DETERMINANTS OF EXPLORATORY PLAY BEHAVIOUR OF 16-MONTH-OLD INFANTS: NOVEL TOY PREFERENCES AS A FUNCTION OF EXPERIENCE AND COMPLEXITY

by

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ABSTRACT

Theories of exploration and empirical data both suggest the high salience of stimulus complexity and novelty as determinants of infant exploratory behaviour. Exploratory preferences for novel and complex stimuli are generally held to be a function of age, with older infants preferring the more novel and more complex. It is argued in this thesis that preference for novel stimuli is experiential (a function of interaction with a stimulus) rather than epigenetic (a function of maturation).

Recent studies of exploratory behaviour in 8- and 12-month-old infants by Hunter suggest the following: 1) if given a choice between two sets of toys, infants will prefer novel toys only if they have been initially allowed to complete exploration of one set -- i.e. achieve habituation; 2) infants whose exploration of a set of toys is interrupted will, in a subsequent choice, prefer to continue exploration of the initial set only if the toys are complex relative to the age of the infant; and 3) age-related complexity can be defined by the number of toys in the set; for example, the same three toy array was complex for 8-month-olds and simple for 12-month-olds (who found a five toy array complex).

In the present study it was hypothesized that 16-month-old infants allowed to habituate to the five toy array would exhibit subsequent preference for novel toys, while those whose exploration was interrupted would show no novel or familiar preference in the test trial, that is, their behaviour would be consonant with that expected for a simple stimulus.

Sixteen male and sixteen female infants (mean age: 16 months) were randomly assigned to one of two experimental groups: habituated or interrupted. During a familiarization trial infants in the habituated group were allowed to explore the five toy array until an individual criterion of habituation was achieved. Infants in the interrupted group were allowed considerably less exploration. During both trials the investigator observed from behind one-way glass and recorded all instances of visually guided manipulation.

Analyses of variance found differences between habituated and interrupted groups. Further tests against expected chance levels showed that infants in the habituated group showed an overall preference for exploratory play with the novel toys in the test trial, while infants in the interrupted group showed overall preference for familiar toys in the test trial. There were no sex differences, no effect of relative novelty of toy location, and no changes over time.

The hypothesis that only the habituated group would show strong novel toy preference in the test trial was supported, thus strengthening the contention that preference for novel stimuli is experiential, not epigenetic. The hypothesis that the interrupted group would show no preference was not upheld.

significant exploratory preference for the familiar toys was manifest by the interrupted group -- a result typical of exploration of complex stimuli.

The behaviour of the interrupted group, and the length of time the habituated group required to complete exploration of the toys strongly suggest that the five toy array was complex for the 16-month-olds. Possible reasons for this finding are discussed. It is suggested that the information processing ability of the infant rather than age *qua* age, must be taken into consideration when defining stimulus complexity.

"The impulse to play in special
ways is certainly instinctive"

William James

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I. Introduction

Until comparatively recently, exploratory behaviour was most commonly explained in terms of extrinsic motivation or drive-reduction theory. However, the findings of researchers such as Tolman and Harlow were inconsistent with such theoretical accounts. Tolman (1925), working with rats, and Harlow (1950), working with monkeys, found that the animals engaged in considerable exploratory behaviour without needing to be stimulated by physical deprivation and subsequent reinforcements. In response to these early observations, various theories have been put forth that offer alternative descriptions of the motivation for exploratory behaviour. The two most prominent of these theories (optimal arousal and information processing) focus on internal states as motivators for behaviour.

Optimal arousal theorists (e.g. Fiske and Maddi, 1962; Hebb, 1955; Leuba, 1955) proposed that within the organism there exists an optimal level of arousal that the organism attempts to maintain through stimulus seeking (exploration) or stimulus avoidance. Exploration, then, is an attempt by the organism to avoid states of monotony or low arousal by varying stimulation in order to sustain a certain level of activation.

Information processing explanations of exploratory behaviour have also been offered in which exploration is typically defined in functional terms as information seeking. Dember and Earl (1957) proposed that exploratory behaviour is co-determined by the amount of information in the immediate stimulus environment and the information processing abilities of the organism. They postulated that for each individual there exists an optimal level of psychological complexity (information processing ability) and that stimuli slightly more complex than the optimal level elicit the most exploratory behaviour.

Hunt (1960) proposed that the motivation for exploratory behaviour is curiousity caused by perceptual or cognitive discrepancy. Exploration is information seeking aimed at reducing the incompatability between existing schemata and environmental novelty or complexity. Hunt's (1965) optimal-incongruity hypothesis predicted that the organism will prefer to explore moderate discrepancies more than highly discrepant stimuli.

Berlyne (1960) incorporated both optimal arousal and information processing explanations of exploratory behaviour in his account of the motivational bases for exploration. Berlyne further distinguished between specific and diversive exploration. Specific exploration was explained as behaviour aimed at reducing uncertainty that elicits curiousity accompanied by increased arousal. Uncertainty could be produced by either perceptual conflict (perceptual curiousity) or conceptual conflict (epistemic curiousity). In either case, Berlyne proposed that exploratory behaviour would occur in an attempt to reduce uncertainty to its optimal level. However, when uncertainty is too high or too low, specific exploration gives way to diversive exploration -- stimulus seeking. Diversive exploration elicited by reduced arousal potential is intended to increase sensory input so as to avoid a state of boredom.

Because exploratory behaviours are motivated by uncertainty or curiousity rather than biological drives, they tend to be stimulus-oriented. Both the optimal arousal and optimal level theories predict the importance of stimulus attributes as major determinants of exploratory behaviour, particularly the degree of novelty and complexity of the stimulus. These parameters have received considerable experimental manipulation in investigations of the determinants of exploratory behaviour and their predicted importance has received much support. However, there remains disagreement and ambiguity as to whether novelty preferences in the exploratory behaviour of the human infant are an epigenetic (age-relevant) or experiential (phase-relevant) phenomenon. As an attempt to clarify the epigenetic-experiential ambiguity, the major purpose of this thesis is to investigate the conditions under which 16-month-old infants prefer to explore novel or familiar stimuli.

The determining conditions for exploration are generally held to be the novelty and complexity of the stimuli. The age of the infant is also often assumed to determine exploratory preferences for novel or familiar stimuli. In the following sections, each of these determinants will be examined in terms of theoretical predictions and empirical findings will be discussed.

Stimulus Novelty and Exploration

The most influential theories of exploratory behaviour (Dember and Earl, 1957; Berlyne, 1960) emphasize the salience of novelty as a determinant of exploration. The relationship between novelty and exploration is generally predicted to be an inverted U-shaped function. Thus, while the amount of exploration a given stimulus is likely to elicit will be partly dependent on the age and experience of the individual, generally, stimuli that are either high or low in novelty are predicted to elicit little exploratory behaviour. Stimuli of intermediate novelty are predicted to elicit the greatest amount of exploration.

Berlyne (1960) postulated three categories of novelty along a temporal dimension: complete novelty, long term novelty, and short term novelty. A completely novel stimulus is one that has never before been encountered. Short and long term novelty refer to stimuli that have previously been encountered, but not within the preceeding days or months (long term) or not within the last few minutes (short term).

Baldwin and Baldwin (1977), Hutt (1970), and Sayman, Ames, and Moffett (1964) maintain that novelty is best defined in terms of temporal dimension. On a time continuum, an object that was once novel becomes familiar. In this way the degree of novelty of a particular stimulus can be measured in terms of the amount of time it has been explored. Thus it is possible to manipulate the degree of novelty in an experimental session by controlling the amount of time an individual interacts (either visually or through manipulation) with a particular stimulus -- i.e. novelty can be an independent variable.

Stimulus Complexity and Exploration

Dember and Earl (1957) proposed that exploratory behaviour is determined by the complexity of the environment (the amount of information the environment contains), and the information processing abilities of the organism. They postulated an optimal level of psychological complexity with stimuli slightly more complex than the optimal level being those that elicit the most exploratory behaviour. Dember and Earl (1957) predicted that an intermediate level of complexity would elicit maximum exploratory behaviour. Similarly, Berlyne (1960) postulated that stimuli high or low in complexity would elicit less exploration than those of intermediate complexity. Based on his beliefs about motivations for arousal balance, Berlyne proposed an inverted U-shaped function between the amount of exploratory behaviour and level of stimulus complexity.

There exists a real problem in trying to define complexity in terms of specific stimulus attributes. Unfortunately there is no unitary scale of complexity, and studies that have investigated stimulus complexity have defined it along a number of different dimensions: for example, amount of contour, number of parts, asymmetry, and the number of random turns in a figure. Complexity of a stimulus can best be defined relative to the past experience and processing ability of the organism to which it is presented. The younger an infant, the fewer stimuli s/he will have encountered. Thus the most frequent hypothesis about complexity is that with increasing age infants will prefer increasingly complex stimuli. Results have been sufficiently consistent to support the theoretical prediction that infants show increasing preference for more complex stimuli with increasing age (Brennan, Ames, and Moore, 1966; Caron and Caron, 1968, 1969; Greenberg, 1971; Greenberg and Weizmann, 1971). By corollary, it may be predicted that what is a complex stimulus for a young infant will be a simple stimulus for an older infant.

Relationship between Novelty and Complexity

Berlyne has subsumed both novelty and complexity under what he calls the collative variables. The major effect of the collative variables is to influence internal states of arousal so as to obtain an optimal level. Exploratory behaviour, then, is governed by seeking stimuli that will maintain the optimal level of arousal.

Berlyne (1970) maintained that the novelty and complexity of a stimulus interact as determinants of exploratory behaviour, and that changes in exploratory behaviour depend on the interaction of a tedium factor and a positive-habituation factor. Positive habituation, Berlyne assumed, reflects an increased liking for a stimulus as the information it affords is processed. Complex stimuli are said to underlie the positive habituation factor because they offer more scope for information processing. Likewise, simple stimuli are more likely to elicit the tedium factor.

Figure 1 shows the effects of stimulus complexity and novelty on exploratory behaviour as derivable from the theoretical predictions of Berlyne. Exploration of simple novel stimuli should decrease monotonically over time because simple stimuli contain little scope for information processing. Complex stimuli will initially elicit increasing exploration, peak, and then show a decrease in exploration over time.

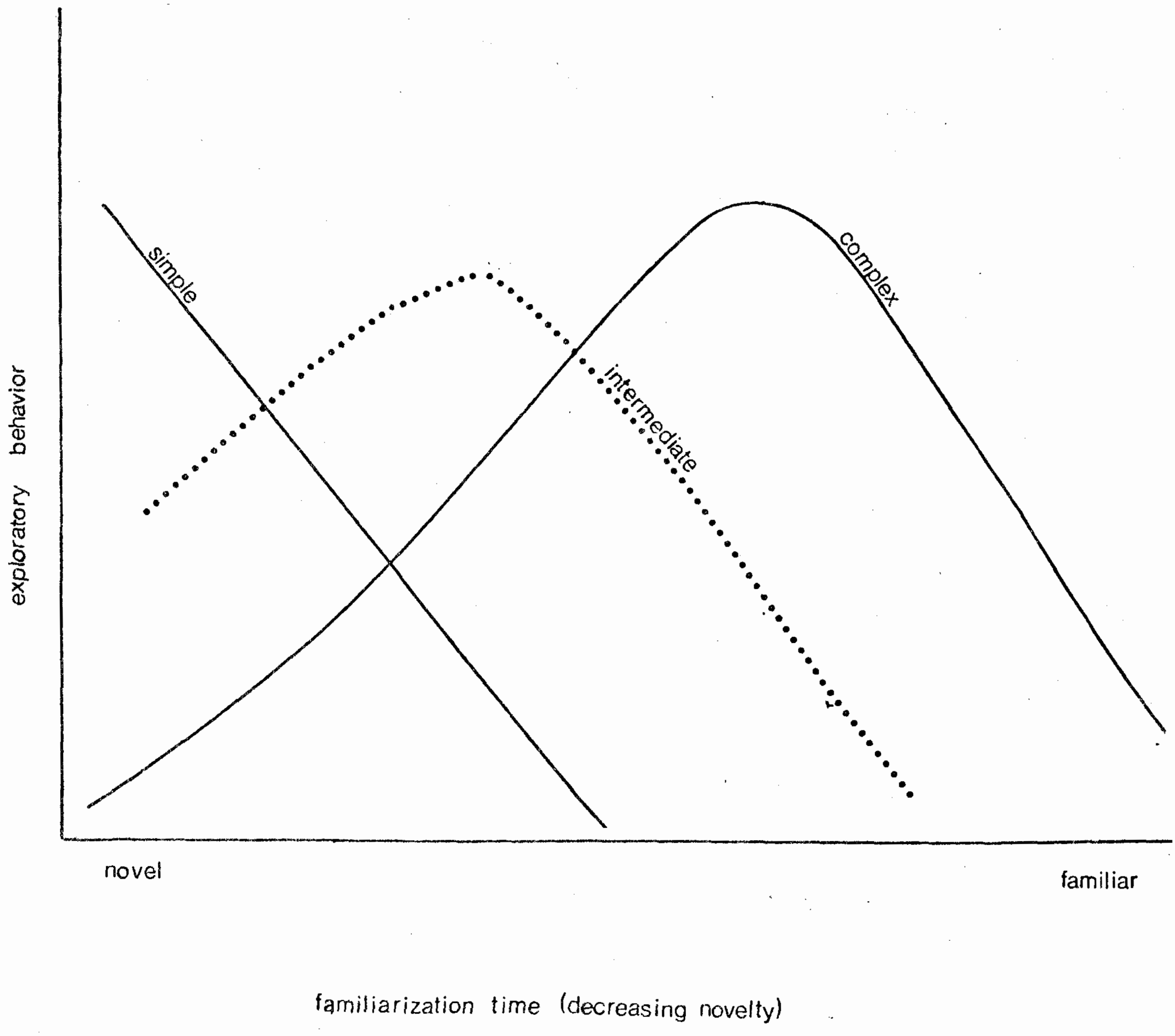

Figure 1: Predicted effects of stimulus complexity and novelty on exploratory behaviour

Stimuli of intermediate complexity will show a similar curve but require less information processing. Thus, exploration of moderately complex stimuli will peak and start decreasing with less time than required by complex stimuli.

Age of Infant and Exploratory Preferences

Hunt's theory, although somewhat ambiguous, suggests that novelty preferences may be an experiential rather than epigenetic phenomenon; that is, rather than being a function of the age of the infant, novelty preferences represent a phase of the infant's experience with a particular stimulus. Based on his own and Piaget's observations, Hunt (1963, 1970) postulated the existence of a three stage epigenesis of motivation inherent in information processing. Initially the infant responds primarily to changes in perceptual input. The second stage is marked by the beginning of activity intended to prolong or elicit interesting sights. At this stage attentional activity is elicited by what has been repeatedly encountered because the infant finds the act of recognition rewarding. With further repetition, however, the excitement of recognition palls, and in the third stage the infant decreases attention to the familiar and manifests increased interest in novel stimuli. Hunt thus proposed a two stage sequence of attentional preference with attention to the novel being preceded by attention to the familiar. Hunt's theory is clearly not based solely on maturational changes because it emphasizes the infant's perceptual interaction with the stimulus. The corollary suggests that with an older infant exploration of relatively complex stimuli may comprise an invariant sequence over time. If given a choice between stimuli, an infant will prefer to explore one until s/he has extracted from it all the information s/he can process, i.e. until intra-stimulus novelty has lessened to the point of habituation. During this exploratory period the infant will show a strong preference for continued exploration of the familiar stimulus (see Figure 2). When the infant has habituated to the familiar stimulus the novel stimulus will be preferred.

The Habituation Paradigm

The habituation paradigm has been the procedure most often used to investigate the relationship between exploration and novelty, both intra-stimulus (the course of exploration over time) and inter-stimulus (preference for familiar or novel). In the usual habituation procedure, an increase in attention to a novel stimulus following a familiarization period is taken as evidence that any decline in attention during that period was due to habituation. Familiarization is any procedure of any duration that gives the infant experience with a particular stimulus.

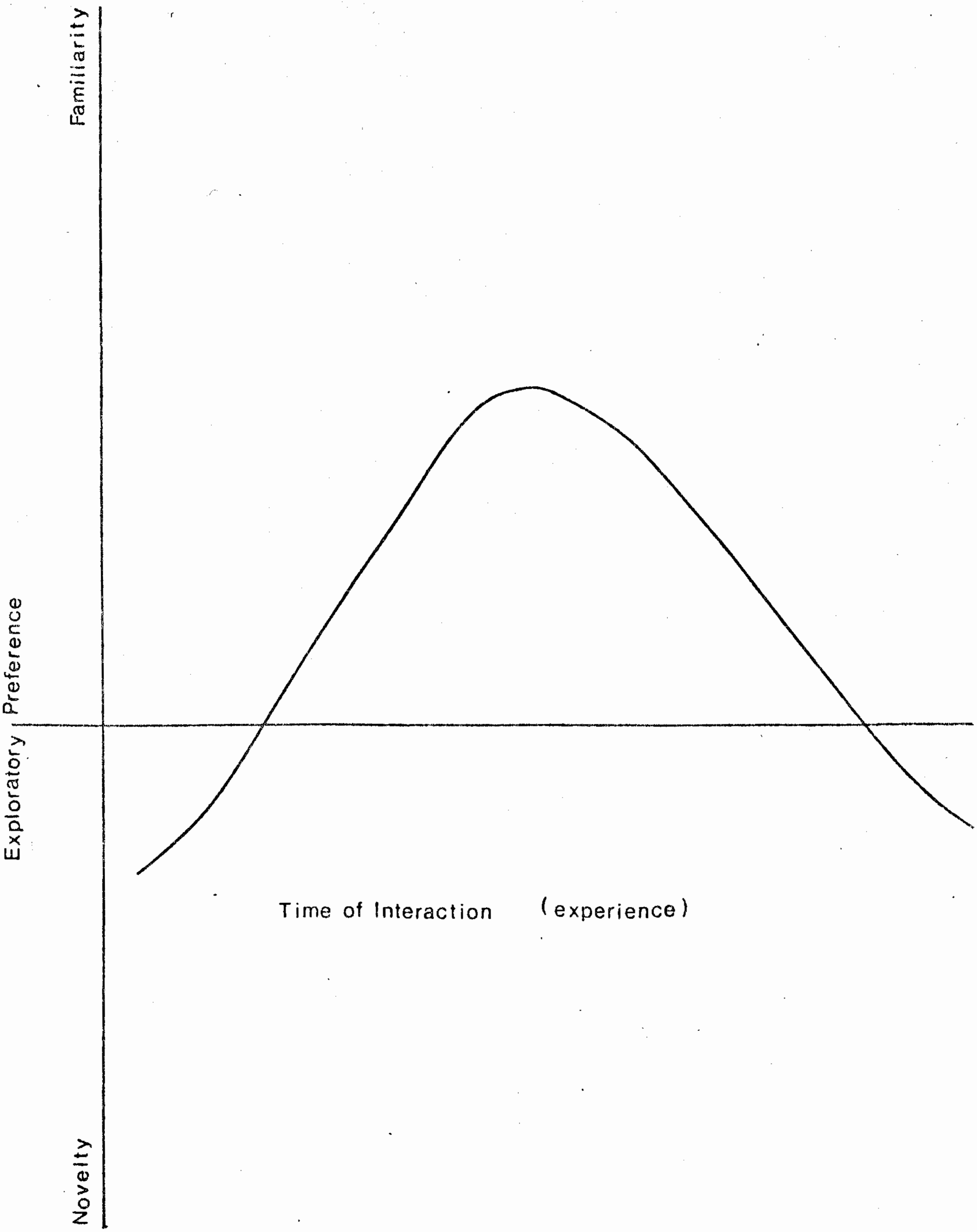

Figure 2: Predicted change in exploratory preference of a relatively complex stimulus with increasing experience

The duration of the familiarization period may or may not be sufficient to produce habituation, which is defined as a response decrement to the familiarized stimulus to a pre-established criterion level. The amount of familiarization time an infant has with a stimulus may well play a crucial role in determining novel or familiar preferences.

For studies of infant memory (e.g. Caron and Caron, 1969; Cohen and Gelber, 1975; Gottfried and Rose, 1980; Pancratz and Cohen, 1970; Wetherford and Cohen, 1973) or discrimination (e.g. Fagan, 1970, 1971; Fantz, 1964; Maurer and Lewis, 1979), the habituation paradigm is an appropriate and useful methodological tool. However, as Hunter (note 1) pointed out there are two fundamental problems with the standard habituation procedure when it is applied to investigations of exploratory preferences for novel or familiar stimuli. First, the use of a fixed period of familiarization time or a fixed number of trials does not allow for individual differences among infants in the rate of habituation, nor can it clearly determine if habituation has occurred. Secondly, having test trials at only one point during familiarization prevents investigation of predictions that preferences for novel or familiar stimuli will vary as a function of familiarization time and whether or not habituation has occurred.

To correct these problems Hunter suggested that studies using novelty as an independent variable should use a procedure that has a criterion of habituation such that occurrence of habituation (completion of exploration) is defined by the infant's behaviour, and that test trials occur both pre- and post-habituation, i.e. when exploration is on the increase as well as decreasing. If the infant's interaction with a stimulus is interrupted before habituation is achieved, s/he may be expected to manifest an exploratory preference for the partially familiar stimulus if given a choice between that stimulus and a novel one. If the infant's interaction with a stimulus is allowed to continue to the point of habituation -- for example, a decrement in response that meets a criterion level such as 50% of the original response -- then a preference for a novel stimulus should be shown.

Empirical Findings

Most researchers have been unable to demonstrate habituation or post-habituation preferences for novel stimuli in young infants, and have therefore interpreted Hunt's theory as age (epigenetic) rather than phase (experiential) relevant. Considerable agreement exists that beyond 2 or 3 months of age infants habituate to a repeated stimulus and subsequently respond to novel stimuli (Cantor, 1964; Cohen, 1969, 1972; Fagan, 1970; Fantz, 1964; Hutt, 1970; Greenberg, 1971; Greenberg, Uzigiris, and Hunt, 1970; Sayman, Ames and Moffett, 1964). Most studies of infants younger than 2 months have failed to find habituation (e.g. Covell, note 2; Fantz, 1964; Martin, 1975; Wetherford and Cohen, 1974). It should be considered that infants under 2 months, because of their limited period of alert wakefulness, have not had sufficient familiarization time for habituation to occur. Generally the greater the familiarization time allowed, the stronger the subsequent preference for novelty.

This is well exemplified in a study by Caron, Caron, Minichello, Weiss and Friedman (1977) of 14- and 20-week-old infants. The infants were presented with unidimensional discrimination problems of varying difficulty under conditions of short and prolonged familiarization periods. They found that for both age groups, the degree of novelty preference was a positive function of the length of familiarization time and of the degree of habituation during the familiarization, as well as of the difficulty of the problem.

Despite such results, data from studies with young infants have led to considerable agreement among researchers that certain cognitive capacities develop such that there is a maturational barrier that precludes habituation and a preference for novelty in infants younger than 2 or 3 months of age.

The ambiguity of epigenetic vs. experiential interpretations of Hunt's theory is exacerbated not only by methodological problems that pervade investigations of visual exploratory preferences of infants younger than 2 months, but also by the confounding of age and experience. For example, in studies using long-term familiarization procedures (Greenberg, Uzgiris, and Hunt, 1970; Uzgiris and Hunt, 1970; Weizmann, Cohen and Pratt, 1971; Wetherford and Cohen, 1973) age was confounded with familiarization time (experience). As a result, novelty preferences can equally well be interpreted as epigenetic or experiential. As Greenberg et al stated, "The issue of whether the shift in preference from the familiar pattern to the unfamiliar one is a matter of maturation or personal interaction with the pattern remains unsettled" (p.132).

It is interesting to note the support from animal studies for the interpretation that novelty preferences are experiential rather than epigenetic. For example, Bateson and Jaeckel (1976) varied the length of exposure of a flashing red light to day old chicks and found that over a 30 minute period preference for the familiar first increased and then decreased. It should be noted that in the study the novelty preference tended to be reversed over time with a return to preference for the familiar; however, this does not negate the support the findings offer to the experiential interpretation of Hunt's theory which requires only that familiar preferences increase before a preference for novelty is observed. In fact, Bateson and Jaeckel (1976) interpret their findings in information processing terms noting the behavioural adaptivity of the chicks' responses. They speculate that it may be ecologically necessary for the chicks to attend to a novel stimulus after processing information about a familiar stimulus in order "to learn the characteristics of different aspects of the mother who presents markedly different front and back views" (p.389).

If, as has been suggested by some researchers, exploratory preferences for novelty are age-related, then it should be increasingly difficult to demonstrate familiarity preferences as infants get older. However, the results of a recent study argue against such an interpretation. Hunter, Ross, and Ames (in press) studied the influence of the amount of familiarization time on the exploratory preferences for novel or familiar stimuli with 12-month-old infants. They reported that infants allowed only a limited interaction with toys with which they were initially unfamiliar preferred these toys to a new set of toys in a subsequent pair comparison test. On the other hand, infants allowed sufficient familiarization time to habituate to the toys subsequently preferred the novel toys. The measure of infant exploratory behaviour in the study was visually guided manipulation. These data strongly support the idea of a relationship between familiarization time or experience and exploration of novel vs. familiar stimuli. The study clearly demonstrates that exploratory preferences for familiar stimuli are not age related but may instead be a function of the amount of familiarization the infant experiences. These findings offer strong empirical support to an experiential interpretation of Hunt's statement that

> attentional preference may be expected to go to objects and patterns and places that have been perceived just often enough to develop central processes that permit tentative recognition, and with more perceptual encounters, attentional preference should shift to what is unfamiliar or novel. (Hunt, 1970, p.101)

The stimulus used by Hunter et al -- a set of five toys -- was considered to be complex for the 12-month-old infants, and therefore was expected to offer considerable scope for information processing. The Hunter et al results were consonant with the theoretical predictions described in Figure 1. In a later study, Hunter (personal communication, 1980) used a simple stimulus (a three toy array) with 12-month-olds and found that in both habituated and interrupted groups less exploratory behaviour occurred than had occurred with the corresponding groups of 12-month-olds who had been presented the complex stimulus. Furthermore, infants in the habituated (simple stimulus) group achieved habituation more rapidly than did infants in the habituated (complex stimulus) group. These data support previous findings that stimuli offering more scope for information processing elicit greater exploration than do stimuli of relatively low information content, assuming that the level of complexity is not too great for the age or experience of the infant.

Another relevant study is that of McCall, Kennedy and Appelbaum (1977), who familiarized infants to a checkerboard pattern and then presented the infants with new checkerboards having different sized squares. They obtained a more inflected U-shaped curve in distribution of attention to the more complex stimulus (denser pattern of squares) than to the simpler checkerboard -- i.e. the infants preferred the novel stimulus that contained more rather than less information. McCall and Kennedy (1980) varied the visual experience of three groups of 4-month-olds by habituating them to stimuli varying in complexity and number. The results showed that those infants who received greater variability of experience in the familiarization period gave greater attention to the more complex of the novel stimuli. These findings are consonant with the theoretical predictions of Dember and Earl, Hunt and Berlyne, and as McCall and Kennedy suggest, are reflective of the infant's naturally occurring exploratory behaviour -- i.e. increased attention with experience to "new but processable information of a progressively more elaborate or detailed nature" (McCall and Kennedy, 1980, p. 287).

Environmental Novelty and Exploration

One further determinant of exploratory behaviour which must be considered is novelty of environment. Empirical findings have been equivocal: some researchers have found that exploratory behaviour increases in novel environments while others have found that novel environments inhibit exploration.

Effects of novelty of environment on visual exploration were investigated by Weizmann, Cohen and Pratt (1971) in a longitudinal study of infants from 4 to 8 weeks of age. During this period, infants were given daily exposure of 30 minutes to a stabile attached to their bassinets. Pair comparison tests were conducted with novel and familiar stabiles in either novel or familiar bassinets. Results showed that male infants preferred a novel stabile when in a familiar bassinet while female infants preferred a novel stabile when in a novel bassinet. Such sex differences exacerbate the lack of clarity of the effects of environmental novelty.

In her review of exploratory behaviour, Hutt (1970) concluded that both stimulus novelty and environmental novelty influence exploratory behaviour. In some of the studies Hutt cited (Arsenian, 1943; Cox and Campbell, 1968; Rheingold, 1968) novel stimuli were found to elicit exploration but novel environments inhibited exploration. However, as Hutt argued, in these studies the infants were without their mothers, and it was most likely that the mother's absence functioned as a greater inhibitor of exploratory behaviour than did the novelty of the environment. In a later discussion on exploration and play in children Hutt (1976) concluded that children will not readily explore a new environment, although they will explore a new object if it is placed in a relatively familiar environment. Other studies by Rheingold and Eckerman (1970) and Ross (1974) demonstrated that when mothers are present infants will explore a novel environment. Ross (1974) and Hunter, Ross and Ames (in press) found an interaction between novelty of stimulus and novelty of environment in determining exploration.

Ross (1974) compared infants' entry into familiar toy rooms with entry into novel toy rooms. She found that infants spent less time near their mothers when allowed to explore in the novel room than in the familiar room, and spent more time exploring the novel toys when in the novel room. Hunter, Ross and Ames found that the novelty of location of toys in a pair comparison test trial influenced the behaviour only of those infants who were initially allowed very limited interaction with the set of toys in the familiarization trial. The exploratory behaviour of the infants allowed to habituate in the familiarization trial was not influenced by the location of the toys. Hunter et al found that the familiarity of location was a major determinant of which toys would be approached first by the infants allowed limited interaction, and further that the proportion of time spent exploring either novel or familiar toys was in part dependent on whether they were in the novel or familiar location. If the familiar toys were in the familiar area during the test trial the infants explored only the familiar toys. However, when the novel toys were in the familiar area during the test trial, the infants first explored the novel toys and then went to the novel room and resumed exploration of the familiar toys. It appears that Hunter et al's 12-month-olds used familiar location as a cue when their exploratory behaviour was interrupted; however, familiarity of stimuli was ultimately of greater determining power.

Summary

Theoretical predictions and empirical findings suggest that the major determinants of infant exploratory behaviour are the complexity of the stimulus defined relative to the age of the infant; the novelty of a stimulus defined individually relative to the amount of experience the infant has with it; and to a lesser extent the novelty of the environment.

Present Study

The purpose of this study was to investigate the above three premises in an attempt (i) to replicate Hunter, Ross, and Ames' findings that exploratory preferences for novel stimuli are experiential and determined by the achievement of habituation; (ii) to show that complexity (as defined by the number of toys) is age related; and (iii) to attempt to clarify the effects of environmental or location novelty on exploratory preferences.

The study used the methodology of Hunter, Ross and Ames (in press) in their investigation with 12-month-old infants. The same number (5) and type of toys were used. Hunter et al used a five toy array which was considered by them to be a complex stimulus for their 12-month-old infants. Hunter (personal communication, 1980) later used a three toy array for 12-month-olds and obtained results consistent with exploratory patterns for a simple stimulus (the habituated groups showed strong novel toy preference and the interrupted group showed no preference). The same 3 toy array was then used with 8-month-olds who behaved similarly to the 12-month-olds with the complex stimulus (the habituated group showed novel toy preference and the interrupted groups showed preference for familiar toys). Thus, Hunter defined and varied complexity by manipulating the number of toys presented relative to the age of the infants. It is expected, therefore, that the use of a five toy array with the 16-month-olds in the present study will give results more in accordance with Hunter's "simple" group (12-month-olds with the three toy array) than with the Hunter et al "complex" group (12-month-olds with the five toy array).

Specifically it was hypothesized that the infants habituated to the stimulus would exhibit a strong preference for novel toys in the test trial, while infants whose exploration was interrupted would show no significant toy preference and overall would have a novel toy preference significantly less than that demonstrated by the habituated group.

The novelty of stimuli was varied as in the Hunter et al study by including two levels of familiarization -- prior (interrupted group) and post (habituated group) habituation. Location novelty was controlled by placing the novel toys in the test trial such that half the infants in each condition encountered the novel toys in the familiarized location, and half encountered the novel toys in the novel location.

II. Method

Subjects

Thirty two infants ranging in age from 15.5 months to 16.5 months (mean 16 months) were selected from among those volunteered for research by their parents in response to a printed request given to mothers in maternity wards of local hospitals, and in response to newspaper advertisements. The infants were randomly assigned to one of the two experimental groups (habituated group and interrupted group) subject to the constraint that there be an equal number of males and females in each group. Of the infants 20 were only children; 3 had a younger sibling; and 9 had older siblings. Three infants had been seen before in studies of visual exploration at age 6 or 12 weeks. An additional nine infants were tested but not included in the analysis due to recording equipment failure (3); refusal to leave the parent during one or both trials (3); and parent's failure to follow instructions (3).

Apparatus and Materials

Testing took place in a carpeted room 4.6 x 6 meters empty of furniture except for a divider and cushion. The divider was a bookcase (122 x 30 x 91 centimeters) completely covered in plain white paper; it was used to bisect one of the longer walls the upper half of which was a one-way vision window. The cushion (71 x 71 centimeters) was directly opposite the divider at a distance of 2 meters. Right and left locations were defined as bounded by the divider, an imaginary line running perpendicular to it, and by two adjacent walls of the room. One of these walls was grey brick, the other was covered in floor to ceiling white curtains (see Figure 3).

Stimuli comprised 18 commercially available toys that offered a variety of visual, tactile, and auditory stimulation.

Exploration was recorded continuously by pressing buttons on a recording box attached to a PCM 12 microprocessor. Separate buttons were used to record the following: entry and exit from either location; looking at either the novel or familiar toys during the 20 second vision period at the start of the test trial; and visually guided manipulation of a toy throughout both trials. The investigator also recorded on audiotape which toy the infant was exploring for each period of visually guided manipulation.

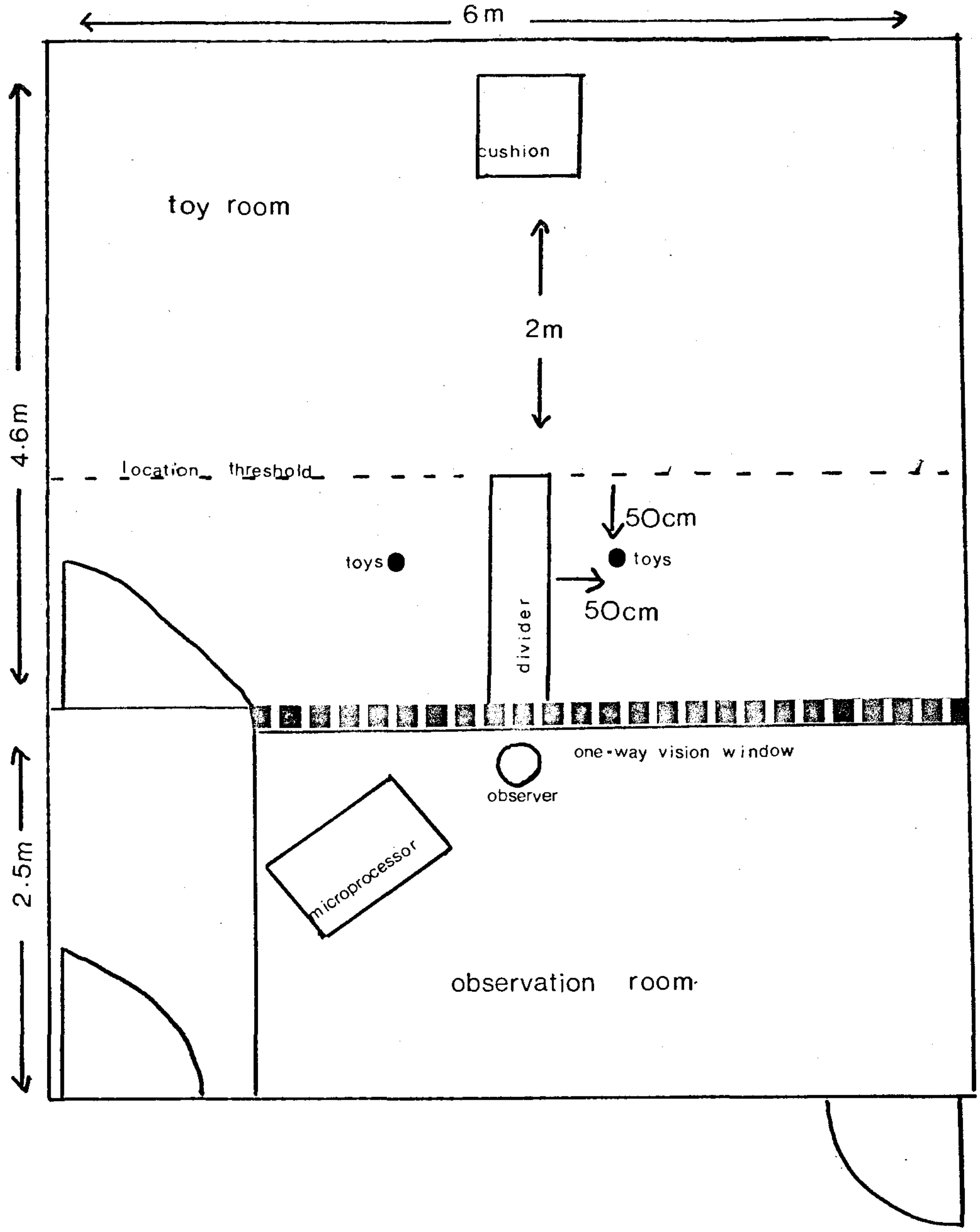

Figure 3: The experimental environment as it appeared during the test trial

A second observer recorded visually guided manipulation for 16 (8 in the interrupted group and 8 in the habituated group) of the infants by pressing a button on a separate box attached to the same system. A standard stopwatch was used to time the 20 second vision alone interval at the beginning of the test trial.

Procedure

Parents of prospective subjects were telephoned and appointments made for them to bring their infants to the university. Prior to testing, the aims and procedure of the study were explained to the parent who was then asked to read and sign a consent form. Color photographs of the toys were then shown to the parent who selected those that the infant did not have at home or at a babysitter's. From these, five were randomly selected by the investigator to be the familiar toys (used in the familiarization trial), and five to be the novel toys (used in test trial only). The selection of these toys was constrained such that across subjects each toy was assigned equally often to the status of novel or familiar. The familiar toys were then placed in a cluster 50 centimeters to the side of the divider in either the left or right location. The location start side was counterbalanced among infants. The parent and infant were then escorted from the reception area to the toy room.

For the familiarization trial, the parent was asked to sit on the cushion holding the infant toward him or her. The investigator, who observed from a control room on the other side of the one-way window, tapped on the window to signal the start of the trial. Upon hearing the tap the parent turned to face the toys and let go of the infant but remained seated on the cushion. The parent was asked to refrain from initiating interaction with the infant or directing the infant's behaviour while in the toy room. Supportive but brief response was suggested for infant initiated interaction. A second tap on the window signalled the end of the familiarization trial at which time the parent brought the infant out of the toy room. The five novel toys were then placed in the room such that half the infants in each group encountered the novel toys in the location which during the familiarization trial had contained the familiar toys -- the familiar location; and half encountered the novel toys in the location which had been empty during the familiarization trial -- the novel location.

The duration of the familiarization trial was determined as a result of the experimental group to which the infant had been assigned (habituated or interrupted), and the amount of exploration the infants engaged in. The infants in the habituated group were allowed interaction with the toys until an individual criterion of habituation had been attained -- two consecutive minutes during which the infant's exploration was

50% or less than the total amount of exploration during the first minute. Infants in the interrupted group were allowed either 60 seconds of accumulated visually-guided manipulation, or 160 seconds of total trial time, whichever came first. The PCM 12 microprocessor was programmed to calculate trial end according to either habituated or interrupted criterion, and to notify the investigator of trial end by means of a printed message on a television screen. The test trial took place as soon as the toys had been repositioned -- inter-trial interval was approximately three minutes.

For all infants the test trial was a 10 minute pair comparison procedure. When the parent took the infant back into the room at the beginning of the test trial s/he was asked to sit on the cushion with the infant on her/his lap. Upon hearing a tap on the window, the parent was to turn the infant such that the infant faced the toys and to point out that there were toys in both locations. The parent held the infant facing the toys for a period of 20 seconds, timed by the investigator on the stopwatch. A second tap signalled the end of this 20 second vision period at which time the parent let go of the infant until 10 minutes later a third tap signalled the end of the test trial and the parent and infant left the toy room. Upon completion, each infant received an Infant Scientist Award certificate.

III. Results

Familiarization Trial

The total length of the familiarization trial was determined by the criteria detailed in the Method section. The mean familiarization trial duration for the habituated group was 506.25 seconds. There were no sex differences in the amount of time taken to habituate to the stimulus ($t(11,5) = 1.53$ $p<.05$). All but one member of the interrupted group accumulated 60 seconds of visually guided manipulation. The remaining infant was interrupted 160 seconds after her initial contact with the toys. Mean trial length for the interrupted group was 93 seconds.

In order to determine if the criterion of interruption had been appropriate, it was applied to the exploration curves of the habituated group. In this group as in the interrupted group all but one infant accumulated 60 seconds of visually guided manipulation before 160 seconds of trial time ; and the exploration of 12 of the 16 infants increased after the point at which they would have been interrupted. Of the four whose exploration decreased after attainment of interrupted criterion, three began the trial with a high percent of exploration (mean 93% during the first 20 seconds trial time). These data provide evidence that the interrupted infants were probably interrupted at the desired time --i.e., when their attention to the stimulus was still high and, in most cases, still increasing.

Separate one-way analyses of variance (ANOVA) were performed on the following measures: total duration of visually guided manipulation; mean duration of visually guided manipulation per toy; and the number of toys touched. The habituated group on average spent significantly more time (271.23 seconds) than the interrupted group (57.12 seconds) in visually guided manipulation, $F(1,30) = 22.63$, $p<.001$. The habituated group on average also explored a significantly greater number of toys (3.94) than did the interrupted group (2.75), ($F(1,30) = 6.52$, $p< .016$). There was no difference between the groups, however, in the average duration of visually guided manipulation per toy ($F<1$).

Inter-observer agreement of visually guided manipulation was calculated for eight infants from the habituated group, and eight infants from the interrupted group. The total number of seconds of agreement (both observers agreeing that behaviour was or was not occurring) was divided by total trial time. In the habituated group the mean inter-observer agreement was .90, and in the interrupted group it was .91.

In summary, during the familiarization trial, the habituated group explored more toys for a longer period of time than the interrupted group, as had been planned by the design of the study.

Test Trial

Time proportions are ratio scales, and the use of log transformations should better reflect the amount of variance that is accounted for by the experimental manipulation; therefore all the following analyses were performed with both proportions and log transformations of these proportions (ln = novel + 1/ familiar + 1). As results from the two analyses were almost identical, however, (F values varied by no more than .7) only data for proportions are reported.

20 Second Vision Period

A 2 x 2 x 2 ANOVA was performed on the proportion of the 20 second vision alone period at the start of the trial that the infant looked at the novel rather than familiar stimulus. Proportion novel was calculated by dividing the total number of seconds the infant looked at the novel stimulus by the total number of seconds s/he looked at both the novel and familiar stimuli. There were no significant main effects of the factors of amount of familiarization time (habituated - interrupted), location (novel toys in familiar or novel location) or sex of infant. Neither were there any significant two-way interactions. There was, however, a significant three-way interaction of familiarization time x location x sex $F(1,24) = 11.53$, $p<.002$. As is shown in Figure 4, the male infants paid attention to the novel location when they were in the habituated group, and paid attention to the familiar location when in the interrupted group, regardless of the location of the novel toys. There was no such consistency of visual preference with the female infants. Only female infants who were habituated and who encountered novel toys in the familiar location showed any preference.

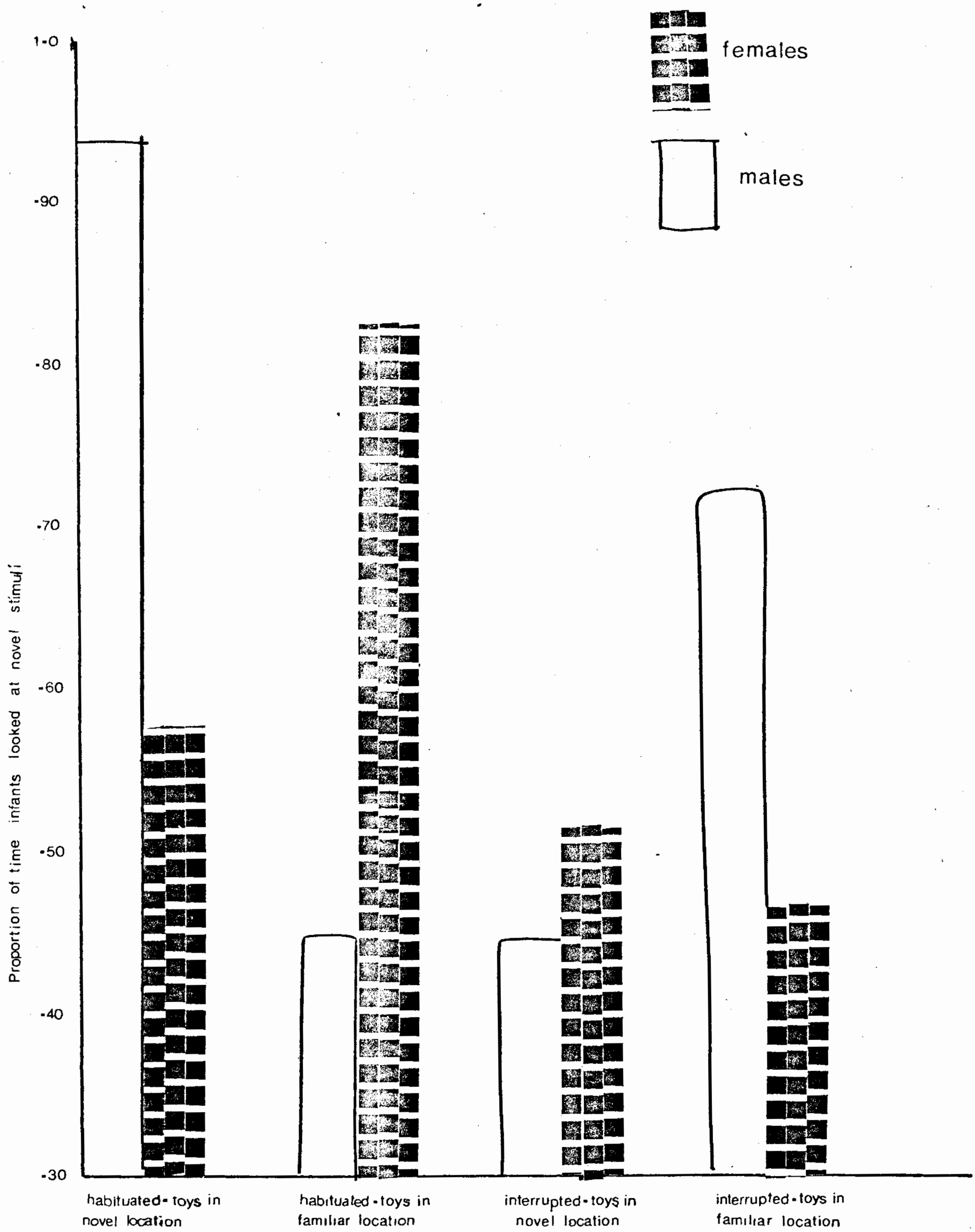

Figure 4: Looking pattern during 20 second vision alone period at start of test trial

Two 2 x 2 ANOVAS were performed on the factors of location and familiarization time with the groups divided by sex of infants. As expected, a significant location x familiarization time effect was found for male infants only; $F(1,12) = 10.37$, $p<.007$. No other interactions or main effects were significant.

10 Minute Exploratory Period

When released by their parents at the end of the 20 second vision alone period, all 16 of the infants in the habituated group went first to the novel toys regardless of whether they were in the familiar or novel location. Fourteen of these infants spent more than half the test trial exploring the novel toys. In the interrupted group, nine infants first touched a novel toy. Of these, five had the novel toys in the novel location, and four had the novel toys in the familiar location. Three of these nine infants stayed more than half their time with the novel toys: one infant who encountered the novel toys in the novel location, and two who encountered the novel toys in the familiar location. The other seven members of the interrupted group first touched a familiar toy. Of these, six had the familiar toys in the novel location and one had the familiar toys in the familiar location.

A 2 x 2 ANOVA was used to analyze the proportion of time spent exploring the novel toys using the factors of amount of familiarization time and novelty of toy location. The analysis showed that the habituated group spent a significantly greater proportion of time exploring the novel toys than did the interrupted group; $F(1,28) = 29.56$, $p < .001$. Means and standard deviations of exploration time are presented in Table 1.

Table 1

Proportion of time spent exploring novel toys in the test trial.

Group	Location	Mean	Standard Deviation
Habituated	Same	.8617	.2429
Habituated	Different	.8726	.2092
Interrupted	Same	.3020	.3126
Interrupted	Different	.3882	.3073

Whether the toys were in the novel or familiar location did not affect the proportion of time spent exploring the novel toys for either group ($F<1$).

If the toy preferences were a result of chance, the infants would be expected to spend approximately equal amounts of time with the novel and familiar toys. T tests were therefore performed for each group between their obtained mean proportions and the expected mean proportion of .5. Both groups differed significantly from the expected mean of .5. For the habituated group, $t = 5.24$, $df = 15$, $p < .01$. For the interrrupted group, $t = -2.21$, $df = 15$, $p < .05$.

Further analyses were performed to examine within and between group changes in the exploratory behaviour of the infants over the 10 minute test trial period (see Figures 5 and 6). The total trial time was first divided into five 2 minute blocks and a repeated measures ANOVA was performed on the proportion of visually guided mnaipulation per block using the between group factors of familiarization time, toy location, and sex of infant, and the within group factor of proportion of time spent per block engaged in visually guided manipulation cf the novel toys.

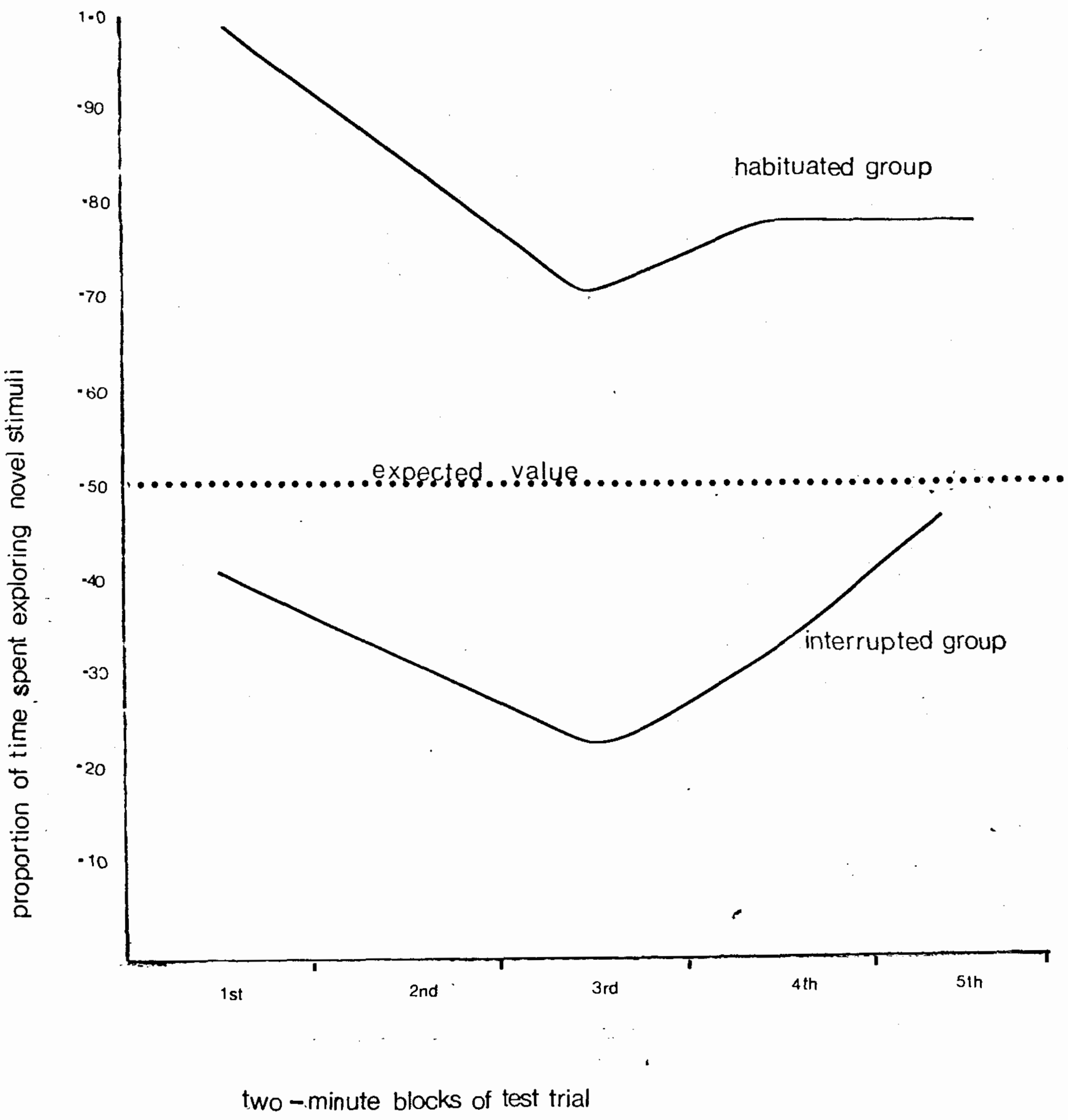

Figure 5: Behaviour over time in test trial: proportion of time spent with novel toys in each two minute block of test trial

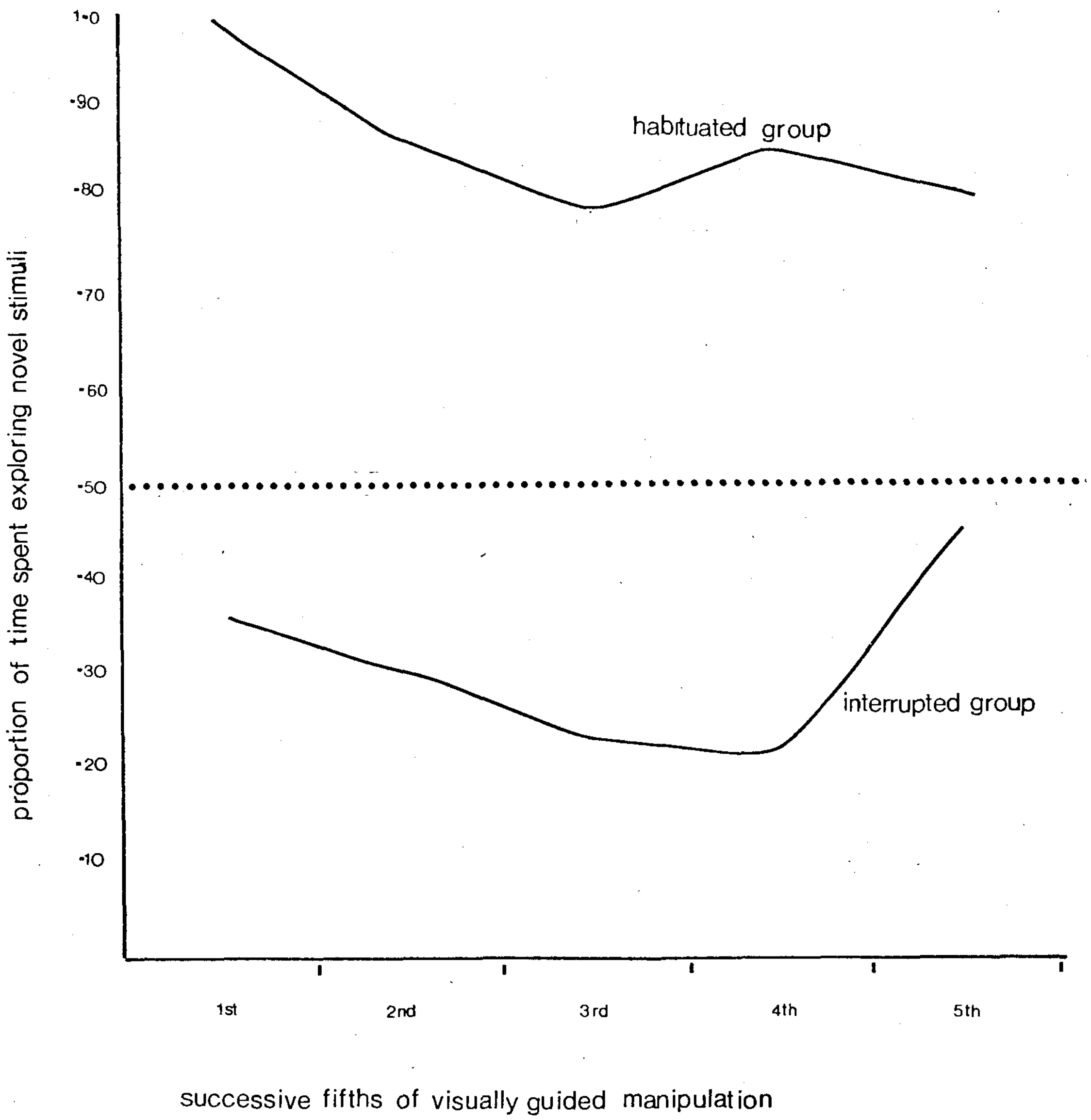

Figure 6: Behavior over time: proportion of time spent with novel toys in each fifth of visually guided manipulation in test trial

There was a main effect for familiarization time with the habituated group engaging in significantly more exploration of the novel toys than the interrupted group; $F(1,24) = 22.64$, $p < .001$. There were no significant main effects or interactions for the variables of sex or toy location (Fs < 1). There were no significant main effects or interactions of the within group measures, i.e. behaviour did not change significantly over the five 2 minute blocks.

The total amount of visually guided manipulation in the test trial was then computed for each infant and his/her total was divided into five segments. The proportion of time spent exploring the novel toys in each fifth was used in a repeated measures ANOVA with the factors familiarization time, toy location, and sex. Again, the habituated group showed a significantly greater proportion of time spent manipulating the novel toys over the five segments, $F(1,24) = 27.98$, $p < .001$. The variables of location and sex were not significant (Fs < 1), and within group behaviour did not significantly change over the duration of the test trial.

Summary

Infants who were assigned to the habituated group for the familiarization trial showed overall preference for exploratory play with novel toys in the subsequent test trial. Infants in the interrupted group showed an overall preference for exploratory play with the familiar toys. The pattern of behaviour of the two groups did not change significantly over time. There was no indication that the relative novelty of toy location had any influence on the behaviour of either group, nor were there any sex differences in behaviour.

IV. Discussion

The major purpose of this study was to determine the conditions in which 16-month-old infants would prefer to explore familiar or novel stimuli. The first hypothesis, viz. exploratory preferences for novel stimuli are experiential and determined by habituation, received strong support. Infants in the habituated group showed strong overall preference for the novel toys in the test trial.

Infants in the interrupted group showed overall preference for the familiar toys in the test trial. This finding was unexpected. Based on Hunter et al's (in press) findings, it was assumed that the five toy array, which had been a complex stimulus for 12-week-olds, would be a simple stimulus for the 16-month-olds. It was therefore expected that, consonant with previous findings for simple stimuli, the interrupted group would not show a significant preference for familiar toys, but simply show less interest than the habituated group in exploring the novel toys in the test trial. Instead, by demonstrating a preference for the familiar stimulus, they behaved in the fashion predicted for infants presented with a complex stimulus.

Two factors indicate that the 16-month-olds found the five toy array to be a complex stimulus: 1) the length of time taken by the habituated group to reach criterion in the familiarization trial, and 2) the behaviour of the interrupted group. The infants in the habituated group actually took longer to habituate to the toys in the familiarization trial than did Hunter et al's 12-month-olds with the complex stimulus. The latter took 410 seconds on average to criterion, while in the present study the average length of time required to achieve habituation was 506.25 seconds. The interrupted group in the present study had a mean familiarization trial length of 93 seconds. In the Hunter et al study, because five infants had to be interrupted after 160 seconds the trial was longer -- 107 seconds. This indicates that the 16-month-olds explored more actively during familiarization than did the 12-month-olds (and thus reached the interrupted criterion sooner). Not only did the interrupted group in the present study reach criterion very quickly, they also continued to interact significantly more with the familiar toys in the test trial. These differences in behaviour between the 12- and 16-month-old infants strongly suggest that the older infants required more interaction than the younger infants to complete exploration of the same five toy array. It appears, then, that Hunter's quantitative definition (i.e. number of toys) of age-related complexity may be limited to infants 12 months of age and younger.

It has generally been accepted that complexity can be defined relative to experience, with experience most frequently defined by age. Within this definitional framework, it had been expected that the greater experience of the 16-month-olds would render the toys less complex than they were for the 12-month-olds. However, this neglected the crucial role played by the information processing ability of the infant in the definition of complexity. The results of this study emphasize the importance of considering information processing ability rather than age _qua_ age. As Baldwin and Baldwin (1977) stated, as an individual grows older increased perceptual, cortical and motor skills give access to new domains of stimulus qualities. Complexity, then, can be defined only as an interaction between the physical stimulus properties and the information processing ability of the infant.

It is highly likely that the 16-month-olds, because of their greater information processing ability, were able to perceive properties and possibilities in the toys that were unavailable to either the 8- or 12-month-old infants. Support for this contention can be found in the literature on the development of symbolic play.

A 12 to 18 month qualitative shift in play toward increased symbolism was observed in studies by Fein and Clarke-Stewart (1973), Fein (1975), and Fenson, Kagan, Kearsley and Zebaso (1976). For example, Fenson et al found symbolic acts (pretend play) were absent at 7 and 9 months, and were evidenced by only one half of the 13-month-olds they studied. By 20 months however, all the infants performed symbolic activities with the toys.

It should also be noted that data exist (cf. El'Konin, 1966; Fein and Robertson, 1974) that show that in the early stages of pretend play (15-20 months) highly prototypical objects enhance pretending. The toys in the present study -- e.g. carpet sweeper, car, lunchkit -- were therefore likely to enhance pretending in the 16-month-olds. Given that the infants' pretend play behaviour is a function of both cognitive developmental level and the characteristics of the objects (Piaget and Marsky; cited in Fein and Clarke-Stewart, 1973), the conditions of the present study can be seen as optimal for eliciting and enhancing pretend behaviour as part of the exploratory play of the 16-month-olds infants.

Unfortunately no measures of pretend play were taken in the present study because there was no a priori reason for doing so. However, the investigator observed many behaviours suggestive of pretend play that had not been observed among Hunter's 12- or 8-month-olds. Toys were combined, for example, the mouse was put inside the cat, and attempts were made to ride the truck.

Inhelder, Lezine, Sinclair and Stamback (1972) found that the period between 12 and 18 months was one of transition between sensorimotor and symbolic functioning. Specifically, they observed numerous instances of discovering the properties of objects at 14 and 15 months, and found that from 15 months on objects were used not only according to their common function but also with respect to other appropriate objects in an integrated sequence.

Kagan's (1972) observations of responses to visual and auditory stimuli led to his postulation that some early form of hypothesis testing may begin as young as 9 months. Kagan's notion of early hypothesis activation was tested by Zelazo and Kearsley (1977, 1980). They investigated relational play (simultaneous association of two or more objects in an non-functional manner exclusive of stereotypic responding) and functional play (conventional use of toys). The highly significant age main effect in symbolic play they obtained suggested a cognitive metamorphosis occurring between 9 and 16 months of age. Zelazo and Kearsley argued that the critical qualitative changes in play during this period result from the infant's developing cognitive rather than neuromotor ability. They state that the change between 9 1/2 and 15 1/2 months

> (that) enables the infant to initiate a sequence of actions appropriate to a particular toy may be the increasing facility to activate prior knowledge of an object's functions and to direct it to a series of object specific manipulations. (Zelazo and Kearsley, 1980, p.113)

It may be concluded that due to age changes in cognitive ability or information processing, particularly as manifest in symbolic play, the exploratory play behaviour of 12- and 16-month-old infants is qualitatively different. Generalizations about the complexity of objects, therefore, cannot be made across ages because complexity is dependent not only on the physical properties of the stimuli, but also on the ability of the infant to explore beyond the properties of any given stimulus.

While the present data show that quantitative definitions of the complexity of objects cannot be generalized across ages, they also suggest that it may not be possible to have a quantitative definition of complexity at all. Many attempts have been made to show that stimulus complexity can be defined on a quantitative dimension despite the lack of consensus as to the relevant dimension. As previously discussed, complexity has been defined on a variety of dimensions -- asymmetry; amount of contour; number of parts; number of random turns in a figure; or number of objects in a set. The results of this study strongly suggest that all such quantitative definitions of complexity may be invalid because complexity cannot be measured independently of the organism. The complexity of an environment or a stimulus can really only be determined a posteriori by observing the exploring organism's reaction to it.

The final purpose of this study was to attempt to clarify the effects of environmental novelty on exploratory preferences and behaviour. Two separate aspects must be considered -- the total novelty of the situation, and the relative novelty of location of the toys in the test trial. The total novelty of the situation was not employed as a variable in the study, but some indication of the effects of the environmental novelty was given by the infants who were comparatively slow or refused to leave the parent; and those whose exploration was noticeably less than average. Two common observations were noted. First, the quietness of the room seemed to cause anxiety to some infants, particularly those from large families. Second, some infants who were regularly in day-care were particularly hestitant to leave their parent. As one parent explained, "I usually leave her when she starts playing with the toys." While the evidence for different exploratory behaviour among these infants is only anecdotal in the present study, the implications for future research are obvious.

The physical difference between the two locations in the experimental room was minimal. It was unlikely, therefore, that any infant who left his/her parent to explore in the familiarization trial would be hesitant to explore toys in the new location during the test trial. Compared to the novelty of the total experimental environment, the relative novelty of a location during the test trial was minimal.

While location change did affect the behaviour of Hunter et al's (in press) interrupted group, it was not by attentuating exploration. The infants in their interrupted group first entered the familiar location in the test trial, regardless of whether the toys there were familiar or novel. Overall, these infants explored the familiar toys more when they were in the familiar location than when they were in the novel location. It appears then, that if exploration of a stimulus is interrupted before it is complete, location is a strong cue in determining future behaviour. No similar location dependence was shown by the interrupted group in the present study. The only effect of location in the present study was in the significant three-way interaction of familiarization time x location x sex that was found in the analysis of looking time during the 20 second vision alone period at the beginning of the test trial. The interaction resulted from the male infants showing considerably greater spatial orientation than the females. The consistently used location was a cue, whereas there was no such consistent effect of location among the female infants.

Male tendency toward greater spatial orientation has been noted in older children, adolescents, and adults (cf. Maccoby and Jacklin, 1974). It is possible, although not likely, that such sex differences in spatial orientation were evidenced by infants in the present study. It should be noted that the measure of vision alone may not have been appropriate for the 16-month-old infants.

McQuiston and Wachs (1979) found that infants of this age in an environment with no restrictions on play, no interference, and variety in stimulation, use visually guided manipulation as the dominant mode of exploration. Very little visual exploration is likely to occur spontaneously. The measure of vision alone was included because the study was based on Hunter et al's (in press) methodology. While it is possible that their 12-month-old infants required the 20 second period to fully realize the relative location of novel and familiar toys, it was observed that the 16-month-olds needed less time. Most of the infants in the present study appeared to comprehend the situation in the first five to ten seconds, and spend the remaining time wriggling in an attempt to free themselves from their parent's grasp. Thus, measurement was somewhat gross, and the obtained interaction may have been artifactual.

In summary, 16-month-old infants who explore a stimulus until an individually defined criterion of habiutation is attained subsequently prefer novel stimuli. The amount of familiarization time needed for habituation depends on the relative complexity of the stimulus -- a concept that can best be defined as an interaction of stimulus properties and the infant's information processing ability. If the infant is given insufficient experience to habituate to a stimulus that is complex relative to the infant's information processing ability, a significant preference for familiarity is shown.

This study has presented further evidence, therefore, that rather than there being an age of preference for all things familiar followed at a later age by preference for all things novel, the familiar-to-novel sequence is more likely to represent phases of acquaintance with properties of an object as, through exploratory play, it moves from being less and less novel to finally being familiar. It seems appropriate, then, to give experiential rather than epigenetic interpretations to Hunt's assertion that:

> encounters with objects, patterns, persons and places lead to attentional preference for these familiar objects, patterns, etc., before they lead to preference for what is unfamiliar or novel. (Hunt, 1970, p.99)

V. Reference Notes

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