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COGNITIVE CLASSICAL CONDITIONING PROCESSES IN INFANT EXPLORATORY BEHAVIOR: A GENERALIZED EXPECTANCY MODEL OF INFANT RESPONSIVENESS TO OBJECTS

By

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ABSTRACT

COGNITIVE CLASSICAL CONDITIONING PROCESSES
IN INFANT EXPLORATORY BEHAVIOR:
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RESPONSIVENESS TO OBJECTS

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The generalization of expectancies derived from prior experience was investigated to account for the direction and selective focus of exploratory behavior in infants 7-9 and 11-13 months old. Infants were exposed to environments in which recurrence of a significant event, the presentation of a novel toy, was either predictable (consistently signalled by the lighting of a plexiglass panel that occurred immediately prior to toy presentation) or nonpredictable (toy presentation occurred independendent of scheduled lights of the panel). In neither environment could the sequence or relationship of these events be influenced by infants' responses.

Different patterns of attention and responsiveness to the stimulus events were observed in the two environments. Among these differences were: (1) visual attention to the lighted panel was sustained across trials in the predictable environment but decreased in the nonpredictable environment; (2) although nearly all infants pressed the lighted panel on the first trial, infants in the predictable environment persisted in this response tendency, but the probability of this response

decreased over trials in the nonpredictable environment; (3) infants in the predictable environment were more interested in exploring the novel toys as they were presented; (4) older infants expressed displeasure with the stimulus-independent relationship between events by crying or attempting to leave the nonpredictable environment.

Generalization of the effects of infants' experience in the experimental environments was indicated by changes in the time infants devoted to visually and manually exploring novel toys in preference to familiar toys. Relative to infants' baseline preferences for novelty, the following changes were noted: (1) infants who experienced the predictable environment looked at and actively manipulated the novel toys more and the familiar toy less than during the baseline exploratory preference test; (2) infants who experienced the nonpredictable environment looked at and actively manipulated the novel toys less and the familiar toy substantially more than during the baseline exploratory preference test.

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INTRODUCTION

Recent conceptualizations of infant cognitive development, particularly those derived from the theoretical perspective of Piaget (1952), ascribe an inherent organization to the behavior of infants. This organization is suggested by the regularity with which a few relatively well-defined behaviors recur during infants' interactions with objects and events in the external environment. A common assumption is that these organized behaviors, or sensorimotor schemes in Piaget's (1952) terminology, provide infants the means to obtain information about environmental relationships and to make sense of this information within the context of prior experience.

Further evidence for this apparent behavioral organization derives from consistencies in the orientation and focus of infants' behavior. In this regard, infants seem particularly responsive to novel aspects of their experience (Fantz, 1961, 1964; McCall, 1974; McCall & Kagan, 1967; Piaget, 1952; Rubenstein, 1967). When infants encounter objects or events that are novel in the sense that they are either new to infants' experience or reflect changes in previously identified environmental relationships, infants typically engage in exploration.

Exploratory behavior takes many forms. Depending on the age of the infant, exploration may include visual searching and scanning, selective attention, active groping and manipulation, or experimentation. Despite its various manifestations, however, exploratory behavior represents a consistent orientation to respond in an organized manner to novelty.

As a means to obtain more comprehensive information regarding cognitive processes in infants, the present investigation focused on factors influencing infants' exploration of novel objects and events. This focus seemed particularly appropriate since the majority of infants' activities reportedly are oriented toward objects (White & Watts, 1974). Exploration of novel objects therefore may represent infants' predominant source of new information about the environment.

Given the apparent reliability of infants' exploratory orientation, the present investigation devoted particular attention to the factors that impel or motivate infants to direct their exploratory activities selectively toward novel objects or events. If, as Piaget (1952) suggests, exploration is a behavioral orientation that represents a functional characteristic of many behaviors rather than a circumscribed set of infant behaviors, then the impulse or motivation to explore novelty may reflect a response tendency sythesized from prior experience that is generalized to a new context.

The present investigation therefore attempted to identify specific characteristics of prior experience that influence infants' exploration of novel objects and to demonstrate a possible mechanism by which generalizations from prior experience affect the direction, selectivity, and form of infant exploratory behavior. Several diverse research literatures were correlated for this purpose. A summary of these literatures, as they pertain to the present investigation, follows.

Approaches to Research on Infant Exploration

Research focusing on the exploratory behavior of infants emphasizes principally the stimulus properties of objects that maintain either the selective visual exploration of patterns, forms, or other visual stimuli or the manipulatory exploration of objects. The resulting evidence indicates that relatively complex stimuli hold visual attention longer than simpler stimuli (e.g., Fantz, 1961), particularly among infants older than three months, and that novel stimuli generally are preferred to familiar stimuli (Fantz, 1964; McCall & Kagan, 1967; Rubenstein, 1967).

In an extensive investigation of infants' manipulatory exploration of objects, McCall (1974) observed that, while complexity of the stimulus configuration of an object influenced manipulative exploration of that object, objects that were relatively novel or responded contingent upon infants' actions sustained exploration for relatively longer periods of time. In McCall's study (1974), as in other investigations of object exploration (Rubenstein, 1967), the discussion centered around factors influencing the amount of time spent in contact with an object once contact was initiated.

The well-documented preference for relatively novel stimuli as the focus of exploratory behavior, both visual and manipulatory, is of particular significance to the present investigation for two reasons. First, this preference, despite the fact that the concept of relative novelty is not defined objectively, suggests that infants maintain some residue of prior experience with particular stimuli that influences their orientation toward those stimuli at a later time. This "residue" has been called various names in different contexts—a scheme in

Piaget's terminology, or a model in the research of Lewis and Goldberg (1969)--but, regardless of the name, something is retained from experience that influences later exploration.

Second, due to the consistency of this preference for relative novelty, at least among normally developing infants, a measure of exploratory preference for novelty could be used as an indicator against which generalization of the effects of experiences in other contexts. could be gauged. Of particular interest would be those characteristics of prior experience that might alter this relative preference for novelty.

Theories of Exploration

The purpose of exploration and the motivational basis of exploratory behavior are topics much debated in the research and theoretical literature. Because of the pervasiveness of exploration as a characteristic of human and animal behavior (Berlyne, 1960; Fowler, 1965), much attention is devoted to exploratory behavior in general theories of behavior.

Piaget (1952) and Hunt (1961, 1963) similarly identify the motivation to explore as deriving intrinsically from cognitive activity. Piaget's (1952) concept of functional assimilation conveys the notion that, once acquired, children seek new opportunities to apply their cognitive schemes. In subtle contrast to Piaget, Hunt (1961, 1963) suggests that information processing activities are self-reinforcing, thereby inducing individuals to seek further opportunities to process new information.

The implications of Piaget's and Hunt's interpretations of exploratory behavior are intriguing to contemplate, as they suggest that exploration contributes significantly to cognitive development by assuring an orientation toward those objects and events in the external environment that promote refinements in cognitive competence. However, as currently formulated, these theories identify no specific factors other than novelty or discrepancy from existing schemes that would influence the direction or intensity of exploratory behavior.

The motivational constructs underlying Berlyne's (1960) and Fowler's (1965) theories of exploration are expressed in terms of the drive-reduction principles of classical psychoanalytic and Hullian learning theory (Hull, 1943). In this tradition, exploration is viewed as either a vacuum activity that alleviates boredom or produces a stimulus change, or as a means to reduce uncertainty aroused by novel or complex stimuli. A cogent and compelling critique of drive-reduction interpretations of behavior was formulated by Robert White (1959), to which the reader is referred for a comprehensive consideration of the arguments.

In the context of this investigation, White's critique imparts dubious significance to the theories of Berlyne and Fowler, for in the process of critiquing the principle of drive-reduction, he proposes a motivation for competence or effectance that could account for the direction and selectivity of exploratory behavior. The main premise of White's theory states that individuals are motivated to become more competent or effective in their adaptations to the environment, impelled by an undifferentiated "urge for competence". In this sense, the theory of competence motivation is compatible with Piaget (1952)

and Hunt (1961, 1963). However, White (1959) elaborates further, suggesting that, with the experience of their interactions with objects and events in the external environment, individuals acquire a general sense of their capabilities with respect to these objects or events. This sense of competence enables them to anticipate the probable success or failure of their actions in later interactions. When the outcomes of these interactions are perceived as likely to produce ultimate success and increased competence, these anticipations will impel the individual to act and direct responding.

Generalized Expectancy Models of Exploration

Based on White's (1959) general theory of competence motivation, generalized expectancy models, like those formulated by Lewis and Goldberg (1969) and Watson (1966, 1967, 1972), were developed to account for the motivation and direction of infant behavior. A theme common to these models is that infants' discovery that their actions have causal or instrumental effects on the course of events around them leads to a generalized orientation of responsiveness to events in the environment.

Lewis and Goldberg (1969) emphasize experience of the contingent (i.e., response-dependent) relationships between the behavior of infants and their parents as the source of information from which this generalized orientation of responsiveness derives. For example, when hungry or wet, infants discover that crying attracts the attention of someone who will act to alleviate their needs. From similar evidence of their instrumentality gained through use of the many other response systems available to them, young infants learn to anticipate the

predictable outcomes of specific acts. In addition, by acting infants may also receive reinforcement for the more generalized expectancy that an orientation of responsiveness to environmental objects and events may produce outcomes that would not occur otherwise. Reinforcement of this generalized expectancy that action is necessary to meet their needs will, Lewis and Goldberg (1969) assert, lead infants to be more active and responsive in later interactions with the environment.

A similar view proposed by Watson (1966, 1967, 1972) posits that a "contingency awareness" emerges in very young infants as a result of interactions between infant and parent. His research indicates that, by the second month of life, infants are particularly sensitive to the influence of their own actions on the surrounding environment. Situations in which reinforcement is clearly contingent upon some infant response are met with sustained attention and responsiveness and evoke cooing and smiling behavior. These latter behaviors are interpreted by Watson (1972) as signs of mastery or competence.

Watson (1966, 1967, 1972) also observed that infants who have developed a sense of contingency awareness generally transfer contingency analysis attempts to new experiences. These attempts are marked by an initial responsiveness to the stimulus events, whether contingent or not, which is maintained until a "judgment" that the events are indeed noncontingent can be made.

The evidence supporting the applicability of a generalized expectancy model to the interpretation of exploratory behavior is mostly indirect, deriving from situations in which effective behavior is impossible. For example, when gratification of children's needs failed to occur contingent upon their expression of need, as in the orphanage

environment described by Provence and Lipton (1962), the children tended to withdraw and become unresponsive to what transpired around them. They appeared to block any attention to or interest in these events. The acquisition of certain skills like locomotion, which is not particularly sensitive to environmental influences, tended to develop when appropriate maturational levels were attained. However, the motivation to apply these skills appeared to be lacking.

Similar observations are reported by researchers of the phenomena of learned helplessness in dogs (Seligman & Maier, 1967; Seligman, Maier, & Solomon, 1971) and learned laziness in pigeons (Engsberg, Hansen, Welker, & Thomas, 1972). Learned helplessness is a product of experience with situations in which these animals were rendered incapable of responding to escape or avoid an aversive event (electric shock). Following surprisingly short exposure to these conditions, the dogs ceased all attempts to escape the shock and simply endured the distress produced. Such prior learning significantly retarded learning in new contexts. Even though an appropriate response now could terminate the distress produced by the electric shock, the dogs that had learned they were helpless earlier made no attempts to discover this response. Engsberg, et. al. (1972) demonstrated that the presentation of positive reinforcers to pigeons with no response contingency produced a state of so-called "learned laziness". Subsequent learning was retarded when a response requirement was introduced, due in part to a general reduction in directed activity.

Generalization of the Effects of Response-Dependent Experience

In the research cited in the preceding section, response-dependent experience was identified as a key factor influencing responsiveness to the external environment. This variable also figures prominently in Harter's (1978) theory of effectance motivation. In her theory, which reformulates White's (1959) construct of competence motivation, Harter (1978) argues that, while effectance motivation is essentially an intrinsic orientation, the relative balance between success and failure in children's attempts to control events and master environmental demands influences the intensity of their motivation for effectance. As one manifestation of effectance motivation described by Harter (1978), exploratory behavior is influenced by generalized expectancies established through evaluation of the outcomes of previous response-dependent experiences.

Powerful effects have been attributed to response-dependent experience in a variety of other developmental contexts as well. In social contexts, for example, parental responsiveness to infants' self-initiated behavior has been shown to promote infants' learning of dyadic patterns of social interaction (Schaffer, 1977) and the development of attachment relationships (Ainsworth, 1973). In cognitive contexts, the responsiveness of objects and other forms of response-contingent stimulation has been observed to sustain exploratory curiosity (McCall, 1974), to increase selective attention and goal-directed behavior (Yarrow, Rubenstein, & Pederson, 1975), and to facilitate later response learning (Finkelstein & Ramey, 1977).

The consequences of response-independent or uncontrollable experience has been investigated less intensively with humans. However,

Watson and Ramey (1972) and Finkelstein and Ramey (1978) demonstrated that response-independent experience can interfere with learning to control stimulation when that opportunity is introduced later. These results are similar to those obtained in the learned helplessness research reported earlier.

The weight of the evidence presented to this point suggests that valuable information regarding the exploratory behavior of infants could be gained through intensive investigation of the effects of response-dependent and response-independent experience. The generalized expectancy models, and particularly Harter's (1978) theory of effectance motivation, further describe a mechanism whereby this prior experience generalizes to later interactions in different environmental contexts, influencing the direction, selectivity, intensity, and form of exploration.

However, to emphasize exclusively the effects of response-dependent experience would ignore the stimulus context of experience. Many environmental events occur with consistency or regularity independent of infants' attempts to control them. These represent an additional kind of contingent experience where stimulus-dependent or predictable relationships can be identified. The effects of predictable or nonpredictable relationships on infant behavior have not been investigated systematically. The nature of these effects is, however, suggested in recent literature on learning.

Stimulus-Dependent Experience and Exploration

Rescorla and Wagner (1972) and researchers of the phenomenon of autoshaping or sign-tracking in animals (Brown & Jenkins, 1968;

Hearst & Jenkins, 1974) provide evidence that attentiveness and responsiveness to environmental events as well as learning effectiveness are promoted by stimulus-dependent experience. In their classical conditioning research, Rescorla and Wagner (1972) demonstrate the significance of stimulus-dependent relationships to the elaboration of conditional responses. According to their evidence, classical conditioning successfully results only when the conditional stimulus (CS) reliably predicts the presentation of the unconditioned stimulus (US). A predictability relationship exists when the US is presented contingent upon the prior occurrence of the CS and, most importantly, never occurs in the absence of the CS.

Research with animals on the phenomenon of autoshaping (Brown & Jenkins, 1968) or sign-tracking (Hearst & Jenkins, 1974), which manipulates reinforcement predictability, suggests the relevance of Rescorla and Wagner's theoretical position to exploratory behavior. In species ranging from rats, quail, and pigeons to monkeys, a strong tendency was observed for animals to approach and contact those localized stimuli that were most predictive of positive reinforcement, even though no response was required. The training paradigm was distinctly Pavlovian, replicating the conditions that Rescorla and Wagner (1972) assert produce the most effective elaboration of conditioned responses (CRs). As an example, in the research conducted with pigeons a plastic response key was consistently lighted 6-8 seconds prior to the presentation of food. After very few trials,the pecking response elicited by the grain backchained to (became associated with) the onset of the keylight and the pigeons began pecking the key. In addition, these responses tended to be localized and directed to stimuli most predictive of

important environmental events (reinforcers) and would persist even when responding prevented reinforcement.

It is very likely that stimulus-dependent experience interacts with response-dependent experience to influence infant behavior. However, the nature of this interaction cannot be identified in the context of response-dependent experience, since the relationship of prediction and control are confounded. This confounding may account for the lack of research attention accorded to stimulus-dependent experience. Experimental investigation of the influence of stimulus-dependent or stimulus-independent experience therefore requires manipulation of predictive or nonpredictive relationships in an environment where responses do not directly affect these relationships. The present research applied this approach to identify the possible effects of environmental predictability on infant behavior, particularly with respect to generalization of the effects of this experience to infants' exploratory orientation to novelty.

Plan of Research

The present research explored the nature of the influence of stimulus-dependent experience by investigating the sensitivity and responsiveness of infants 7-9 and 11-13 months of age to predictable or nonpredictable sequences of events. These conditions were manipulated in an environment in which these sequences were unaffected by any of the infants' responses.

The experimental paradigm approximated the autoshaping or sign-tracking procedures of Brown and Jenkins (1968). Infants were permitted periodic access to novel toys hidden behind a door in an apparatus called the Toy Box. For half of the infants, each presentation of a toy was consistently signalled by the lighting of a plastic panel below the door. The remaining infants experience Rescorla's truly random control procedure (Rescorla, 1967) in which the onset of the light was independent of the presentation of the toy and the two events were completely random with respect to each other. The only constraint on this randomness was that one event could not be initiated during the other event.

With each opening of the Toy Box door, a different toy was available, since previous research by Koch (1968) demonstrated that presentation of novel objects on each trial is more reinforcing that is the redundant presentation of the same object. Within the context of the proposed generalized expectancy model, exposure to a different toy behind the door on each trial enabled infants to anticipate only that an interesting toy would be found behind the door each time it opened. The exact nature of the toy was not revealed to the infants until the moment the door opened.

Observations also were made of the impact of this experience on subsequent exploratory behavior, as indicated by infants' preference for novelty. Preference for novelty was selected as an index of one manifestation of effectance motivation in infancy (Harter, 1978). This assessment was developed from an exploratory preference procedure reported by Rubenstein (1967). Before and after exposure to the predictable or nonpredictable experimental environments, infants were presented a single toy. Following this period of familiarization, five novel toys were successively paired with the familiarized toy. Observations were recorded of infants' visual attention and manipulatory

exploration of the familiarized and novel toys. Using this technique, it was possible to identify effects of predictable or nonpredictable experience on a more generalized response orientation.

The following behavioral differences were expected between the groups of infants experiencing predictable and nonpredictable events:

(1) Infants experiencing predictable events would learn to anticipate the sequence of events. This would be reflected in greater attentiveness and responsiveness to the events. In contrast to infants experiencing nonpredictable events, they should: (a) look at the toy sooner upon opening of the door, since the light cued them of its impending presentation; and (b) look at the lighted panel longer and more consistently over trials, as the light had information value as a predictive stimulus.

(2) As in the autoshaping research, the expectancy derived from experiencing the predictable sequence of events would evoke contact of the lighted panel in anticipation of toy presentation. Infants in the predictable group were expected to approach and contact the response panel more frequently and maintain this response tendency at a higher probability.

(3) Since pilot research on the experimental paradigm indicated possible negative emotional consequences on infants' experience of nonpredictable sequences of events, counts were made of fussing or crying episodes and attempts to escape the experimental environment. Infants in the nonpredictable environment were expected to show a significantly greater incidence of these behaviors.

(4) Expectancies established in the Toy Box experiment would differentially influence the level of visual attention and manipulatory exploration exhibited in subsequent interactions with novel objects.

METHOD

Subjects

A total of 40 infants participated in this study, with half 7-9 months old (mean = 8.3 months) and half 11-13 months old (mean = 12.2 months). Equal numbers of male and female infants were obtained for each age group.

Infant participants were normally developing and had experienced no serious birth incidents or later complications. All were white and from predominantly middle-class families living in the vicinity of Michigan State University. At three to four months of age, all infants had participated in an unrelated study of visual recognition memory.

Participation of infants was solicited by telephone contact with their parents. Approximately 88 percent of those parents contacted consented to participate following explanation of the purpose and procedures of the research. (See Appendix A for outline of information provided to parents and Appendix B for sample consent form.)

Infants were randomly assigned to the two experimental treatment conditions (predictable or nonpredictable experience), with equal distribution by sex and age in each experimental group. The mean age and age range for the resulting groups (see Table 1) did not differ by more than ten days for the 7-9 month old infants and six days for the 11-13 month old infants.

Table 1. Mean Ages of Infants in Experimental Treatment Conditions

	7 - 9 Month Old Infants			
		Predictable		Nonpredictable
Male	Mean:	8.1 months	Mean:	8.4 months
	Range:	7-12 to 9-0	Range:	7-27 to 9-5
Female	Mean:	8.2 months	Mean:	8.6 months
	Range:	7-9 to 9-2	Range:	7-6 to 9-6
	11 - 13 Month Old Infants			
		Predictable		Nonpredictable
Male	Mean:	12.5 months	Mean:	12.5 months
	Range:	11-0 to 13-0	Range:	11-0 to 13-0
Female	Mean:	12.0 months	Mean:	11.8 months
	Range:	11-0 to 12-23	Range:	11-7 to 12-28

Materials and Apparatus

Objects were presented to infants for exploration in all phases of this research. They were all easily manipulated toys available commercially and age-appropriate. (See Appendices C and D for descriptions of the specific toys used.)

Experimental conditions were manipulated by means of an apparatus identified as the "Toy Box" (see Figure 1 for schematic diagram). The Toy Box consisted essentially of a three panel plywood screen 76 cm high and 132 cm wide with a sliding door in the middle panel centered 28 cm from the base of the Toy Box. The door opened by being raised from behind to reveal a chamber, 25.5 cm high, 30.5 cm wide, and 25.5 cm deep, that contained a toy for the infants to explore. Two 10 by 15 cm translucent plexiglass panels were mounted at a 40 degree angle from the vertical, 2.5 cm below the door. Only the left panel was used during this experiment. The plexiglass panel could be illuminated from behind by two red 12 watt dc lightbulbs. Electromechanical programming equipment was used to operate the lights according to schedule and to signal the experimenter when to raise the door and permit access to the toy.

Behaviors observed throughout the experiment were recorded on an Esterline-Angus 10 pen event recorder that was keyed by an observer who manually operated a panel of microswitches. All observations were made through a one-way mirror from an adjacent room. The occurrence of stimulus events and responses to the plexiglass panel was automatically recorded.

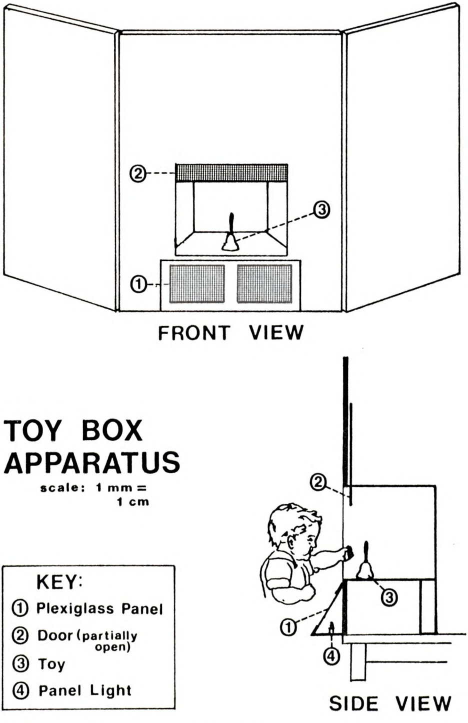

Figure 1. Schematic diagram of Toy Box apparatus

Procedure

When the infants and their mothers[1] arrived at the laboratory, the aims and procedures of the experiment were detailed more fully and written permission for participation was obtained. Then, a brief interview was conducted to obtain background information on the infants and to allow infants time to acclimate to the laboratory setting and the presence of strangers.

Observations of the infants' behaviors were then made in three phases of the research: (1) a baseline test of exploratory preference (hereafter called the Exploration Pretest); (2) exposure to predictable and nonpredictable environmental events (Toy Box trials); and (3) a posttreatment reassessment of exploratory preference (Exploration Posttest). An outline of these three research phases is presented in Table 2.

Exploration Pretest. The research participation of all infants began with an Exploration Pretest which assessed their initial baseline preference for familiar or novel toys. This preference was expressed in terms of the differing amounts of time infants devoted to looking at (visually attending) and actively manipulating (exploring) each of two toys, one novel and the other previously familiarized. Passive contact with a toy was not recorded as exploration.

For the Exploration Pretest, infants were seated in their mothers' laps before a table. The initial familiarization period of the Exploration Pretest consisted in the presentation of a toy randomly selected

[1]With the exception of one case, all infants were accompanied exclusively by their female parent. Frequently, siblings would also come to the laboratory. During periods of data collection, they were entertained in an adjacent room

Table 2. Research Phases and Procedures Experienced by Infants

Phase I: <u>EXPLORATION PRETEST</u>

(All Infants)

1. Familiarization Period

   Toy available 2.5 minutes

2. Paired Comparisons

   Familiarized toy reintroduced with novel toy for 30 seconds

   (Five trials given with a different novel toy each trial)

Phase II: <u>TOY BOX TRIALS</u>

Predictable Condition		Nonpredictable Condition
(5 males and 5 females 7-9 months old and 5 males and 5 females 11-13 months old)	OR	(5 males and 5 females 7-9 months old and 5 males and 5 females 11-13 months old)
20 trials with CS light on for 6 seconds, followed immediately by opening of Toy Box door, exposing toy		20 presentations of CS light and 20 presentations of Toy. Events occur independent of each other

Phase III: <u>EXPLORATION POSTTEST</u>

(All Infants)

Procedure identical to Exploration Pretest, but uses different set of toys

for each infant from the set of infant toys. The toy was placed on the table 15 cm in front on the infants. All infants were allowed to interact freely with the toy for a period of 2.5 minutes. If the toy fell from the table or was dropped, it was quickly retrieved and represented to the infant.

Following the familiarization period, the familiarized toy was removed and then reintroduced five more times, paired with a different randomly selected novel toy each time. Each such paired comparison was 30 seconds in duration. The left-right placement of the familiarized and novel toys before the infant was counterbalanced across trials.

Toy Box Trials (Treatment Conditions). Immediately following the Exploration Pretest, infants were introduced to the Toy Box apparatus. Those infants who clearly preferred to walk on their own were placed before the Toy Box and permitted to roam within a limited area 1 meter by 2 meters in front of the Toy Box. Exit from the area was blocked on two sides by the walls of the room, on a third side by the Toy Box apparatus itself, and on the fourth side by the infant's mother who was seated near the Toy Box. The younger infants were either placed in an infant walker or seated in their mothers' laps before the Toy Box, depending upon their locomotor ability and preference. For all infants, the Toy Box was raised or lowered to locate the plexiglass panel and door opening at a height that facilitated access to the toys. If the infants had any difficulty obtaining the toys, the mothers were encouraged to provide the needed assistance, but only once her infant had made an initial attempt to reach a toy. Mothers also were instructed not to call their infants' attention to the environmental events.

Infants' exposure to the Toy Box marked the only time throughout the experiment when they experienced differing conditions (see Figure 2). Half of the infants experienced a predictable relationship between stimulus events in which a red light illuminated the left plexiglass panel of the Toy Box apparatus for six seconds, followed consistently and immediately by the opening of the Toy Box door. The door remained open for 16 seconds, permitting infants access to a novel toy. At the end of the 16 second interval, the door was closed.

If a toy had not been removed by an infant, it was replaced by a new toy before the next trial. Thus, a different toy was available each time the Toy Box door opened to sustain infants' interest in this event. At the end of the 16 second toy access period, no attempt was made to remove any toys infants may have retrieved from the Toy Box. Pilot research found this to be extremely disruptive. In most cases, infants' interest in a specific toy waned before (or as) the next toy was presented.

Infants in the predictable environment were exposed to 20 discrete trials in which the opening of the Toy Box door was contingent upon prior onset and offset of the panel light. The door never opened except when immediately preceded by the lighting of the plexiglass panel, and it never failed to open immediately following offset of the panel light. Onset of the panel light was not predictable, as a variable time interval was introduced between each closing of the Toy Box door and the next lighting of the plexiglass panel. The mean length of this variable intertrial interval (ITI) was 26.5 seconds, with intervals ranging from 10-51 seconds. Using a formula devised by Catania and Reynolds (1968), onset of the panel light was scheduled to occur at a

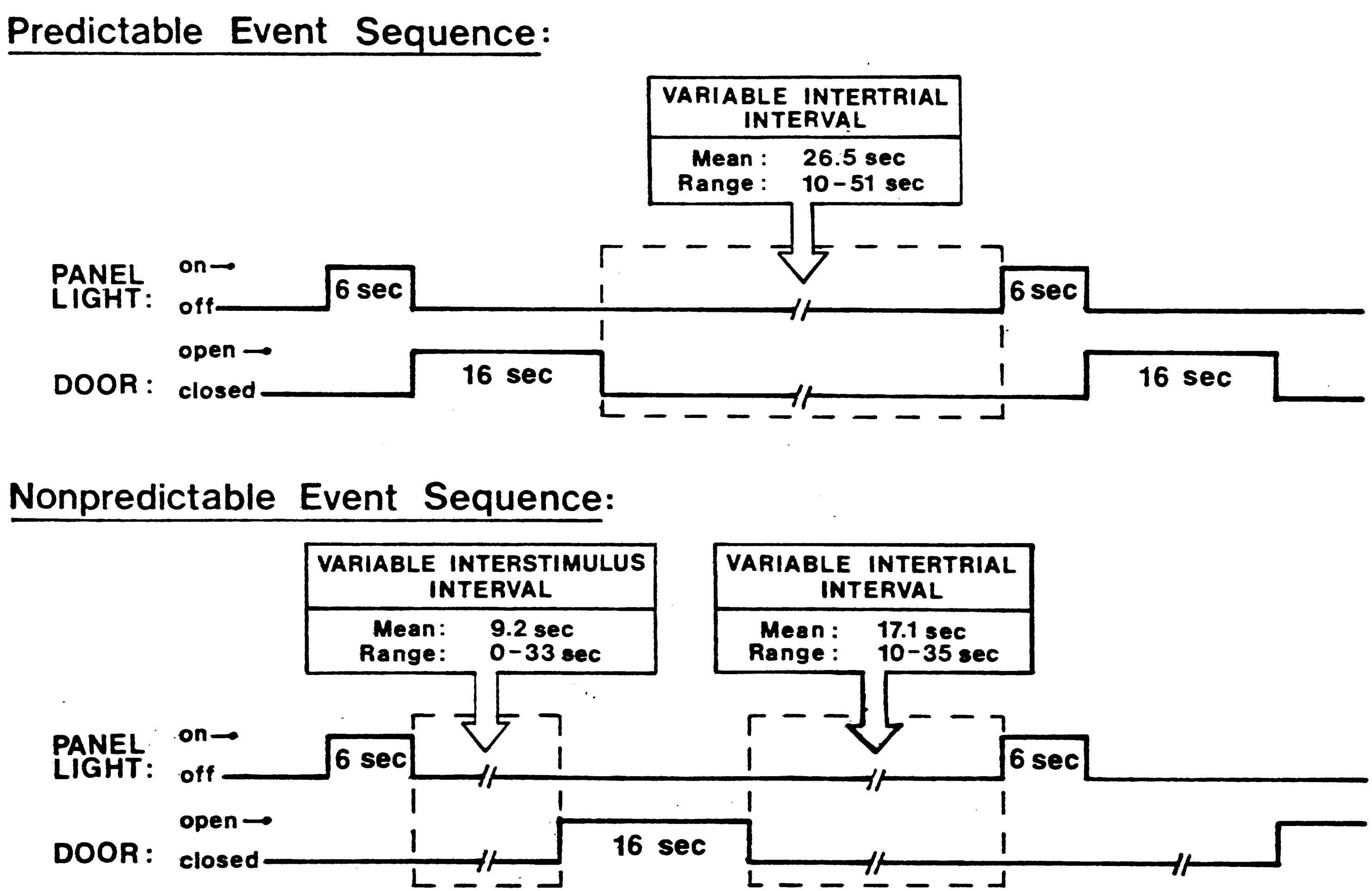

Figure 2. Sequence of events in predictable and nonpredictable experimental conditions

constant overall probability within ten seconds after closing the Toy Box door. Thus, once ten seconds had elapsed after the door closed, onset of the panel light was equally likely during each subsequent second of the variable intertrial interval.

Throughout infants' exposure to the predictable environment, the sequence of stimulus events and the contingent relationship between these events was not affected by of the infants' actions. They could do nothing to open the door (or cause it to open sooner); nor could they produce any stimulus change. However, for these infants the opening of the Toy Box door was predictable since it was signalled consistently by the lighting of the plexiglass panel.

The remaining infants experienced the nonpredictable relationship between stimulus events. As in the predictable environment, the plexiglass panel lighted 20 times throughout the session, for six seconds each time. The Toy Box door also opened 20 times to permit 16 seconds access to a novel toy. The nonpredictable environment differed exclusively in the temporal relationship between the onset/offset of the panel light and the opening of the door that permitted access to the toy. These events were completely independent of each other in the nonpredictable environment.

This independence was accomplished by introducing a variable interstimulus interval (ISI) between light offset and door opening that destroyed the contiguous and contingent pairing of the events that existed in the predictable environment. The ISI averaged 9.2 seconds and ranged from 0-33 seconds. Door closing was followed by a variable ITI that averaged 17.1 seconds, ranging from 10-35 seconds. The schedule of events in the nonpredictable environment retained the same average frequency of panel lighting and door opening as occurred in the predictable environment. However, the specific intervals between consecutive panel lightings and door openings were randomized. Each event therefore occurred on an independent schedule, with the exception that the Toy Box would never open while the panel light was on; nor would the panel light while the door was open.

As was also true of infants in the predictable environment, infants' actions in the nonpredictable environment could not influence the opening of the door or produce any stimulus change. For these infants, opening of the Toy Box door and access to the toy was nonpredictable since these events were unrelated to the random lighting of the plexiglass panel.

Infants' total exposure time to the experimental environments, whether predictable or nonpredictable, was 20 minutes.

Exploration Posttest. Upon completion of the Toy Box trials, the exploratory preferences of all infants were reassessed. The procedure was identical to that followed in the pretest. A new set of toys was introduced, however, which included none of those used previously.

Response Measures

During the Exploration Pretest and Posttest, the primary dependent variables of interest were the amounts of time infants devoted to looking at (visually attending with eyes directed toward the toy) and exploring (actively manipulating the toy, including movement of the hands, mouth, tongue, lips, etc. over the toy or any movement of the toy) the novel toys and the familiarized toy. Records were also made of time devoted to looking at or exploring the toy introduced during the familiarization phase to assess the relative attractiveness of that toy selected as the to-be-familiarized object. This was necessary in case a toy was so inherently attractive that it obscured the influence of the familiarization experience.

During infants' exposure to the experimental environments, a continuous event record was made of the duration and direction of infants' visual attention to the plexiglass panel (when lighted or dark), to the Toy Box door, and to the toys. Any manipulative/exploratory contacts of these same components were similarly recorded, as were fussing and crying episodes and attempts to escape.

One observer recorded all infant behaviors that could not be detected directly by the Toy Box apparatus and programming equipment. To check observer reliability, videotapes were made of five randomly selected infants and observations were made by an independent observer who recorded only one response category (e.g., looking at the panel) with each viewing of the videotape. Observer agreement on these infant observations ranged from 85-97 percent for response frequency measures, 81-90 percent for response latency measures (to within 1 second following occurrence of events such as door openings or light onsets), and 84-92 percent for response duration measures (to within 1 second).

Scoring of event records was performed by two independent raters. The data derived from these ratings reflect consensus between raters to within 1 occurrence for frequency measures and to within 0.5 seconds for duration measures. Once agreement within these tolerance limits was achieved, the mean of the raters' scores was recorded.

Analysis of Data

Infants' sensitivity to events occurring predictably or nonpredictably independent of their own actions was assessed primarily by their responses to the lighting of the plexiglass panel beneath the Toy Box door. Further information was derived from measures of anticipation of door openings, defined in terms of looks directed to the Toy Box door while the panel was lighted, and responsiveness to the toys presented.

Responses recorded during the Toy Box trials were analyzed in blocks of 5 trials each by Analysis of Variance. For purposes of data analysis, the time between the onset of the panel light and its reoccurrence constituted one trial. Included in the Analysis of Variance of these responses were environmental predictability (predictable or nonpredictable), age (7-9 months or 11-13 months), and sex as between subjects variables, with trials (4 levels) as a within subjects variable.

With regard to the question of the generalization of the effects of response-independent experience in predictable or nonpredictable environments, changes in exploratory preference from pretest to posttest were analyzed for measures of the time infants devoted to looking at and exploring the novel and familiarized toys. Variables in the Analysis of Variance of these response measures included environmental predictability, age, and sex as between subjects variables, and toy familiarity (novel or familiarized), and exploration test (Pretest or Posttest) as within subjects variables.

RESULTS

Highly reliable differences were observed in the patterns of infants' attentiveness and responsiveness to predictable or nonpredictable events as manipulated in the present experiment. Significant differences similarly were found in infants' relative preferences for novel or familiarized toys following exposure to the experimental environments.

For clarity of presentation, results obtained during distinct research phases are described separately. The results of the experimental phase (Toy Box trials) are presented first, organized according to response mode and the object or event that is the focus of these infant responses. Of the results presented, some are meaningful principally as control measures to indicate whether groups of infants had equal opportunities to experience the environmental events and discover the event relationships. Results of the exploration tests are then presented together, as the key data of interest were any changes from baseline (pretest) levels of novelty preference that could be observed on the exploration posttest subsequent to experience with predictable or nonpredictable environmental relationships.

Infant Responses to Predictable or Nonpredictable Events

Looking at the lighted panel. All infants looked at the plexiglass panel when lighted on an equivalent percentage of trials, independent of the predictive or nonpredictive nature of that event (see summary of Analysis of Variance, Appendix E, Table 3). However, infants 7-8 months old tended to look at the lighted panel significantly more consistently overall that did the 11-13 month old infants, attending to the light on an average of 89 percent of trials, compared to an average of 72 percent of trials for the older infants. In addition, over trial blocks the percentage of trials on which infants looked at the light decreased significantly in both age groups.

Analysis of the mean amount of time infants looked at the lighted panel revealed significant main effects due to sex, age, predictability condition, and trials, and significant interactions of both predictability with trials and age with trials (see summary of Analysis of Variance, Appendix E, Table 4). Male infants generally looked longer at the lighted panel, averaging 2.85 seconds (out of a possible 6 seconds) to the female infants' 2.28 seconds. The younger infants averaged 2.98 seconds looking at the lighted panel, whereas the older infants averaged 2.14 seconds, significantly less than the younger infants. Infants experiencing the predictable relationship between the lighted panel and door opening/toy presentation looked significantly longer at the lighted panel, 2.86 seconds, than did infants experiencing the nonpredictable relationship, 2.26 seconds. Across trials, overall looking time decreased significantly.

As indicated in Figure 3, this decrease in looking time over trials differed in the predictable and nonpredictable environments. Within groups, infants in the predictable environment showed no significant change in looking time across trials, whereas infants in the nonpredictable environment showed a progressive decrease in looking time

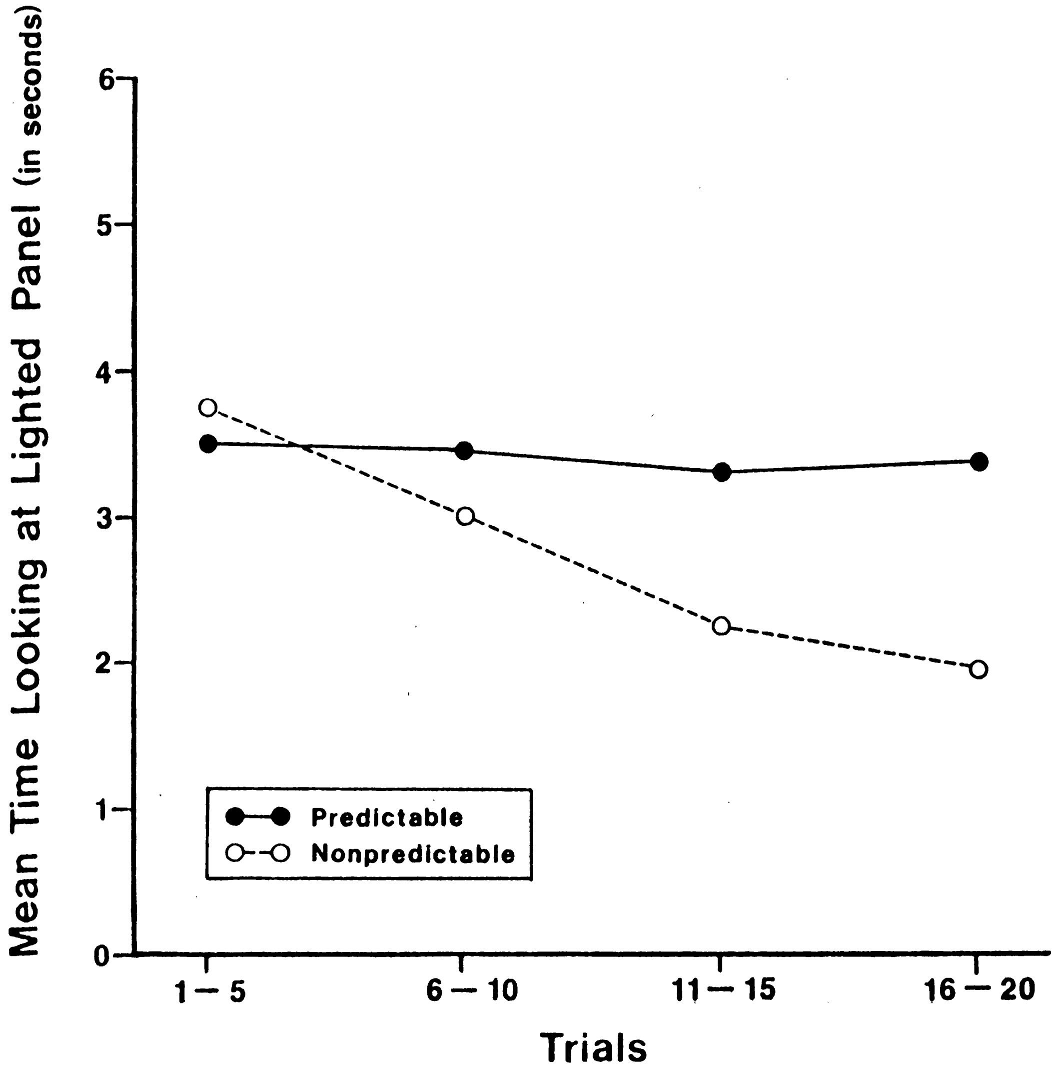

Figure 3. Mean time infants within experimental environments looked at lighted panel over trials

over trials.

The significant age x trials interaction (see Figure 4) indicates further that the decrease in looking time differs with the age of the infant independent of the predictability condition. The younger infants showed a decline in visual attention much later in their exposure to the experimental conditions, yet by the final block of five trials, their attention to the light panel matched that of the older infants.

Contacting the lighted panel. Nearly all infants pounded on the plexiglass panel the first time it was lighted, even before they had any exposure to the fact that the Toy Box door would open to permit access to a novel toy. This was observed with 95 percent of the 7-9 month old infants and 85 percent of the 11-13 month olds infants.

With subsequent lightings of the plexiglass panel, significant differences were observed in the percentage of trials with at least one measurable panel press. Age and trials were significant main effects. In addition, significant age x trials, sex x trials, predictability x trials, and predictability x sex x trials interactions were found. (See summary of Analysis of Variance, Appendix E, Table 5.)

Overall, the younger infants contacted the lighted panel on a significantly greater percentage of trials than did the older infants: 67.8 percent of trials for 7-9 month old infants versus 45.0 percent of trials for 11-13 month old infants. Across trials, there was an overall reduction in the percentage of panel lightings to which infants responded. On trials 1-5, infants contacted the lighted panel 69.6 percent of the time, then decreased to a low of 40.6 percent of the trials by trials 16-20.

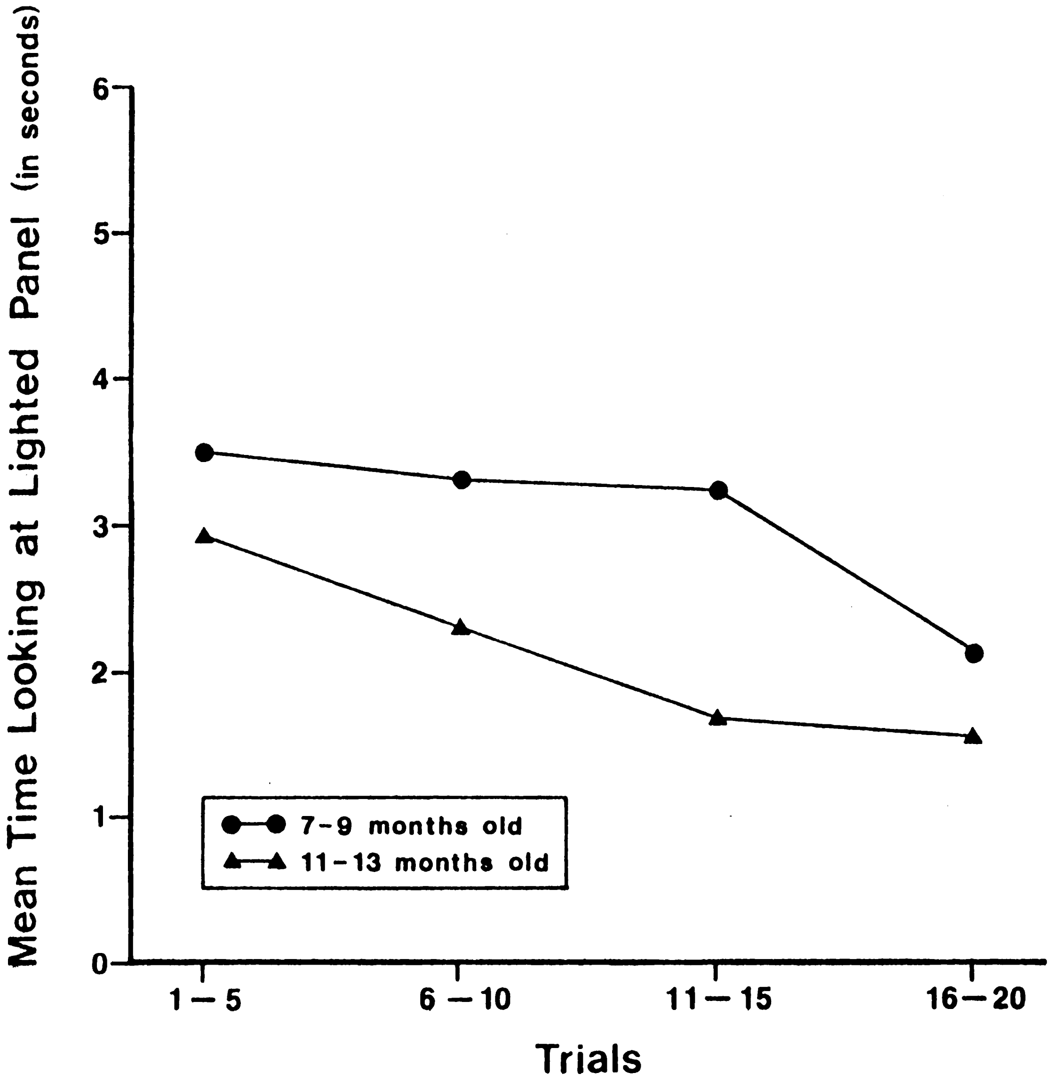

Figure 4. Mean time infants within age groups looked at lighted panel over trials

The significant age x trials interaction is represented in Figure 5. Infants 11-13 months of age contacted the lighted panel less frequently during the first block of trials than did 7-9 month old infants. The older infants responded on a decreasing percentage of trials across each subsequent trial block. The younger infants, however, showed no significant decrease in the tendency to respond to the lighted panel until the final block of five trials. This reflects closely the response patterns observed for infants' visual attention to the lighted panel that were reported previously (refer back to Figure 4).

Figure 6 depicts the significant sex x trials interaction. Male infants appear more likely to contact the lighted panel, at least early in their exposure to the Toy Box apparatus. With increasing exposure to the experimental paradigm, both sexes show a decrease in response tendency. However, this decrease seems to occur more rapidly among the male infants until, by the final block of trials, no significant difference remains between the response tendencies of the male and female infants.

Of greater importance to the present research are the significant predictability x trials and predictability x sex x trials interactions. As Figure 7 demonstrates, infants in the predictable and nonpredictable environments initially responded to the lighted panel on an equivalent percentage of trials. However, infants in the predictable environment maintained this level of responding across all trial blocks. Infants in the nonpredictable environment exhibited a marked decline in their tendency to press the lighted panel at each successive block of trials. This pattern of sustained levels of responsiveness to panel lightings

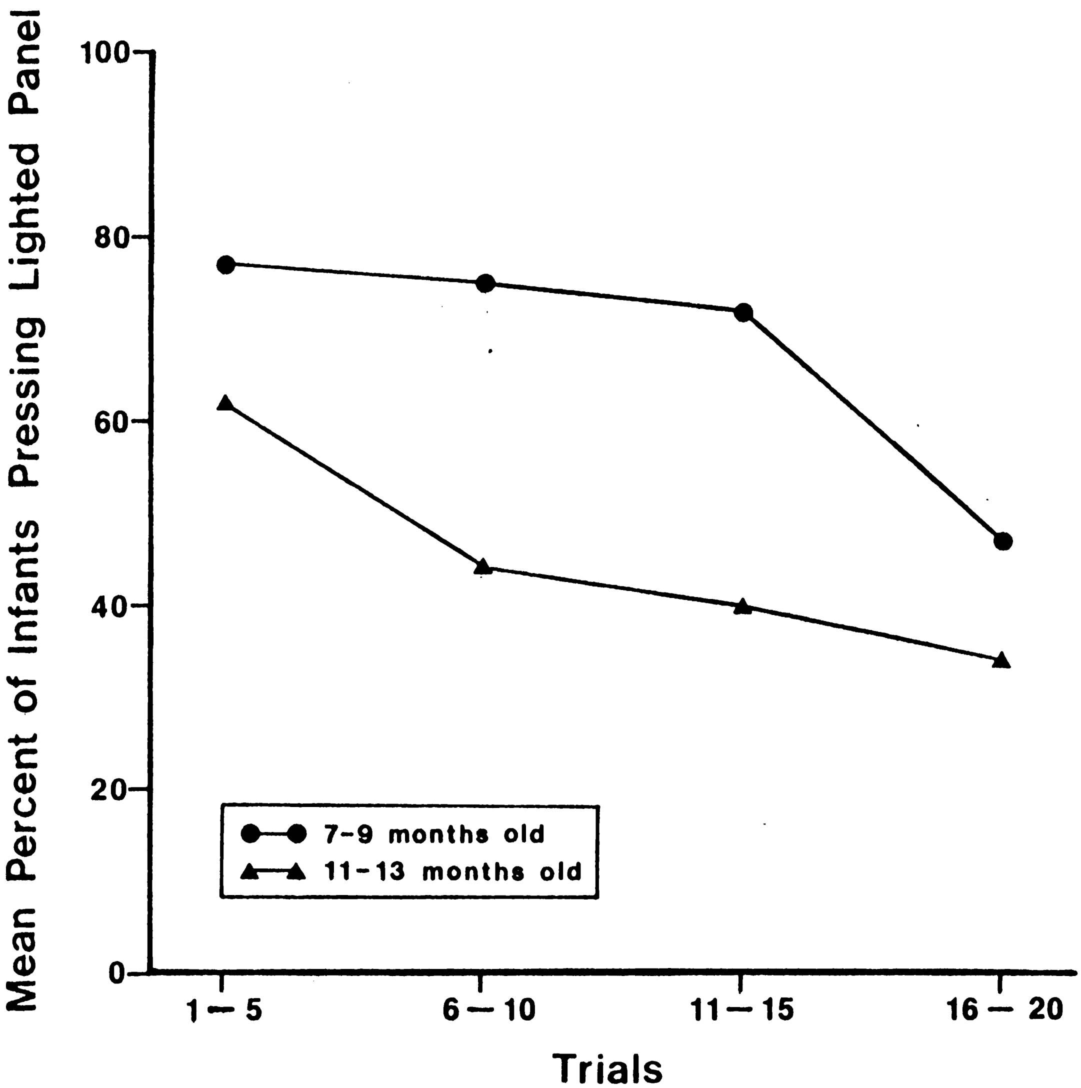

Figure 5. Mean percent of infants within age groups pressing lighted panel over trials

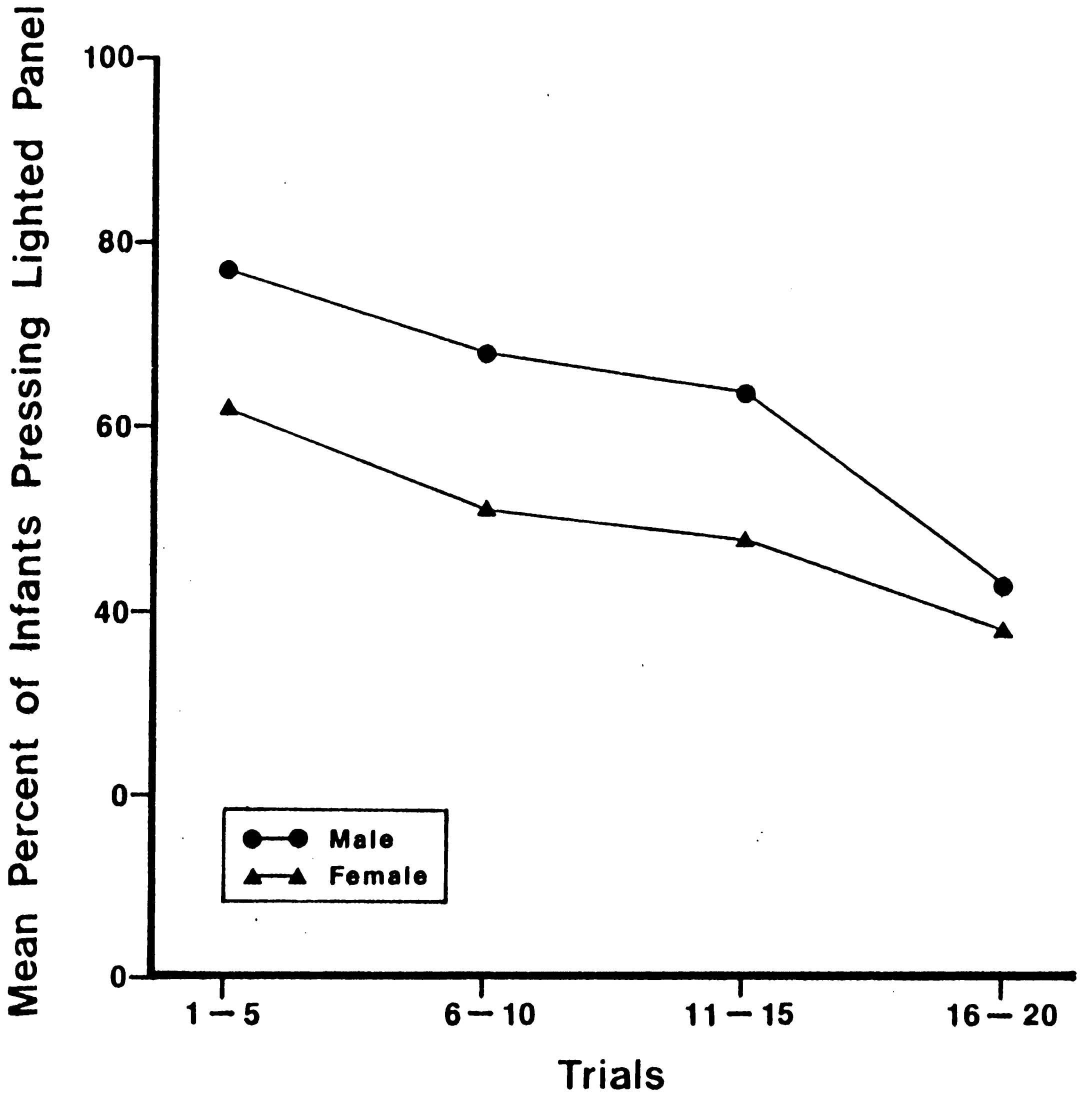

Figure 6. Mean percent of male and female infants pressing light panel over trials

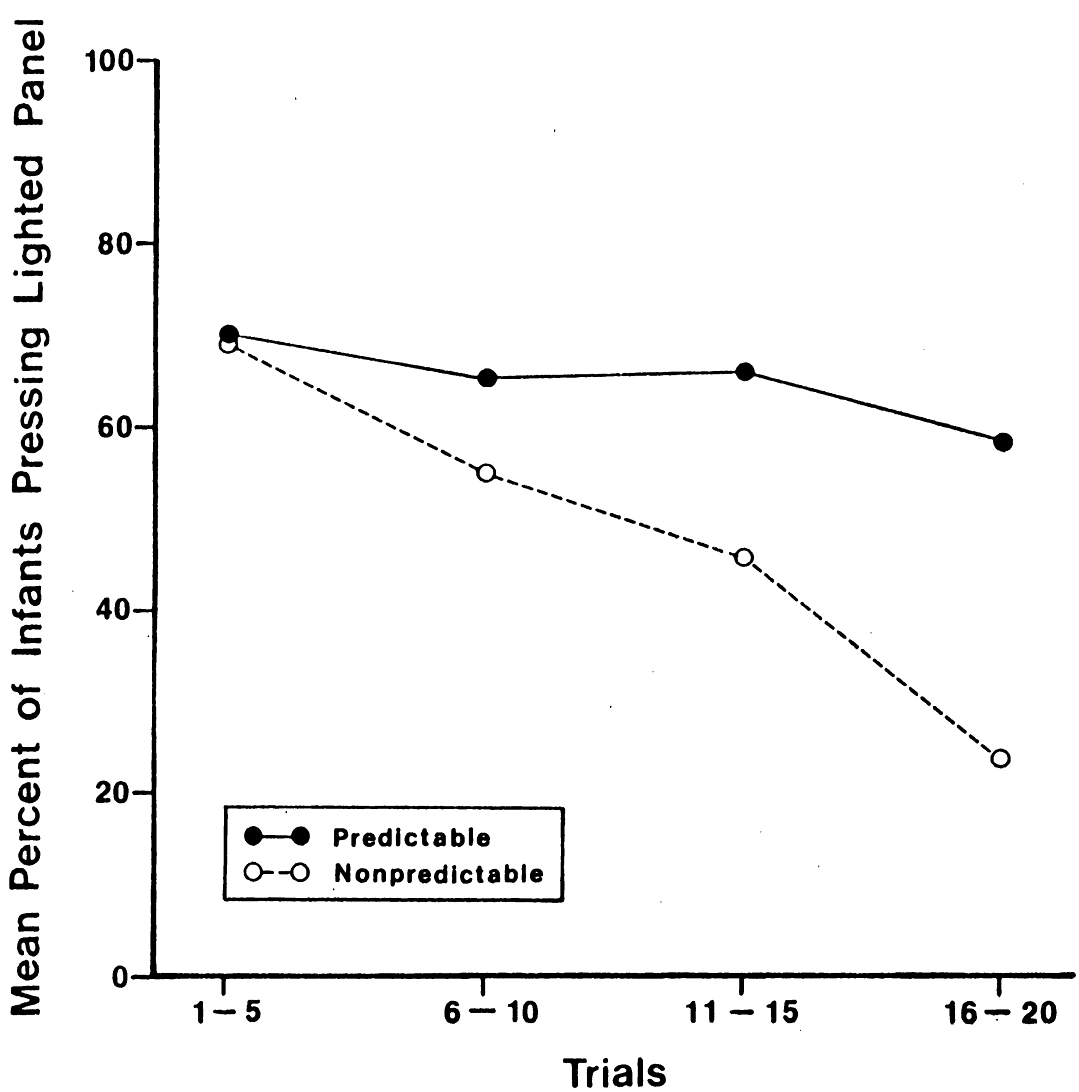

Figure 7. Mean percent of infants within experimental environments pressing lighted panel over trials

in the predictable environment, with steadily diminishing response tendencies in the nonpredictable environment, mirrors the relationship observed for visual attention to the lighted panel as presented previously in Figure 3. When the added factor of the infants' sex is introduced to this relationship, as represented in Figure 8, it appears that female infants reduced their tendency to respond to the lighted panel in the nonpredictable environment earlier in their exposure to this stimulus relationship than did the male infants.

Analysis of the mean number of panel presses directed to the lighted panel per trial revealed significant main effects due to age and trials, and a significant age x trials interaction. These effects are consistent with results obtained for the related measure of the percentage of trials with a panel press, reported previously (see summary of Analysis of Variance, Appendix E, Table 6). An additional main effect of environmental predictability, although significant, showed slight differences in the mean number of responses to the lighted panel. Infants in the predictable environment produced a mean of 1.4 panel presses per trial, while a mean of 1.0 panel presses per trial was found for infants in the nonpredictable environment. Within blocks of trials, the mean number of panel presses per trial held constant in the predictable environment but decreased in the nonpredictable environment. Figure 9 illustrates this significant predictability x trials interaction.

Anticipatory responses. While the plexiglass panel was lighted, responses directed toward the Toy Box door--whether looking or approach and contact responses (e.g., attempts to open the door)--were very rare and never exceeded an overall mean of 3 percent of trials.

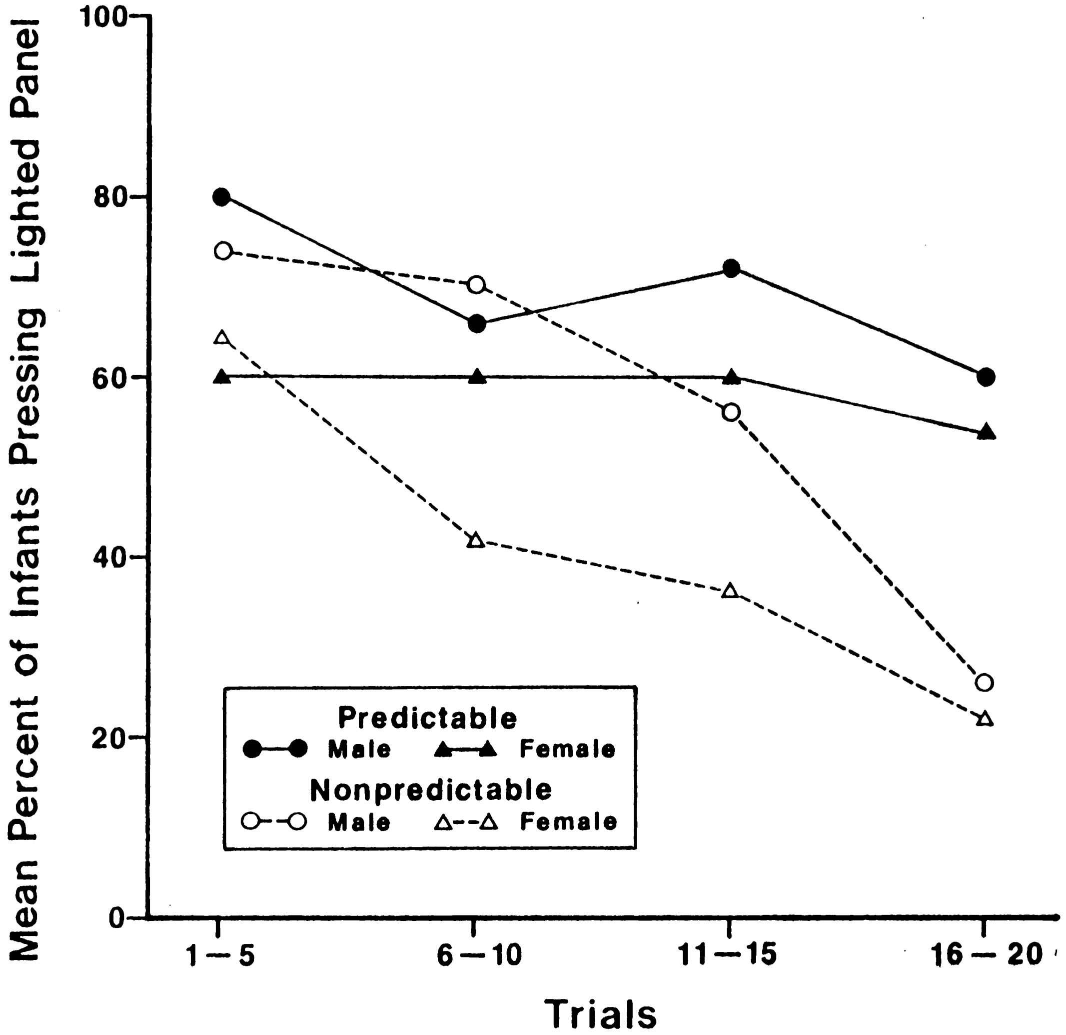

Figure 8. Mean percent of male and female infants within experimental environments pressing lighted panel over trials

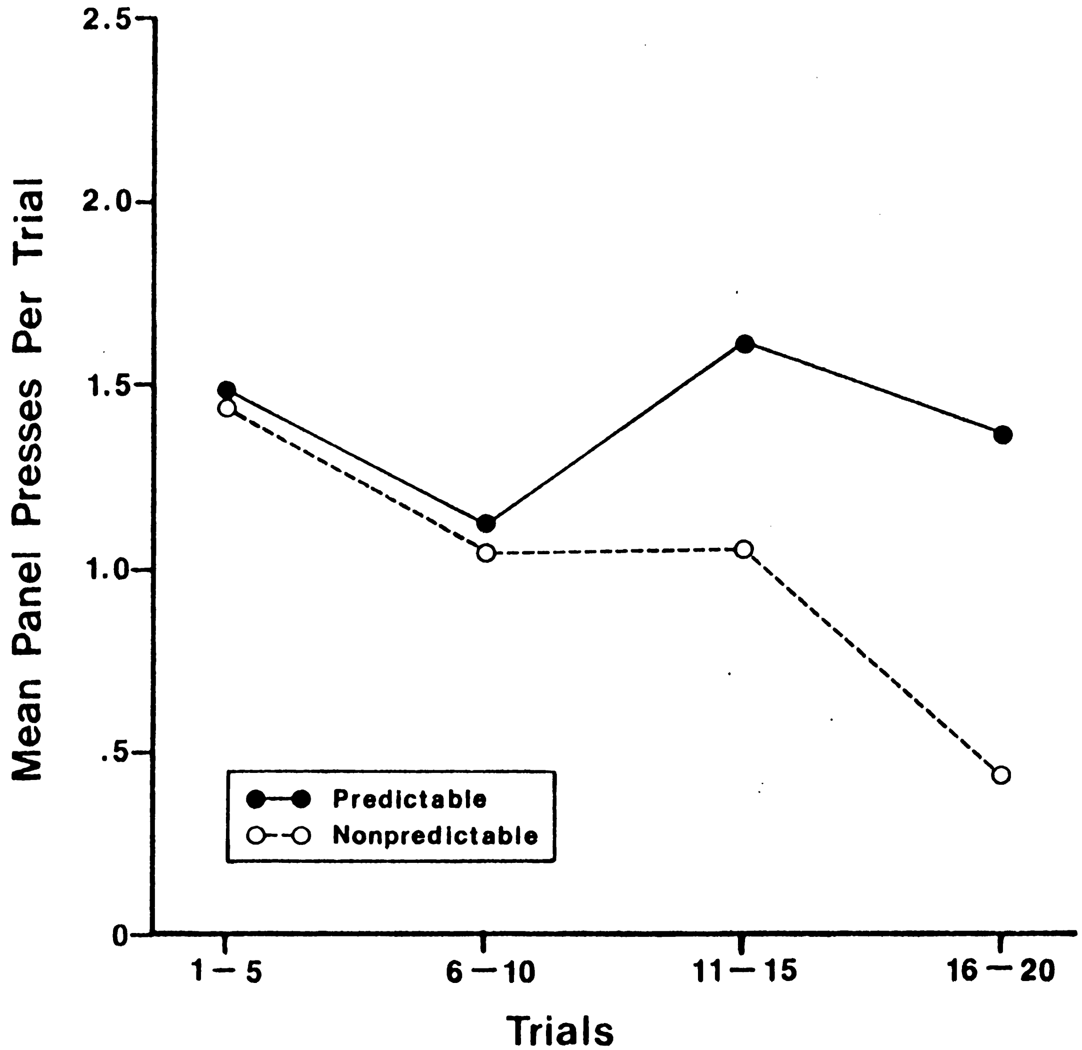

Figure 9. Mean panel presses per trial by infants in experimental environments over trials

No significant differences in the frequency of these anticipatory responses were found for any group. In addition, the frequency of these responses when the panel was lighted did not differ from the frequency of such responses during the intertrial interval when the panel was dark.

Looking at the toys. All infants looked at the novel toy exposed with each opening of the Toy Box door on an equally high percentage of trials, averaging 97 percent overall. No significant differences were observed for age, sex, predictability condition, or trials.

However, analysis of the mean latency to look at the toy following door opening revealed significant main effects due to the age of the infants and the environmental predictability condition they experienced. (See summary of Analysis of Variance, Appendix E, Table 7.) The younger infants looked at the toy significantly sooner than did the older infants, with the former averaging a 2.81 second latency and the latter averaging a 3.97 second latency. Infants in the predictable environment looked at the toy within an average of 2.94 seconds following opening of the Toy Box door, while infants in the nonpredictable environment looked significantly later, averaging a 3.85 second latency.

Contacting the toys. When consideration was given to the percentage of trials during which infants reached for the toy and removed it from the Toy Box, a significant effect due to predictability and a significant sex x trials interaction were found (see summary of Analysis of Variance, Appendix E, Table 8). Infants in the predictable environment contacted the toy on 88 percent of the trials, while infants in the nonpredictable environment contacted the toy on 79 percent of the trials overall.

The sex x trials interaction, presented in Figure 10, shows a significant difference in the probability of toy contact during trials 1-5. Male infants contacted the toy an average of 95 percent of trials 1-5. Female infants reached for the toy significantly less frequently, averaging 79 percent during trials 1-5. All other apparent sex differences across trials were nonsignificant.

Emotional responses. Fussing and crying were relative low incidence behaviors except among 11-13 month old female infants during their exposure to the nonpredictable environment, as revealed by a significant predictability x age x sex interaction. These older female infants fussed or cried a mean of 6.6 times. Some fussing or crying was observed in all other groups of infants (mean frequency = 1.2 episodes), but no significant differences were identified among these groups. The only group approaching the fussing or crying frequency of the older female infants was comprised of 7-9 month old female infants who fussed or cried a mean of 2.56 times during their exposure to the nonpredictable environment.

Attempts to escape the constraints of the experimental environment were observed only among 11-13 month old infants when the sequence of events was nonpredictable. In the nonpredictable environment, the older male infants attempted escape a mean of 5.6 times, while the older female infants attempted escape a mean of 1.4 times. A two-tailed test of the difference between these group means revealed a nonsignificant trend toward more escape attempts among the males, $\underline{t}\,(8)=2.045$; $p < .10$. However, only two of the older female infants ever attempted a single escape, whereas four of the five older male infants in the nonpredictable environment attempted five or more escapes.

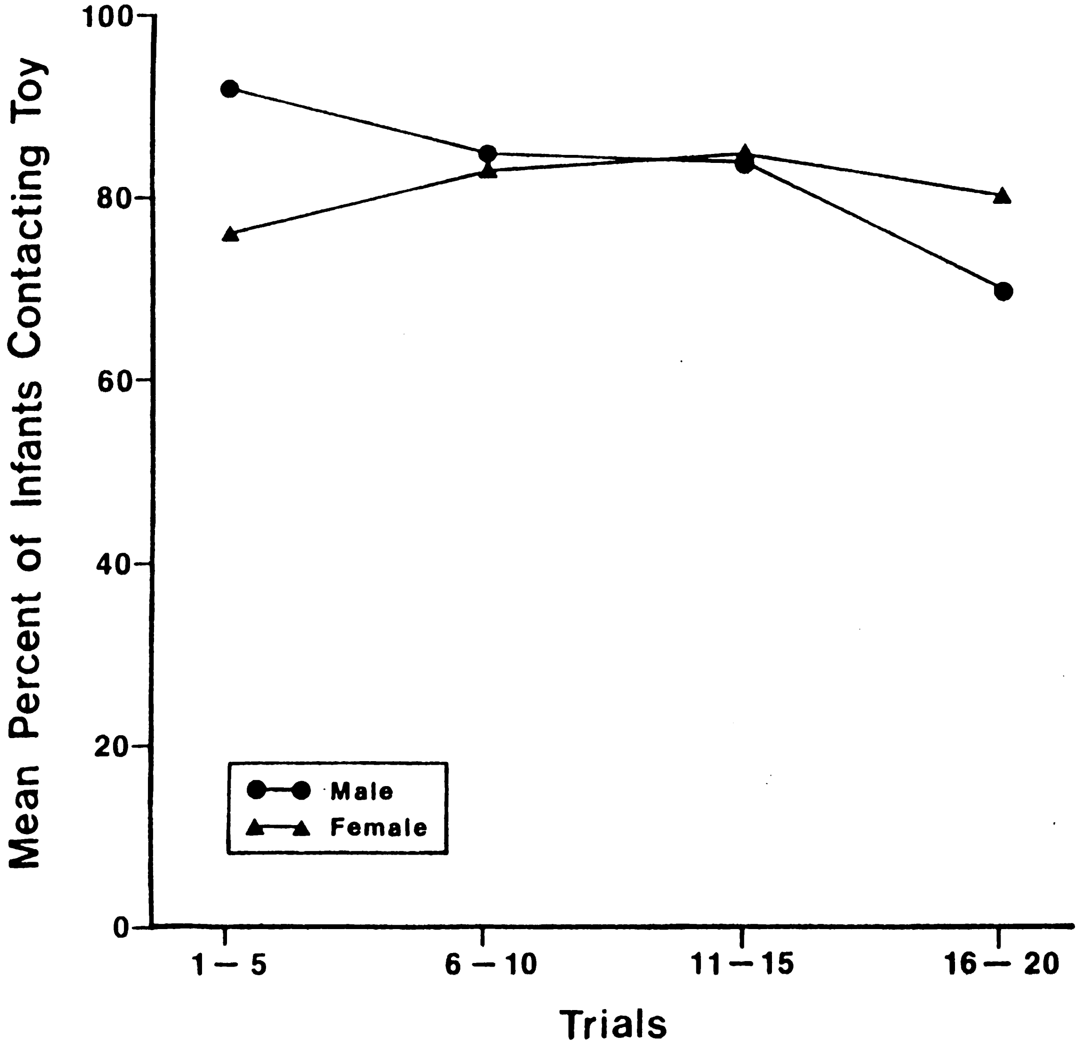

Figure 10. Mean percent of male and female infants contacting toy over trials

Infant Exploratory Preferences

During the familiarization period of both the Exploration Pretest and Exploration Posttest, no significant group differences were noted in mean time engaged in looking at or actively manipulating the toy presented for familiarization. Nor were significant differences identified in the relative attractiveness of toys selected for familiarization.

Looking preferences. When the novel and familiarized toys were presented in paired comparison during the Exploration Pretest, 37 of the 40 infants preferred the novel toy. This preference was indicated by a greater mean looking time directed toward the novel toy across the five paired comparisons. The other three infants showed a slight overall preference for the familiarized toy. Two of the infants later experienced the predictable environment.

This preference for novelty, when expressed as the mean time spent looking at the novel toy versus the familiarized toy, was highly significant. On each 30 second paired comparison trial, infants devoted a mean of 17.8 seconds to the novel toy and 5.3 seconds to the familiarized toy. No significant differences in visual attention were observed between groups on the Exploration Pretest.

Relative looking preferences changed significantly following experience with predictable or nonpredictable events. When mean looking times devoted to the novel versus familiarized toys during the Exploration Pretest were compared with those times recorded during the Exploration Posttest, the following significant interactions were noted: Exploration test x toy familiarity; predictability x Exploration test x toy familiarity; and sex x toy familiarity (see summary of Analysis of Variance, Appendix E, Table 9).

Disregarding, for the moment, the effects of environmental predictability as experienced during the Toy Box trials, there was a significant tendency for attention to the familiarized toy to increase on the posttest a mean of 1.7 seconds from pretest levels, with a corresponding decrease of a mean of 2.0 seconds in attention to the novel toy from pretest to posttest. This effect must be interpreted cautiously in view of the significant three-way interaction among predictability, exploration test, and toy familiarity, since experimental groups did not contribute equally to the effect. In fact, as Figure 11 indicates, infants experiencing the predictable environment showed no significant change in looking time from the exploration pretest to the exploration posttest. Infants who experienced the nonpredictable environment increased, by a mean of 2.4 seconds, the visual attention they directed to the familiarized toy on the Exploration Posttest. These same infants decreased attention to the novel toy a mean of 4.5 seconds.

The significant sex x toy familiarity interaction reflects a general tendency for the female infants to look less at the familiarized toy (5.8 seconds) and more at the novel object (18.1 seconds) than did the male infants. The male infants looked at the familiarized toy a mean of 7.8 seconds and the novel toy a mean of 16.3 seconds.

Despite the significant shifts in the direction of attention described above, overall visual attention to the test toys (the combined looking times for the novel and familiarized toys) was not significantly different for any group on either the Exploration pretest or posttest and was not significantly influenced by the environmental

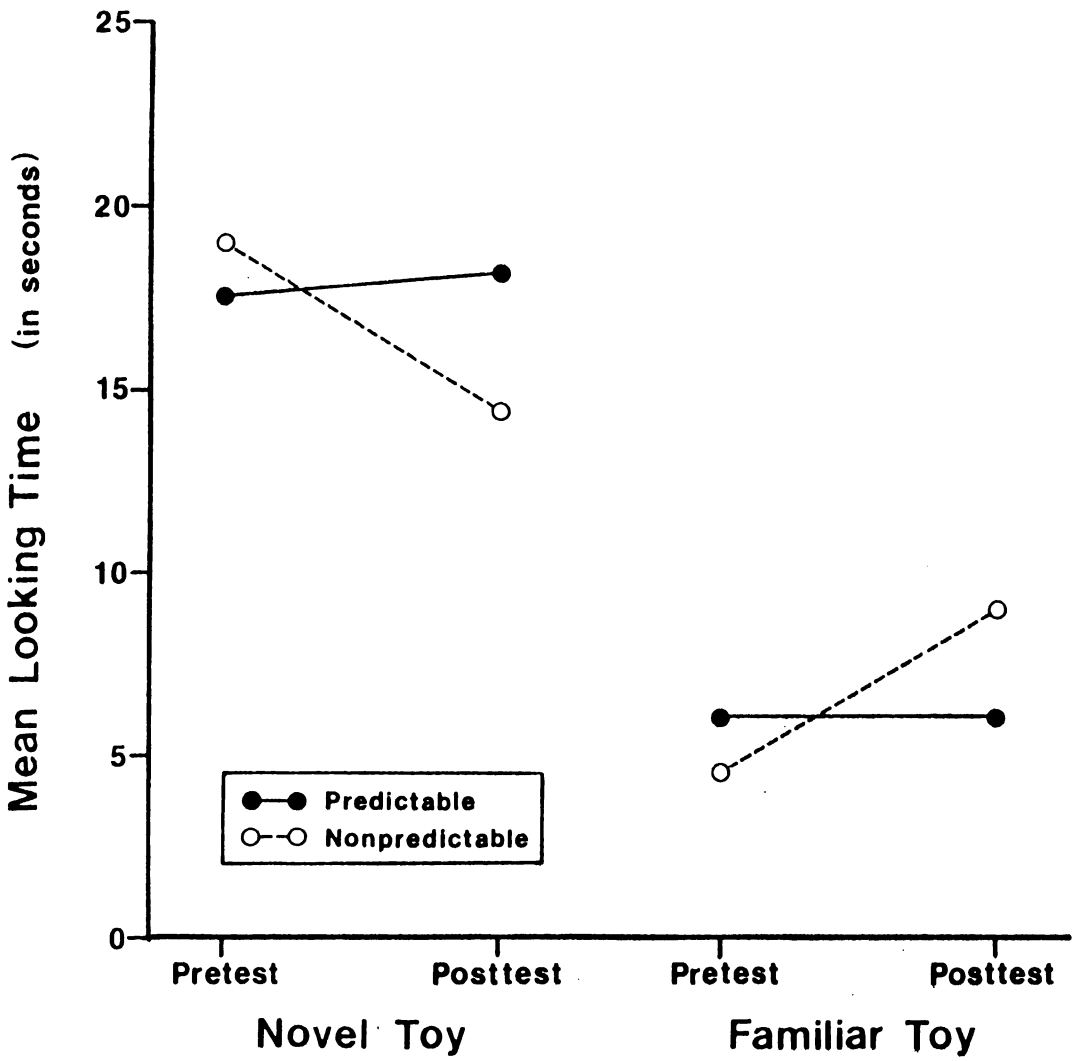

Figure 11. Mean time infants experiencing experimental environments looked at toys during exploration tests

conditions experienced during the Toy Box trials.

<u>Manipulative exploration preferences</u>. During the Exploration Pretest, 36 of the 40 infants actively explored the novel object longer than the familiarized object, based on the mean of the five paired comparisons. Of the four infants who explored the familiarized toy longer overall, three later experienced the predictable condition.

Changes in the focus of exploration were produced by exposure to the predictable or nonpredictable environments. The most meaningful changes in infant performances from the Exploration pretest to the posttest are revealed by the significant five-way interaction of sex, age, predictability, exploration test, and toy familiarity. Other significant interaction effects (see summary of Analysis of Variance, Appendix E, Table 10) can be described more effectively through analysis of this higher-order interaction.

As illustrated in Figure 12, 11-13 month old infants who experienced the predictable Toy Box environment exhibited no significant changes from pretest levels in the mean amount of time spent exploring the familiarized toy, but showed an increased mean time exploring the novel toys. On the other hand, 11-13 month old infants, subsequent to experiencing the nonpredictable Toy Box environment, increased the amount of time devoted to active exploration of the familiarized toy and decreased, by a nearly equivalent amount of time, active exploration directed toward the novel toys.

A more complicated pattern of effects was observed among infants 7-9 months of age. For example, no significant changes in relative exploratory preferences occurred in these younger infants, whether male or female, following exposure to the predictable environment.

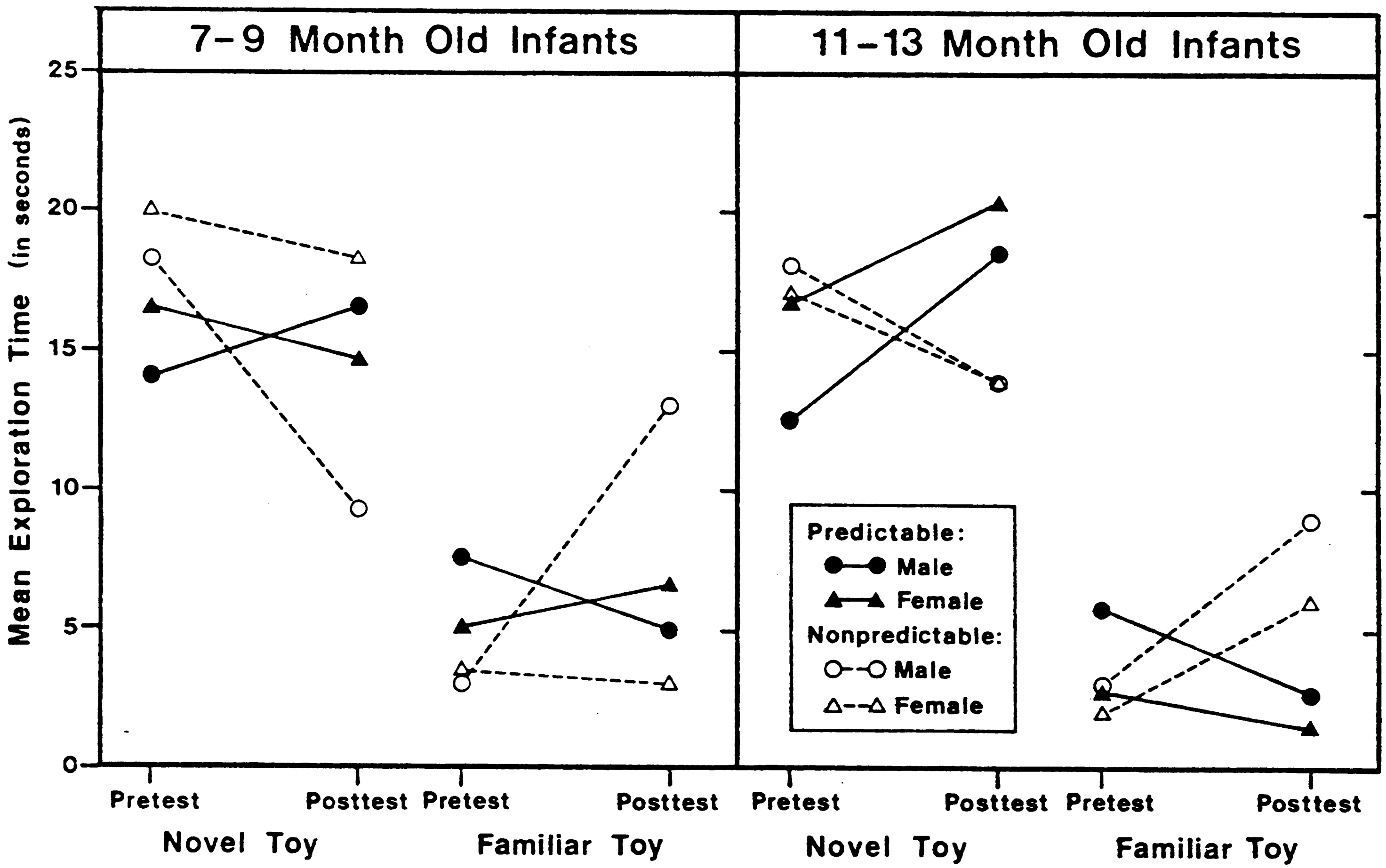

Figure 12. Mean time infants by sex, age, and experimental environment explored toys during exploration tests

However, after experiencing the nonpredictable environment, 7-9 month old male infants increased their preference for the familiarized toy so dramatically that they actually reversed their pretest preferences, exploring the familiarized toy longer than the novel toys. In contrast, 7-9 month old female infants who similarly experienced the nonpredictable environment showed no significant differences in the time they devoted to exploration of either toy on the pretest and posttest.

One trend that more generally represents the effects of environmental predictability as manipulated in this experiment is reflected by the significant predictability x exploration test x toy familarity interaction. As depicted in Figure 13, experience with the predictable environment evoked little substantive change in exploratory preference. However, exploration of the familiarized toy significantly increased while exploration of the novel toys significantly decreased as a result of experience with the nonpredictable environment.

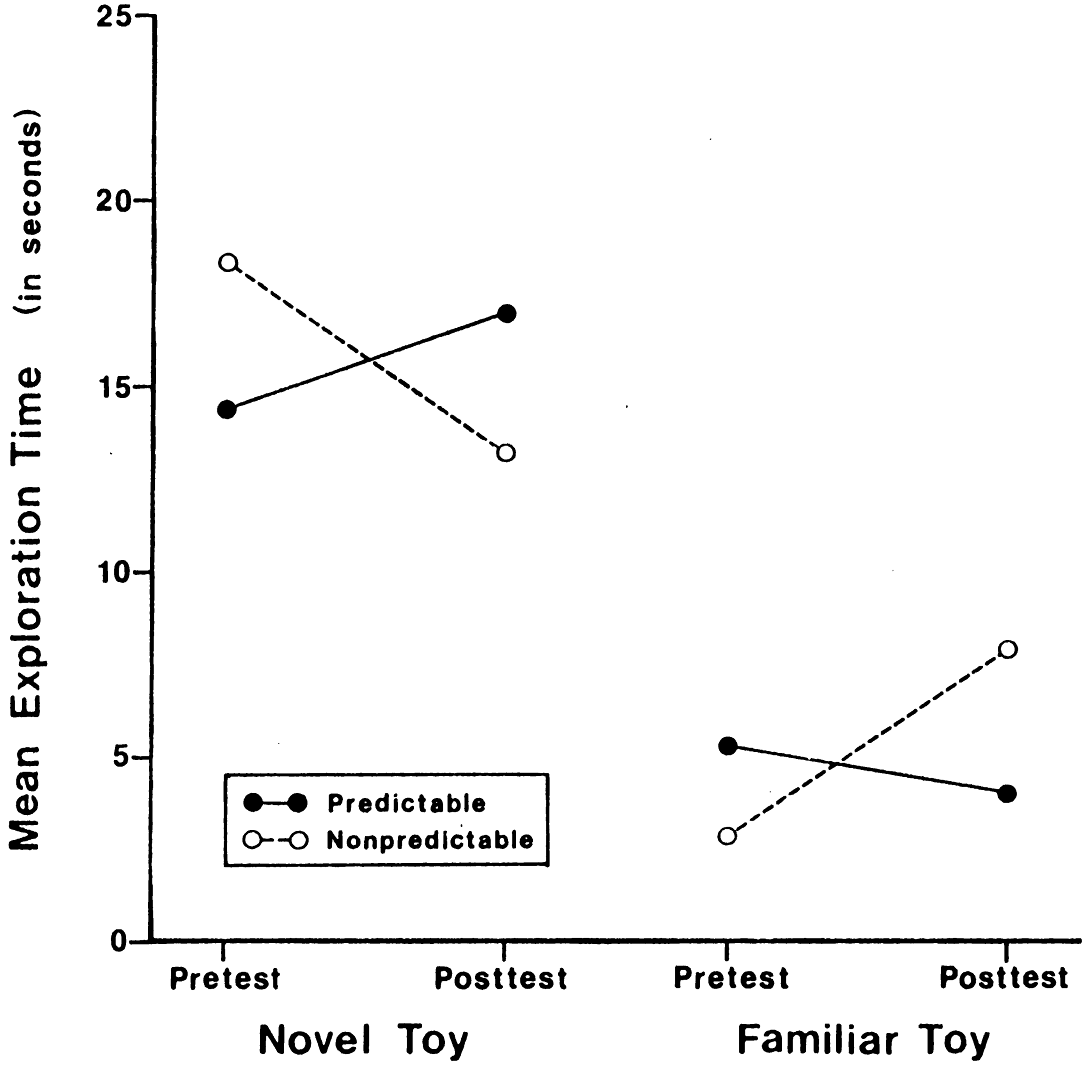

Figure 13. Mean time infants experiencing experimental environments explored toys during exploration tests

DISCUSSION

With a high degree of consistency, the response measures recorded in this investigation reveal a significant role that experience with predictable or nonpredictable events plays in initiating, directing, and maintaining infants' exploration of toys. The impact of this experience was shown sufficient to affect infants' relative preferences for novel versus familiarized toys in an exploration test that followed exposure to 20 trials in which toy presentation was either stimulus-dependent (predictable) or stimulus-independent (nonpredictable). In the course of infants' exposure to these experimental environments, information also was obtained that contributes measurably to an understanding of infants' cognitive processing of environmental events and their relationships.

Infants' Sensitivity to Environmental Relationships

Signal-value of panel light. The differing patterns observed in visual attention to the lighting of the plexiglass panel suggest an awareness and sensitivity on the part of infants to the predictable or nonpredictable relationship between stimulus events during the Toy Box trials. Despite the fact that infants in both experimental groups looked at the lighted panel on an equivalent percentage of trials, group differences sustained in attention to this event reflect infants' reactions to the information or signal-value inherent in the lighting of the panel.

Because the conditions established within the predictable environment replicate those described by Rescorla and Wagner (1972) as necessary to invest signal or information value in an event, the lighting of the plexiglass panel can be identified objectively as an informative stimulus. The conclusion that this stimulus event was subjectively informative to infants in the predictable environment, but not to infants in the nonpredictable environment, derives from research on the process of habituation.

As represented in Sokolov's (1963) theory, and Cohen (Cohen, Gelker, & Lazar, 1971; Cohen, 1972), and Jeffrey's (1968) research on infant visual attention, habituation, or a decrement in response intensity or duration with repeated exposure, occurs when a stimulus event provides no new or meaningful information to an individual. When meaningful, as in the sense of predicting significant environmental events, responding should persist.

The patterns of decreased visual attention (habituation) over time noted among infants experiencing the nonpredictable relationship between events and sustained attention to the lighted panel among infants experiencing the predictable relationship, indicate that infants are sensitive to the experimental conditions and appear to respond to the information value of the stimulus event (lighting of the plexiglass panel) as objectively defined.

Directing influence of panel light. The other event of significance to infants during their experience of the experimental environments was the opening of the Toy Box door that permitted access to a novel toy. Nearly all infants looked at the toy on every trial regardless of their age, sex or experimental condition. However, infants in the predictable environment looked significantly sooner at the toy upon opening of the door. This decreased response latency may reflect an advantage due to the directing influence of the predictive stimulus, as proximity to the Toy Box door was promoted by sustained attention to the lighted plexiglass panel. Infants for whom the lighted panel was not predictive tended to wander about the experimental area or to focus their attention on previously obtained toys. For them, presentation of a new toy was signalled only by the noise of the door as it opened. The time required for these infants to redirect their attention to the toy shows up as a significantly greater response latency.

Interest in events. Although all infants looked at the toy with equal frequency, infants in the predictable environment were more likely to reach for the toy in the Toy Box and retrieve it. In conjunction with other impressions derived from infants' reactions to the experimental conditions, this appears to represent both a greater sustained interest in exploring the novel toys and overall enjoyment of their experience. Whereas infants in the predictable environment shifted the focus of their exploratory manipulation to each new toy as presented, infants in the nonpredictable environment seemed to concentrate their activities on a small subset of toys. Although they looked at each new toy as it was presented, they often would return their attention to toys they had previously retrieved from the Toy Box.

Older infants' expression of apparent displeasure or boredom with the events occurring in the nonpredictable environment, as evidenced by a significant number of crying episodes among 11-13 month old girls and increased attempts to escape the confines of the experimental area among 11-13 month old boys, also support an inference that the experience of predictable events is more enjoyable to infants.

Infants' Responsiveness to Environmental Relationships

Pressing the lighted panel. Throughout their experience of the predictable or nonpredictable sequence of events, infants were unable to respond in any way that would influence this sequence. Nevertheless, all infants attempted to interpolate a response into this sequence by pounding on the lighted plexiglass panel. Most striking in this regard is the very high percentage of infants who pressed the panel the first time the light came on, before they ever observed that the Toy Box door would open to reveal a novel toy. This initial contact was typically swift and direct, producing a resounding noise.

Since it is highly unlikely that specific prior experience can account for the consistency of this particular response, it seems plausible to assert that the infants generalized a previously established response orientation to this new environmental event. Although not directly verifiable from the present data, this response orientation may be the expression of a generalized expectancy, derived and reinforced by infants' prior experience, that objects typically respond to physical contact and manipulation. Through such physical exploitation of objects, as the theories of competence (White, 1959) or effectance motivation (Harter, 1978) would predict, these infants may anticipate successful discovery of new competencies. Or, from a Piagetian perspective (Piaget, 1952), the infants may be applying a generalized scheme in order to determine the characteristics of the Toy Box, a complex new object in their lives.

However appropriate these interpretations may be, increased exposure to the experimental conditions significantly influenced infants' persistence in contacting the lighted panel. Infants in the predictable environment continued to contact the lighted panel on a relatively constant percentage of trials, while infants in the nonpredictable environment were decreasingly likely to respond with successive lightings of the plexiglass panel. This differential pattern of responsiveness duplicates that found for visual attention to the panel when lighted.

The infants in this investigation used the panel press response in a manner reminiscent of Watson's (1966, 1967, 1972) process of contingency analysis. Their repeated presses of the panel when lighted seemed to constitute a test to determine what response contingencies were in effect. In the face of clearly response-independent, stimulus-independent events, infants in the nonpredictable environment quickly reduced their responding/testing. However, the contingency analysis concept must be applied cautiously in the present investigation, since the infants in Watson's studies were never introduced to the response-independent but stimulus-dependent relationships between events experienced by infants in the predictable environment.

Adventitious reinforcement of panel pressing. It is possible that infants in the predictable environment assumed erroneously that their responses affected the opening of the Toy Box door. Nevertheless, the persistence of the panel press response in this environment probably cannot be attributed solely to adventitious reinforcement that might have occurred whenever the door opened shortly after a response was made. Infants tended to contact the panel soon after it was illuminated. The resulting delay of possible reinforcement was rather long,

averaging two to four seconds. Such a delay is likely to reduce significantly the effectiveness of reinforcement (Miller, 1972). Further evidence arguing against adventitious reinforcement as an explanation for this response persistence is the lack of any significant increase over trials in the number of contact responses directed toward the lighted panel in the predictable environment.

Stimulus relationships influencing panel pressing. The relationship between the events in the predictable environment may itself account for the persistence of the panel press response. To the extent that information derived from autoshaping/sign-tracking research with animals (Brown & Jenkins, 1968; Hearst & Jenkins, 1971) can be generalized to these human infants, it appears that responding is evoked and maintained as long as a predictive relationship exists between stimulus events, regardless of any response contingencies that may also be in effect. Furthermore, responding tends to be directed toward the localized stimulus which is most predictive of another significant event. In the present context, one could argue that infants in the predictable environment directed their responses to the lighted panel primarily because this event most consistently preceded opening of the door and access to the toy. The lighted panel was the most predictive stimulus available. Responding to the lighted panel persisted due to the stimulus-dependent relationship that was maintained throughout infants' exposure to these events in the predictable environment.

Anticipation of event sequences. In view of the above evidence suggesting the sensitivity and responsiveness of infants to predictable or nonpredictable relationships among events, it seems somewhat paradoxical to observe few behaviors directed toward the Toy Box door that would indicate either anticipation of the sequence of events or attempts to intervene in this sequence. A possible resolution of this paradox also is suggested by the autoshaping/sign-tracking literature. The essence of this resolution resides in the relationship between stimulus localization and directed responding. As mentioned previously, responding is directed toward localized stimuli most predictive of significant events. For infants in the nonpredictable environment, the only stimulus remotely predictive of each toy presentation was the sound produced as the Toy Box door opened. However, since this sound could be detected from any orientation within the experimental setting, vigilance to any particular localized site on the Toy Box was unnecessary. In addition, the sound of the door lacked salience as a stimulus that could readily be isolated from other events in the environment. Hence, responding directed toward the door in anticipation of its opening or to hasten its opening, would not have been expected.

For infants in the predictable environment, illumination of the plexiglass panel was a prominent (salient) event that prompted attention. Yet, the event was sufficiently localized to prohibit anything but almost direct orientation if the signal for toy presentation was to be detected. In addition, the panel light was more meaningful as a predictive stimulus than was the opening of the Toy Box door, since it provided more time to prepare for toy presentation in anticipation of the door opening. This localized, predictive stimulus, and not the door, would then provide the focus for attention and responding.

Age Differences

On those response measures indicating significant age differences, the 7-9 month old infants responded quicker, more consistently, and longer to stimulus events than did 11-13 month old infants. Before such evidence can be considered reflective of any meaningful developmental differences, however, the experimental conditions must be more directly equated. The younger infants, seated as they were in their mothers' laps, were less mobile and consequently less likely to have their attention diverted elsewhere. At all times, their proximity to the Toy Box remained relatively constant. In their roaming about the experimental space, the older infants could occasionally be caught at a considerable distance from the Toy Box when a new event was initiated.

Overall, the older infants contacted the lighted panel less than did the younger infants. With increasing exposure to the experimental conditions, the tendency to respond in this manner decreased dramatically faster among the 11-13 month old infants. If, as suggested earlier, infants directed responses to the lighted panel as a test of the response contingencies in effect, then the swifter overall reduction in the use of these responses by the 11-13 month old infants may imply that they acquired this information sooner than the 7-9 month old infants. This conclusion is consistent with Watson's (1966, 1967, 1972) research findings.

In conjunction with their simultaneously decreasing visual attention to the lighted panel, this may also provide evidence of the older infants' greater information processing efficiency, since Lewis and Goldberg (1969) indicate that information processing efficiency correlates directly with the rate of decrement in responding to a novel

stimulus. The 11-13 month old infants' more rapid decline in visual attention and responsiveness to the lighted panel would therefore reflect their greater efficiency.

Sex Differences

Few significant sex differences were observed in infants' responses to predictable or nonpredictable sequences of events. However, male infants in both age groups showed greater tendencies to press the lighted panel and to reach for the novel toys early in their exposure to the Toy Box. These initial differences in response orientation, due perhaps to sex differences in prior experiences, faded as infants gained more information about the relationship between events in their experimental environment.

The female infants, however, appeared to process this information more efficiently. Although they devoted less attention to the lighted panel than the male infants, they showed a more significant decrement in the response of pressing the lighted panel earlier than the male infants when that event was not predictive of toy presentation.

Interesting sex differences were also noted in the emotional responses of 11-13 month old infants to the nonpredictable environment. Whereas the older female infants reacted by crying, the older male infants attempted to escape the conditions of the nonpredictable environment through such acts as crawling under or around the Toy Box apparatus or squeezing past their mothers. This emphasis by each sex on a different response mode--emotional expressiveness by the girls and instrumental activity by the boys--may be an early product of the differential socialization of girls and boys.

Generalization of the Effects of Predictable or Nonpredictable Experience

Preference for novelty. The exploratory behavior of all infants as they began their participation in this experiment was marked by a clear preference to look at and actively manipulate novel toys. Following experience with predictable or nonpredictable sequences of events, the magnitude of infants' relative preference for novel over familiarized toys was altered significantly.

Experience with predictable events did not appreciably reduce the extent of infants' baseline preference for novel toys as either the object of visual attention or the focus of their exploratory manipulations. In fact, an exaggeration of this novelty preference was exhibited,at least among the 11-13 month old infants after exposure to stimulus-dependent, but response-independent events.

In contrast, with the exception of 7-9 month old female infants, prior experience with nonpredictable events produced a significant increase in visual attention and manipulatory exploration directed to the familiarized toy.

The younger female infants apparently did not generalize the effects of their prior experience to the context of the exploration tests, as their exploratory preferences subsequent to nonpredictable experience did not differ significantly from their baseline preferences expressed at the outset. This lack of generalization is especially evident in the measure of active manipulation of the toys. Although less pronounced, the visual attention that these 7-9 month old female infants devoted to the toys does demonstrate a generalization of the effects of prior nonpredictable experience similar to that observed for the other infants. This inconsistency among the younger female infants cannot be explained on the basis of existing research evidence. If replicated in subsequent research, this inconsistency may represent the operation of additional factors that influence the generalization of the effects of prior experience to new contexts.

Generalized expectancies affecting exploratory preference. The general increase in infants' interest in the familiarized toy following experience with nonpredictable events poses an intriguing question regarding the interaction between specific experiences and previously established generalized expectancies. All infants displayed an initial orientation of attentiveness and directed responsiveness toward novel objects and events. What changed as a consequence of limited exposure to a controlled environment in which events were stimulus-independent (nonpredictable) and response-independent (uncontrollable)?

Extrapolating from the learned helplessness research (Seligman & Maier, 1967; Seligman, Maier, & Solomon, 1971) it is possible that, in the nonpredictable environment, infants learn that their actions have no consequences and generalize this knowledge of their helplessness to new contexts. Competence or effectance motivation theory (White, 1959; Harter, 1978) would further suggest that infants' sense of perceived competence may be shaken by events in the nonpredictable environment. Thus, their increased interest in the familiarized toy may derive from knowledge of their specific competence with respect to this toy gained during familiarization. When later faced with the choice between this familiar toy and a novel one, the uncertainty of their competence with the novel toy may cause them to devote increased attention and exploration to the familarized toy.

Summary

Consistent with the view that exploration is a behavioral orientation and not a circumscribed set of specific behaviors, the present research stressed the direction and selective focus of two highly organized infant behavioral systems, visual attention and prehension/manipulation, as indicators of infants' exploratory orientation. The 7-9 and 11-13 month old infants who participated in this research initially approached their encounters with novel toys with a strong tendency to investigate them, both visually and manually, in preference to familiar toys. However, a substantial reduction in infants' exploratory preference for novelty was induced by brief exposure to a controlled environment in which events of interest to the infants occurred unpredictably and uncontrollably. The exploratory orientation of infants exposed to uncontrollable but predictable events was slightly accentuated following this experience.

This latter observation is contrary to learned helplessness research (Seligman & Maier, 1967; Seligman, Maier, & Solomon, 1971) which predicts, at least for animals, a generalized attenuation of attention and responsiveness whenever events occur uncontrollably. What the results of the present research suggest is that a phenomenon similar to learned helplessness can be produced in human infants, but only when events are simultaneously uncontrollable and unpredictable.

The direction and focus of infants' behaviors in the experimental environments was influenced profoundly by the relationships that pertained between stimulus events. This was reflected in the attentiveness and responsiveness of infants to the events. In addition, the information that infants synthesized about these specific event relationships apparently interacted with previously established generalized expectancies to produce the orientations observed in infants' subsequent exploratory preferences for novel or familiar toys.

In the predictable environment, where presentation of a toy was contingent upon prior lighting of a plexiglass panel, visual attention consistently was directed to this predictive stimulus and was sustained throughout repetitions of this event. Although no response could affect this stimulus-dependent relationship between events, infants pressed the panel from its first lighting and persisted in this directed response each time the panel subsequently lighted.

In the nonpredictable environment, where toys were presented independent of scheduled lightings of the plexiglass panel, infants' initial tendency to look at and contact the lighted panel rapidly waned. A corresponding tendency to explore the toys as they were presented in this environment decreased similarly with prolonged exposure to the uncontrollable and nonpredictable sequence of events.

As a general conclusion from the present research, infants' exploratory orientation to novelty is influenced, at least in part, by generalizations from prior experience. The specific content of these generalizations may derive from a cognitive classical conditioning, wherein stimulus-dependent or predictable relationships are discovered that direct the orientation of infants' responses to those salient stimulus events that signal most reliably other events of significance to infants.

APPENDIX A

OUTLINE OF INFORMATION PROVIDED TO PARENTS

Outline of Information Provided to Parents

1. Introduction of research personnel: names, roles.
2. Purpose of experiment: To gain a better understanding of why infants devote so much time to exploring and playing with toys, and what infants learn from toys.
3. Total time commitment: 1 hour
4. Procedures to expect: Unobtrusive observations would be made of infants' free play with toys presented by the experimenter (Exploration Tests), and of infants' reactions to toys presented in in the Toy Box. The Toy Box apparatus was described, emphasizing the events that would occur and observations that would be recorded regarding infants' responses to these events. Parents were assured that their own behaviors were not going to be recorded.
5. Possible risks: Although unlikely, infants' fingers might get pinched when Toy Box door closed. Informed parents that door was closed manually by an experimenter who could see the infants, but recommended some parental vigilance. Also, assured parents that there was no possibility of shock from the panel light, as the lightbulb and all connecting wires were inaccessible. Indicated to parents that, based on pilot research, some infants became fussy or cried as a result of their experience with the Toy Box.
6. Termination of experimental participation: Parents could interrupt research activities or discontinue their infants' participation at any time. No justification was needed.

7. Confidentiality of Information: Parents were assured that information and data collected during their infants' research participation would be confidential. Any reports of data collected would contain no information that could identify their infants.
8. Results of the experiment: If they requested, parents would be provided a general summary of the results upon completion of the experiment. However, no specific report of the performance of individual infants would be made.

APPENDIX B

RESEARCH CONSENT FORM

Michigan State University
Department of Psychology

RESEARCH CONSENT FORM

1. I have freely consented to permit my child to take part in a scientific study of infant exploratory behavior being conducted by Thomas L. Kodera under the supervision of Dr. Hiram E. Fitzgerald, Associate Professor of Psychology at Michigan State University.

2. The study has been explained to me and I understand the explanation that has been given and what my child's participation will involve.

3. I understand that I am free to discontinue my child's participation in the study at any time without penalty.

4. I understand that the results of the study will be treated in strict confidence and that my child will remain anonymous. Within these restrictions, results of the study will be made available to me at my request.

5. I understand that my participation in the study does not guarantee any beneficial results to me or to my child.

6. I understand that, at my request, I can receive additional explanation of the study after my child's participation is completed.

Signed______________________________

Date______________________

APPENDIX C

TOYS PRESENTED DURING EXPLORATION TESTS

Toys Presented During Exploration Tests

For each infant participating in this research, two sets of six toys each were created by random selection from the toys described below. Within each set, one toy was chosen at random and presented for familiarization during each exploration test. No toy was ever used in both the Exploration Pretest and Exploration Posttest.

1. Metal bell
2. Pink plastic hammer (rattle)
3. Wooden duck
4. Yellow raccoon (squeeze toy)
5. Plastic cup
6. Green foam block
7. Blue plastic telephone
8. Balloon (partially inflated)
9. White plastic rabbit (rattle)
10. Ring of plastic disks (multicolored)
11. Red elephant (squeeze toy)
12. Ring of plastic balls (multicolored rattle)

APPENDIX D

DESCRIPTION AND SEQUENCE OF TOYS PRESENTED DURING TOY BOX TRIALS

Description and Sequence of Toys Presented
During Toy Box Trials

1. Yellow plastic tiger (squeeze toy)
2. Blue dumbell rattle
3. Ring of plastic keys (multicolored)
4. Orange cat (squeeze toy)
5. Large soft-plastic hammer
6. Mirror
7. Boy with sombrero (squeeze toy)
8. String of beads (multicolored)
9. Orange musical rattle
10. Yellow plastic cube
11. Tan kangaroo (squeeze toy)
12. Blue plastic fish (rattle)
13. Interlocking rings (rattle/orange)
14. Strand of large pop-beads (multicolored)
15. Elephant-shaped ball (pink/white)
16. Blue plastic bell (rattle)
17. Green musical bird
18. Liquid-filled teething ring (clear plastic)
19. Pink bear (squeeze toy)
20. White rocking horse

APPENDIX E

ANALYSIS OF VARIANCE TABLES

Table 3. Summary of Analysis of Variance of Mean Percent of Infants Looking at Lighted Panel

Source	df	MS	F
Predictability (P)	1	10.0	.60
Age (A)	1	102.4	6.16*
Sex (S)	1	48.4	2.91
P x A	1	4.9	.29
P x S	1	1.2	.07
A x S	1	4.9	.29
P x A x S	1	.4	.02
Between groups error	32	16.6	----
Trials (T)	3	17.2	3.44*
P x T	3	2.6	.52
A x T	3	2.9	.58
S x T	3	1.8	.36
P x A x T	3	3.2	.64
P x S x T	3	1.8	.36
A x S x T	3	.03	.006
P x A x S x T	3	9.4	1.88
Within groups error	96	5.0	----

*p < .025

Table 4. Summary of Analysis of Variance of Mean Time Looking at Lighted Panel

Source	df	MS	F
Predictability (P)	1	15.38	4.27*
Age (A)	1	26.57	7.38**
Sex (S)	1	15.63	4.34*
P x A	1	1.60	.44
P x S	1	.90	.25
A x S	1	1.85	.51
P x A x S	1	.29	.08
Between groups error	32	3.60	----
Trials (T)	3	11.90	25.32***
P x T	3	4.02	8.55***
A x T	3	1.34	2.85*
S x T	3	.02	.04
P x A x T	3	.88	1.87
P x S x T	3	.07	.15
A x S x T	3	.10	.21
P x A x S x T	3	.25	.53
Within groups error	96	.47	----

*p < .05
**p < .025
***p < .001

Table 5. Summary of Analysis of Variance of Mean Percent of Infants Pressing the Lighted Panel

Source	df	MS	F
Predictability (P)	1	1056.25	3.79
Age (A)	1	2162.25	7.76***
Sex (S)	1	650.25	2.33
P x A	1	30.25	.11
P x S	1	12.25	.04
A x S	1	30.25	.11
P x A x S	1	90.25	.32
Between groups error	32	278.69	----
Trials (T)	3	632.25	33.68****
P x T	3	254.25	13.55****
A x T	3	72.25	3.85**
S x T	3	64.25	3.42*
P x A x T	3	38.92	2.07
P x S x T	3	52.92	2.82*
A x S x T	3	28.25	1.51
P x A x S x T	3	42.92	2.29
Within groups error	96	18.77	----

*p < .05
**p < .025
***p < .01
****p < .001

Table 6. Summary of Analysis of Variance of Mean Number of Panel Presses Per Trial

Source	df	MS	F
Predictability (P)	1	620.16	4.20*
Age (A)	1	1911.31	12.95***
Sex (S)	1	85.56	.58
P x A	1	.01	.00
P x S	1	5.26	.04
A x S	1	178.51	1.21
P x A x S	1	142.51	.97
Between groups error	32	147.63	----
Trials (T)	3	229.02	7.69*****
P x T	3	194.22	6.52****
A x T	3	117.11	3.93**
S x T	3	24.36	.82
P x A x T	3	33.61	1.13
P x S x T	3	38.79	1.30
A x S x T	3	11.37	.38
P x A x S x T	3	55.51	1.86
Within groups error	96	29.78	----

*p < .05
**p < .025
***p < .01
****p < .005
*****p < .001

Table 7. Summary of Analysis of Variance of Mean Latency to Look at Toy

Source	df	MS	F
Predictability (P)	1	34.56	4.61*
Age (A)	1	54.71	7.29**
Sex (S)	1	.18	.02
P x A	1	3.49	.47
P x S	1	10.94	1.46
A x S	1	22.38	2.98
P x A x S	1	2.66	.35
Between groups error	32	7.50	----
Trials (T)	3	1.16	.36
P x T	3	3.48	1.08
A x T	3	2.55	.79
S x T	3	5.20	1.61
P x A x T	3	1.12	.35
P x S x T	3	1.33	.41
A x S x T	3	8.30	2.58
P x A x S x T	3	.85	.26
Within groups error	96	3.22	----

*p < .05
**p < .025

Table 8. Summary of Analysis of Variance of Mean Percent of Infants Contacting Toy

Source	df	MS	F
Predictability (P)	1	3062.5	4.38*
Age (A)	1	22.5	.03
Sex (S)	1	122.5	.18
P x A	1	202.5	.29
P x S	1	302.5	.43
A x S	1	2402.5	3.44
P x A x S	1	1322.5	1.89
Between groups error	32	698.8	----
Trials (T)	3	702.5	2.20
P x T	3	9.2	.03
A x T	3	89.2	.28
S x T	3	1282.5	4.02**
P x A x T	3	749.2	2.35
P x S x T	3	29.2	.09
A x S x T	3	309.2	.97
P x A x S x T	3	29.2	.09
Within groups error	96	319.3	----

*p < .05
**p < .01

Table 9. Summary of Analysis of Variance of Mean Looking Time During Exploration Tests

Source	df	MS	F
Predictability (P)	1	312.20	2.33
Age (A)	1	358.50	2.68
Sex (S)	1	306.64	2.29
P x A	1	167.08	1.25
P x S	1	361.50	2.70
A x S	1	1.70	.01
P x A x S	1	76.31	.57
Error	32	133.72	----
Exploration Text (E)	1	.83	.01
P x E	1	86.29	.53
A x E	1	194.70	1.19
S x E	1	74.94	.46
P x A x E	1	41.51	.25
P x S x E	1	59.41	.36
A x S x E	1	135.98	.83
P x A x S x E	1	2.62	.02
Error	32	163.97	----
Familiarity (F)	1	109385.45	148.17***
P x F	1	337.85	.46
A x F	1	2445.31	3.31
S x F	1	4217.89	5.71**
P x A x F	1	8.79	.01
P x S x F	1	169.13	.23
A x S x F	1	217.39	.29
P x A x S x F	1	1719.38	2.33
Error	32	738.25	----
E x F	1	3955.12	4.69*
P x E x F	1	4725.19	5.60*
A x E x F	1	42.54	.05
S x E x F	1	1246.01	1.48
P x A x E x F	1	638.00	.76
P x S x E x F	1	2120.64	2.51
A x S x E x F	1	211.27	.25
P x A x S x E x F	1	98.44	.12
Error	32	843.60	----

*$p < .05$
**$p < .025$
***$p < .001$

Table 10. Summary of Analysis of Variance of Mean Exploration Time During Exploration Tests

Source	df	MS	F
Predictability (P)	1	303.88	.94
Age (A)	1	785.44	2.42
Sex (S)	1	24.41	.08
P x A	1	11.02	.03
P x S	1	453.94	1.40
A x S	1	2.14	.01
P x A x S	1	534.73	1.65
Error	32	323.95	----
Exploration Test (E)	1	161.00	.81
P x E	1	35.43	.18
A x E	1	346.63	1.73
S x E	1	86.29	.43
P x A x E	1	13.51	.07
P x S x E	1	47.85	.24
A x S x E	1	10.76	.05
P x A x S x E	1	10.76	.05
Error	32	200.00	----
Familiarity (F)	1	118673.79	70.67***
P x F	1	5.81	.00
A x F	1	794.33	.47
S x F	1	6547.20	3.90
P x A x F	1	728.89	.43
P x S x F	1	4574.03	2.72
A x S x F	1	92.26	.05
P x A x S x F	1	3548.51	2.11
Error	32	1679.18	----
E x F	1	1991.63	2.32
P x E x F	1	10473.31	12.18**
A x E x F	1	895.39	1.04
S x E x F	1	138.88	.16
P x A x E x F	1	352.54	.41
P x S x E x F	1	4321.20	5.03*
A x S x E x F	1	524.71	.61
P x A x S x E x F	1	3534.02	4.11*
Error	32	859.86	----

*p < .05
**p < .005
***p < .001

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