. Events which formerly elicited progressively decreasing amounts of attention unexpectedly recruit increasing amounts of attention. Kagan feels that fixation time thus becomes a sensitive index of the density and strength of cognitive structures, i.e., the more extensive the repertoire of hypotheses, the longer the infant can work at interpretation and the more prolonged his attention.

Lewis, Wilson, and Baumel (1971) exposed 60 twenty-five-month-old children to 4 achromatic stimuli that varied in complexity and incongruity (three men, one man, three-headed man, man with inverted head). Analysis of data previously collected at 13 months on these same infants revealed that those infants who attended more to an incongruous face as opposed to a normal face were the same infants who at 25 months attended more to the incongruous than to the normal human form. There were no attentional differences in the infants' response to to the three-headed man and the three men comparison leading Lewis and his colleagues to conclude that the schema of the human form was not fully developed at 2 years. An alternative explanation is that the particular stimulus selected and the mode of presentation was not sufficiently incongruent for those infants at that age. Neither Kagan nor Lewis used refined indices of expressive behavior as measures though Kagan (1971) did note a directional relationship between fear of the three-dimensional faces and membership in the top half of the social class distribution at both 8 and 13 months.

There have been a series of recent studies using the habituation-dishabituation paradigm to produce violation of expectancy. Bower, Broughton and Moore (1971) observed 7 to 22 week infants' responses to featural and trajectory information under a normal and impossible conditions. For a dependent measure, they used the infants' anticipatory glances to the reemergence of an object that had disappeared behind a screen. One procedure involved an object moving along a track and going behind a screen. At the moment when the object should have emerged a totally different object emerged and proceeded down the track a short distance before reversing and repeating the entire cycle in the opposite direction. In this sequence, the original and transformed objects differed in size, shape, and color. Infants older than 20 weeks glanced at the opposite side of the screen as if they were searching for the original object. Infants less than 20 weeks continued to track the transformed object with an absence of glancing behavior and no sign of being disturbed. When impossible trajectories involving similar but featurally identical objects were presented, the younger infants became upset and refused to track. Bower, Broughton and Moore hypothesize that infants below 20 weeks do not know that a moving object can stop and become stationary. Bower (1971) also reports presenting multiple mirror images of mothers to their respective infants. Infants older than 20 weeks became quite upset by the sight of more than one mother while the younger infants would characteristically smile, coo and arm wave.

Gardner (1971) presents additional evidence to support the findings of Bower, Broughton and Moore. A trial series was presented during which half the time the original object would reappear from behind a screen while the other half of the time a transformed object appeared. The screen occluded the moving object for one second. Glancing at the opposite side of the screen occurred with the 18- and 21-week-old infants while younger age infants either showed actions indicative of description or simply tracked the object. No additional events are reported such as surprise or length of fixation that would add weight to her findings.

Cohen (1974) observed the attentional behaviors of 48 infants, 5 and 8 months old following systematic face-voice matching and mismatching of mother and a female stranger. Though the overall results regarding responses to incongruity were equivocal, the strongest finding was the consistently shorter first fixations to the violation of expectancy manifested by the 8-month-old girls. In explaining the short first fixations, Cohen suggests that the infants were either directing their attention away from the mismatch to search for the owner of the voice or the cause of the incongruity or, secondly, rejecting the event that transpired. Four 8-month-old subjects were unable to complete the experiment because of distress. Cohen cites Kagan (1971) finding in suggesting that these subjects may have been more advanced in their development. The acute distress may be reflecting a well developed concept of person permanency, the violation of which induces avoidance behavior. This reaction is consonant with Hebb's (1946) classic formulation on the basis of fear.

Grellong (1973) presented 48 infants at 15, 18 and 21 months of age with a task that violated expectancy. Any of 4 alternative knobs would open a jack-in-the-box. After 5 successive trials in which the knobs were operable, all knobs became inoperative. Infants were judged on affect from a nine point scale based on expressive (facial) and vocal cues. They were also rated on a three point surprise scale, i.e., neutral, sober-attentive, and animated. Infants who had higher positive affect on the pre-transformational tasks manifested more animated surprise when their expectancy was violated. Surprise, in turn, instigated attention to the task and thereby led the infant to remain longer with the task.

Charlesworth (1964) reported similar findings using a violation of expectancy paradigm with 32 preschoolers and 80 first and third graders. The Ss used a marble drop apparatus, the appearance of which compelled belief that whatever was inserted into it must, by necessity, come out unchanged. In the surprise condition, output marbles always varied in color and sometimes in number from the input marbles. Observers rated Ss' facial, verbal and vocal responses along a five point scale. Preestablished definitions of surprise were used with mouth movements, raising of the eyebrows, exclamations, and questions indicative of surprise. Of the dependent measures, facial response was the most discriminatory. The Ss who were presented with discrepancy between input and output expressed facial changes associated with surprise more frequently and intensely than children in all other conditions. The Ss who were surprised by the marble transformations played the game longer than controls, suggesting that surprise is capable of instigating curiosity behavior. Charlesworth (1966) also found that infants eight months of age manifested change in affect, puzzlement, active visual search and active manual search after being confronted with the disappearance of a toy observed being hidden. When the toy was found in the hiding places, these behaviors did not occur.

Lewis and Goldberg (1969) used 44-month-old children in a violation of expectancy study. Twenty children (10 boys and 10 girls) were given 6 successive 30-second presentations of 4 sets of stimuli (slides) interspersed by 30-second intertrial intervals. On trial 7, the 4 sets of stimuli were variously transformed along the following dimensions: achromatic to chromatic, form, content, and curvature. Ss showed significant response recovery of visual fixation to the stimuli presented on the transformation trials. Data were also collected showing the effects of cardiac response, smiling, pointing and surprise. There were not enough instances of surprise recorded to permit any statistical analyses. However, the recorded instances of surprise occurred, with one exception, on either the initial or transformation trial. The amount of recovery of visual fixation approached but did not exceed the total fixation on the initial trials.

In a cross-sectional study, infants at 9, 12 and 18 months were observed for characteristic expressive and instrumental behavior following a violation of expectancy (LeCompte and Gratch, 1972). It was hypothesized that higher levels of surprise and search behavior would be age-related with older infants manifesting the most intense reactions. Infants were exposed and had opportunity to manipulate a toy that was hidden in a trick box. After three successive pre-transformational trials, the original toy was transformed into a highly discrepant toy while hidden from the infant's view. The sequence of hiding the transformed toy was continued for three additional trials followed by a transformation back to the original toy. Two rating scales were used for the expressive and the instrumental reactions in order to assess infant responsiveness to the disconfirming transformation. The 18-month-old infants had significantly higher levels of expressive behavior and more instrumental search behaviors than did the 9-month-old infants. The 12-month-old infants responded at an intermediate level and with high variability. LeCompte and Gratch felt their findings provided evidence to support Piaget's account that infants in Stage VI have a well developed object concept.

In a short-term longitudinal study, Schaffer, Greenwood, and Parry (1972) tested infants monthly from 6 to 12 months of age on visual fixation and manipulative latency to an incongruous object. Though the authors themselves describe the transformation stimulus as an "unfamiliar stimulus," the experimental paradigm fits the violation of expectancy model suggested in this paper.

A nonsense toy was mounted on a wooden base by a steel rod that permitted a limited amount of movement around its axis. The object was mechanically transported and hidden behind a screen after a 30-second exposure. The infants had manipulative access to the toy during the trials. On the transformational trial, an object identical in shape, differing only in color from the original object (green to red) emerged. The responses recorded during the 7 pre-transformational trials, the transformation trial, and a post-transformational trial were visual fixation time and latency to touch the stimulus. Though visual responsiveness to the transformed object was apparent at all ages, the most dramatic increase occurred between the 8 and 9 month testing intervals. At 9 months, the visual fixation to the transformed object exceeded that of the initial trial, the pattern of which held for all succeeding months. A parallel finding on latency to touch indicated that it was indiscriminate throughout the trials up to 8 months of age. Shaffer, Greenwood and Parry felt that wariness, defined in terms of manipulative latency, was found in its fully developed form at 9 months, having been completely absent at 8 months. The effect of repeated testing on infant memory for previous encounters is mentioned as a possible explanation but discounted by the authors because of the dramatic appearance of the behavior and because of some additional cross sectional data. These findings mirror those of Kagan (1972) and are in line with his theory that between 8 and 9 months a new cognitive process emerges. This process involves active comparison and interpretation of incoming discrepant stimuli with existing cognitive structure.

A final study to be considered is that of Kagan (1973). Comparisons are made between 84 American and 80 Guatemalan infants at 5½, 7½, 9½, and 11½ months of age with 10-24 infants from each culture at each age level. Details on the experimental procedure are sketchy. In the block episode, each child was shown a 2 inch wooden orange block for six or eight successive trials (six for the older ages, and eight for the younger ages) followed by three or five transformation trials in which a 1½ inch block was presented. These transformations were followed by three representations of the original 2 inch block. A second test episode was given in which there was a transformation regarding the onset of light. The child was shown 8 or 10 repetitions of a sequence in which a hand moved an orange rod in a semicircle until it touched a bank of three light bulbs which were lighted upon contact between the rod and the bulbs. In the five transformation trials that followed, the hand appeared but the rod did not move and the lights lit after a four second interval. Following the transformation, the original event was presented for three additional trials. Fixation time, smiling, vocalizing, and fretting or crying were coded for each of these episodes.

Kagan found that the American infants had longer fixation times to both novel and to the transformation stimuli at 9½ and 11½ months. Kagan's conclusion that the American infants entered the "activation of hypothesis" stage three months prior to the Guatemalan infants is based on recovery to the standard stimulus data. In fact, the experimental results suggest that neither group exhibited response recovery to the transformation trials and that the infants continued to habituate. These data are suspect in terms of the violation of expectancy model where response recovery is expected to equal or exceed initial values. Kagan also mentions the Guatemalan infants' fear of the unfamiliar test conditions and its contribution to response variability.

Direction of the Research

In considering the research on discrepancy and violation of expectancy, there are a number of problems that are apparent.

The first question relates to the selection of the stimulus and the nature of the transformation performed upon it. Does the transformation violate an invariant rule learned in the natural environment or is the rule that has been violated experimentally induced? In either case, the transformation is arbitrarily determined to vary in a systematic way from the original stimulus or to be sufficiently discrepant from lawful phenomena in order to engage cognitive structure. In the literature previously reviewed, violations of expectancy induced during the experimental procedure have not been potent enough to provide unequivocal evidence in support of the discrepancy hypothesis, i.e., the provision of a similar but unassimable stimulus that instigates avoidance or nonattending behavior. In the violation of expectancy paradigm, stimulus transformations are arbitrarily selected and subject to post hoc argumentation as to whether they constitute a violation of nature. Grellong's (1973) inoperable jack-in-the-box and Kagan's (1973) light episode are examples where weaker than expected response to transformation can be attributed to experimental induction. Similarly, Kagan's (1973) diminished orange ball may have failed to produce response recovery because of an insufficient transformation in size. Form transformations (Bower, 1971; Gardner, 1971; LeCompte and Gratch, 1972) yield information about age related responses to object permanence but it is not helpful in terms of identifying specific transformed features that recruit infant attention. Kagan's (1973) size transformation and Schaffer's et al. (1972) color transformation are examples of one dimensional transformations within the violation of expectancy paradigm.

The research is lacking in longitudinal parametric studies that systematically vary stimuli and transformations. This would create a frame of reference in order to give meaning to discrepancy continuums and to the response indices. The research conducted by Schaffer et al. (1972) is an example of one such study. Varying age with a standard violation of expectancy transformation is a relatively straightforward approach to learn about the acquisition of cognitive structure. The research suggests the existence of rudimentary object permanence from 22 weeks (Bower, 1971; and Gardner, 1971), expectations regarding person-voice congruity from 8 months (Cohen, 1973), color permanence from 9 months (Schaffer et al., 1972), and human facial permanence from 5½ months (Fagan, 1972; and Caron et al., 1973). There has been no study that has compared transformations along several disparate dimensions at different points in the age continuum. Kagan (1972) hypothesized that a new process begins to operate on cognitive structures at 8 or 9 months, i.e., the active comparison of incoming information with existing schemas. An alternative hypothesis at which experimentation could be directed is the question of whether each particular cognitive structure, e.g., faceness, object permanence, moving objects can stop, has its own threshold at which contradictory information is rejected and avoidance behavior is instigated.

A host of questions suggest themselves regarding situational experimental conditions. There is a wide disparity in the manner in which the standard stimulus and its transformation are presented. Some studies offer the opportunity for manipulation (LeCompte and Gratch, 1972;

Schaffer, Greenwood and Parry, 1972; Grellong, 1973) while others allow visual observation (Bower, 1971; Gardner, 1971; Kagan, 1973; and Lewis and Goldberg, 1969). In each of these situations, basic variables are manipulable, e.g., length of occlusion, number and duration of trials, length of inter-trial intervals, the effects of which are largely unknown.

An equally pertinent question has to do with the selection and meaning of the infant responses. The most frequent measure selected is that of fixation time. Investigators either use length of first fixation or total fixation time of a trial. Cohen (1973) has argued persuasively for a two-process model of infant attention including an attention-getting and an attention-holding mechanism. He suggests that mean fixation time per trial is the most sensitive indicator of infant information processing. None of the violation of expectancy studies have used this measure. Kagan (1972) feels the length of the fixation is directly related to the amount of time the infant spends trying to assimilate the discrepancy and is therefore a valid indicator of cognitive activity. What is not clear with such a straightforward measure is what happens when the infant interrupts his gaze to engage in search behavior, or assuming the discrepancy hypothesis, rejects the stimulus. Both of these activities may be indicative of a higher functioning infant whose visual behavior is consonant with the task requirement. Fixation data may also vary when a proximate cause for the discrepancy is present, e.g., the experimenter, or the availability of an object to manipulate. Only four ratings of expressive behavior were noted in the literature and these, with the exception of an attempt by Lewis and Goldberg, were not used in conjunction with the standard measure, fixation time, in assessing response to violation of expectancy. Including both measures in a violation of expectancy paradigm may shed light on the meaning of both.

Habituation rate has been used in discrepancy studies (McCall et al., 1973) but has not been applied to violation of expectancy paradigm. McCall (1971) suggests that rapid habituators may be acquiring an internal representation of the stimulus at a faster rate than their cohorts. Rapid habituators would be expected to perform at a higher level on additional measures of cognitive development (Lewis and Goldberg, 1969).

A final suggestion involves the inclusion of the most commonly used measures in the same experiment to observe their intercorrelations. Lewis, Wilson and Baumel (1971) found weak relationships among the various measures used to assess cognitive activity. Further experimentation is necessary to determine which measures are the most fruitful and predictive of cognitive development.

Sex differences have been found (Kagan, 1971; Cohen, 1974) favoring females while other studies report no differences on the sex variable. The reported sex differences are consistent with studies which indicate boys and girls process auditory and visual information differently (Kagan and Lewis, 1965; Watson, 1969). Cohen (1973) also summarizes literature that girls as compared to boys attend to different aspects of the environment. Kagan (1971) reviews some studies that support the view that girls are biologically precocious. Additional work is needed to clarify the biological aspects in differential attending and responding to the environment.

Social Class Differences and Cognitive Development in Infancy

Evidence for demonstrating social class differences in infancy using traditional infant IQ tests has largely been negative (Bayley, 1965; Hindley, 1962; Golden and Birns, 1968; and Knoblock and Pasamanick, 1953). Where SES differences were found on these tests, they were not generally found to be related to IQ as measured by the Stanford-Binet at later ages. Explanations of the negative results center on the non-overlapping content between the infant scales and IQ test, i.e., a shift from sensory-motor to language items. A recent group of studies, however, have shown some predictive validity with infant scales to later IQ (Knoblock and Pasamanick, 1967; Erickson, 1968; Willerman, 1972; Werner et al., 1967; Drillien, 1964). These studies had in common broader samples with higher likelihood of incidence of abnormality (e.g., retardation, birth complications, prematurity) and greater representation of infants from lower socioeconomic groups. These findings generally support the view that the infant tests have more usefulness in predicting low IQ's than in predicting average or above average IQ's (Illingsworth and Birch, 1959). From Willerman's study it is suggested that the combination of low SES and low infant IQ are predictive of later cognitive functioning. Higher infant performance within a low SES population and infant performance of high SES groups does not correlate with assessed IQ at a later age. These studies indicate that low SES interacts with slow or impaired development to produce predictable negative outcomes.

Though little direct evidence is available on within SES differences on infant cognitive functioning (Grantham-McGregor and Hawke, 1971), several studies have found within class differences among low SES preschool and school age children (Greenberg and Davidson, 1972; Stedman and McKenzie, 1971; Minuchin, 1971; and Herzog, Newcomb and Cisin, 1972). These investigators have variously used paternal occupation and education, maternal occupation and education, income level, orderly living space and standard of housing, and room density ratios as indicators of SES status. Their findings suggest that meaningful variation occurs within the low SES population as to the provision of learning environments for their children. Heterogeneity of caretaking practices among poverty populations has been well documented.

By extension, this suggests that environmental influences on infant cognition can be fruitfully studied by examining subpopulations within low SES populations.

Focus of Present Study

The focus of the present study was, first, to demonstrate age-dependent relationships for various measures of visual and expressive responsiveness to stimuli transformed along dimensions that disconfirm fundamental expectancies of invariance. The present investigation took a longitudinal form by comparing infants at two stages in their development, i.e., at approximately 11 and 18 months of age. The longitudinal study is appropriate for the investigation of developmental trends in that it is possible to observe transition in infant responsiveness. Evidence pertaining to this issue was obtained by observing and rating infant responses to a series of transformational tasks, given successively, using an habituation-dishabituation paradigm. It was hypothesized that infants at the older age would manifest more aggregate surprise, greater visual response recovery to transformed stimuli and a more rapid rate of habituation than was manifested at the younger age. This is a partial replication of LeCompte and Gratch (1972). Patterns of age-dependent divergence and continuity among the expressive and visual behaviors were also analyzed along with their interrelationships at the two ages.

A second focus of the study concerns the relationship between environmental background and infant responses to transformational tasks. Mothers from a low income area were rated by known demographic characteristics and independently following a home visit and observation. In accordance with Burton White's (1972) hypothesis that maternal behavior significantly affects infant cognitive development during the second year of life, it was hypothesized that infants from positively rated environments would manifest more surprise and a more rapid habituation rate at the older age while no differences would be found at the younger age. As suggested by the discrepancy hypothesis, the possibility of disruption of visual response recovery to transformational tasks is more likely at the older age because of search and/or avoidance behavior. No linear relationship between surprise and visual response recovery was anticipated for infants coming from backgrounds rated favorably according to the methods used in the study.

Third, evidence on the relationship between sex and infant responding to violation of expectancy was obtained. No specific predictions were made on sex effects. A result, however, indicating a higher level of cognitive ability in females would be generally consistent with findings of other studies.

The types of transformational tasks themselves were analyzed for differential impact on infant responsiveness.

This represents an effort at the mapping and scaling of perceptual-cognitive ability using expressive and visual response systems within the context of a violation of expectancy paradigm. The tasks varied among themselves in the specific dimensions transformed, i.e., color, size, form, direction of trajectory, human form and facial permanence. Of the tasks administered, it was hypothesized that human form and facial permanence would elicit higher surprise and greater response recovery to discrepancy than object permanence transformations or transformation of direction of trajectory.

In summary, questions are raised concerning the effects of age, sex, and environmental background in relation to a series of stimulus event transformations within the violation of expectancy paradigm. It was hoped that the findings would shed additional light on the meanings of infant expressive and visual responsivity and their relationship to cognitive development.

METHOD

The data from the present study were obtained as part of a much larger investigation involving infants and their mothers. In addition to infant assessment, the full study included home observations, maternal attitude questionnaires, observation of mother-infant interactions and parental training. Studies already available on the project include Farmer (1974), Lamm (1974), Berg (1974) and Ketchel (1974).

Subjects

This research was conducted with the cooperation and approval of the staff and advisory board of the El Rio Santa Cruz Neighborhood Health Center. This clinic services a low income population residing within the Model Cities boundaries in the city of Tucson, Arizona. From the records of registered patients, a pool of names was obtained of all mothers whose infants were born between October 1, 1971 and February 28, 1972. Parents were contacted by mail and given a written description of the Infant Development Project. Follow-up home visits were made by project coordinators, giving further explanation of the project and inviting the mothers to participate. To enhance participation, transportation was offered to the University of Arizona Medical Center along with a small gift upon completion of the evaluation. Of the potential 107 mother-infant dyads, 67 ultimately participated in some phase of the evaluation procedure. In the longitudinal study, at least one test was obtained from 59 subjects and complete data from 46.

Table 1 presents demographic data available on the subjects included in the longitudinal study.

Apparatus

The transformational tasks were administered to all Ss in the T.V. studio at the University of Arizona Medical School. The room was devoid of extraneous stimulation and screens were used to partially shield the cameras employed in the study.

A schematic of the apparatus used is shown in Figures 1, 2 and 3. The test apparatus consisted of three white screens mounted on a wooden base 68 inches long. The side screens were each 16 inches wide by 11 7/8 inches high by 1/4 inch deep. The center screen was 15½ inches wide by 11 7/8 inches high by 1/4 inch deep. The open spaces between the side panels and the center panel were 10¼ inches wide. The front panels were placed on a 15° slope away from S. Set six inches to the rear of the base of the front screens and serving as a backdrop to the right and left viewing foci were two light blue screens, 15 3/4 inches wide

Table 1. Demographic Characteristics of Mothers

Characteristic	Category	N	%
Marital Status	Single	10	22
	Married	33	72
	Divorced/Separated	3	6
Age	Less than 18	3	6
	18-22	15	33
	23-27	20	44
	27-31	6	13
	More than 31	2	4
Ethnic Group	Black	4	9
	Mexican-American	37	80
	Indian	5	11
Employment of Mother	In school	3	6
	Housewife	35	76
	Working	4	9
	Unemployed	4	9
Employment of Head of Household	In school	5	11
	Working	17	37
	Unemployed	12	26
	No male head	12	26
Index of Social Pos.*	Category #4	12	26
	Category #5	34	74
Annual Income	0 - 999	10	22
	1,000 - 1,999	6	13
	2,000 - 2,999	7	15
	3,000 - 3,999	15	33
	4,000 - 4,999	5	11
	5,000 - above	8	16
Welfare Status	On Welfare	8	16
	Not on Welfare	38	84
Education of Mother (in years)	Less than 7	6	13
	7-8	6	13
	9-10	11	24
	11-12	19	41
	Some college	4	9

Table 1, continued.

Characteristic	Category	N	%
Education of Father (in years)	Less than 7	6	13
	7-8	6	13
	9-10	4	9
	11-12	14	31
	Some college	2	4
	No father in home	12	26
	Unknown	2	4
Type of Residence	Single family home	33	72
	Public housing	2	4
	Apartment	11	24
Tenancy Status	Own	4	9
	Rent	24	52
	Allowed to occupy for services	18	39
Total Family Members	2	10	22
	3	17	37
	4	4	9
	5	3	6
	6	3	6
	7	3	6
	8	0	0
	9	1	2
	10 or above	5	11

*Hollingshead and Redlick, Two-Factor Index of Social Position, 1957.

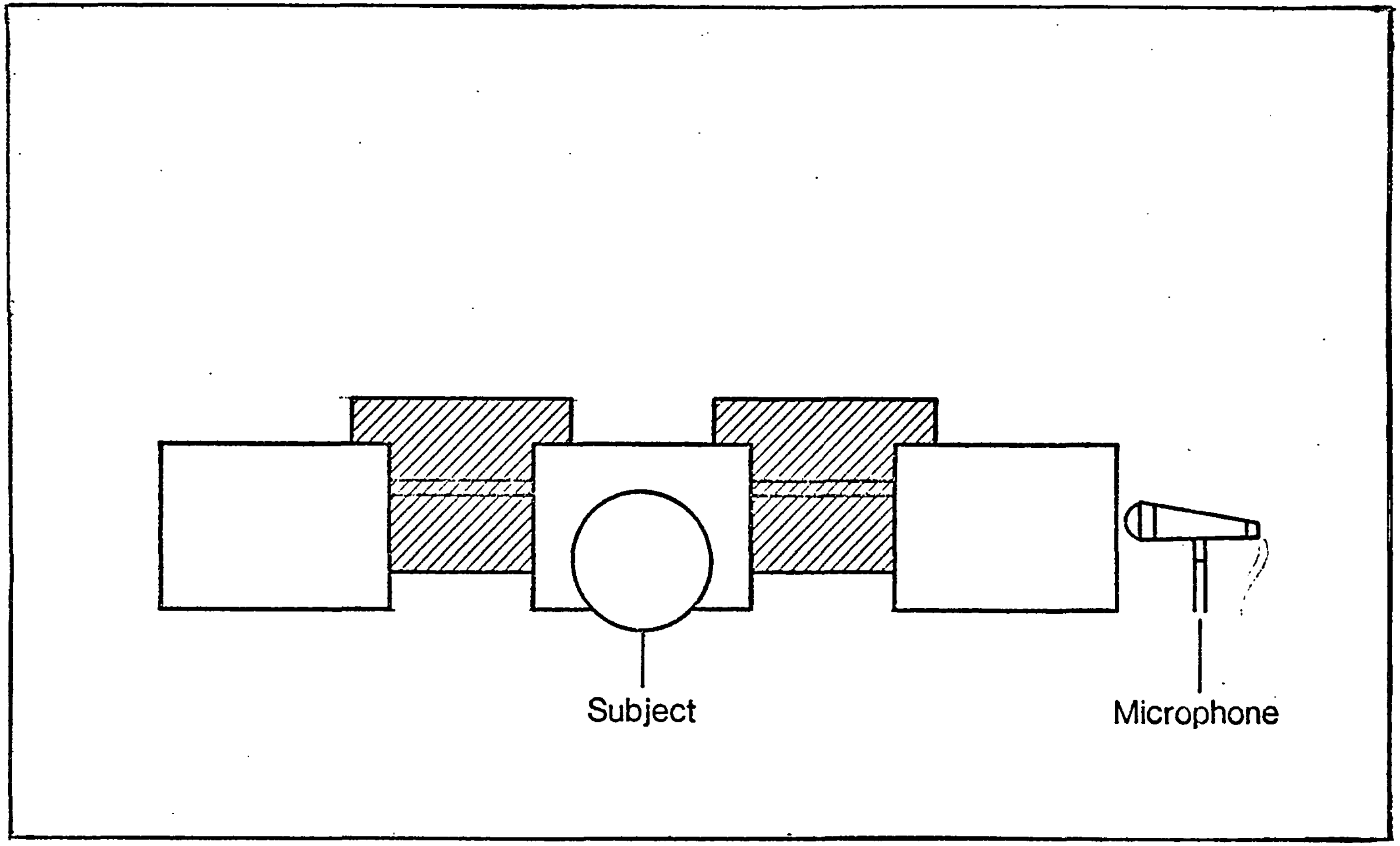

Figure 1. Front View of Test Apparatus.

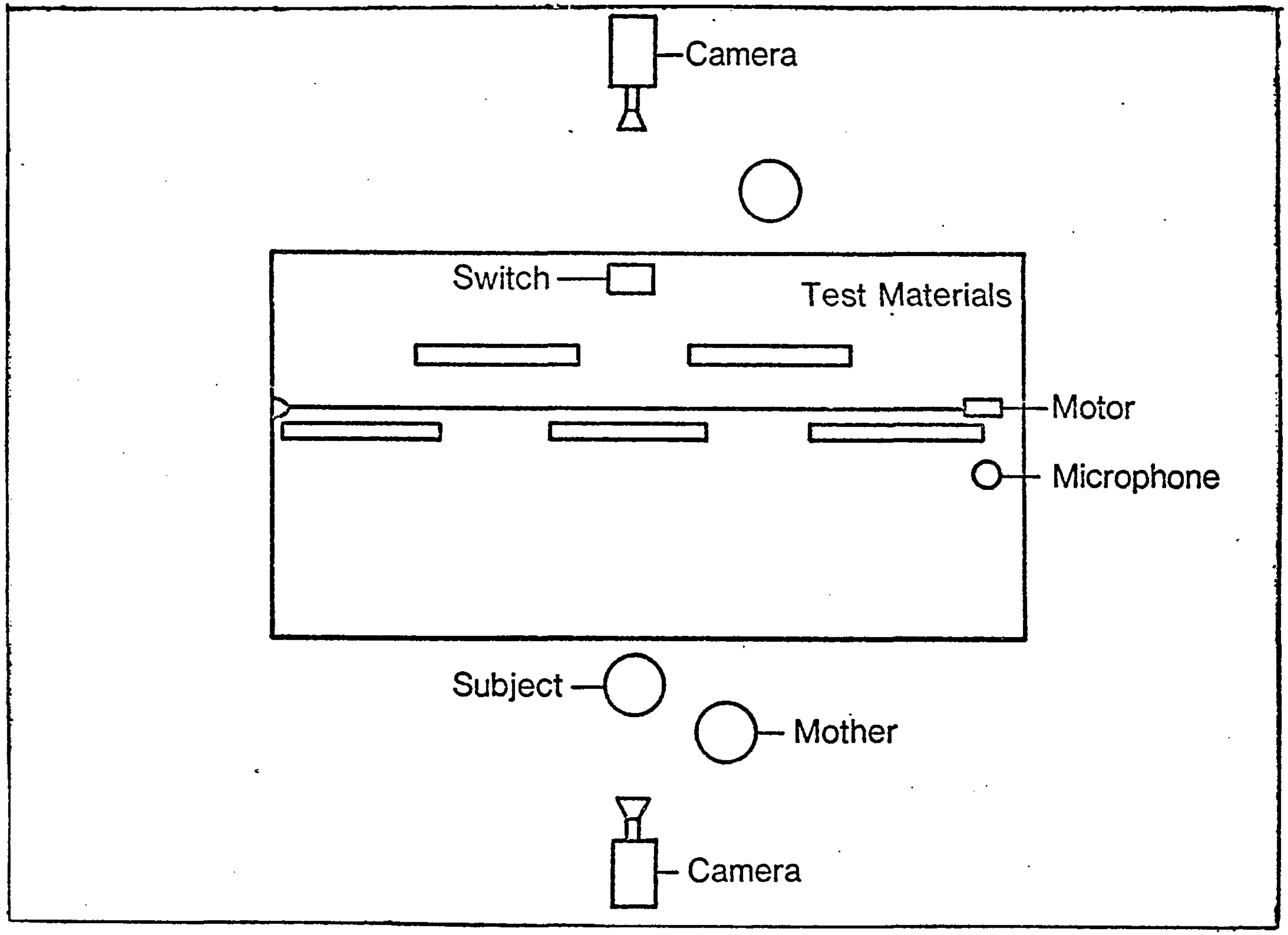

Figure 2. Top View of Test Apparatus.

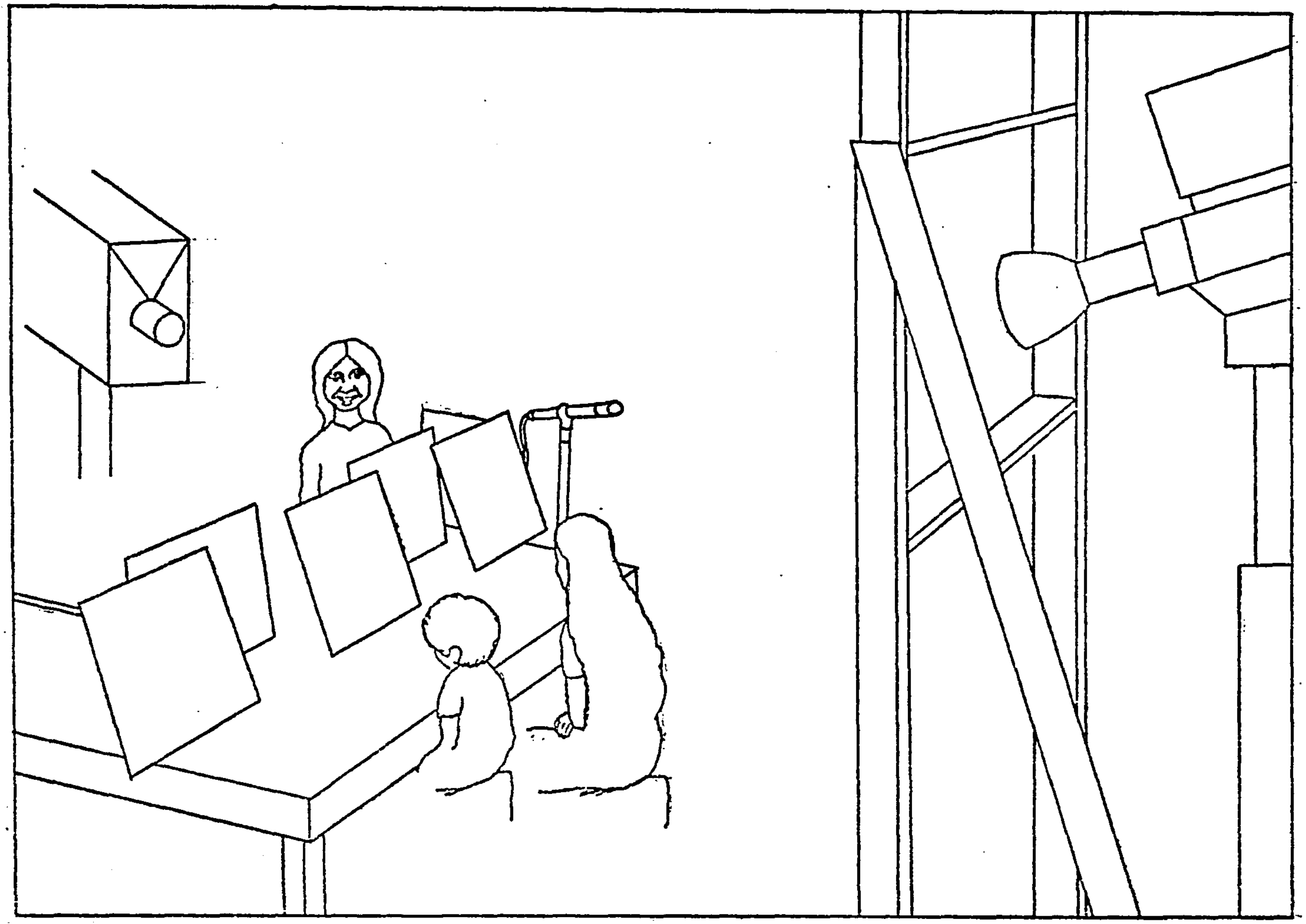

Figure 3. Illustration of Infant Test Environment.

by 12½ inches high by 1/4 inch deep. These screens were set perpendicular to the base and placed so as to exclude extraneous stimuli behind the apparatus from view.

A Bodine variable speed reducer (speed is reduced 60.1) with solid state speed control and reversal capability was used to transport fish line suspended by 1 inch pulleys. The line transported right to left was 9¼ inches off the base while the line moving left to right was 8 3/4 inches above the base. The motor was situated behind the side screen to the S's right. The motor produced an audible humming sound when in operation. To the rear of the backdrop screens was a place for E to store stimuli used for the various tasks, record behavior and operate a speed control switch.

The apparatus was placed 20 inches from the edge of the table and out of reach of the Ss. The distance from S to the center of the left and right foci was 28 inches. Thus S had to turn his head roughly 50° if he were attending to the left focus and desired to attend to the right focus or visa versa.

The elapsed time to transport the test stimuli from the center of the right focus to the center of the left focus was 4.5 seconds. Test stimuli were occluded by the center screen for 3 seconds. Speed of movement was 5.8 in/sec.

Object position was monitored by a Sony 4600 camera with an 8:1 Cannon Zoom lense mounted on a Herculus tripod dolley located behind the S. An identical unit was mounted behind the display to monitor the S's head and upper body. A Sony SEG 2 switcher and special effects generator, located in an adjacent control room, combined the output of the two cameras, providing a simultaneous record for subsequent analysis of object position and head and eye position. The split screen image was recorded on an Ampex VR-5100 using 3M 1 inch videotape. Face to film plane and visual display to film plane was 4 feet, 8 inches.

Stimulus Materials

Task One -- Color:

One green and one yellow cylinder, 2½ inches high by 1 1/8 inches deep with 3/4 inch diameter hole in center, made by Fisher-Price.

Task Two -- Size:

One blue cube, 2 3/4 inches high by 2 3/4 inches wide by 2 3/4 inches deep.

One blue cube, 1 3/8 inches high by 1 3/8 inches wide by 1 3/8 inches deep.

Task Three -- Form:

Inflated orange plastic fish, 5 inches high by 3½ inches wide at widest extremity, made by Imperial Toy Corp.

Female doll with brown hair, red dress and red shoes, 3 3/4 inches high by 1 inch wide. Head size, 1 3/4 inch high.

<u>Task Four -- Reversal</u>:

A wooden dog with black body and ears, red collar, and white face, 2 inches high, head size, 3/4 inch, made by Fisher-Price.

<u>Task Five -- Doll (Pretest)</u>:

Ken doll in red bathing suit, 12 inches tall, head size, 1 3/4 inch, made by Mattel.

Ken doll in red bathing suit, 11½ inches tall, deer head, 1¼ inch.

<u>Task Five -- Doll (Posttest)</u>:

Deer, 5½ inches long.

Deer, 5½ inches long with attached Ken-doll head.

<u>Task Six -- Disguise</u>:

Black eyeglass frames with false nose attached.

<u>Procedure</u>

Administration

The <u>S</u> was placed by his mother in a high chair in a well-lighted room. The mother was to the infant's right and slightly to the rear. She was well within the infant's line of vision so that he could look at her, if he desired, without having to climb out of his seat or turn his body. E engaged the mother in a conversation about the experimental procedure. During this time S usually played with a toy or watched his mother and E. The mother was strongly cautioned not to attempt to influence the infant's behavior during the experiment. An exception was made if the infant began to fret and cry and not attend to the test stimuli. The test was stopped and the mother was allowed to comfort and calm the baby.

Two Es were trained on a number of trial infants prior to inception of the experiment. Uniformity of procedure was stressed. Training goals included precision of timing in removing the test stimuli, observation of infant anticipating, glances, avoidance of stimulation following initiation of trials, and establishment of rapport with the infants. The Es were unaware of any environmental ratings or groups to which the infants and mothers had been classified.

The order of administration on Tasks 1-5 was counterbalanced using a random numbers table while Task 6 was uniformly presented last. The presentation of stimuli on Tasks 1-3 was also counterbalanced. Data analysis revealed that there were no effects of the order of administration that had a systematic influence on the outcome of testing.

Tasks 1-4 were the pulley tasks and consisted of transformations of color, size, form, and direction of trajectory. E placed the standard stimulus in the center of the focus to the S's right and attracted his attention to the object. When S fixated on the object, E triggered the switch operating the motor-driven pulley line. Objects suspended from the line moved from stationary place at the infant's right to the stationary place at the infant's left, passing behind the center screen. The switch was again triggered to bring the object to a halt. E recorded the completion of the trial on the procedure sheet and observed a stop watch in order to remove the stimulus at the end of a standard 15 second interval. This procedure was repeated until the infant cast an anticipatory glance to the left of the screen prior to the emergence of the standard stimulus. Following successful anticipation, two additional trials were administered prior to the presentation of the transformational or trick trial. Intertrial intervals were approximately 3 t0 5 seconds.

The trick trial was accomplished by E exchanging objects on the pulley line while the standard stimulus was occluded by the center screen. In the case of Task 4, the familiar standard stimulus was removed from the pulley line moving with a right to left trajectory and placed on the pulley line moving left to right.

On Task 5, E handed S the Ken doll for three successive 20 second intervals. At the termination of a trial, E would request and obtain the doll, hide it briefly behind the center screen and return it to S. At posttest, the same procedure was followed for a deer doll and its transformation as the test stimuli. If S dropped the doll during the trial, the doll was returned to S to complete the 20 second test interval.

For Task 6, E engaged S's attention by calling his name, dropped out of sight below the screens and emerged stating "Peek-a-boo." E held stationary for 10 seconds, observing the stopwatch, and then repeated the trial. After three successive trials, E donned the glass frames and false nose while occluded from view and emerged stating "Peek-a-boo." Again E held stationary for 10 seconds prior to termination of the test. The average testing period for all six tasks was from 15 to 20 minutes.

Scoring and Rating of Videotapes

Eight junior and senior level psychology undergraduates were trained to record and rate the behaviors from videotape recordings. Training of raters was accomplished by a training tape and rating manual developed by Dr. Gerald Gratch of the University of Houston. After several training sessions, a tripartite definition of surprise was agreed on and used in the training program.

Raters were trained to observe and record eye movements, facial expressions and non-fixation behavior on an Esterline-Angus event recorder. Three observers could simultaneously view the videotape and record behavior by depressing and releasing microswitch buttons on 14 separate channels. One of the channels was used to indicate initiation and termination of a trial. Since the cameras were conjugate with the visual display and the infant, the judgments could be made with great accuracy (see also Gibson and Danielson, 1963). Recordings of facial expressions indicating surprise were made only on the transformation trials. See Appendix A for behavior codes for the event recorder and the operational definition for levels of surprise.

Upon completion of a task, the transformation trial would be repeated and the raters make judgments on the level of surprise. After arriving at individual judgments, the raters would then confer and arrive at the consensus judgment on the level of surprise. If there was disagreement, the transformation trial was replayed and discussion ensued in the process of arriving at unanimity of opinion. Data were ultimately transcribed on to prepared data sheets for each _S_. All raters were unaware of environmental background or the assigned group in which the infants fell.

Reliability

Students rated video tapes previously rated by trained raters to establish mean interscore agreement. The eight raters had average observer reliabilities of .95 for visual behaviors and .89 for expressive behaviors.

Statistical analyses were based on the mean scores of the observers. Average observer reliability for level of surprise was .87. During pre- and post-testing videotapes of 18 Ss were selected at random at each testing interval as a further check on reliability. Two different teams of raters independently recorded and rated the videotapes. Interobserver reliabilities were equal or above the reliabilities established during training.

Design and Dependent Measures

Two age levels, approximately 11 months and 18 months of age, were selected to sample the continuum of early cognitive development. The administration of the test took place during November and December, 1972 and readministered during June and July, 1973. The test stimuli were presented as a part of an assessment battery in a longitudinal study of infant development (Farmer, 1974). The administration of this measure was generally accomplished on a separate day from other testing. On occasion, however, the test was administered preceding or following the administration of other infant tests.

A series of univariate analyses of variance and correlational procedures, including the use of partial correlation, were utilized to determine the separate effects of age, transformation tasks, sex, and environmental background. Among the dependent variables were duration and frequency of visual fixation, direction of fixation, frequencies of defined expressive behaviors denoting surprise, a surprise rating scale developed to differentiate and weight surprise expressions, and a measure of successful anticipation of the emergence of objects from behind a screen. Additional variables such as vocalization, smiling, glancing at the experimenter, and manipulative behavior with the doll were also recorded but are not discussed in this paper. With the exception of the surprise rating scale, the dependent variables were recorded on an Esterline Angus Event Recorder by observers viewing videotape reproductions of the experiment. A list of definitions for recording behaviors and rating surprise responses is found in Appendix A. A description of the variable codes and derivations is contained in Table 2.

Language Examiner Risk

The effect of environmental risk was determined by a subjective rating of mothers by the administrator of an infant bilingual receptive language measure. The examiner made home visits to the project participants to assess infant language ability. Detailed notes of the home visit and mother-infant interactions were recorded just after termination of the visit and testing experience.

At the conclusion of the testing program, the examiner ranked the mothers in terms of environmental and

Table 2. Description of Variables by Abbreviation Code.

Name of Variable	Abbreviation Code
<u>Surprise Variables</u>	
Level of surprise (high = 3, medium = 2, low = 1)	LS
Level of surprise recoded (high, medium = 2, low = 1)	LS2
Freezing behavior (frequency)	FZ
Eyes and mouth open widely and simultaneously (frequency)	EM
Frowning and sobering (frequency)	FS
Questioning glance (frequency)	QG
<u>Fixation Variables</u>*	
Absolute habituation rate (Amount of fixation on first trial minus the amount of fixation on the pretransformation trial)	HAB
Relative habituation rate (The HAB total divided by the amount of fixation on the first trial)	RHAB
Absolute fixation recovery rate (Amount of fixation on the transformation trial minus the amount of fixation on the pretransformation trial)	FIX
Relative fixation recovery rate (The FIX total divided by the amount of fixation on the transformation trial)	RFIX
Glances at opposite end of screen (Frequency)	GS
<u>Other Variables</u>	
Language examiner risk (1 = low, 2 = medium low, 3 = medium high, 4 = high)	LER

Table 2 continued.

Language examiner risk controlling for effects of sex	LER.S
Sex (1 = male, 2 = female)	SEX
Sex controlling for effects of risk	SEX.L
Cry (1 = no crying on a task, 2 = crying on a task)	CRY
Number of trials administered on first pulley task	TT

*All fixation times are mean values obtained by dividing the total fixation time on a given trial by the number of glances directed at the target.

maternal support for infant cognitive development. The mothers were rated along a four point scale including low, medium low, medium high, and high risk. The examiner did not review the scoring of the infant language performance in making the determination of rank. She was also unaware of the results of other infant and maternal measures or ranking systems. The following criteria was used in the assignment of risk.

Low risk mothers: They seem to be very interested and responsive to their infants, infant accomplishment elicited praise, laughter, excitement and affection; they were not upset or angry if their baby did not perform a task or got it wrong; they seemed to have a genuine feeling for developmentally appropriate behavior of their infants and evidenced interest and understanding for the issues of child development encompassed in the language test; they seemed to be sensitive to the infant's need for environmental support during the test, e.g., turning off the TV or getting people out of room where the test was being given.

Medium low risk mothers: These mothers seemed to be just as interested and concerned about their child and his development as the low risk mothers; their enthusiasm for their child's accomplishment either showed less awareness of his development status or a tendency to be intrusive or controlling of her child's play; they tended to be less accepting of poor performance in that they either scolded the infant or could not resist the temptation to give exaggerated prompts despite explicit instructions by the examiner not to do so; they also were more easily distracted than low risk mothers by other people, children and interests in the household.

Medium high risk mothers: These mothers seemed to care for their children, but showed little interest in the test or in their infants' task related behavior; they didn't give any praise or show any excitement when their infant achieved on a task; they strongly scolded their child upon poor performance and were easily distracted by events around them; they showed minimal control over their child; there was a lot of noise and confusion in their homes with numerous people and children coming and going during the test.

High risk mothers: There were two distinct subgroups the language examiner identified. One group consisted of mothers who seemed to have a basic attachment for their infants but seemed helpless and inadequate in fulfilling the mother role. They did not speak much to their babies nor seem to have meaningful interaction with them. They held and seemed protective of them. They seemed unable to impose themselves on their infants and were totally helpless in the face of frequent tantrum behaviors they readily gave in to; the infants ignored any demands that were placed upon themselves. The second group of high risk mothers seemed to be very self-centered and responded only to their own impulses and needs. They seemed not to care for their children and looked upon them as an unwanted burden. They ignored both the infant and the language examiner during the test situation. A common method of controlling their children was by loud yelling and harsh discipline to which the infants seemed to have habituated. Excessive noise, people, and confusion were again prevalent in these environments.

Of the 46 mothers whose infants were included in the longitudinal sample, 43 were assigned a risk rating by the language examiner. The high and medium high risk categories were collapsed into a single high risk category containing 18 mothers. Similarly, the low and medium low risk categories were collapsed into a single low risk category containing 25 mothers.

As a cross-validation, two other methods were used independently to rank mothers according to risk. A nurse practitioner interviewed a sample of project mothers in the home in relation to the infants' health histories. Using different subjective criteria (see Farmer, 1974), risk ratings were assigned. The resultant degree of association between the two risk systems using Kendall's Tau B was .4778.

The second method involved the assignment of points to mothers based on demographic indicators. Previous investigators have attempted to develop indices to make SES distinctions with the lower socioeconomic class (Stedman and McKenzie, 1971; Greenberg and Davidson, 1972; Herzog, Newcomb and Cisin, 1972). The particular demographic risk system used was taken, in part, from other indices, but not previously utilized or validated. Factors used in assigning risk included: maternal education, employment status of the head of household, income level, marital status, and household density. A description of the criteria employed to assign risk by demographic variables is contained in Table 3. These factors were summed. The higher point totals are in the direction of low risk, while the low point totals are in the direction of high risk. The demographic risk index was applied to the participants in the longitudinal sample. The 46 participating mothers had the following point totals: 1 = 0; 9 = 1; 9 = 2; 9 = 3; 15 = 4; and 3 = 5.

Demographic risk and language examiner risk were collapsed in high and low risk categories. The two risk systems were cross-tabulated to ascertain the level of agreement between them. There was agreement on 11 high risk mothers and 19 low risk mothers while 13 mothers were rated in the opposite direction by each of the risk systems. The degree of association between the demographic risk index and language examiner risk using Kendall's Tau B was .4132 (Farmer, 1974).

Table 3. Demographic Risk Variables

Category	Points Received	
Maternal Education:	11th grade or above	= 1 point
	10th grade or below	= 0 points
Employment Status of Head of Household:	Employed	= 1 point
	Unemployed	= 0 points
Income Level:	$3,000 or above	= 1 point
	$2,999 or below	= 0 points
Marital Status:	Other marital status	= 1 point
	Single parent	= 0 points
	One or less non-nuclear family member residing in household	= 1 point
	Two or more non-nuclear family members residing in household	= 0 points

RESULTS

Ages of Sample

The mean age of the infants at pretest was 10.7 months with a standard deviation of 1.65; at posttest the mean age was 17.66 months with a standard deviation of 1.83 months. For language examiner risk, there were no significant age differences at pretest ($F = .7565$, $p =$ n.s.) between high and low risk categories nor at posttest ($F = .1383$, $p =$ n.s.).

Longitudinal vs Control Group

In order to determine the effects of prior testing, the group of 13 infants who had not received the pretest experience with the transformation tasks but who were subsequently posttested at age 18 months were compared with the 46 subjects who had previously been tested at the younger age (see Appendix B for data presentation). Of the dependent variables, only one revealed an essential difference. A comparison of the mean of the control group shows the subjects in the longitudinal sample to be significantly less surprised ($t = 2.59$, $df = 1/58$, $p < .025$) on the doll task.

The effects of order of task administration was determined by a series of one-way analyses for each of the dependent variables at pretest and posttest (Task 6 was deleted from the analysis). Despite the greatly increased risk of a type 1 error due to this procedure, none of the F values reached the 5 percent significance level, indicating that order of administration did not have a systematic effect on the outcome of testing.

Age, Task and Trials Effects

Tables 4, 5, and 6, with mean scores and standard deviations, illustrate the effects of task on level of surprise (LS), relative habituation rate (RHAB), and relative fixation recovery rate (RFIX), respectively.

Intermeasure correlation matrices were computed at pretest and posttest from combined scores and derivations on all six transformation tasks. The matrices given in Table 7 (pretest) and Table 8 (posttest) depict the relationship of values summed across the six transformation tasks. Correlation matrices for each of the individual tasks at pretest and posttest are presented in Appendix C. Appendix C also contains the means and standard deviations on fixation data for each of the six tasks at posttest only.

Table 9 shows the means and standard deviations for all variables summed across the six transformation tasks at pretest and posttest along with a t test comparison of the differences of the means. Table 10 illustrates a

Table 4. Summary of Task Analysis on Mean Level of Surprise (LS) at Pretest and Posttest Plus Differences of Means.

Test Interval		Tasks					
		1. Color	2. Size	3. Form	4. Location	5. Doll	6. Disguise
Pretest	M	1.15	1.17	1.26	1.06	1.61	1.41
	SD	.36	.38	.54	.25	.65	.50
Posttest	M	1.26	1.24	1.52	1.26	1.44	1.91
	SD	.54	.48	.69	.54	.66	.76
Pretest-Posttest	M	.11	.07	.26	.20	-.17	.50
	SD	.57	.65	.83	.58	.13	.91
Difference of Means	t*	1.30	.68	2.14[b]	2.28[b]	-1.35	3.71[c]

Pretest Task Comparison	Posttest Task Comparison	Pretest-Posttest Difference of Means
N = 46	N = 46	N = 46
df = 5/270	df = 5/270	df = 45
F = 8.510	F = 8.12	*two-tailed test of significance
$p < .000$	$p < .000$	a < .10
Duncan Test < .05	Duncan Test < .05	b < .05
5, 6 > 1, 2, 3, 4	6 > 1, 2, 3, 4, 5	c < .01
5 > 1, 2, 3, 4, 6	3, 6 > 1, 2, 3, 5	
3, 5, 6 > 1, 2, 4	2 < 1, 3, 4, 5, 6	

Table 5. Summary of Task Analysis on Mean Relative Habituation Rate (RHAB) at Pretest and Posttest Plus Differences of Means.

Test Interval		Tasks					
		1. Color	2. Size	3. Form	4. Location	5. Doll	6. Disguise
Pretest	M	.18	.16	.19	.20	-.11	-.71
	SD	.54	.52	.54	.57	1.76	1.39
Posttest	M	.05	-.05	.04	.12	-.05	-.82
	SD	.66	1.06	.97	.69	.70	1.96
Pretest-Posttest	M	-.13	-.21	-.13	-.08	.06	-.11
	SD	.82	1.22	1.06	.96	1.85	.36
Difference of Means	t*	-.85	-1.31	-.89	-.55	.22	.75

Pretest Task Comparison	Posttest Task Comparison	Pretest-Posttest Difference of Means
N = 46	N = 46	N = 46
df = 5/270	df = 5/270	df = 45
F = 5.742	F = 4.668	*two-tailed test of significance
$p < .000$	$p < .000$	
Duncan Test $< .05$	Duncan Test $< .05$	
$6 > 1, 2, 3, 4, 5$	$6 > 1, 2, 3, 4, 5$	

Table 6. Summary of Task Analysis on Mean Relative Recovery of Visual Fixation (RFIX) at Pretest and Posttest Plus Differences of Means.

Test Interval		Tasks					
		1. Color	2. Size	3. Form	4. Location	5. Doll	6. Disguise
Pretest	M	.31	.33	.34	-.11	.15	-.11
	SD	. 6	.58	.53	.76	.82	1.12
Posttest	M	.18	.39	.13	-.01	.44	.34
	SD	.85	.65	1.54	-.85	.36	.66
Pretest-	M	-.13	.06	-.21	.10	.31	.45
Posttest	SD	.86	.77	1.67	1.20	.82	1.37
Difference of Means	t*	-.76	0.56	-0.86	0.50	2.50[b]	2.21[b]

Pretest Task Comparison

N = 46
df = 5/270
F = 3.735
$p < .003$
Duncan Test $< .05$
1, 2, 3 > 4, 5, 6
4, 6 < 1, 2, 3, 5

Posttest Task Comparison

N = 46
df = 5/270
F = 1.796
$p < .114$

Pretest-Posttest Difference of Means

N = 46
df = 45
*two-tailed test of significance
a = $p < .10$
b = $p < .05$
c = $p < .01$

Table 7. Relationships Among Variables Summed Across Six Transformation Tasks at Pretest. -- Figures are simple and partial Pearson's Product-Moment correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.18	-.10	$.34_b$	$.35_b$	.12	.20	-.01	-.14	-.17	-.10	-.20	.07	.10	.09	.02	.00
LS		-	$.93_c$	-.01	.00	-.12	.03	.10	$.36_a$	$.26_a$	$.39_c$	.00	$-.32_b$	$-.28_a$	$-.27_a$	.10	.02
LS2			-	.04	.05	.05	.16	.18	$.43_c$	$.36_b$	$.47_c$	.03	-.15	-.22	-.24	-.01	-.09
HAB				-	$.96_c$	$.29_a$	$.41_c$	.01	-.04	.13	.00	-.07	-.04	-.01	-.03	-.06	-.07
RHAB					-	$.34_b$	$.52_c$	.01	-.02	.11	-.04	-.09	.03	-.03	.05	-.02	-.03
FIX						-	$.89_c$	$.38_b$	.13	$.36_b$	$.30_b$	-.17	$.37_b$	.00	-.06	-.20	-.21
RFIX							-	.22	.14	$.25_a$	.19	-.15	.21	-.12	-.14	-.04	-.09
FZ								-	$.45_c$	.05	.07	-.12	.22	-.17	-.23	-.18	-.25
EM									-	.22	.05	.08	.01	-.18	-.19	.00	-.05
FS										-	$.55_c$	-.12	.22	.18	.15	-.14	-.09
QG											-	.07	.07	$.29_a$	$.28_a$	.06	.03
GS												-	-.15	-.23	-.14	$.38_b$	$.34_b$
TT													-	.25	.21	-.17	-.13
LER														-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table 8. Relationships Among Variables Summed Across Six Transformation Tasks at Posttest. -- Figures are simple and partial Pearsons Product-Moment correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	.10	.07	$.37_b$	$.32_b$	.25	$.38_b$	.16	.09	.09	.10	.22	-.02	.19	.14	-.20	-.15
LS		-	$.95_c$	-.22	-.21	-.24	$-.29_a$	$.77_c$	.21	$.36_b$	$.68_c$	.13	-.18	-.21	-.11	$.41_c$	$.37_b$
LS2			-	-.14	-.18	-.27	$-.30_b$	$.72_c$	$.27_a$	$.46_c$	$.70_c$	.07	-.17	-.22	-.14	$.35_b$	$.31_b$
HAB				-	$.94_c$	.24	$.38_b$	-.14	.20	.16	-.09	$.31_b$	.11	-.09	-.13	-.11	-.14
RHAB					-	.19	$.38_b$	-.05	.20	.13	.01	$.29_a$	.09	-.14	-.18	-.08	-.13
FIX						-	$.79_c$	-.07	-.24	$-.32_b$	-.15	.04	.24	.23	.19	-.18	-.12
RFIX							-	-.02	-.25	$-.43_c$	-.12	.06	.18	.18	.13	-.23	-.19
FZ								-	.12	.15	$.68_c$	.19	-.18	-.12	-.08	.16	.13
EM									-	$.60_c$	-.07	.04	-.04	-.10	-.10	.03	.00
FS										-	.12	.03	-.20	-.16	-.12	.15	.11
QG											-	.11	-.08	-.06	-.03	.13	.12
GS												-	-.09	.10	.06	-.16	-.14
TT													-	.02	-.04	-.22	-.22
LER														-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table 9. Means and Standard Deviations of the Variables Summed Across Six Transformation Tasks with a Comparison of Differences of Means Between Pretest and Posttest Scores. (N = 46)

	Pretest		Posttest		t
Variable	M	SD	M	SD	(difference of means)
CRY	1.07	.38	1.18	.39	-2.54*
LS	1.28	.50	1.44	.65	-2.82**
LS2	1.26	.44	1.35	.48	-2.16*
HAB	.73	3.38	.56	3.47	1.22
RHAB	-.01	1.06	-.12	1.14	1.71
FIX	1.77	4.44	2.50	3.75	-2.54*
RFIX	.15	.76	.25	.90	-2.36*
FZ	.06	.37	.12	.37	-1.87
EM	.07	.31	.06	.26	.38
FS	.17	.52	.24	.65	-1.06
QG	.11	.46	.23	.63	-2.43*
GS	.21	.61	.20	.57	.06
TT	5.22	1.34	4.04	.21	5.88***
FIX1[a]	3.23	3.09	3.41	3.42	-.63
FIXP[b]	2.51	2.58	2.84	2.79	-1.99
FIXT[c]	4.28	4.65	5.34	4.15	-3.19**
FFIX1[d]	2.82	1.76	2.53	1.49	*
DFIX1[d]	8.07	5.78	7.41	4.91	*
FFIXP[d]	2.82	1.74	2.38	1.37	*

Table 9 continued.

Variable	Pretest M	Pretest SD	Posttest M	Posttest SD	t (difference of means)
DFIXP	6.26	5.05	5.93	4.75	n.s.
FFIXT[d]	2.89	1.87	2.30	1.30	*
DFIXT	9.68	7.24	9.90	5.69	n.s.

*$p < .05$

**$p < .01$

***$p < .001$

a = Pearson's r (pretest and posttest) = .28, p = .06

b = Pearson's r (pretest and posttest) = -.04

c = Pearson's r (pretest and posttest) = .15

d = Posttest means lie beyond 95 percent confidence interval for pretest means. Exact t score was not computed.

Table 10. Intercorrelation of Pretest Variables Summed Across Six Transformational Tasks with Posttest Variables Summed Across Six Transformational Tasks.--Figures are Pearson's Product-Moment correlation coefficients. N = 46.

Pretest Variables	Posttest Variables												
	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT
CRY	.08	-.03	-.04	-.07	-.03	.05	.01	-.03	-.17	-.04	.04	-.14	-.10
LS	.06	$.33_b$	$.30_b$	-.25	-.23	$-.36_b$	$-.32_b$	$.34_b$	.14	.13	.10	.14	-.14
LS2	.09	$.26_a$	.24	-.17	-.16	$-.26_a$	-.22	$.30_b$	.08	.09	.11	.08	-.09
HAB	$.33_b$	.21	.20	.21	.25	-.06	.06	.11	-.10	-.07	$.35_b$	$.26_a$	-.09
RHAB'	$.29_a$	.17	.17	.15	.21	-.04	.06	.06	-.10	-.04	$.28_a$	.23	-.05
FIX	.15	-.10	-.08	$.28_a$	.20	.23	$.31_b$	-.11	-.16	-.09	.05	-.02	$.32_b$
RFIX	.07	.05	.09	.11	.11	.18	$.27_a$	.02	-.22	.01	.14	-.03	$.26_a$
FZ	-.10	-.10	-.10	.23	.18	-.15	-.05	-.04	-.08	-.03	.01	.11	-.07
EM	-.04	.04	.09	.07	.07	-.15	-.05	.05	-.03	-.01	-.01	.01	.14
FS	.20	-.09	-.10	.07	-.05	-.02	.05	-.06	$.27_a$	-.16	-.23	.21	-.08
QG	.15	-.09	-.08	.18	.06	-.05	.04	-.04	-.02	.05	-.08	.16	-.22
GS	-.13	.15	.15	.22	.24	.15	.21	.22	-.23	-.02	.22	.03	-.16
TT	.14	$-.31_b$	-.23	.20	.16	$.41_c$	$.34_b$	$-.29_a$	-.08	$-.33_b$	-.20	-.17	.04

a = $p < .10$

b = $p < .05$

c = $p < .01$

longitudinal correlation matrix showing the degree of association of pretest and posttest performance.

Table 11 compares the amount of change in fixation between the first trial (FIX1), the pretransformation trial (FIXP) and the transformation trial (FIXT). The raw data on the numbers of infants manifesting surprise (LS2) to each of the tasks is broken down by sex and risk (LER) at both pretest and posttest and is shown in Appendix D. Appendix E presents pretest and posttest correlation matrices wherein tasks 1 through 4 and tasks 5 and 6 are summed separately in an effort to differentiate the effects of object and person permanence.

Table 11. Differences in Summed Visual Fixation Between Trials at Pretest and Posttest.

Summed Fixation (sec)		Pretest	Posttest
FIX1	M	3.23	3.41
	SD	3.09	3.41
FIXP	M	2.51	2.84
	SD	2.58	2.79
FIXT	M	4.28	5.34
	SD	4.65	4.15
FIX1 vs	t	5.09***	3.07**
FIXP	r	.29*	.50***
FIX1 vs	t	-3.73***	-6.88***
FIXT	r	.29*	.47***
FIXP vs	t	-6.94***	-.8.87***
FIXT	r	.23	.49***

N = 46

t = two-tailed t test

r = Pearson's Product-Moment Correlation

*$p < .05$

**$p < .01$

***$p < .001$

DISCUSSION

The longitudinal design used in this study helped to delineate patterns of relationships that would not have been obvious in a cross-sectional study. Such overt infant behaviors as visual fixation, orienting to the stimulus, expressive behavior, and habituation rate all offer differing perspectives to cognitive processes in infancy. The leap of inference from these behaviors to cognitive structure is hazardous at best, primarily because of temporal and spatial variation in stimulus arrays, the state of the infant, and the variation in experimental procedures. The decision was made to assess several response systems simultaneously in order to present a composite view of the response systems in relation to one another.

Once the number of free parameters is reduced, experimental conditions can be created to test hypothetical formulations that are expected to hold, and then the remaining parameters can be estimated. The laborious process of mapping and scaling responses at different ages to test stimuli under standardized conditions is essential to clarify meanings of particular behaviors. In particular, the longitudinal analysis is especially crucial if the behaviors are changing rapidly during the time span in question. Without doubt, the data from this study are weak and equivocal and subject to interpretation, however, inferences are risked because so much is unknown and the clues offered may be useful to other investigators.

The effects of the various transformation tasks will be reviewed separately and also in conjunction with other independent variables. The effects of age, environmental background and sex will be discussed under separate headings though interaction effects are interspersed when appropriate. The interrelationship of the various response measures are considered under age effects and to a lesser degree, under risk and sex variables.

Task Effects

Task and Surprise Behavior

The six tasks were selected arbitrarily with respect to age and cognitive level of the infants. The use of a center screen in masking transformations of moving objects was inspired from Bower's work (1971) while the idea of the doll transformation came from Kagan (1971).

Evidence is presented (Table 4) showing significant increments of surprise occurring on the disguise, form, and location tasks from pretest to posttest. There was also a tendency towards less surprise by older age infants on the doll task.

This trend towards lower surprise on the doll task is subject to various explanations. The effect can be explained in terms of pretest familiarization with the doll transformation. Perhaps, a single exposure was sufficient to reduce the probability of surprise on repetition despite a seven month time lapse between testing. This explanation is supported by the differential responding between the longitudinal and control groups on the doll task (see Table B-1). The control group responded with significantly more surprise than did the longitudinal group with a history of prior exposure.

An alternative explanation that can be advanced is the possibility that infants become familiar and observant of distorted or incongruous human forms (broken, deformed, or headless dolls) from one year to 18 months.

Another interpretation and probably the most persuasive is a methodological error committed in reversing the transformation from pretest to posttest (animal head on human form to human head on animal form). The salience of human facial features relative to human form is supported in the literature (Caron et al., 1973; Lewis, Wilson and Baumel, 1971). In essence, two different tasks were presented instead of one, weakening generalization from the data.

Employing the notion of surprise as an index for the development of cognitive structure, the conclusion is drawn that the concept of continuity of direction of an object moving along a trajectory emerges between 11 and 18 months (Table 4, $t = 2.28$, $p < .05$). This particular task demonstrates the utility of the violation of expectancy paradigm in mapping the development of cognitive structure. The near absence of surprise at one age and the significant presence of surprise at another age may reflect the ontogenesis and elaboration of cognitive structure. Also comparisons of the amount of surprise exhibited to different transformations at each age may index the relative strength and depth of cognitive structures.

As reflected in Table 4, form transformation significantly evoked more surprise than did color, size, and location transformations at the two test periods. It is logical to assume that multidimensional transformations engage cognitive structure with greater facility than component unidimensional transformations. Such multidimensional transformations may be useful in learning about different response parameters at different ages and populations and about broad concepts of object permanence.

The drawback is that little is learned about what specific cognitive structures are being violated. It is difficult to ascertain whether a violation of expectancy occurred because of a configuration of stimuli, a rule regarding the permanence of objects in general or a specific featural aspect of the stimulus event. It is notable that form transformation elicited a significant increment in surprise from pretest to posttest while unidimensional transformations of color and size did not. Also in terms of the risk data (see Table D-2), form transformation discriminated between groups more efficiently than did the unidimensional transformations. No clear explanation is available for the lack of increased surprise on color and size transformations at the older age. Certainly, systematic manipulation of color and size parameters in longitudinal studies are needed to yield data on the development of these cognitive expectancies.

Conforming to theoretical expectation, person permanence tasks (tasks 5 and 6) produced the greatest amount of surprise at pretest (see Table 4). These results support previous findings (Bell, 1970; Fagan, 1972; Caron et al., 1973) that person and facial permanence emerge prior to 11 months and tend to precede the development of object permanence. At posttest, the disguise and form transformations evoked the greatest amount of surprise. The failure of the doll task to rank ahead of form transformation at posttest may be explained in terms of experimental error and/or testing effects. The relationship between the person permanence tasks and risk will be entertained later.

The transformation of E's face on the disguise task also resulted in a significant increase in surprise from pretest to posttest (Table 4, $t = 3.71$, $p < .01$). The constancy of exposure of infants to invariant human faces for an additional seven months adds strength to these expectations and an increased sensitivity to violation of facial permanence. The percentage of infants showing surprise to the disguise task during this time frame increased from 40 percent to 64 percent. Presumably, discounting organic state factors and other sources of variability, this percentage would increase towards unanimity as the infant grows older. These data suggest that from 11 months to 18 months, the concept of facial permanence continues to develop and be refined.

Task, Recovery of Fixation and Habituation Rate

The fact that cognitive structures pertaining to color, size, and form permanence exist in a rudimentary degree at pretest is supported by fixation recovery data (see Table 6). Color, size, and form transformations evoked a greater than 30 percent fixation recovery rate over the pretransformation trial. These three tasks differed significantly from the remaining three tasks in which fixation recovery was not as pronounced. Schaffer et al. (1972), using a color transformation task, found a dramatic increase in visual fixation between eight and nine months of age. The location transformation did not produce increased looking on the transformation trial at pretest, thus supporting the conclusion from the surprise data that this concept had not yet emerged at 11 months. In view of these data, it is assumed that recovery of fixation to a transformed stimulus event can be straightforwardly interpreted as an index of cognitive structure during the latter months of the first year of life. As will be discussed later, the posttest data is complicated by the possibility of reduced fixation to violations of firm cognitive expectancies.

The disguise and doll tasks behaved somewhat differently with respect to habituation. The infants' interest did not wane from trial to trial. In the case of the disguise task, the failure of habituation was significant in comparison to other tasks at both pretest and posttest (see Table 5). The game-like quality of the peek-a-boo task elicited more and more interest as the trials progressed. In addition, there was a significant decrease in the amount of fixation recovery to the transformation trial between the disguise task in comparison to the color, size, form and doll tasks at pretest. (See Table 6.) Possibly this task succeeded in eliciting avoidance responses in some infants, thus lowering the fixation recovery data.

The significant increase in fixation recovery on the doll task from pretest to posttest (see Table 6) is confounded by weaknesses in experimental design and no further explanation is offered here.

Combining the habituation data on all six tasks obscured trends in the data for summed variables. Examination of the individual tasks in Appendix C may offer greater insight on habituation than relying on the grouped data. In particular, the summed values are distorted by the extreme dishabituation effect of the disguise task.

Age Effects

Habituation Rate

The hypothesis that older age infants would show a more rapid rate of habituation (Table 9) was not supported by the findings. The assumption leading to this hypothetical formulation was that 18 month infants would code and store information about the stimulus event more economically and thus decrease fixation time as the trials progressed. One explanation for the lack of findings to support this notion is that the older age infants may have been less wary of E and of the experimental environment, less reliant on their mothers for support, thus freeing them to extract more information from the various tasks. In addition, it is conceivable that the tasks themselves had attention eliciting properties (e.g., the movement of objects reverberating on a pulley string) that may have affected fixation time. The extractable information may have produced a more appropriate cognitive match for 18 month infants, thereby exerting control over fixation behavior.

Overall, this experiment did not have the level of control over extraneous variables necessary to produce reliable data on habituation. The presence of E, the infant's mother, the comparative short number of trials and the lack of habituating criteria are all variables that may have obviated the expected age effect for habituation. The aforementioned task differences also mitigate against summing habituation rate across tasks as was done.

On the summed variables, habituation rate (RHAB is used in describing the data) was associated with crying during a task at pretest (Table 7, $r = .35$, $p < .05$) and at posttest (Table 8, $r = .32$, $p < .05$). A methodological defect in the data collection prevented distinctions from being made between habituation due to boredom, fatigue, or wariness versus cognitive processing of information. The correlations between habituation rate and crying suggest that infant state variables are confounded with cognitive factors.

There is no relationship between habituation rate and surprise and a slight nonsignificant negative relationship between amount of surprise and rapid habituation at posttest (Table 8, r = -.21). Low surprise at pretest (Table 10, r = -.23) is also associated with rapid habituation at posttest.

From Table 11, t test comparisons of FIX1 vs FIXP at both pretest and posttest show significant decreases in looking time over trials. The correlation between FIX1 and FIXP at pretest is .29, $p < .05$, and .50, $p < .001$ at posttest. This suggests greater continuity or stability of looking style for older age infants.

Level of Surprise

As hypothesized, 18 month old infants displayed more surprise to the summed transformation tasks than they did at 11 months (Table 9, t = -2.82, $p < .01$). This replicates the findings of LeCompte and Gratch (1972) and adds weight to Charlesworth's (1969) contention that surprise behavior is functionally related to cognitive processes and development.

The two definitions of surprise employed in this study are highly correlated at each age. Viewed collectively, the interactions of LS and LS2 with other variables are parallel with the tripartite definition generally showing higher correlations and potency vis-a-vis theoretical expectation. There were only 6 instances of high surprise at the younger age and 25 high surprise reactions out of 276 transformation trials administered each testing interval. For mild surprise there were 65 and 71 respectively.

The meanings of specific surprise behaviors at each age are unclear. Associated with freezing at pretest was raised eyebrow and open mouth phenomena (Table 7, $r = .45$, $p < .01$). Frowning and sobering were associated with questioning glances at pretest (Table 7, $r = .55$, $p < .01$). These patterns did not hold true at posttest. Freezing behavior was strongly related to questioning glances (Table 8, $r = .68$, $p < .01$) and frowning and sobering was paired with eyebrow and mouth movement (Table 8, $r = .60$, $p < .01$). There was also a significant increment in the frequency of questioning glances from pretest to posttest (Table 9, $t = 2.43$, $p < .05$).

The meanings of such behaviors and their combination appear to change topographically with age, making speculation quite problematic. The categorization of frowning and sobering and questioning glances as "mild surprise" was arbitrary. Post hoc review of the data leads to the inference that avoidance responding may be cognitively appropriate when expectations are firmly established (see Tables 7 and 8 for the consistent patterning of FZ and FS with other key variables). Combining related but potentially distinct responses as frowning and sobering each with different subjective weightings for surprise also obscures the action of these variables.

The correlation between LS at 11 months and 18 months was .33, $p < .05$ (Table 10). The continuity of surprise behavior between the two ages lends credence to its utility and validity as a measure of cognitive development in infancy. Admittedly, the correlation is low but nevertheless exciting because it represents a thread of stability in cognitive structure from age 11 months.

The intercorrelations of pretest with posttest variables (Table 10) yield interesting patterns to support the relationship between surprise and cognitive structure. At pretest, high surprise was related to fewer tracking trials on the initial pulley task (Table 7, $p = -.32$, $p < .05$) and tended to be associated with infants who were identified as low-risk (Table 7, $p = -.27$, $p < .10$, with the effect of sex partialed out). At posttest, these effects were in the same direction though not reaching significance. Finally infants who took fewer tracking trials at pretest were significantly more surprised at posttest (Table 10, $r = -.31$, $p < .05$).

Trials to Track

From pretest to posttest, there was a sharp decline in the number of trials required to successfully anticipate the emergence of the disappearing object (Table 9, $t = 5.88$, $p < .001$).

One explanation entertained is that pretest exposure to objects moving along trajectories from full view to occlusion to full view was a sufficient learning experience to alter posttest tracking behavior. Alternatively, in view of the small standard deviation at posttest, these results may be explained by the fact that the vast majority of infants became proficient at tracking trajectories of moving objects from age 11 months to 18 months. Data previously described relating surprise behavior to the location transformation at posttest support the hypothesis that tracking behavior improves dramatically during the second year of life.

The pretest relationship between rapid tracking and surprise has already been mentioned. Pretest data also show low risk infants taking fewer trials than high risk infants (Table 7, $r = .25$, $p < .11$). At posttest, trials to track is not associated with risk and the relationship to surprise is weaker. Of interest, however, is the association of rapid tracking at pretest with high surprise at posttest (Table 10, $r = -.31$, $p < .05$), shorter response recovery ($r = .34$, $p < .05$), more frequent freezing ($r = -.29$, $p < .10$) and frowning and sobering ($r = -.33$, $p < .05$). Pretest trials to track is not associated with posttest tracking behavior ($r = .04$).

From the pretest variables, trials to track seems to be the most efficient predictor of posttest cognitive functioning. The same measure at posttest seems to be unrelated to the key variables felt to be related to cognitive processes.

Fixation Recovery

The anticipated effect for increased recovery of fixation (RFIX) to transformations at the older age was confirmed (Table 9, $t = -2.36$, $p < .05$). Without taking into consideration infant looking on the pretransformation trial, mean looking time on the transformation trials (FIXT) increased from pretest to posttest (Table 9, $t = -3.19$, $p < .01$).

Further analysis revealed this to be a function of decreased frequency of glances at the transformed object, thus increasing mean looking time, rather than an increase in the total duration of the fixations (See Table 9, FFIXT, DFIXT). It was also found that frequency of glancing at test stimuli decreased significantly from pretest to posttest on first fixations (FFIX1) and pretransformation fixations (FFIXP). The overall mean fixation of FIX1 and FIXP were not significantly greater at posttest when compared to pretest totals because of concurrent decreases in duration of looking time on these variables at posttest. As such, the present study reaffirms Cohen's (1973) theoretical formulation of mean looking time being a more sensitive indicator of cognitive functioning than measures based solely on total duration of fixation.

Comparisons of t tests (Table 11) reveal looking times on the transformation trials to exceed fixation on the first trials at pretest ($t = -3.73$, $p < .001$) and posttest ($t = -6.88$, $p < .001$). More directly meaningful, however, is the data showing highly significant increases in fixation time from the pretransformation trial to the transformation trial at pretest ($t = -6.94$, $p < .001$) and posttest ($t = -8.87$, $p < .001$). Table C-13 in the appendix task breakdown of the means and standard deviations of FIX1, FIXP, and FIXT for the individual tasks at posttest.

The intratest correlations of FIX1 with FIXP and FIXP with FIXT (Table 11) or even FIX1 with FIXT indicate more continuity in looking style at age 18 months than at age 11 months. From pretest to posttest, only fixations on the first trial showed a degree of stability over time (see Table 11, footnote). When rate of response recovery is taken into consideration (FIX and RFIX), pretest response to discrepancy was weakly correlated with posttest values (Table 10, $r = .27$, $p < .10$).

The absolute fixation recovery (FIX) and relative fixation recovery (RFIX) are correlated at pretest (Table 7, $r = .89$, $p < .01$) and at posttest (Table 8, $r = .79$, $p < .01$). An examination of their interrelationships with other variables leads to the possible conclusion that they are somewhat independent of each other and tap slightly different cognitive mechanisms. The pretest data suggest that absolute differences in fixation between the pretransformation and transformation trials may be the more valid indicator of cognitive functioning whereas posttest data seems to favor the relative measure. One assumption for this finding, if it is indeed the case, is that fixation behavior is more closely linked to a style of looking at age 18 months while fixation recovery for 11 month infants is more likely to be under stimulus control.

Regardless of which measure is taken into consideration, some interesting patterns of relationships emerge. The various components of surprise (FZ, EM, FS, QG) are positively related to fixation recovery at pretest and negatively correlated at posttest (see Tables 7 and 8). This reversal of relationship has implications for the inverted U function of the discrepancy hypothesis. At posttest, there was less fixation recovery by infants showing more surprise (Table 8, $r = -.29$, $p\ .10$), crying less ($r = .38$, $p\ .05$) and displaying more frequent frowning and sobering ($r = -.43$, $p\ .01$). Moreover pretest variables of high surprise (Table 10, $r = -.32$, $p < .05$) and fewer tracking trials ($r = .34$, $p < .05$) were associated with less fixation recovery at posttest. Other patterning of variables at posttest (Table 8), though not significant, also relate less fixation recovery to fewer tracking trials, low risk infants, and females.

One possible explanation that could account for disruption of looking time following a surprising event might be curiosity and search behavior for the cause of the transformation. The infant may glance at the opposite side of the screen, give a quizical look at the experimentor or look to his mother for explanation. The posttest results, however, seem to fit an avoidance hypothesis in that refusal to look and negative hedonic states accompany strong violations of expectancy. The disconfirming stimuli are perceptually screened and avoided if possible. It is felt that the violation of expectancy experiences presented to 18 month old infants produced a cognitively appropriate combination of surprise and visual rejection of the discrepant event. Further evidence to support this contention will be presented in discussing sex and risk effects in relation to surprise and fixation recovery.

Sex Effects

The Pearson product-moment correlation coefficients between level of surprise and sex on the summed variables at each age are presented in Tables 7 and 8. An examination of these coefficients indicates that no relationship exists between sex and level of surprise at pretest ($r = .02$) while a strong relationship was demonstrated at posttest ($r = .37$, $p < .05$ with the effects of risk partialed out). To be specific, females showed more surprise to violation of expectancy at 18 months than did their male counterparts. The effect was most pronounced on the color, form, and disguise transformations (see Table D-2). The disguise task is interesting in that a reversal occurs from pretest to posttest. Males showed more surprise and less fixation recovery at pretest, conversely, females showed the same pattern of response at posttest (see Tables C-11, C-12).

On the pretest variable of glancing to the opposite side of the screen, females looked more frequently than males (Table 7, $r = .34$, $p < .05$), with the effects of risk partialed out). It is notable that this sex effect occurred dramatically on the location transformation (see Table C-7) which matched the cognitive requirements of the task. No other sex differences were found at pretest.

On the summed data at posttest (Table 8), a pattern of responses occurs showing males to be less surprised, having longer fixation recovery times, more tracking trials, and more crying behavior. Of these results, only the surprise data reached the level of significance. The general configuration of the data does lead to the assumption that females were performing at a higher cognitive level than the male infants.

There was a moderate trend in the data showing a degree of association between risk designation of the mother and the sex of the infant (Tables 7 and 8, $r = -.28$, $p < .10$). Mothers labeled as low risk tended to have female infants in this sample. The sex effect for surprise at posttest may be explicable in terms of the interaction of the maternal caretaking style and the seven month developmental period spanned by this study. This would be in accord with Burton White's (1972) hypothesis that from age 10 months maternal behavior becomes a major source of influence on infant cognitive development.

Another explanation, that is becoming more prevalent in the literature, is the biological precocity of female infants (Messer and Lewis, 1972). No explanation for this finding will be discussed here.

One hypothesis, worthy of exploration, in this sample of predominantly Mexican-American mothers of lower class background, is the close identification and quality of attachment of mothers for their daughters. The strong sex effect in this study could be a function of these mothers uniformly providing a more cognitively supportive environment for daughters as opposed to their sons. The data seem to indicate that females from high risk environments may not be as vulnerable as males from similar environments during the time frame encompassed by this study. It is not clear whether cultural or socioeconomic influence would produce this effect. Kagan (1971) marshals evidence to make a case in the opposite direction. He feels that females in lower class environments more accurately reflect the influence of their background than do males. Further study is obviously required prior to a definitive answer on the relationship of sex of the infant and early environmental influence.

One unexplained factor that may have affected the outcome in an unknown way was the sex of E. This variable was not controlled in the experimental design.

Risk Effects

Infants of low risk mothers showed a trend towards higher surprise reactions to the summed transformations than did infants of high risk mothers (Table 7, $r = -.27$, $p < .10$ with the effects of sex partialed out). The pattern of high surprise, fewer tracking trials on the first pulley task, less crying, and long fixation recovery occurred together, chiefly on the doll and disguise tasks (see Tables C-9, C-11, D-2, and E-2). This finding takes on added importance when the theoretical expectation of greater violations of expectancy to person permanence tasks at pretest is taken into consideration. The pairing of long fixations with high surprise in low risk infants on these tasks is also important in scaling behavior in terms of the inverted U discrepancy hypothesis.

At posttest, the predicted effect for high surprise among low risk infants did not occur as anticipated. When the effects of sex were partialed out, there was a low order correlation between risk and the level of surprise that did not reach significance. The possible influence of high risk mothers on their daughters has already been discussed. Another factor taken into consideration is a division of object and person permanence tasks at posttest. There were no risk differences on the doll and disguise tasks (Table E-4) at posttest while there was an association between surprise and low risk (Table E-3; LS, $r = -.25$, $p < .11$; LS2, $r = -.29$, $p < .10$). The violation of expectancy experiences of facial and person permanence seem to uniformly elicit surprise reactions from infants regardless of environmental background. In contrast, the object permanence tasks tended to elicit differential response from high and low risk infants. On tasks 1-4 at posttest, for low risk infants, there was a pattern of less crying, more surprise, more frowning and sobering, and shorter fixation recoveries to the transformations (see Table E-3). When these findings are summed with tasks 5 and 6, the effects are masked and weakened.

Also, using the risk data as a frame of reference, the reciprocal relationship between surprise and length of fixation on the object permanence tasks is in theoretical accord with the discrepancy hypothesis. When associated with high surprise, the finding of short fixations suggest an apparent downturn in the inverted U function of the discrepancy hypothesis.

CONCLUSION

This limited longitudinal study provided some preliminary answers to questions raised concerning infant visual and expressive behavior following a series of transformations designed to violate cognitive expectancies. The violation of expectancy paradigm was useful in touching on issues relating to maternal influence on infant cognition, sex determinants, age-dependent response patterns, the emergence and strength of specific cognitive expectancies and, lastly, an elaboration of the meanings of various response indices by observing their simultaneous interrelationships.

The influence of maternal risk on infant cognition at 11 months appears to be supported by the data. The pattern of high surprise, fewer tracking trials on the first pulley task, less crying and long fixation recoveries on the person permanence transformations favored the low risk infants. The most sensitive indicator and the one most predictive of high performance at 18 months seems to be the tracking measure.

The differences between high and low risk infant performance at pretest tend to disconfirm White's (1972) thesis that no meaningful variation in infant cognition occurs as a result of early maternal influence during the first year of infancy. Perhaps the method of using infant visual and expressive behavior as indices of cognitive development will prove useful in further studies of infant cognition and its relationship to environmental variation. Though refinement of experimental procedures is certainly indicated, the violation of expectancy paradigm offers much promise in gaining information about developmental status, particularly the status of infants who may be exposed to harmful rearing conditions.

The procedures for determining risk in this study are weak and not amenable to experimental replication. Further research is suggested, using less clinical, more reliable, and more objectifiable criteria for assessing environmental and maternal influence. Nevertheless, despite the drawbacks, there were patterns of data showing divergence of responsivity between high and low risk infants as early as 11 months.

One suggestion for further research would be additional comparisons between infants from middle class and lower class socioeconomic backgrounds using the violation of expectancy paradigm. The differences between environments would be accentuated and the findings should be less equivocal. Instead of moving toward more global characterizations of environment, the opposite tact of using behavioral assessment techniques could be used to thoroughly assess environmental conditions and maternal behaviors, thus refining the subjective criteria employed in this study. Pilot studies establishing validity of the measure would also add to the credibility of the results.

The failure to find strong overall risk effects at 18 months was disappointing. The strong sex effect and tasks of differing cognitive requirements (person permanence, trajectories, and object permanence) were sources of confounding error that may have obscured the expected finding. When the person permanence tasks were separated from the other data, the relationship between low risk and surprise gained in strength. Another conclusion from these data suggests that concepts in the process of acquisition may be more sensitive indices of environmental influence than expectancies formed earlier in development, i.e., a ceiling effect.

The presence of sex differences in this study are interesting and, as usual, do not yield to easy interpretation. For these data, the sex differences at 11 months were essentially negligible, while, at 18 months, a general pattern of responses, especially higher surprise behavior, suggests the cognitive precocity of females.

One explanation is that females may be biologically and psychologically more differentiated than males due to general developmental maturity midway through the second year of life. An alternative explanation requires no biological assumptions. An argument advanced for this particular sample assumes cultural and ethnic child rearing practices differentially favoring the development of female infants in a predominantly Mexican-American community. A direction for further research would be the systematic investigation of mother-son and mother-daughter interactional patterns in a low income Mexican-American sample.

Mean fixation time to the summed transformations increased significantly from pretest to posttest. However, the interpretability and usefulness of this response as a straightforward measure of cognitive ability is not indicated. At posttest, long fixation recoveries were not associated with other indices of cognitive development, i.e., surprise, fewer tracking trials, less crying, low risk infants and females. Longitudinal correlations of surprise and trials to track also support this view. At pretest, shorter fixation recoveries were not associated with surprise, except in the case of the disguise transformation.

One explanation for these results is the operation of the discrepancy hypothesis. Perceptual screening of highly incongruous events under control of central cognitive processes may have resulted in defensive avoidance of the traumatic input by looking away from the stimulus. The extreme degrees of discrepancy seem to have produced a downturn in fixation recovery in cognitively advanced infants at the older age. The violation of expectancy paradigm and the selected tasks used in this study seems to be reasonably effective in eliciting avoidance behavior to discrepant stimuli. Frowning and sobering responses were the most frequent responses associated with short fixation recoveries at posttest.

Fixation data also pointed to the role of mean duration of fixation as being the most cognitively appropriate measure in infant attention studies. Younger age infants consistently glanced more frequently at the stimulus event than they did at 18 months. Though total fixation times between the ages are similar, there was a strong age difference in glancing patterns.

Contrary to expectation, there were no age-related differences in habituation rate nor did the measure correlate well with other measures of cognitive development. No generalizations from these findings are offered because of several confounding sources of variance introduced in the experimental procedure.

Charlesworth (1969) describes in detail his theory for implicating surprise into the framework of the ontogenesis of cognitive structures and its possible value in assessing the presence of cognitive structure.

He speculated that under normal environmental conditions, cognitive structures are driven through a predictable ontogenetic sequence of development. When a particular violation of expectancy occurs, surprise reactions are felt to show in infants ability to discriminate between events and reflect the presence of a cognitive structure that faithfully represents the lawfulness of the situation. It also follows that surprise reactions become more intense over time as the child improves his capacity to make increasingly more precise expectancies.

These hypothetical formulations were supported by this study. Infants increased the frequency and intensity of their surprise reactions to violations of expectancy from 11 to 18 months. Theoretical expectations regarding surprise in relation to other variables indexing cognitive development (risk, trials to track, crying, fixation recovery, sex) tended to confirm its validity as a response measure. There was also modest continuity between surprise reactions at pretest and the tendency to be surprised at posttest. The use of a surprise measure in conjunction with fixation time and other measures helped to lay down a multidimensional configuration of data roughly supporting the inverted U function of the discrepancy hypothesis.

The surprise data also seemed useful in assessing the relative strength of various law-violating transformations and their developmental impact from one age to another. Another area of interest, just barely touched upon in this study, is the association of various types of surprise behaviors with other response measures. Additional research is indicated to tease out the meanings of these behaviors and to understand their relationship to approach/avoidance reactions and to positive and negative hedonic states. There is the suggestion in this study that cognitively appropriate surprise reactions fall in spectrum of avoidance responding.

Surprise behavior and subsequent instrumental responding may also be closely interrelated (see LeCompte and Gratch, 1972 and Schaffer et al., 1972) though not a focus of this study.

In general, the strength of this study belies its central weakness. A global look at several response parameters following violation of expectancy experiences was provided at the expense of experimental rigor directed at each of the several research problems it encompassed. The methodology was indeed useful in tapping into cognitive processes in the preverbal infant. What needs to be done, it seems, is the manipulation of one or two independent variables with considerable refinement of the experimental procedure and the dependent measures. Varying transformations along specific dimensions in short term longitudinal studies would increase knowledge about the acquisition of specific cognitive structures and the threshholds of discrimination. Basic variables such as length of occlusion, number and duration of trials, length of intertrial intervals, and the opportunity for instrumental behavior, could all be manipulated systematically. The violation of expectancy model, using visual and expressive cues, offers exciting and "surprising" research possibilities.

APPENDIX A

COMPILATION OF GUIDELINES AND DEFINITIONS UTILIZED IN THE EXPERIMENTAL PROCEDURES

Table A-1. Definitions for Recording Behaviors on Puzzlement Measure

1. Initiation and termination of recording period. Button is depressed briefly when E touches string to remove object from pulley. Recorder calls out stop and start to other recorders. Doll trial begins when E places doll in S's hand and stops when E extends hand to retrieve doll.

2. Freezing: A stunned look appears on the subject's face. Eyes widen. Definite sudden interruption of previous facial expression. Double take.

   There may be also concomitant freezing of the body, i.e., hand stopping in mid-air.

3. Mouth falls open, eyes widen and eyebrows move up concurrently.

4. A strong persistent frown appears on subject's face. The eyebrows knit, the face sobers up, a tightness appears in the mouth. The frown may be directed at E in a complaining suspicious manner.

   Sobering: A gradual change of a previous facial expression. A very slight frown appears on the subject's face and a sobering occurs. There is no freezing of the body and the intensity of the stare at the toy is lower.

5. Bafflement: A loosening of the face with a vague, confused questioning look. The questioning look may be directed at E. There is no frowning. Eyebrows move up -- not accompanied by freezing behavior.

6. Search Behavior: (A) Subject leans forward towards the screen in attempt to determine what has happened. Subject reaches out for stimulus to inspect it further. (B) Subject glances on floor or in direction of screen for original doll. Subject may glance at E in a questioning or suspicious manner.

7. Fixation: Subject has eye contact with stimulus presentation. When subject drops head down below screen or his eyes are otherwise not visible, do not score this category.

Table A-1 continued.

8. Glances at E. The glance will be upward and to a particular quadrant of videotape.

9. Glances at opposite side of screen.

10. (Blank)

11. Rejection of Doll: Subject attempts to hand doll back to E. Subject drops doll to floor. Subject acts as if he cannot accept or reject the doll. He persistently picks up and puts down the doll and treats the doll as if it had some eerie quality.

12. Exploration: Subject actively explores the doll's head by visual scanning, fingers, or by mouthing. If subject glances away from the doll but continues to finger or mouth doll, then the category continues to be scored.

13. Vocalization: Audible sounds emitted by subject. May include speech, laughter, etc. Stop recording at natural breaks in vocalization patterns.

14. Smiling: An up turn at corners of mouth. May be accompanied by a narrowing of the eyes and vocalizations indicating pleasure.

15. Crying, fretting, fussing.

Table A-2. Definitions of Surprise.*

High Surprise	
	1. Freezing
	2. Mouth falls open -- eyebrows shoot up
	3. Frowning
Mild Surprise	
	1. Sobering
	2. Bafflement
Low Surprise	
	1. No expression

*Definitions are expanded in Table A-1.

APPENDIX B

COMPARISONS OF LONGITUDINAL AND CONTROL GROUP ON SURPRISE, HABITUATION RATE, AND FIXATION RECOVERY RATE AS MANIFESTED ON POSTTEST TASKS

Table B-1. Comparison of Longitudinal Group with Control Group on Mean Level of Surprise (LS) on Posttest Tasks.

Experimental Groups		Tasks 1. Color	2. Size	3. Form	4. Location	5. Doll	6. Disguise
Longitudinal Group	M	1.26	1.24	1.52	1.26	1.44	1.91
	SD	.54	.48	.69	.54	.66	.76
	N	46	46	46	46	46	46
Control Group	M	1.46	1.39	1.77	1.08	2.00	1.77
	SD	.78	.65	.83	.28	.71	.83
	N	13	13	13	13	13	13
t test* Difference of Means		.88	.75	.98	-1.67_a	2.59_b	-.56

df = 1/56

* = two-tailed test

a = $p < .10$

b = $p < .05$

Table B-2. Comparison of Longitudinal Group with Control Group on Mean Relative Habituation Rate (RHAB) on Posttest Tasks.

Experimental Groups		Tasks: 1. Color	2. Size	3. Form	4. Location	5. Doll	6. Disguise
Longitudinal Group	M	.05	-.05	.04	.12	-.05	-.82
	SD	.66	1.06	.97	.69	.70	1.96
	N	46	46	46	46	46	46
Control Group	M	-.17	.13	.14	-.25	-.03	-2.17
	SD	1.00	.93	.47	.87	1.04	5.25
	N	13	13	13	13	13	13
t test* Difference of Means		-.77	.62	.48	-1.43	.07	-.85

df = 1/56

*two-tailed test

Table B-3. Comparison of Longitudinal Group with Control Group on Mean Relative Recovery of Visual Fixation (RFIX) on Posttest Tasks.

Experimental Groups		Tasks: 1. Color	2. Size	3. Form	4. Location	5. Doll	6. Disguise
Longitudinal Group	M	.17	.39	.13	-.01	.44	.34
	SD	.85	.65	1.54	.85	.36	.66
	N	46	46	46	46	46	46
Control Group	M	-.04	.43	.36	-.45	.18	.07
	SD	.96	.82	.63	1.36	.59	1.19
	N	13	13	13	13	13	13
t test* Difference of Means		-.75	.16	.78	-1.08	-1.54	-.77

df = 1/56

*two-tailed test

APPENDIX C

INTERCORRELATIONAL MATRICES AMONG VARIABLES ON EACH OF THE SIX TRANSFORMATION TASKS AT PRETEST AND POSTTEST

The means and standard deviations of fixation data on each of the six tasks at posttest are also included.

Table C-1. Relationship Among Variables on Color Transformation at Pretest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.07	-.09	.15	.23	-	-	-.05	-.03	-.09	.03	.21	.22	.00	.06
LS		-	$.92_c$	.19	.18	-	-	$.50_c$	$.35_b$	.07	.07	-.21	-.16	.19	.10
LS2			-	.19	.15	-	-	$.55_c$	$.38_b$	.06	.17	-.14	-.10	.14	.10
RHAB				-	$.67_c$	-	-	-.02	.13	.18	-.24	.22	.15	$-.32_b$	$-.27_a$
RFIX					-	-	-	.16	.16	-.11	-.13	.24	.17	$-.31_b$	$-.26_a$
FZ						-	-	-	-	-	-	-	-	-	-
EM							-	-	-	-	-	-	-	-	-
FS								-	-.03	.02	-.05	-.16	-.11	.22	.18
QG									-	-.06	.20	.22	$.27_a$	.16	.23
GS										-	-.14	-.13	-.05	$.28_a$	.25
TT											-	.25	.21	-.17	-.13
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-2. Relationship Among Variables on Color Transformation at Posttest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	.11	-.07	$.33_b$	.09	$.29_b$	-.09	-.01	.02	-.16	-.12	.17	.19	.05	.11
LS		-	$.93_c$	.03	-.06	$.70_c$	.20	$.57_c$	$.50_c$	.13	-.12	-.21	-.14	$.26_a$	.22
LS2			-	-.07	-.16	$.47_c$	$.28_a$	$.58_c$	$.57_c$	.21	-.11	$-.28_a$	-.20	$.33_b$	$.29_a$
RHAB				-	$.43_c$	.01	-.19	.04	.14	.22	$-.26_a$	.09	.11	.07	.11
RFIX					-	.16	-.20	.05	.03	.07	.07	$.26_a$	.20	-.25	-.20
FZ						-	-.04	.13	.05	-.11	-.06	.08	.08	.00	.02
EM							-	-.05	-.06	-.06	-.04	-.18	-.14	.15	.11
FS								-	$.44_c$	.12	-.07	$-.31_b$	$-.28_a$	.16	.08
QG									-	.10	-.09	$-.31_b$	-.23	$.39_b$	$.32_b$
GS										-	-.07	-.13	-.13	.03	.00
TT											-	-.01	-.04	-.22	-.23
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-3. Relationship Among Variables on Size Transformation at Pretest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	.04	.05	.02	-.03	-.09	-	-.07	-.09	-.15	.00	-.03	.01	.16	.12
LS		-	1.000_c	.05	-.09	$.57_c$	-	$.46_c$	$.57_c$	-.05	$.41_c$	-.16	-.16	.00	-.01
LS2			-	.05	-.09	$.57_c$	-	$.46_c$	$.57_c$	-.05	$.41_c$	-.16	-.16	.00	-.01
RHAB				-	$.29_a$	.00	-	.05	.21	-.19	$-.33_b$	.05	.13	.23	.21
RFIX					-	.08	-	.08	.09	-.04	-.22	.22	.25	.07	.03
FZ						-	-	$.37_b$	-.08	.12	.10	$-.33_b$	$-.31_b$	.09	.09
EM							-	-	-	-	-	-	-	-	-
FS								-	$.37_b$	.10	.19	.02	.02	.00	.00
QG									-	-.12	.21	$.30_b$	$.29_a$	-.09	-.10
GS										-	.09	-.20	-.17	.13	.17
TT											-	.25	.21	-.17	-.13
LER												-	-	$-.28_b$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-4. Relationship Among Variables on Size Transformation at Posttest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.07	-.05	.07	.11	$.28_a$	-.13	.12	-.11	.01	-.21	.25	.19	-.22	-.16
LS		-	$.95_c$	.25	.03	.23	$.34_b$	$.67_c$	$.48_c$	-.01	-.16	-.01	-.02	-.04	-.05
LS2			-	$.27_a$	.04	$.27_a$	$.40_b$	$.68_c$	$.30_a$	-.07	-.19	-.08	-.08	.00	-.02
RHAB				-	$.43_c$	.22	.02	$.30_a$	.14	.02	-.20	-.22	-.17	.21	.15
RFIX					-	.20	-.04	-.07	.12	-.08	-.23	.05	.06	.05	.06
FZ						-	-.03	.25	.14	-.07	.01	-.05	-.10	-.15	-.18
EM							-	-.09	-.07	-.10	.17	-.14	-.12	.00	.04
FS								-	.17	-.02	.01	-.12	-.13	.00	.04
QG									-	.04	-.16	.02	-.02	-.23	-.15
GS										-	.04	.18	.11	-.23	-.19
TT											-	-.01	-.04	-.22	-.23
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-5. Relationship Among Variables on Form Transformation at Pretest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.13	-.14	.18	.16	.04	-.07	-.06	-.08	-.11	.00	-.11	-.15	.09	.05
LS		-	$.93_c$	.22	.25	$.51_c$	$.48_c$	$.55_c$	$.38_b$	.13	-.14	.14	.14	-.04	.00
LS2			-	$.26_a$	$.26_a$	$.30_b$	$.50_c$	$.41_c$	$.53_c$	.22	-.11	.02	.01	.06	-.05
RHAB				-	$.55_c$	.01	.15	.05	.08	.04	$-.33_b$	.07	.03	-.16	-.14
RFIX					-	.08	.14	.08	.10	-.05	-.22	.10	-.07	.07	.04
FZ						-	$.38_b$	$.89_c$	.04	-.06	.11	-.12	-.06	-.16	-.10
EM							-	$.33_b$	-.07	.13	.08	-.14	-.14	.00	-.04
FS								-	.22	$.30_b$	.19	.17	.12	-.21	-.17
QG									-	$.39_c$	.09	-.01	.04	-.09	-.09
GS										-	.22	$-.27_a$	$-.27_a$	.04	-.04
TT											-	.25	.21	-.17	-.13
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-6. Relationship Among Variables on Form Transformation at Posttest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	.03	.04	-.18	.04	-.17	-.10	-.07	.00	-.04	.10	-.20	-.25	-.12	-.19
LS		-	$.90_c$	.05	.14	$.54_c$	.13	$.56_c$	$.51_c$	-.02	-.24	$-.26_a$	-.20	$.27_a$	.21
LS2			-	.04	.16	$.40_c$	.24	$.46_c$	$.57_c$	.08	-.23	-.21	-.15	.24	.19
RHAB				-	$.26_a$	.03	.13	.09	.02	.09	.04	.03	.12	$.28_a$	$.30_a$
RFIX					-	.15	.08	-.01	.13	.14	.04	-.13	-.15	-.06	-.11
FZ						-	-.08	$.49_c$	.18	-.13	-.10	-.22	-.06	.00	.19
EM							-	.15	.00	-.11	-.06	$-.26_a$	-.21	.22	.16
FS								-	.18	-.13	-.12	-.23	-.24	.00	-.06
QG									-	$.61_c$	-.15	.11	.08	-.13	-.11
GS										-	.09	.13	.11	-.11	-.08
TT											-	-.01	-.04	-.22	-.23
LER												-	-	$.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-7. Relationship Among Variables on Location Transformation at Pretest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.07	-.07	.08	.09	-.05	-	-	-.07	-.17	.11	.03	.03	.00	.01
LS		-	1.000$_c$	.10	.14	-.03	-	-	1.000$_c$	.02	-.41$_c$	-.17	-.17	.00	-.05
LS2			-	.10	.14	-.03	-	-	1.000$_c$	.02	-.41$_c$	-.17	-.17	.00	-.05
RHAB				-	.31$_b$	.02	-	-	.10	.02	.07	-.03	.02	.16	.16
RFIX					-	.05	-	-	.14	-.07	-.02	-.30$_a$	-.31$_b$	-.01	-.10
FZ						-	-	-	-.03	-.08	.08	-.18	-.14	.16	.11
EM							-	-	-	-	-	-	-	-	-
FS								-	-	-	-	-	-	-	-
QG									-	.03	-.22	-.17	-.17	.00	-.05
GS										-	-.14	.01	.14	.40$_c$	.41$_c$
TT											-	.25	.21	-.17	-.13
LER												-	-.28$_a$	-	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-8. Relationship Among Variables on Location Transformation at Posttest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.06	-.02	.02	-.24	-	.23	.25$_a$	-.11	.06	.04	.28$_a$	.27$_a$	-.05	.02
LS		-	.93$_c$	.01	.16	-	.42$_c$	.28$_a$	.48$_c$	.59$_c$	.04	-.17	-.12	.17	.13
LS2			-	.02	.19	-	.58$_c$	.40$_c$	.40$_c$	.61$_c$	.01	-.13	-.10	.11	.07
RHAB				-	.44$_c$	-	-.03	.16	.12	.02	.07	-.05	-.04	.05	.04
RFIX					-	-	-.01	.13	-.06	.08	-.13	.04	.09	.16	.18
FZ						-	-	-	-	-	-	-	-	-	-
EM							-	.52$_c$	.07	.41$_c$	-.10	-.03	-.08	-.16	-.18
FS								-	-.05	-.01	-.06	-.16	-.12	.17	.13
QG									-	.09	-.06	-.07	-.07	.00	-.02
GS										-	-.14	.09	.06	-.12	-.10
TT											-	-.01	-.04	-.22	-.23
LER												-	-	-.28$_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-9. Relationship Among Variables on Doll Transformation at Pretest. -- Figures are simple and partial Pearson r correlation Coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LS		-	$.92_c$	-.01	.11	-.05	$.38_b$	$.39_c$	.25	-	-.11	-.07	-.07	.00	.02
LS2			-	.05	.13	-.09	$.27_a$	$.42_c$	$.36_b$	-	.04	-.16	-.15	.05	.00
RHAB				-	$.30_a$	.04	.10	.11	.03	-	.16	.07	.13	.19	.21
RFIX					-	.19	.16	.10	-.04	-	.12	$-.32_b$	$-.38_b$	-.14	-.25
FZ						-	$.53_c$	.12	-.08	-	$-.49_c$	-.15	-.20	-.15	-.20
EM							-	.11	-.12	-	$-.31_b$	-.19	-.19	.00	.06
FS								-	$.42_c$	-	.00	.20	.21	.20	.19
QG									-	-	.09	.25	.24	-.07	.00
GS										-	-	-	-	-	-
TT											-	.25	.21	-.17	-.13
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-10. Relationship Among Variables on Doll Transformation at Posttest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.09	-.05	.21	$.36_b$	-.06	.22	.19	-.13	-	-.10	.03	-.06	$-.32_b$	$-.32_b$
LS		-	$.92_c$	-.06	-.11	$.50_c$	$.38_b$	$.55_c$	$.60_c$	-	-.19	-.05	.00	.21	.21
LS2			-	-.17	-.24	$.30_a$	$.39_c$	$.65_c$	$.52_c$	-	-.18	-.05	.00	.20	.19
RHAB				-	$.51_c$	.07	.10	.06	.02	-	$.31_b$	-.21	$-.33_b$	$-.33_b$	$-.41_c$
RFIX					-	.06	.06	-.01	-.17	-	.22	.04	.03	-.07	-.06
FZ						-	.21	.20	$.29_a$	-	-.06	-.18	-.17	.07	.01
EM							-	$.27_a$	-.11	-	-.07	.06	.04	-.09	-.07
FS								-	$.43_c$	-	-.12	.11	.16	.15	.19
QG									-	-	-.11	-.08	-.03	.15	.14
GS										-	-	-	-	-	-
TT											-	-.01	-.04	-.22	-.23
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-11. Relationship Among Variables on Disguise Transformation at Pretest. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.22	-.05	.01	-.08	-.10	-.10	-.02	-.11	-	.11	$.27_a$	.21	$-.27_a$	-.21
LS		-	$.91_c$	$-.30_a$	.07	$.30_a$	$.26_a$	$.65_c$	$.32_b$	-	-.21	$-.27_a$	$-.30_a$	-.03	-.08
LS2			-	-.22	-.08	$.33_b$	$.28_a$	$.71_c$	$.35_b$	-	-.14	-.14	-.20	-.18	-.20
RHAB				-	.15	.10	-.13	-.20	-.09	-	-.10	-.19	-.24	-.15	-.22
RFIX					-	-.18	.18	-.13	-.25	-	-.15	-.22	-.11	$.33_b$	$.29_a$
FZ						-	-.07	-.05	.18	-	-.01	.08	.01	$-.26_a$	-.24
EM							-	.06	-.07	-	-.05	-.02	-.03	.00	-.01
FS								-	.15	-	.07	.04	-.01	-.21	-.20
QG									-	-	.07	.15	.18	.09	.14
GS										-	-	-	-	-	-
TT											-	.25	.21	-.17	-.13
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-12. Relationship Among Variables on Disguise Transformation at Post-test. -- Figures are simple and partial Pearson r correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	RHAB	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	.17	.06	.13	.06	.23	-.09	-.13	-.06	-	$-.34_b$	.18	.13	-.19	-.14
LS		-	$.86_c$	-.03	-.25	$.58_c$	.23	$.28_b$	$.36_b$	-	-.07	-.10	.01	$.38_b$	$.37_b$
LS2			-	-.21	-.13	$.52_c$	.15	$.36_b$	$.34_b$	-	-.05	.03	.11	.25	$.26_a$
RHAB				-	.17	.02	.11	-.09	-.07	-	-.08	.00	-.01	-.02	-.02
RFIX					-	-.05	-.60	$-.32_b$	-.13	-	-.11	.07	-.02	$-.33_b$	$-.32_b$
FZ						-	.21	.01	-.14	-	.05	-.05	-.01	.12	.11
EM							-	$.30_b$	-.10	-	.02	-.06	-.05	.07	.05
FS								-	.02	-	-.24	.07	.07	.00	.02
QG									-	-	.04	-.01	.09	$.35_b$	$.37_b$
GS										-	-	-	-	-	-
TT											-	-.01	-.04	-.22	-.23
LER												-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table C-13. Means and Standard Deviations of Fixation Data on the Six Transformation Tasks at Posttest. (N = 46)

	Task											
	1. Color		2. Size		3. Form		4. Location		5. Doll		6. Disguise	
Variable	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
FIX 1	2.45	1.86	2.25	1.52	3.60	2.85	3.17	2.74	5.45	5.90	3.50	2.91
FIX P	1.96	1.47	1.97	1.84	2.46	1.90	2.07	1.74	4.12	4.31	4.51	3.17
FIX T	3.91	4.09	3.97	2.71	5.00	3.78	3.31	3.38	7.65	4.43	8.20	3.67
HAB	.80	2.25	.28	2.08	1.14	2.66	1.10	3.05	1.33	5.57	-1.00	3.56
RHAB	.05	.66	.12	.93	.14	.47	.12	.69	-.05	.70	-.82	1.96
FIX	1.95	4.04	2.02	2.59	2.55	4.27	1.23	3.20	3.53	3.70	3.69	4.00
RFIX	.18	.85	.39	.65	.13	1.54	.02	.85	.45	.36	.34	.66

APPENDIX D

CROSS-TABULATION OF INFANTS SHOWING SURPRISE ON THE SIX TRANSFORMATION TASKS AT PRETEST AND POSTTEST BROKEN DOWN BY SEX AND RISK (LER)

Table D-1. Cross-tabulation of Level of Surprise (LS2) by Sex of Infant on the Six Transformation Tasks at Pretest and Posttest. (N = 46)

Task		1. Color		2. Size		3. Form		4. Location		5. Doll		6. Disguise	
Sex		Male	Fe	Male	Fe	Male	Fe	Male	Fe	Male	Fe	Male	Fe
Pretest Level of Surprise	Lo	22	17	21	17	19	17	23	20	12	10	13	14
	Hi	3	4	4	4	6	4	2	1	13	11	12	7
Posttest Level of Surprise	Lo	23	13	20	16	18	9	21	15	18	12	10	5
	Hi	2	8	5	5	7	12	4	6	7	9	15	16

Table D-2. Cross-tabulation of Level of Surprise (LS2) by Risk of Infant (LER) on the Six Transformation Tasks at Pretest and Posttest. (N = 42)

Task		1. Color		2. Size		3. Form		4. Location		5. Doll		6. Disguise	
Risk (LER)		Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi	Lo	Hi
Pretest Level of Surprise	Lo	20	16	19	15	19	14	22	18	10	11	13	12
	Hi	4	2	5	3	5	4	2	0	14	7	11	6
Posttest Level of Surprise	Lo	16	16	17	15	11	12	17	15	16	12	9	6
	Hi	8	2	7	3	13	6	7	3	8	6	15	12

APPENDIX E

INTERCORRELATIONAL MATRICES COMBINING THE SUMMED VALUES OF TASKS 1-4 AND TASKS 5 AND 6 AT PRETEST AND POSTTEST, RESPECTIVELY

Table E-1. Relationship Among Variables Summed Across First Four Transformation Tasks at Pretest. -- Figures are simple and partial Pearson's Product-Moment correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.06	.01	.17	.22	.11	.17	-.04	-.10	-.12	-.12	-.21	.04	.00	.03	.09	.10
LS		-	$.94_c$	.14	.08	.07	.16	$.60_c$	$.54_c$	$.45_c$	$.50_c$	.15	-.16	-.22	-.15	.15	.09
LS2			-	.11	.05	.11	.20	$.65_c$	$.59_c$	$.48_c$	$.52_c$	.07	-.01	-.16	-.15	.03	-.02
HAB				-	$.89_c$	.12	.03	-.16	.01	-.09	.13	-.21	-.24	-.07	-.05	-.11	-.11
RHAB					-	.06	.08	-.17	-.05	-.09	.05	-.17	-.18	-.03	-.02	.02	.02
FIX						-	$.89_c$	.13	.05	.25	.15	.07	.03	-.04	.00	-.12	-.11
RFIX							-	.17	.01	.17	.19	.07	.03	-.02	-.02	.01	.01
FZ								-	$.75_c$	$.66_c$	.12	.10	.17	-.20	-.19	.06	.00
EM									-	$.71_c$	.02	-.04	.10	-.14	-.15	.00	-.04
FS										-	.22	.05	.16	.04	.04	-.04	-.02
QG											-	.08	-.01	.15	.15	-.05	-.01
GS												-	-.15	-.23	-.14	$.38_b$	$.34_b$
TT													-	$.26_a$	.21	-.20	-.13
LER														-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table E-2. Relationship Among Variables Summed Across Tasks 5 and 6 at Pretest. -- Figures are simple and partial Pearson's Product-Moment correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.07	-.03	.25	$.26_a$	-.06	.13	-.05	-.07	-.01	-.04	-	.12	$.27_a$	.21	$-.27_a$	-.21
LS		-	$.91_c$	-.14	-.11	-.25	.07	-.10	.22	.23	.15	-	-.32	-.21	-.23	-.03	-.10
LS2			-	-.08	-.09	-.04	.17	.02	.25	$.36_b$	$.33_b$	-	-.21	-.20	-.24	-.10	-.17
HAB				-	$.77_c$	$.53_c$	$.57_c$	$.26_a$	.14	-.07	-.03	-	.20	-.06	-.05	.04	.03
RHAB					-	$.31_b$	$.41_c$	.19	.10	.02	.01	-	.12	-.08	-.07	.04	.02
FIX						-	$.71_c$	$.31_b$	.10	.20	$.36_b$	-	$.37_b$	.00	-.06	-.20	-.21
RFIX							-	.20	.21	.15	-.02	-	.19	-.25	$-.27_a$	.05	-.13
FZ								-	$.49_c$	-.06	-.07	-	.17	-.11	-.19	-.25	$-.29_b$
EM									-	-.03	-.03	-	.06	-.15	-.19	-.11	-.17
FS										-	$.39_c$	-	.18	.21	.18	-.17	-.11
QG											-	-	.08	$.26_a$	$.26_a$	-.04	.04
GS												-	-	-	-	-	-
TT													-	.25	.21	-.17	-.13
LER														-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table E-3. Relationship Among Variables Summed Across First Four Transformation Tasks at Posttest. -- Figures are simple and partial Pearson's Product-Moment correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	.14	.08	.09	.23	.24	$.32_b$	.08	-.01	.16	.28	.07	.02	.18	.15	-.12	-.07
LS		-	$.93_c$	-.02	-.05	-.13	-.07	$.56_c$	.16	$.40_c$	$.61_c$	.21	-.17	-.25	-.17	$.34_b$	$.29_a$
LS2			-	.09	.07	-.05	.03	$.56_c$	$.28_a$	$.51_c$	$.61_c$	.18	-.14	$-.29_a$	-.23	$.28_a$	.22
HAB				-	$.90_c$	$.34_b$	$.48_c$	-.21	.07	$.26_a$	.12	.02	$-.34_b$	.02	.08	.19	.20
RHAB					-	$.35_b$	$.61_c$	-.19	.03	.17	.18	.04	-.23	-.02	.02	.12	.12
FIX						-	$.80_c$	.14	-.10	-.20	.11	.07	-.04	$.29_a$	$.27_a$	-.13	-.05
RFIX							-	.10	-.10	-.08	.17	-.05	-.05	.12	.10	-.08	-.05
FZ								-	-.01	.15	$.46_c$	.21	-.11	-.03	-.01	.10	.09
EM									-	$.41_c$	-.03	.14	.13	-.14	-.13	.05	.01
FS										-	.15	-.09	-.10	$-.27_a$	-.24	.15	.08
QG											-	.25	-.16	-.02	-.04	-.05	-.06
GS												-	-.09	.10	.06	-.16	-.14
TT													-	.02	-.04	-.22	-.22
LER														-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

Table E-4. Relationship Among Variables Summed Across Tasks 5 and 6 at Post-test. -- Figures are simple and partial Pearson's Product-Moment correlation coefficients. Note: N = 42 for each correlation, one subject was dropped because of coding error.

	CRY	LS	LS2	HAB	RHAB	FIX	RFIX	FZ	EM	FS	QG	GS	TT	LER	LER.S	SEX	SEX.L
CRY	-	-.15	-.13	-.06	.00	.22	.03	-.02	-.04	-.08	-.18	-	-.12	.17	.07	$-.40_c$	$-.37_b$
LS		-	$.91_c$	-.08	-.16	-.03	-.11	$.63_c$	$.29_a$	.18	$.60_c$	-	-.14	-.08	.02	$.36_b$	$.36_b$
LS2			-	-.08	-.25	-.12	-.17	$.52_c$	$.34_b$	$.35_b$	$.54_c$	-	-.14	-.01	.07	$.27_a$	$.27_a$
HAB				-	$.65_c$	.19	$.38_b$	-.10	$.30_b$	.13	-.15	-	.09	.03	-.05	$-.26_a$	$-.26_a$
RHAB					-	$.35_b$	$.51_c$	.02	.11	-.15	-.16	-	.14	$-.32_b$	$-.44_c$	$-.28_a$	$-.41_c$
FIX						-	$.82_c$	-.15	-.19	-.26	-.08	-	.18	-.06	-.11	-.14	-.17
RFIX							-	-.15	$-.28_a$	$-.43_c$	-.07	-	.08	-.02	-.05	-.09	-.10
FZ								-	.11	-.09	$.37_b$	-	-.17	-.14	-.11	.13	.10
EM									-	$.39_b$	.06	-	-.07	-.02	-.02	.01	.00
FS										-	.15	-	.08	.14	.15	.02	.06
QG											-	-	-.14	-.08	.02	$.33_b$	$.32_b$
GS												-	-	-	-	-	-
TT													-	.02	-.04	-.22	-.22
LER														-	-	$-.28_a$	-

a = $p < .10$

b = $p < .05$

c = $p < .01$

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