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Choice responding in infants and preschoolers: The effects of child control over stimulus presentation

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CHOICE RESPONDING IN INFANTS AND PRESCHOOLERS: THE EFFECTS OF CHILD CONTROL OVER STIMULUS PRESENTATION

by

Phyllis Jean Cushing

A Dissertation Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
1987

Approved by

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APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

Dissertation Adviser

Committee Members

6/23/87
Date of Acceptance by Committee

9/2/87
Date of Final Oral Examination

CUSHING, PHYLLIS JEAN, PH.D. Choice Responding in Infants and Preschoolers: The Effects of Child Control Over Stimulus Presentation. (1987) Directed by Dr. P. Scott Lawrence. 104 pp.

Studies of operant conditioning with infants have suggested that control over environmental events is reinforcing. Interpretations of the pleasure derived from controlling stimuli have been largely based upon observation and anecdotal reports of increased attention and positive affect (e.g., smiling, cooing) under conditions of infant-controlled stimulation and observations of negative affect (e.g., fussing, crying) when control is taken away.

The purpose of the present study was to empirically validate whether infants and young children do, in fact, prefer contingent over noncontingent stimulation. To accomplish this, children aged 12 to 51 months were provided with a series of opportunities to choose between contingent and noncontingent visual stimuli. The stimuli consisted of a series of slides of colorful cartoon and storybook characters projected onto plexiglass panels. Choice between the two schedules was used as a measure of preference. Rates of responding (i.e., panel pressing) to the two schedules following each choice were also analyzed.

Statistical analyses of child data indicated no preference for contingent over noncontingent stimulation based upon measures of choice responding to the two schedules. Differences between rates of responding to the two schedules following each choice were also found to be nonsignificant. Thus, the results of the present investigation do not confirm previous allegations as to the reinforcing value of control over stimulus events. The results are also in opposition to previous documentation of preference for control over reinforcer delivery with animals.

The results are discussed in terms of methodological issues which may be responsible for the failure to confirm previous suggestions of infant preference for control and to replicate animal findings of preference for control with human infants and preschool-aged children. Specific issues addressed are: (a) selection of preference measures, (b) the discriminability of contingent and noncontingent stimulation, (c) the ability to switch schedules, and (d) the availability of a response manipulandum under conditions of noncontingent stimulus presentation.

ACKNOWLEDGEMENTS

Appreciation is extended to Dr. Scott Lawrence for serving as my adviser and for his support and guidance in the completion of requirements for the degree of Doctor of Philosophy. Appreciation is further extended to the members of my committee for their guidance in completion of this dissertation as well as the excellent educational experiences provided to me by them throughout my graduate studies. Special thanks is given to Dr. Jim Favell of Western Carolina Center for his unbridled assistance to me in equipment programming and maintenance. Finally, I would like to express my gratitude to Ms. Pam Lowman for her assistance in the preparation of this manuscript and to Mr. Wayne deLoriea for his assistance in conducting statistical analyses.

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CHAPTER I

INTRODUCTION

One-year-old Elroy Smith is a veritable whirlwind of activity; an expert on fun and adventure. Zooming down the hallway in his plastic, no-door sedan, he spies an open door and makes his entry--the bathroom. Taking careful stock of the place, he comes across the toilet paper. He tugs on the piece of paper which so temptingly flutters from the end of the roll. He sets it in motion. A stream of white paper makes its way to the floor. Another tug...more paper. Faster and faster the roll spins. Elroy is really on to something. At a frenzied pace, he gets the roll up to 30 R.P.M. Too much! Elroy squeals with delight. This is truly high adventure! On hearing the laughter, Elroy's mother comes to the doorway. The fun abruptly ends. But, by noontime, he has discovered the source of power behind the television set...on...off...on...off...on... . Elroy's adventures are, at times, a source of great frustration for his mother. They are also a problem for behavior scientists who try to explain why Elroy behaves the way he does.

Accumulating demonstrations of operant conditioning studies with human infants have revealed that infants of all ages can learn at least simple contingencies between their own responses and environmental events (c.f., Hulsebus, 1973; Fitzgerald & Porges, 1971; Lancioni, 1980; Lipsitt & Werner, 1981; Millar, 1976; Sameroff & Cavanaugh, 1979).

Moreover, anecdotal and experimental evidence has been provided to indicate that control over environmental events is pleasurable to infants. This evidence includes (a) demonstrations of increased positive affect when engaged in operant performance (Rovee-Collier & Capatides, 1979; Uzgiris & Hunt, 1965; Watson & Ramey, 1972) and (b) demonstrations of negative affect when control over environmental events is taken away (DeCasper & Carstens, 1981; Rovee-Collier & Capatides, 1979).

This evidence has led to the proposal that "controllability" is a characterisitc of stimulus events that infants can discriminate and which seems to increase the reinforcing value of the stimulus. A leading advocate of this proposal is J.S. Watson (1966; 1972a, 1972b; 1981). Watson refers to the infant's ability to discriminate between contingent and noncontingent stimulus events as "contingency awareness." According to Watson (1966), "contingency awareness refers to an organism's readiness to react adaptively in contingency situations when they occur" (p. 123-124). He goes on to say that "the general reward value of a stimulus...will be raised if the stimulus has previously been contingent on the same or even a different response" (p. 133).

In looking at controllability, however, one must also consider the effects of controllability on the physical characteristics of the stimulus. It is highly likely that the qualities of the stimulus (e.g., rate, periodicity, intensity) under conditions of infant-controlled stimulus presentation will be different from the qualities of the stimulus under experimenter-controlled stimulus presentations. It is a well-established fact that infants can detect variations in stimuli along a number of dimensions and that they have definite preferences for some types of variations over others (c.f., Haywood & Burke, 1977; McCall & McGhee, 1977; Wach, 1977).

Let us return to Elroy for a minute. From a behavioral standpoint we would have to say that Elroy is being reinforced for his behavior because he continues to engage in it (at least until Mom arrives on the scene). What then is the nature of this reinforcement? Is it the spectacle of paper cascading off the roll and across the bathroom floor (i.e., stimulus change)? Is it his ability to control the flow of the paper? Or is it a combination of both of these factors? That is, would Elroy be equally delighted if he went into the bathroom only to find the roll spinning by itself?

The proposed study is intended to determine empirically whether or not the "controllability" of stimulus change has a significant effect on infants' choice responding between two stimuli varying along this dimension. To this end, a review of relevant literature is presented first to address the following questions:

- What types of stimulus change are reinforcing to infants?
- What behaviors of the human infant can be conditioned?
- What evidence is there to support the notion that infants are aware of the relationship between their own responding and changes in environmental events?
- What evidence is there that control is reinforcing to infants?

CHAPTER II

REINFORCING PROPERTIES OF STIMULUS CHANGE

Studies of infants' preferences for visual stimuli have led many investigators to adopt the discrepancy hypothesis as a theoretical framework to structure their findings and to guide future research. The discrepancy hypothesis had its origins in the 1950's with the writings of Dember & Earl (1957), Hebb (1955), Helson (1948), Leuba (1955), and Piaget (1952). Basically, the hypothesis predicts that organisms prefer and approach stimuli that are moderately discrepant from what is currently familiar to them. An inverted-U or butterfly-shaped relationship is thus predicted between the organism's approach to or preference for stimuli and the discrepancy of stimuli from the organism's current adaptation level. Preference therefore increases and then decreases as the amount of discrepancy increases in either direction from the organism's adaptation level.

The discrepancy hypothesis is intuitively appealing based upon informal observations of infants' attentional and exploratory behavior. An infant's interest in toys and other objects in his environment tends to wane with repeated exposure. Slight variations in these same objects often results in renewed interest and exploration. If, however, the variations are too different from what the infant is accustomed to, the infant may be hesitant to approach the object or may even display signs of fear. For example, if the infant's mother puts on a floppy hat, the infant may show increased interest and smile or laugh at the spectacle. If, however, she puts on a wig, a pair of glasses, or a fake moustache, the infant may hesitate in approaching her or begin to cry.

The limited motor abilities of the very young infant have resulted in the use of visual attention as the primary measure of stimulus preference. With older infants, choice responding has been used to determine preference. Measures of infants' affective responses (e.g., smiling) to stimulus variation have also been employed but to a far lesser extent. The following sections will provide an overview of studies using these three measures (attention, choice, affect) of preference for stimulus variation. As it turns out, verification of the discrepancy hypothesis is far from simple despite its intuitive appeal.

Studies of Visual Attention

Measurement

Two basic methods have been used to assess preference on the basis of visual fixation: (a) the visual preference technique and (b) the familiarization paradigm. The visual preference technique involves the presentation of a variety of stimulus patterns to an infant for an equal number of trials. The amount of time that the infant attends to each pattern is totalled across trials. If the infant looks at some of the patterns more than others, it is considered to be a demonstration that the infant preferred those patterns with the largest total fixation times. The familiarization paradigm consists of repeated presentation of a single stimulus pattern to an infant until it is presumed or demonstrated that the infant is familiar with the pattern. Following familiarization trials with the "standard" stimulus, the infant is presented with new stimulus patterns which differ from the standard along a number of dimensions. Again, total fixation times to all stimulus patterns are compared to determine preferences.

Stimulus Sets

The stimulus dimensions of complexity, novelty, and discrepancy have been the primary focus of investigations of infant preference. The distinction between these dimensions of stimulus change is often clouded, in that it is difficult to change one dimension without affecting another. In addition, the operational definitions within each dimension of stimulus change vary considerably from study to study. Operational definitions of complexity have included the number of elements in the stimulus patterns (Greenberg & O'Donnell, 1972), the number of positions of a flashing light (Cohen, 1969; Haith, Kessen, & Collins, 1969), the number of turns in a random shape (Hershenson, Munsinger, & Kessen, 1965), the degree of redundancy or asymmetry in a pattern (Fantz & Fagan, 1975; Karmel, 1969), the amount of contour (Karmel, 1969), and the number of squares in a checkerboard pattern (Brennan, Ames, & Moore, 1966; Greenberg, 1971; Thomas 1965). Novelty of stimulus patterns has also been manipulated in a number of ways, including the replacement of one, two, or three elements in a stimulus pattern with totally unfamiliar elements (McCall & Kagan, 1970) and the changing of one or more basic attributes (e.g., color or form) of the stimulus pattern (e.g., Cohen, Gelber, & Lazar, 1971; Saayman, Ames & Moffett, 1964; Welch, 1974). Whereas novelty refers to the presentation of unfamiliar stimulus patterns, discrepancy refers to the rearrangement of the pattern of elements in a stimulus (McCall & McGhee, 1977). Discrepancy has been defined by the degree of elongation or sphericity of rotating shapes (Zelazo, Hopkins, Jacobson, & Kagan, 1973), the pattern of arrangement of stimulus elements (McCall, 1973; McCall & Kagan, 1967; McCall & Melson, 1969), changes in the direction of pointing of arrowlike stimuli (McCall, Hogarty, Hamilton, & Vincent, 1973), and variation in the serial arrangement, symmetry of arrangement, and rotation of arrangement of stimulus elements (Super, Kagan, Morrison, Haith, & Weiffenbach, 1972).

Factors Affecting Attentional Preference

In general, it has been found that infants prefer more complex stimuli to less complex stimuli, they prefer novel stimuli to redundant or familiar stimuli, and they prefer discrepant presentations of stimuli to familiar presentations (c.f. Haywood & Burke, 1977; McCall & McGhee, 1977; Wachs, 1977). Beyond this general pattern, however, the patterns of infant preference are much less clear. A number of inconsistencies appear in the literature. For example, some studies (Cohen, 1969; Greenberg, 1971; Hershenson et al., 1965; Karmel, 1969; Thomas, 1965) have found that infants prefer intermediate levels of complexity, while other studies (Horowitz & Paden, 1969, cited in Greenberg & O'Donnell, 1972; Munsinger & Weir, 1967) have reported a linear relationship between complexity and infant attention. Similarly, some investigators have reported that infants prefer moderately discrepant or novel stimuli (Collins, Kessen, & Haith, 1972; Hopkins, Zelazo, & Kagan, 1973; McCall

& Kagan, 1967; McCall & Melson, 1969; Super et al., 1972; Zelazo et al., 1973) while others have reported a linear relationship between the magnitude of discrepancy or novelty and the amount of attention (McCall & Kagan, 1970; Saayman et al., 1964; Welch, 1974).

A number of factors have been found to contribute to an infant's preference for variations in stimulus patterns. Among these factors are age, sex, temperament or state of the infant, biomedical factors, genetics, and the experiential history of the infant (c.f. Haywood & Burke, 1977). Of all these factors, age and experience appear to be the most important in predicting an infant's preference.

The Effects of Age. A clear age-by-complexity preference interaction has been found in a number of studies of infant attention (Brennan, Ames, & Moore, 1966; Greenberg & O'Donnell, 1972; Greenberg & Weizman, 1971). In all of these studies, younger subjects tended to prefer less complex stimuli than older subjects. There is also fairly general agreement that infants' attention to novel stimuli increases with age (e.g., Uzgiris & Hunt, 1970). In fact, it has been found that infants up to five or eight weeks of age actually prefer familiarity to novelty (Greenberg, Uzgiris, & Hunt, 1970; Hunt, 1970; Uzgiris & Hunt, 1970; Weizman, Cohen, & Pratt, 1971). Despite the converging evidence of age-mediated preference for complexity, novelty, and discrepancy, conflicting evidence can be found (Horowitz, 1969; McCall & Kagan, 1967a). For example, Horowitz (1969) reported that the age-by-complexity preference prediction was not consistent for longitudinal changes of individual subjects or for groups of subjects.

The Effects of Experience. Knowledge of the infant's degree of familiarity with a particular stimulus dimension has been demonstrated to be a key factor in predicting preference for variation along stimulus dimensions. How, though, does one know what is familiar to an infant? The familiarization paradigm provides a starting point. In early studies, the familiarization paradigm consisted of the experimenter's deciding apriori the number of presentations of the "standard" stimulus that the infant would receive prior to test trials. It soon became apparent, however, that not all of the infants became equally familiar with the standard. Those who habituated to the stimulus during the familiarization trials showed a preference for discrepancy on subsequent test trials, while those who did not habituate to the standard did not show differential responding to discrepant presentations (e.g., McCall & Kagan, 1970).

The current approach for insuring infant familiarization with the standard stimulus is the "infant control" procedure (Horowitz, 1975). This procedure consists of providing as many presentations of the standard stimulus as are necessary, until the infants habituate to a certain criterion of fixation time. In addition, the stimulus is available on each trial until the infant looks away from it. When this approach is used, a more consistent pattern of infant preference (i.e. attention) is found for subsequent variations in complexity, novelty, or discrepancy. In fact, familiarization with the standard may override the effects of individual differences such as state, sex, and even age.

If younger and older infants are presented with the same number of familiarization trials with a standard stimulus, the older infants will demonstrate more preference for discrepant stimuli on subsequent test trials (Cohen & Gelber, 1975; McCall, 1971). If, however, both older and younger infants are presented with the standard stimulus until a given criterion of habituation to the standard occurs, the effects of age are eliminated. That is, the younger infants are just as likely to respond positively to the discrepant stimuli on test trials (Friedman, Bruno, & Vietze, 1974). Although the infant control procedure produces more consistent results than using a predetermined number of familiarization trials, it is not without its complications. The length of time required by infants to habituate to the standard can have considerable effects on their responses to test trials. Infants who require many presentations of the standard stimulus prior to habituation prefer greater magnitudes of discrepancy on test trials than do infants who require only a few trials before reaching the habituation criterion for the standard stimulus (McCall, Hogarty, Hamilton, & Vincent, 1973; McCall, Kennedy, & Applebaum, 1975, cited in McCall & McGhee, 1977).

In addition to variations of subject parameters (e.g., age, sex, state) and variations in procedures (e.g., visual preference technique, predetermined number of familiarization trials, infant control procedure of familiarization), there are also great differences in the stimuli which are used across studies. First, there is considerable variation in the types of stimuli which are used (two-dimensional vs. three-dimensional; chromatic vs. achromatic; movement vs. stationary).

Second, the methods used for the scaling of stimuli varies. Third, in some investigations the stimuli vary in dissimilarity along a single dimension, while in others the stimuli may vary along two or more dimensions (e.g., novelty and discrepancy). It is little wonder that inconsistencies are found across studies with regard to the function of infant preference for stimulus change. How does one try to make sense of it all? Can any conclusions be reached as to the specific factors or formulae which determine an infant's preference for stimulus change?

Discrepancy versus Relative Novelty

McCall & McGhee (1977) propose that inconsistencies in the literature regarding the relationship between discrepancy and infant attention are largely attributable to differences in the definitions of discrepancy. In particular, McCall & McGhee believe that a distinction must be made between discrepancy and relative novelty because the infant's cognitive processing of these two types of stimulus variation are quite different. Hence, the infant's attentional behavior will also vary as a function of which type of stimulus change is employed. According to McCall & McGhee, a quadratic trend will be found in the infant's distribution of attention when stimulus variation involves only discrepancy from the standard stimulus. If, however, stimulus variation involves changes in relative novelty, infant attention will be distributed in an increasing linear fashion with more attention given to greater degrees of novelty.

> Consider the cognitive processes involved when an infant confronts a new stimulus. First, the infant detects whether the stimulus is familiar or not. If it is familiar, then the subject is disposed to scan the memory

> for relevant engrams and continuously make a detailed comparison between the new stimulus and whatever appropriate memories exist in storage. This process engenders subjective uncertainty (Berlyne, 1966), and attention is predicted to be an inverted-U function of subjective uncertainty. However, if the infant decides that the new stimulus is not familiar, then no scanning or comparisons with memory engrams occurs; rather the stimulus is studied as a function of the amount of new but processable information contained in its physical form (e.g., contour density, color variation, and tonal rhythm). Attention increases linearly with the amount of "information potential" inherent in the physical nature of the stimulus. (pp. 190-191)

In support of their proposal, McCall & McGhee (1977) conducted a review and analysis of nine different experimental studies that only involved stimulus discrepancy and found consistent quadratic trends in attention as a function of magnitude of discrepancy. The nine studies that were analyzed involved a variety of stimulus scaling methods, familiarization procedures, and experimental designs. The nine studies included at least 17 separate samples of infants (ages 28 hours to 7 1/2 months) and five different stimulus sets. An inverted-U (quadratic trend) was found for all 17 infant samples. That is, infants of all ages preferred a moderate level of discrepancy from the familiarized standard stimulus.

McCall & McGhee (1977) further propose that when a stimulus set involves a mixture of discrepancy and variations in information potential (i.e., novelty and complexity), a combination of the inverted-U and the increasing linear function of attention will appear. That is, attention will be greater with both reductions in information potential (negative discrepancies) and increases in information potential (positive discrepancies) than it will be with the standard stimulus. Even so, attention to positive discrepancies will be greater than attention to negative discrepancies as a result of the residual information which is available for processing.

A study by McCall, Kennedy, & Appelbaum (1975, cited in McCall & McGhee, 1977) provides support for the notion of combined functions when stimulus sets involve both discrepancy and variation in information potential. They familiarized 2 1/2- to 3 1/2-month-olds with one of four black and white checkerboard patterns (2 x 2, 4 x 4, 8 x 8, or 16 x 16 checks). For some of the infants, subsequent presentations of a discrepant stimulus represented a shift toward greater information potential (e.g., switch from a 4 x 4 pattern to an 8 x 8 or a 16 x 16 pattern). For other infants, the discrepancy was a switch to a pattern containing less information potential (e.g., switch from an 8 x 8 pattern to a 4 x 4 or 2 x 2 pattern). The results showed a curvilinear trend for both directions of discrepancy; the inverted-U for positive discrepancies, however, was more inflected than it was for negative discrepancies.

Studies of Choice Responding

Measurement

With older infants, choice responding is frequently used as a measure of stimulus preference. For example, the PLAYTEST apparatus designed by Bernard Freidlander (1970, 1971) has been used to determine older infants' preference for a variety of stimuli. The PLAYTEST consists of a panel which can be attached to the infant's playpen or crib, a response counter, and a control unit. On the panel are two large transparent response knobs. The two knobs are independently programmed to produce different audiovisual feedback to the infant. An internal timer on the control unit can be set to reverse the position of each feedback at periodic intervals in order to control for possible position biases in the infants' responding. Infants are allowed access to the apparatus several times a day and cummulative records of their responding to each of the two knobs is compared to determine their preference for the different types of feedback.

Preferences

Using the PLAYTEST apparatus, Friedlander (1970, 1971) has demonstrated that infants are quite capable of discriminating the contingencies for the two types of feedback available and that they have definite preferences for some types of feedback over others. This preference is reflected by a greater frequency of responding for one of the two stimuli which are available. In general, Friedlander's work has demonstrated that infants produce higher response rates for more complex or varied stimuli than for less varied or redundant stimuli. For example, in one study (Leuba & Friedlander, 1968) 7-to 11-month-olds were presented with a choice between activation of the sound of a door chime and the simultaneous lighting of a small string of lights (channel 1) or activation of a single clicking noise (channel 2). Cummulative response records showed that the infants produced twice as many responses for activation of the more varied feedback (channel 1). In another study (Friedlander, 1970), infants were given the choice between two forms of the same auditory information. One channel produced a highly redundant segment of a story. The other channel produced a longer, less redunant segment of the same story. Over a 14-to 20-day period of choice responding, the infants produced two to three times as many responses to activate the less redundant story segment than they produced for the highly redundant story segment.

Cross-Over Effect

An interesting and persistent finding in Friedlander's (1970, 1971) work with the PLAYTEST is that infants often show an initial preference for less varied or more redundant stimuli followed by a rapid switch to more varied or less redundant stimuli, which is sustained thereafter. For example, in the study involving the story segments (Friedlander, 1970), the majority of infants showed an initial preference for the redundant story segment.

Thus, preference measured by choice responding with older infants is consistent with the findings of preference using attentional responses with younger infants. That is, the infants in Freidlander's studies showed a preference for more complex stimuli. In addition, more complex stimuli only occurred following experience (i.e., familiarization) with less complex forms of the same stimuli. This is evident in the cross-over effect.

Affective Responses to Discrepancy

Studies of infants' smiling to familiar and discrepant stimuli have been conducted but to a far lesser extent than have studies of attention. This is largely because smiling is a much less reliable and less prevalent behavior. What research has been done, however, is concordant with the patterns of attentional and choice behavior described above. For example, Zelazo & Komer (1971) conducted a familiarization procedure with 13-week-old infants using a brief auditory stimulus. They found that the most frequent smiling occurred during the middle trials of the series of presentations. Furthermore, smiling decreased considerably on the second day of testing. Similar results were also found in a comparable study (Zelazo, 1972) using a visual stimulus.

In a subsequent study (Zelazo, et. al, 1973), two different age groups of infants (5 1/2 - 7 1/2 months and 9 1/2 - 11 1/2 months) were compared using the familiarization procedure. It was found that the frequency of smiling for the younger group was curvilinear, rising gradually to a peak and then declining. In contrast, the older infants smiled during the first presentations and the frequency of smiling on subsequent presentations rapidly declined. Both groups of infants were then presented with a transformation of the standard stimulus (i.e. a discrepancy). The younger infants showed an immediate decline in smiling upon presentation of the first discrepant stimulus, whereas the older infants showed a rapid curvilinear increase in smiling and then a decline.

Following a three-week familiarization period in the infants' own homes, Super et. al. (1972) provided infants with repeated presentations of several degrees of discrepancy from the standard stimulus. On early trials the infants smiled at small degrees of discrepancy, but on later trials the frequency of smiling was greatest to more extreme discrepancies. Increased smiling to discrepancies in the moderate range has also been reported by Hopkins et al. (1975) in their study with 7-month-olds.

Finally, in a series of studies conducted by McCall (1972; McCall & Kagan, 1970; Melson & McCall, 1970, cited by McCall & McGhee, 1977) it has been shown that only those infants who habituate to the standard stimulus will exhibit increased smiling to discrepant presentations of the standard stimulus.

In short, studies of affective responses to stimulus discrepancy have revealed that the relationship of smiling to discrepancies closely parallels that of attention and choice responding to discrepant stimuli. Why though does smiling occur to presentations of discrepant stimuli?

<u>Smiling as an Index of Perceptual-Cognitive Processing</u>

Zelazo (1972) and McCall (1972; McCall & McGhee, 1977) propose that smiling occurs as a function of perceptual-cognitive processes. More specifically, they propose that habituation to a standard stimulus during the familiarization phase of discrepancy studies signifies that the infant has developed a memory engram for the standard stimulus. Subsequent introduction of a transformation of that stimulus (i.e., discrepancy) results in the infant's retrieval of the memory engram and a sustained comparison of the discrepant stimulus with the memory of the standard. The fact that the discrepant stimulus does not exactly "match" the memory of the standard produces a state of subjective uncertainty which is accompanied by a state of tension (McCall & McGhee, 1977). Resolution of this state of subjective uncertainty and consequent relief from tension can only occur if the infant is successfully able to relate the new stimulus to the existing memory. In Piagetian terms, this involves the cognitive processes of assimilation and accomodation. Smiling is an indication of successful assimilation or a cognitive matching of the transformed stimulus with the existing memory engram, in that it follows relief from the tension generated by subjective uncertainty.

Haith (1972) proposes a slightly different interpretation of infants' smiling to discrepancies. While not disputing the cognitive processes proposed by Zelazo and McCall, he believes that they overlook the intrinsic pleasure derived from learning. According to Haith; "Smiling does not reflect recognitory assimilation...per se; it reflects the pleasure resulting from these accomplishments" (p. 322).

In summary, stimulus change appears to be a reinforcing event for infants, providing that the changes are not too discrepant from what is already familiar to the infant. It has also been shown that preference for variation is idiosyncratic across infants and is based upon factors such as age, experience, and their individual habituation rate. It has also been proposed that intermediate levels of stimulus change are rewarding to infants because they present a cognitive challenge which can be achieved. That is, "cognitive control" over stimulus events is pleasurable. In the next section the effects of providing infants with the opportunity to physically control stimulus events (i.e., operant conditioning) will be explored.

CHAPTER III

OPERANT CONDITIONING WITH INFANTS

Newborn Learning

Given the proper environmental arrangements, infants as young as one to four days of age have been found capable of learning a simple contingency between their own behavior and an environmental event (Butterfield & Sipperstein, 1972; DeCasper & Carstens, 1981; Lipsitt, Kaye, & Bosack, 1966; Siqueland, 1968; Sameroff, 1968, 1972; Krafchuk, Sameroff, & Barkow, 1976, cited in Sameroff & Cavanaugh, 1979). As a result of the limited motor abilities of newborns, the majority of operant studies have used sucking or headturning as the response to be conditioned and have used gustatory reinforcers (e.g., dextrose, milk).

Sucking

Lipsitt, et. al. (1966) demonstrated that newborn infants could be conditioned to increase their sucking of a rubber tube (previously a weak elicitor of sucking) when dextrose was delivered through the tube during the last five seconds of each 15-second insertion of the tube into the infants' mouths. A control group received an equal amount of dextrose solution, but dextrose delivery occurred only during the intertrial interval between tube insertions. No increase in sucking on the tube was found for the control group.

Sameroff (1968, 1972) also demonstrated conditioning of newborn sucking through contingent nutritive reinforcement. Infants were differentially reinforced for one of two types of sucking (a) direct suction/negative pressure or (b) expression/positive pressure. It was demonstrated that the infants changed their ratio of positive and negative pressure sucking as a function of the type of sucking which was reinforced.

Using vocal music as a reinforcer, DeCasper & Carstens (1981) demonstrated that another aspect of newborns' sucking patterns could be conditioned. They calculated the infants' interburst intervals for sucking during baseline. Then, they determined the 70th percentile of the interburst intervals. This was used as the criterion for presentation of vocal music during the conditioning phase. It was shown that infants learned to increase the spacing between bursts of sucking when reinforcement (i.e., singing) was contingent upon greater spacing of sucking. Infants receiving noncontingent singing did not show changes in their sucking patterns.

Butterfield & Sipperstein (1970) also used music as a reinforcer for variation in newborn infants' sucking patterns. Using one- and two-day-old infants, they demonstrated that the infants switched to longer sucking durations when music was contingent upon sucking and decreased their sucking when the onset of sucking terminated the music.

<u>Headturning</u>

Siqueland (1968) used nonnutritive sucking as a reinforcer for headturning. Using newborns as subjects, a headturn of 10 degrees in either direction was reinforced by allowing the infants to suck on a nonnutritive nipple for five seconds. Following 25 reinforcements, eight infants who were on a CRF schedule of reinforcement increased their rate of headturning from five to eighteen responses per minute. A second group of eight infants were started on a CRF schedule, but switched to a FR3 schedule. These infants increased their rate of headturning to 25 responses per minute. Also included in the study was a group of infants who were reinforced for not making a head movement for 20 seconds (DRL 20). This group showed a nonsignificant decrease in headturning. Most important, this last group argues against elicitation as a factor in the increase in headturning for the other two groups of infants.

Learning of Older Infants

Operant conditioning with newborns has been somewhat restricted as a result of their limited motor abilities; however, numerous studies have been conducted with older infants. A number of infant behaviors and reinforcing consequences, in various combinations, have been used in demonstrations of successful conditioning with infants between three and eighteen months of age. Infant behaviors which have received experimental attention have included arm movements, leg kicking, looking, vocalizations, as well as the operation of manipulandum such as levers and panels. Reinforcing consequences have been similarly varied and have included visual, auditory, gustatory, and tactile stimuli. In addition to demonstrations of simple operant learning, several studies have shown more complex learning abilities with older infants.

Sucking

Conditioning of sucking has also been demonstrated with older infants. For example, Siqueland & Delucia (1969) showed that four- and eight-month-old infants would increase or decrease their rate of sucking of a nonnutritive nipple when visual reinforcement was presented or withdrawn contingent upon sucking. In this study, a conjugate reinforcement schedule was used in which the intensity of the visual reinforcer was directly related to the rate of sucking. A more detailed discussion of conjugate reinforcement will be presented in a later section of this paper.

Headturning

Headturning has similarly been used as an operant in studies of instrumental conditioning with infants beyond the newborn period (Caron, 1967; Caron, Caron, & Caldwell, 1971; Levison & Levison, 1967; Siqueland, 1964; Watson & Ramey, 1972). For the most part, however, it has been restricted to infants four months of age or younger due to the increasing motor abilities of infants beyond this age.

Conditioning of headturning with older infants has typically involved the use of visual reinforcers as opposed to the use of nutritive or nonnutritive sucking used with newborns. There has also been an attempt to control for the possible eliciting effects of the visual reinforcer by requiring headturns in a direction away from the reinforcer. To accomplish this, several studies have incorporated a prompting procedure on the first few conditioning trials. For example, Levison & Levison (1967) in conditioning three-month-olds used a small blinking light to the side to elicit headturning in a direction away from midline (reinforced response) for the first three trials. Visual reinforcement occurred in the midline position. Similarly, Caron (1967) and Caron et. al. (1971) elicited a 20 degree headturn to the left by having the infants track a rattle or beads from midline to that position for the first two or three responses. Again, the visual reinforcer for headturning was located at the midline. Siqueland (1964) accomplished conditioning of headturning in a direction away from the reinforcer with four-month-olds without the use of eliciting stimuli.

Manipulative Responses

The increasing motor coordination of infants beyond three months of age enables investigation of a number of responses that are not possible with very young infants. In particular, the infant's arm movements and hand movements (e.g. reaching and grasping) become increasingly skilled and, thus, conditionable. At the same time, the increasing activity and motor coordination of the infant makes it much more difficult to condition behaviors requiring a passive subject in a supine position (e.g. sucking, headturning). Consequently, investigations of operant conditioning with older infants have most often involved infant behaviors consisting of arm, hand, and leg movements.

Studies, of operant conditioning of manipulative responding may be divided into two types (a) discrete reinforcement, in which each response produces a predetermined reinforcing event (e.g. chime, colored lights, music) and (b) conjugate reinforcement, in which the intensity of the reinforcer is directly determined by the intensity of the infant's responding (e.g. harder or faster kicks produce increased movement of an overhead mobile). Thus, with discrete reinforcement the experimenter determines the duration and intensity of the reinforcer, whereas, with conjugate reinforcement the infant determines these same qualities of the reinforcer.

Discrete Reinforcement. In a classic study by Millar (1972) four- and eight-month-olds were conditioned to increase their rate of arm pulling when audiovisual reinforcement was contingent upon this behavior. The infants were seated in front of a white plexiglass panel which housed colored lights and miniature loudspeakers. Nylon cords were pinned to the cuffs of the infants' clothing in such a manner than an armpull in a direction away from the panel resulted in activation of the lights and sound. Infants receiving noncontingent reinforcement did not demonstrate an increase in armpulling. A similar procedure was used in an earlier study by Lipsitt (1963) in a demonstration of discrimination learning with eight-month-olds.

In a more recent study, Finkelstein & Ramey (1977, Experiement 1) replicated Millar's (1972) study with six- to ten-month-olds. Infants participated in eight-minute conditioning sessions each day across four consecutive days. Infants receiving contingent audio-visual reinforcement for armpulls showed an initial increase in armpulls in contrast to a noncontingent control group. On the fourth day, however, the contingent group showed a decrease in armpulling and the control group increased their armpulls such that there was little difference in rates of armpulling between the two groups. The authors interpreted these finding as a declining value of the reinforcer across days for both groups. The contingent group was no longer interested in "working" for the reinforcer and the noncontingent group's agitation resulted in overall increased activity which included increased arm movements.

In light of these results, Finkelstein & Ramey (1977, Experiment 2) conducted a second study with six-month-old infants using a similar reinforcer in a discrimination training procedure. This time, however, the response to be conditioned was movement of a lever as opposed to arm pulls. In this investigation, a clear conditioning effect was found. Lever movement for the contingent group rose sharply and remained at high levels across conditioning days, whereas lever movement for the noncontingent control group remained at or near baseline levels. Manual manipulation in the form of panel pressing (Lipsitt, Pederson & DeLucia, 1969; Simmons, 1964) and touching knob-like manipulandum (Friedlander, 1970; Leuba & Friedlander, 1968) have also been successfully conditioned in infants between seven and 12 months of age.

Conjugate Reinforcement. Conjugate reinforcement deserves special mention because of its proven ability to maintain high and prolonged rates of responding in human infants. This procedure consists of variations in the intensity of a reinforcer which are directly related to the intensity of the infant's responding. Reinforcement is not episodic but rather is continuously available and at maximum intensity. Rovee-Collier and Gekoski (1979) argue that the effectiveness of conjugate reinforcement with infants is largely due to the fact that it more closely approximates those conditions which the infant encounters in the natural environment.

> Finally, the conjugate schedule more accurately reflects the normal pattern of infant-niche interactions than do traditional reinforcement schedules. An infant typically exhibits responses (e.g. crying, sucking) which vary along a number of quantitative dimensions (e.g. loudness, pressure). These, in turn, effect consequences which also vary in a manner which corresponds roughly to the rate and/or amplitude of the original response (e.g. mother approaches more rapidly and with additional vocalizations to louder and more frequent cries; milk comes quicker and is more plentiful following faster and harder sucks). (p. 199-200)

Conjugate reinforcement has been used to condition a number of infant behaviors including sucking, legkicking, and panel pressing (see Rovee-Collier & Gekoski, 1979 for an excellent review). Conjugate reinforcement of sucking was discussed in an earlier section. This discussion will be confined to manipulative responding (i.e. hand, arm, and leg movements).

The most frequent application of conjugate reinforcement to infant conditioning has been footkick-produced visual stimulation. Rovee and Rovee (1969) provided the first controlled demonstration that infant legkicks could be operantly conditioned using conjugate reinforcement. Two- and three-month-old infants could activate an overhead mobile by means of a ribbon which was attached between their ankle and the mobile. Increased rates of legkicks produced more intense movement of the mobile (i.e. colliding figures). The infants showed high and stable rates of legkicking throughout the 15-minute conditioning session. Within three minutes, their rate of legkicks had doubled their baseline rates and within six minutes of conditioning most had tripled it. Responding returned to baseline levels during a subsequent 5-minute extinction period (i.e. motionless mobile). Control subjects receiving noncontingent mobile movement showed no change in rate of legkicking across the three experimental phases (motionless mobile, noncontingent movement, motionless mobile). These findings have been replicated in a number of other investigations (Siqueland, 1968; Rovee & Fagen, 1976; Rovee-Collier, Morrongiello, Aron, & Kupersmidt, 1978; Rovee-Collier & Capatides, 1979).

Rovee-Collier et. al., (1978) further demonstrated that infants quickly learned to differentiate whick leg controlled responding. Following an initial conditioning session, infants were re-conditioned, but this time they were reinforced for movement of the originally nonpreferred (less active) leg. All 13 infants in the study showed a spontaneous switch to movement of the alternate leg. Five of the infants then received an additional reversal of contingencies in which reinforcement of the two legs was again switched. Four of the five infants showed a rapid and complete switch in leg dominance.

Lipsitt, Pederson, & Delucia (1966) used a conjugate reinforcement procedure with 12-month-old infants. The infants were seated in front of an initially darkened viewing box. Pressing a panel which was mounted on the viewing box resulted in illumination of the box's interior which housed a rotating picture of a colorful clown. Increases in the rate of panel pressing produced gradual increases in the frequency and intensity of illumination. The infants demonstrated rapid and reliable acquisition of the contingency.

Discrimination Learning

Operant conditioning procedures have demonstrated that infants can learn simple discrimination problems at a very young age. Using his own infant as an experimental subject, Sheppard (1969) reported discrimination learning to occur before the age of three months. Following successful conditioning of his infant's vocalizations, Sheppard instituted a disjunctive schedule in which a light was a signal (S^D) that vocalizations would be reinforced and kicking would not be reinforced. The absence of the light was an S^D that kicking would be reinforced and vocalizing would not be. The infant learned to adjust his behavior in accordance with the schedule. Sheppard's demonstration of differential responding under stimulus control was the first such demonstration with an infant under three months of age.

Routh (1969) has also reported discrimination abilities in very young infants. Infants aged two to seven months were differentially reinforced over a five-day period for emitting vowel or consonant sounds. Reinforcement consisted of social reinforcement by the experimenter in the form of smiling, three "tsk" sounds, and light stroking of the infant's abdomen. The infants showed a significant change in their ratio of emitted vowel and consonant sounds in line with the conditions of reinforcement.

By and large, discrimination learning has been most often demonstrated with older infants (6-18 months). Discriminative stimuli have included different colored lights (Lipsitt, 1963; Simmons, 1964), different tones (Silverstein, 1972), the presence or absence of a visual stimulus (Finkelstein & Ramey, 1977, Experiement 2), a continuous vs. a flashing light of the same wavelength (Weisberg & Simmons, 1966), and different geometric figures (Weisberg, 1969).

Simmons (1964) trained 12-month-olds to differentially respond in the presence of a red and blue light in a single session. In the presence of a red light (S-) panel pressing was reinforced by an auditory stimulus (two-tone door chime). Panel pressing was not reinforced in the presence of the blue light (S=). This procedure was replicated and found successful in training discriminative responding to eight-month-olds by Lipsitt (1963). Using an armpull response as an operant, responding was differentially reinforced in the presence of a red and green light. Illumination of a lamp was the reinforcer. The infants were found to be capable of making this distinction and responded accordingly. Interestingly, Lipsitt also attempted to teach the infants an oddity problem but was unsuccessful.

Even more difficult discriminations have been successfully trained using operant techniques with infants one year of age or older (Weisberg, 1969; Weisberg & Simmons, 1966). For example, using an adapted Wisconsin General Test Apparatus, Weisberg & Simmons (1966) taught 12-to 16-month-olds to discriminate between two geometric figures. Bits of cookie and cereal were used in reinforcers for correct responding. Following successful performance on the original discrimination problem, some infants were also successful on a reversal of the discrimination. Finally, the work of Bernard Friedlander using the PLAYTEST apparatus (discussed earlier) demonstrates that older infants are quite capable of performing discriminative responding.

Effects on Future Learning

Enhancement Effects of Response-Contingent Stimulation

Experience with response-contingent stimulation appears to have additional benefits which extend beyond the immediate learning situation. Learning to control environmental stimulation has been shown to enhance an infant's ability to learn new contingencies (Finkelstein & Ramey, 1977; Ramey & Finkelstein, 1978).

In a series of three experiments conducted with infants ranging from 4 1/2 to 10 months of age, Finkelstein & Ramey (1977) provided evidence to show that infants who experienced response-contingent stimulation showed superior performance on a subsequent learning task compared to infants who received no prior experience with contingent stimulation. In their first experiment, a group of 10 infants between the ages of 6 and 10 months were given a pre-test on an operant conditioning task. The task consisted of a panel press response which controlled the presentation of colored lights. Following the pre-test, half of the infants were trained to make an armpull response which resulted in audiovisual stimulation (vocal-instrumental music and a slide of an unfamiliar adult female face). Training took place across four consecutive days. The other infants (Control Group) received noncontingent presentations of the same audiovisual stimuli across the four days. Following training on the armpull response, the infants were again presented with the panel press task (post-test). A comparison of the children's pre- and post-test responding revealed that only those infants who received prior experience on the armpull task showed a significant increase in responding between pre-test and post-test.

A similar enhancement effect of prior experience with response-contingent stimulation was demonstrated in a second study with 6-month-olds (Finkelstein & Ramey, 1977, Experiment 2). Infants receiving prior training on a lever movement response to produce audiovisual feedback demonstrated enhanced performance on a subsequent task requiring vocalizations to produce a visual reinforcer. Infants receiving noncontingent stimulation in a manner identical to their pairmates in the contingent group (i.e. yoked control) did not show transfer effects. Interestingly, neither the contingent group nor the yoked control group learned to perform a panel press response to control the same audiovisual stimulation which was used in the previous treatment sessions for both groups of infants.

To control for the possibility that the enhancement effects described above were not the result of a generalized "energizing effect" of contingent stimulation on all responses in the infant's repretoire, Finkelstein & Ramey (1977, Experiment 3) conducted a third study in which a discrimination learning task was employed as the post-test. They reasoned that in a discrimination task high rates of responding do not ensure successful learning, but rather the infant must learn when responding results in reinforcement and when it does not and adjust their responding accordingly. The authors also employed a No Stimulation control group to determine whether "...posttest differences were due to (1) a facilitating effect of prior contingent stimulation, (2) an interference effect of prior noncontingent stimulation, or (3) both." (p. 815). The initial task consisted of controlling the onset of audiovisual stimulation through vocalizations. Infants receiving contingent stimulation increased their rates of vocalization over a six-week training period. Infants receiving no stimulation during experimental sessions did not change their rate of vocalization. More important, only the infants experiencing prior response-contingent stimulation learned to discriminate conditioning and extinction periods in the subsequent lever pressing task.

In a subsequent investigation, Ramey & Finkelstein (1978) demonstrated that the positive transfer effects of experience with response-contingent stimulation can also be trans-situational. Three-month-olds who experienced response-contingent stimulation in their own homes showed enhanced learning on a new task in a laboratory setting compared to infants who received no additional stimulation in their own homes prior to encountering the new task in the laboratory.

Evidence is also available which suggests that the provision of response-contingent stimulation to infants is positively associated with cognitive and social development. Positive correlations have been found between the amount of social and nonsocial contingent stimulation experienced by the infant and the infant's performance on scales of infant intelligence (Yarrow, Rubenstein, Pedersen, Jankowski, 1972). Other investigators (Ainsworth & Bell, 1974; Clark-Stewart, 1973; Lewis & Goldberg, 1969) have similarly concluded that mothers' contingent responding to their infants' behaviors is correlated with the infants' social and cognitive competence. Although these findings are intriguing, they are correlational data and must be viewed cautiously.

Interference Effects of Prior Exposure to Noncontingent Stimulation

The effects of noncontingent stimulation on future learning have been similarly investigated and evidence has been provided which suggests that exposure to noncontingent stimulation can have a detrimental effect on future learning (DeCasper & Carstens, 1981; Finkelstein & Ramey, 1977; Watson, 1971, 1977; Watson & Ramey, 1972). Watson (1971; Watson & Ramey, 1972) presented 2-month-olds with a mobile that rotated noncontingently for 10 minutes a day over a 14-day period. Later, the infants were brought into a laboratory situation where the mobile was made contingent upon the infants' behavior. These infants failed to learn the relationship between their own responding and mobile rotation. By comparison, a group of infants who had experience with contingent mobile rotation over the same 14-day period did learn the contingency when brought into the laboratory. A third group of infants who had simply been exposed to a stationary mobile for the 14-day period also learned the contingency when brought into the laboratory. Six weeks following the initial laboratory task, the infants were brought back again for a second try. Although the infants had no intervening mobile experience, the infants who had previously received noncontingent mobile movement still did not learn. More recently, Watson (1977) has provided anecdotal reports of similar difficulties in conditioning two-month-olds to produce movement of an overhead mobile. He attributed this difficulty to the increasing incidence (60%) of commercially available mobiles to which young infants were exposed.

Interference effects of noncontingent stimulation have also been demonstrated with infants older (Finkelstein & Ramey, 1977) and younger (DeCasper & Carstens, 1981) than the infants in Watson's studies. DeCasper & Carstens (1981) discovered that exposing newborns to 15 minutes of noncontingent singing 4 to 24 hours prior to a conditioning session in which the same auditory stimulation was contingent upon alterations in sucking patterns, prevented them from learning the contingency. Finkelstein & Ramey (1977, Experiments 1 & 2) have also reported interference effects when six-and nine-month-olds were exposed to noncontingent stimulation over a three or four day period, respectively, prior to conditioning. These effects were found when the stimuli used in conditioning were the same (6 months) or different (9 months) from the stimuli used in the previous sessions of noncontingent exposure.

Negative transfer effects as a result of exposure to noncontingent stimulation are common; however, exceptions have been reported (Ramey & Finkelstein, 1978; Millar, 1972, Experiments 3 and 4; Gekoski & Fagen, 1984). For example, Ramey & Finkelstein (1978) found no differences in the ability to condition three-month-old infants who had received prior contingent or noncontingent stimulation. In this study, infants in the contingent group were exposed to brief presentations of a cartoon movie plus music in their own homes contingent upon nonfussy vocalizations. Infants in the noncontingent group received the same pattern of stimulation (i.e. yoked control). Both groups of infants learned to control the presentation of a visual stimulus (color slide of a toy animal) through a visual fixation response in a subsequent laboratory-based conditioning session. Infants who were not exposed to the prior stimulation (cartoon movie and music) did not learn to control the presentation of the visual stimulus in the laboratory test.

Millar (1972, Experiments 3 & 4) also found that exposure to noncontingent stimulation did not have a detrimental effect on future learning. Six- and seven-month-olds who were exposed to a brief (3 minutes) period of noncontingent stimulus presentation immediately prior to a conditioning session were found quite capable of learning to control (armpull response) the stimulation. In fact, brief noncontingent stimulation appeared to have a <u>facilitative</u> effect on subsequent conditioning. This is in direct contrast to the findings of DeCasper & Carstens (1981) who found an interference effect of brief exposure to noncontingent stimulation.

Noting the equivocal findings regarding the effects of noncontingent stimulation on subsequent learning, Gekoski & Fagen (1984) attempted to delineate the conditions under which noncontingent stimulation would and would not interfere with subsequent conditioning. Two experiments were conducted to assess the effects of noncontingent exposure to an overhead mobile on subsequent conditioning of a legkick response to produce mobile movement using three-month-olds as subjects. Variations in the methods of noncontingent exposure consisted of (a) exposure to noncontingent stimulation versus no prior exposure, (b) long-term versus short-term prior exposure, (c) exposure to moving versus stationary mobiles, (d) exposure to the same or to a different mobile than the one used in conditioning, and (e) exposure to the same (jerky) or to a different (rotating) type of mobile movement than the one encountered in conditioning. These variables were combined in a number of ways across the two experiments.

Of all these factors, the only one which was found to interfere with subsequent conditioning was a combination of factors c and d described above. Infants exposed to a stationary mobile prior to conditioning did not learn to produce legkicks to control mobile movement. However, this was only true when the same mobile was used in the noncontingent and contingent phases. Infants who had prior exposure to a stationary mobile that was different from the mobile used in conditioning, were successful on the conditioning task in which a novel mobile was used. The authors interpreted their findings on the basis of expectancy theory and, more specifically, the discrepancy hypothesis: "...they found the moving mobile interesting, yet it may have been so discrepant from what they had learned to expect from this stimulus that they did not kick very much because a high rate of kicking would make the mobile too discrepant from what they were use to." (p. 2231).

Overall, the evidence provided by operant conditioning studies with infants demonstrates that they can learn at a very early age and that learning occurs quite rapidly when proper arrangements are made to allow them to experience such contingent relationships. Futhermore, the benefits derived from response-contingent stimulation appear to extend beyond the immediate learning effects. Contingency experience has been shown to enhance the infant's ability to learn future contingencies as well as contingencies occurring in different situations. The effects of experience with noncontingent stimulation are less clear. However, it has been shown that under certain circumstances exposure to noncontingent stimulation can interfere with the infant's ability to recognize and respond to subsequent response-contingent stimulation. Taken together, the advantages of providing infants with a responsive environment are readily apparent.

In addition to increases in the rate of operant responding, concomitant changes in attentional and affective behaviors are frequently observed during conditioning sessions with infants. These behavior changes have prompted many investigators to propose that infants derive pleasure from controlling stimulus presentations and, thus, prefer contingent stimulation over noncontingent stimulation. A review of these concomitant behavior changes is presented next.

Concomitant Changes in Attention and Affect

Changes In Attention

Increases in infant attention have been reported to occur when stimulation is presented contingently. Foster, Vietze, & Friedman (1973) provided infants with an opportunity to observe a noncontingent moving mobile. Following habituation to the stimulus, as measured by visual attention, the infants were provided with the opportunity to control the movement of the mobile. A ribbon was attached to the infant's ankle and to the mobile such that legkicks produced mobile movement. This resulted in a recovery of the infants' attention to the previously habituated stimulus. Rovee and Fagen (1976) showed similar increases in attention to a response-contingent mobile. In this study, three-month-olds were presented with response-contingent mobiles over four consecutive days. Each day consisted of a 3-minute baseline during which the mobile was visible but nonresponsive, a 9-minute period of response-contingent mobile movement, and a 3-minute extinction phase during which the mobile was visible but once again nonresponsive. Significant increases in visual attention to the mobile occured between the baseline and conditioning phase on Day 1. Attention also increased linearly across the daily baseline periods and remained essentially asymptotic in all blocks except extinction. Attention decreased considerably in all extinction periods. In essence, attention paralleled the pattern of operant responding (leg kicks) produced by the infants.

In other studies, functional relationships between attention and response-contingent presentation of stimulation have not been found. Rovee-Collier and Capatides (1979) found no significant difference in infants' visual attention to a contingent and noncontingent mobile when they were presented in alternation to each infant. One mobile was responsive to the infants' leg kicks and the other remained motionless. Similarly, Finkelstein & Ramey (1977, Exp. 2) found no relationships between attention to stimulus presentation and learning to control stimulation. One group of infants received a noncontingent visual display and a second group of infants were trained to manipulate a simple lever to produce the same stimulus. Not only were there no significant differences in attention to the stimulus between the two groups, but there were nonsignificant differences indicating more attention on the part of infants receiving noncontingent stimulation. In the same study (Finkelstein & Ramey, 1977, Experiment 2) measures of attention to response performance were also obtained, that is, looking at the lever manipulandum. An analysis of this measure revealed that infants in the contingent group looked at the lever more frequently than infants in the control group (noncontingent), but only during those periods when infants in the contingent group could control stimulation. Differences in attention to the lever were not found between the two groups during extinction and no stimulation conditions. The authors postulate that the subsequent positive transfer effects which were demonstrated by the contingent group may have been mediated by changes in attention to repsonse performance.

The conflicting evidence regarding relationships between infant attention and response-contingent stimulation can perhaps be explained by the changes in the properties of the stimulus which accompany presentation of contingent stimulation. For example, in the Foster, et. al. (1973) study switching from noncontingent to contingent stimulation also involved a change from periodic to aperiodic stimulus presentation. It has been shown in a subsequent study (Vietze, Friedman, & Foster, 1974) that when both periodic and aperiodic stimulation are presented noncontingently, the aperiodic stimulus presentation produces increased attention. The role of changes in the properties of the stimulus in producing attentional changes are even more obvious when comparisons are made between a stationary, redundant stimulus and one which produces response-contingent movement (e.g., Rovee and Fagen, 1976). Overall, attention does not appear to be a good measure of preference for response-contingent stimulation (see also Mast, Fagan, Rovee-Collier, & Sullivan, 1980).

Changes in Affect

Changes in affective behaviors have also been proposed as evidence that experience with contingent stimulation is pleasurable to infants. The acquisition of control over stimulus presentations is frequently accompanied by positive affective behaviors such as smiling, cooing, vocalizations, and laughter. These behaviors were quite unexpected in early investigations of contingent stimulation. Consequently, only anecdotal reports of positive affect are made. For example, Uzgiris and Hunt (1965) provided the following description of infants' reactions to a mobile which moved contingently upon their behaviors.

> ...the infants developed what may be called a "relationship" with the responsive pattern: the infant's kicking would set the pattern in motion, which he then watched with signs of delight like cooing and laughing until the movement almost stopped, and then the infant would lick again, repeating such interaction for a considerable length of time. All the infants who developed such a relationship preferred the responsive pattern to the unresponsive one, but these cases were too few for a statistical test. (Uzgiris & Hunt, 1965, p. 10)

Watson & Ramey (1972) were provided with similar descriptions of infants' reactions to a response-contingent mobile through interviews with mothers whose infants were participating in a fourteen-day in-home study. The mothers reported that the infants engaged in a great deal of smiling, vocalizing, cooing, and laughing when they had control over the mobile's movements. Two of the mothers reported that their infants' first broad smiling and cooing occurred while they were playing with the mobile and that a few days later these behaviors were directed toward the parents.

The pervasive findings of increases in positive affective behaviors as a reuslt of engagement with response-contingent stimulation has prompted more recent investigations to include objective measures of these behaviors as dependent variables. For example, Rovee-Collier & Capatides (1979, Experiment 1) provided infants with two mobiles which were alternated during training sessions. One mobile (S+) produced response-contingent movement; the other (S-) was unresponsive. Smiling and cooing to presentations of S+ was exhibited by 5 of 10 infants. No instances of smiling or cooing occurred for any of the infants during the S- component of the multiple schedule.

Not only is the acquisition of control over stimulation associated with increases in positive affective responses, but the loss of control over stimulation frequently results in negative affective behaviors. Rovee-Collier and Capatides (1979) found that crying occurred at least once during the S- component (extinction). No negative affect was exhibited by any of the infants during presentations of the S+ component (reinforcement). The display of negative affect in the form of whimpering, fussing, or crying is a common finding in studies which include an extinction phase or when reinforcement is switched from contingent to noncontingent presentation (DeCasper & Carstens, 1981).

It should be noted, however, that noncontingent stimulation is not aversive if it is presented initially. It is only when the infant experiences prior control over stimulation that noncontingent stimulation results in fussing and crying (DeCasper & Carstens, 1981). These findings have been taken as evidence that the loss of control over stimulus presentation is aversive to infants, thereby, further implying that control over presentation is reinforcing.

Demonstrations of concomitant changes in affective behavior as a function of the presentation or withdrawal of control over stimulus presentation are quite impressive. Nevertheless, they do not provide definitive evidence that control is actually reinforcing to infants. Once again, changes in the physical properties of stimuli (e.f. McCall & McGhee, 1977) and the temporal patterning of stimuli (Vietze, Friedman, & Foster, 1974) have been shown to produce the same changes in affect using only noncontingent stimulus presentation. More direct measures of the reinforcing value of contingencies are obviously necessary.

In order to definitively say that infants derive pleasure from their control over stimulus presentation, it must first be shown that (a) infants are aware of the relationship between their responses and stimulus change when a true contingency exists and (b) they prefer to work to produce such stimulation (i.e. response-dependent schedule) over getting a free lunch (i.e. response-independent schedule). In the next two sections a brief review of the literature on animal learning related to these two issues will be presented.

CHAPTER IV

THE DETECTION OF CONTINGENCIES

There are two schools of thought regarding the process by which learning occurs during operant conditioning. These are (a) that temporal contiguity between a response and a reinforcer is the major factor in learning and (b) that the correlation between rates of reinforcement and rates of responding is the most important variable. Neither of these views denies the role that the opposing factor plays. The difference lies in the relative importance of one factor over the other. As shall be shown, this point of emphasis can have considerable impact on explanations as to why learning occurs.

Contiguity-based Law of Effect

Thorndike (1911) was the father of the contiguity view. In his initial statement on the law of effect he stressed the temporal relationship between a response and a reinforcer in conditioning: "...those responses which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur.: (p.244). The emphasis on temporal contiguity has been upheld by Thorndike's followers (e.g., Hull, Skinner, Spence, and Mowrer).

According to contiguity theory, any response which is followed immediately by a reinforcer will be strengthened (or "stamped in," to use Thorndike's expression). Furthermore, the strengthening of the behavior will occur whether or not the reinforcer is truly contingent upon the organism's responding. It is merely the temporal pairing of the response and the reinforcer which increases the liklihood that the behavior will be repeated.

The emphasis on temporal pairings of the response and the reinforcer has led proponents of this view to explain all behavior in terms of moment-to-moment consequences of the organism's behavior. Each discrete behavior of the organism over time must be explained by its immediate consequences (i.e. reinforcement or punishment). For relatively simple instances of learning, such as food reinforcement of a pigeon's key pecking or a rat learning to jump a barrier to escape shock, the temporal contiguity view provides a parsimonious explanation of the animal's behavior. The theory has not been as successful in retaining its parsimony in the explanation of more complex behaviors such as avoidance and behavior chains.

Rats and pigeons learn very rapidly to respond in such a way as to avoid an aversive stimulus (e.g., shock). This behavior is maintained for prolonged periods without the animal ever experiencing another instance of shock. Avoidance responding can not be explained by temporal pairing with a positive or negative reinforcer, in that, there is no shock and the animal is not rewarded for avoidance with food or other primary reinforcers. To explain avoidance behavior, the contiguity theorists (e.g., Mowrer) have had to resort to the use of classical conditioning in a two-factor theory of avoidance behavior. It is presumed that the stimuli (e.g., experimental chamber) which are associated with shock in the initial training of avoidance come to evoke the same autonomic responses ("fear") as the original shock through Pavlovian conditioning. Avoidance, then is viewed as escape behavior which is easily handled by temporal contiguity theory. The immediate consequence of avoidance is termination of a conditioned negative reinforcer (i.e. fear reduction). It should be noted, however, that even this explanation has been seriously challenged (Herrnstein, 1969).

Behavior chains have posed similar problems for a contiguity-based law of effect. Even casual observation of animals and humans points to the fact that they engage in long sequences of behavior prior to encountering any obvious form of reinforcement. This is especially true in the case of graduate students' dissertations. So how does contiguity theory explain such phenomena?

Again, classical conditioning has been invoked as an explanatory factor. It is proposed that the stimuli correlated with each link in the chain serve as reinforcers for the behaviors that produce them in the previous link. Although these stimuli are initially neutral, their reinforcing capacity is acquired through numerous pairings with primary reinforcers in the terminal link of the chain (i.e. classically conditioned). Similarly, complex explanations are necessary to account for organisms' responding on a number of reinforcement schedules when temporal contiguity is upheld as the primary factor in the learning and maintenance of behavior (Ferster & Skinner, 1957).

Correlation-based Law of Effect

Over the past 15 years a number of criticisms have been levied against reliance on response-reinforcer contiguity as the primary factor in the law of effect (Baum, 1973; Bloomfield, 1972; Herrnstein, 1969, 1970; Seligman, Maier, & Soloman, 1971; Staddon & Simmelhag, 1971). These authors propose that a molar perspective of learning must be taken to explain instrumental behavior.

The correlation-based law of effect proposes that behavior cannot be explained on the basis of isolated, moment-by-moment correlations of responses and reinforcers (i.e. temporal contiguity). Rather, behavior is viewed as a continuous flow of interactions between the organism and the environment over time. The organism is in constant interaction with the environment and receives "feedback" from the environment as a consequence of its behavior. Put simply, the organism integrates feedback over time to get the "big picture" of what effect its behavior has on the environment. Thus, reinforcement operates in a cummulative fashion as opposed to on a moment-by-moment (discrete) basis. In Baum's (1973) own words:

> ...time is a fundamental dimension of all interactions between behavior and environment...Performance of the system can be assessed only as it extends through time. This means that no particular momentary event should be seen in isolation, but rather as part of an aggregate, a flow through time...a continuous exchange. Continuous flow is measured as a rate. (p. 139)

When there is a true contingency between the organism's behavior and the delivery of reinforcement, there will be a positive correlation between the organism's rate of responding and the rate of reinforcement. Increases in the organism's rate of responding will result in increases in the rate of reinforcement. Decreases in response rate will result in decreases in reinforcement rate. Over time, the rate of responding will increase until the organism achieves a rate of responding which maximizes the rate of reinforcement which is available.

Baum (1973) likens this relationship to a regression line of the correlation between responses rate and reinforcement rate. While momentary time samples may not show a good correlation between responding and reinforcement, they nonetheless, cluster around the ideal match between response rate and reinforcement rate. The next logical question, however, is can an organism detect a <u>rate</u> of reinforcement?

Brownstein & Pliskoff (1968) presented pigeons with two different colored lights. Each light was correlated with a different schedule of response-independent food delivery. The pigeons could switch from one color to the other by pecking on a response key and, thereby, change the rate at which free food was delivered. Using this procedure, it was found that the proportion of time that the pigeons spent in the presence of the two lights was directly related to the reinforcement rate associated with each light. The ratio of time allocation equalled the ratio of the rates of reinforcer delivery. A similar correlation between pigeons' time allocation and rates of response-independent reinforcement was found by Baum & Rachlin (1969). It appears then that organisms are sensitive to variations in reinforcement rate.

Herrnstein (1970) reviewed a number of studies involving choice responding in pigeons. He found that, regardless of the schedules employed (i.e. simultaneous or successive), the <u>relative</u> rate of reinforcement between the two schedules is the variable most directly related to the rate of responding. Herrnstein's findings resulted in his proposal of the "matching law":

$$\frac{t_1}{t_2} = \frac{v_1}{v_2}$$

The matching law states that the ratio of time spent in two activities is directly proportional to the ratio of the values of those two activities. The value of each activity is a function of the feedback it produces (e.g., rate of reinforcement, duration of reinforcement). Most important, in a concurrent schedule an animal may switch from one activity (schedule of reinforcement) to another. This momentary switching, however, is inconsequential from a correlational perspective. It is the overall pattern of behavior (i.e. proportion of time spent in two activities) that matters.

Although the correlation-based law of effect suggests that contiguity between response and reinforcers, alone, cannot account for instrumental behavior, it does not deny that contiguity plays a role. It is a well-established fact that delay of reinforcment interferes with response performance. Therefore, it is suggested that temporal contiguity acts to ensure a good correlation between response rate and reinforcement rate. With long reinforcement delays (especially during small samples), there cannot be a good correlation between responding and reinforcement. It should also be noted that long reinforcement delays often have the additional effect of lowering reinforcement rate as well. As we have seen, lower rates of reinforcement result in a reduction in response rate.

It was stated in the beginning of this section that the difference between a contiguity-based law of effect and a correlation-based law of effect is not absolute. It is more a matter of emphasis. The basic difference between these two schools of thought is the time frame in which behavior is viewed. The correlation-based law of effect looks at molar patterns of behavior over time and their relationship with molar patterns of environmental feedback (e.g., reinforcement). Taking this perspective, explanations of complex behaviors such as avoidance responding and behavior chains are much simpler.

How does the correlation-based law of effect deal with avoidance responding and behavior chains? Baum (1973) suggests that a more parsimonious explanation of these two phenomenon is offered when the correlation between response rate and reinforcement rate is considered over time. He proposes that avoidance behavior is correlated with a reduction in the rate of punishment (e.g., shock) and thereby maintained. Baum further suggests that behavior chains are maintained because the stimuli in one link of the chain act, not as conditioned reinforcers, but as discriminative stimuli (signals) that a higher-valued situation (e.g., increased rate of reinforcement) is forthcoming.

CHAPTER V

RESPONSE CONTINGENCIES AND PREFERENCE

In the preceeding section it was shown that, given a choice, an organism will select the schedule which is associated with the highest rate of reinforcement. The biological advantages of such choice responding are obvious; especially in the case of food reward. It would also seem logical for an organism to prefer schedules requiring less effortful responding. Nevertheless, this has not been shown to be true. Investigations of choice responding between schedules requiring different rates of responding (i.e., effort) have found animals to be indifferent to the two schedules (Herrnstein, 1964; Moore & Fantino, 1975; Killeen, 1968; Neuringer, 1969a) or to actually prefer the schedule requiring more effort (Cotton, Lewis, & Metzger, 1958; Jensen, 1963; Singh, 1970).

In an early study, Jensen (1963) provided rats with a choice between eating free food in a cup at one end of a Skinner box and lever pressing for food at the other end of the box. He found that only one rat out of the 200 ate 100% of his pellets from the food cup. Not only did the majority of rats engage in lever pressing during the choice period, but 44% of the rats earned over half of the pellets eaten by lever pressing. Using both rats and pigeons as subjects, Neuringer (1969b) also demonstrated that animals will work for food in the presence of continuously available free food. Moreover, Neuringer demonstrated that original learning of a manipulative response (key pack, lever press) can occur without food deprivation and in the presence of free food.

Using a slightly different approach, Singh (1970) presented evidence to both support and extend the work of Jensen (1963) and Neuringer (1969b). Prior to preference testing, rats experienced both response-dependent and response-independent food reinforcement in separate chambers (black and white). Unlike the previous studies, the response-independent condition in Singh's study consisted of dispensing pellets at the same rate that the rat produced for himself in the response-dependent chamber (i.e. yoked control). During the preference testing phase both chambers, with their associated schedules, were continuously available. Thus, the rats could switch from one schedule to the other at any time. When the response-independent (no-work side) and response-dependent (work side) schedules produced identical rates of reinforcement, the rats obtained significantly more reinforcement from the work side. This was true when the work schedule was a FR-1, FR-3, FR-11 (Experiment 1) or a FI-30 second (Experiment 2) schedule of reinforcement.

In light of these findings Singh (1970) conducted a third experiment to determine if rats would still prefer the work side if "freeloading" was made more attractive. To accomplish this, rats received free food on the no-work side either 12.5, 25, or 50 percent faster than they did on the work side. Surprisingly, rats in the 12.5 and 25 percent faster conditions still obtained significantly more reinforcement on the work side across all four days of testing. A different picture emerged for the rats in the 50% faster group. They obtained more reinforcement on the no-work side.

Studies of pigeons' choice behavior as a function of response rate have similarly involved the use of concurrent schedules. The reinforcement rate is held constant across the two schedules. Differences in the response rate required in the terminal links of the two schedules serve as the independent variable. Using this procedure, Killeen (1968) demonstrated that pigeons were indifferent to radical differences in the response rates required for the two schedules. There was no preference between the two schedules even when the response rate generated by one schedule was 50 times greater than that generated for the alternate schedule (i.e. 52.3 responses per minute <u>versus</u> 0.95 responses per minute). Moore & Fantino (1975, Experiment 1) have offered comparable results using response-dependent (VI schedule) and response-independent reinforcement in the terminal links. The response-dependent schedule in their study involved a limited hold procedure and demanded very high rates of responding; so high that the two pigeons in the study failed to meet the response requirements on approximately 10% and 11% of their exposures to the schedule. Even so, their choice behavior was not influenced by the required response rates. They remained indifferent in their selection of the two schedules.

In a second experiment, Moore & Fantino (1975, Experiment 2) found that such indifference did not hold true for periodic schedules. In the response-independent schedules a FT (fixed time) schedule was employed. The response-dependent schedule consisted of either a tandem FR FI schedule or a chain FR FI schedule of reinforcement. It was found that the six pigeons in the study preferred the response-independent schedules (i.e., a free lunch). Based upon these findings, as well as similar findings in an earlier study (Fantino, 1969), Moore & Fantino propose that preference for the response-independent schedule is not attributable to the higher response rate required by the response-dependent schedule. Rather, the periodic response-dependent schedule is less preferred because it "...requires the pigeon to initiate responding in advance of the time when responding ultimately produces reinforcement. That is, the response requirements of the schedule necessitate a response pattern that is at variance with the response pattern ordinarily produced by the temporal parameters of a periodic schedule." (p. 345)

In summary, the available evidence suggests that animals are indifferent to even drastic differences between the response rates required by two schedules. This finding stands in sharp contrast to their strong preferences in favor of schedules associated with higher rates of reinforcement. Furthermore, several studies (Cotton, et. al., 1958; Jensen, 1963; Singh, 1970) have suggested that animals may actually prefer to work for reinforcement than to receive a free lunch. This is not to say, however, that working (lever pressing, pecking) has any intrinsic appeal in and of itself. It has been demonstrated (e.g., Jensen, 1963) that working must lead to reward for its continuance.

Research on children's preferences for contingent or noncontingent reinforcement is sparse. However, Singh (1970) conducted a study with 5 1/2 to 6 1/2 year old children and found results which paralleled the author's findings with rats. The children in the study were given a choice between sitting in one chair and receiving marbles which dropped automatically from a dispenser or sitting in another chair and pressing a lever (FR-10 schedule) which resulted in marble delivery. Marble delivery on the noncontingent side was yoked to the rate of marble delivery that the child produced on the response-contingent side. The children were free to switch between the two chairs throughout each session. The results showed that the children obtained significantly more marbles by lever pressing than they did on the noncontingent side.

Where, then, does this leave us with regard to the human infant? As was stated earlier, the findings of (a) renewed interest in a previously habituated stimulus when the stimulus is subsequently made contingent upon infant responding, (b) increases in positive affective behaviors during interactions with response-contingent stimulation, and (c) displays of negative affective behavior when control is taken away from the infant have led many to propose that control over stimulus presentation is rewarding to the infant. Nevertheless, there has been no attempt, to date, to empirically verify this hypothesis.

CHAPTER VI

PURPOSE OF PRESENT STUDY

The purpose of the present study was to determine empirically whether or not control over the presentation of visual stimuli is reinforcing to infants and preschool-aged children. That is, the present study was conducted to answer the question: Is the stimulus characteristic of "controllability" one which the infants and preschoolers can discriminate and does it serve to enhance the reinforcing properties of a stimulus? To accomplish this, children aged 12 to 51 months were presented with a series of choices between concurrently available response-contingent and response-independent schedules of stimulus presentations. A comparison of the frequencies of selection of the two schedules was conducted to determine relative preferences.

As pointed out in the preceding review, changes in the physical properties and temporal patterns of visual stimuli can have a considerable impact upon young children's preferences. Moreover, infants' preferences for visual stimuli have been shown to be specific to the individual infant's previous exposure to stimuli and their rate of habituation. In light of these facts, a yoked control procedure was used in the present study with each child serving as his or her own control. Identical stimuli were used in the response-dependent and response-independent schedules and the rate of stimulus change that each child selected in the response-dependent schedule was used in the response-independent schedule.

CHAPTER VII

METHOD

Subjects

Subjects were identified through birth records available at the local county courthouse. Parents were contacted by phone or letter to briefly describe the study and inquire about their willingness to participate. Parents indicating an interest were scheduled for an appointment at a time which was convenient for them. Children who were born premature, those having an obvious handicapping condition, or who were otherwise at risk for developmental delays were not included in the study.

A total of twenty-one children (10 males, 11 females) between the ages of 12 months and 51 months (Mean age = 28.29 months) served as participants. Three additional children were recruited but were not included in the study. Two of these children (aged 12 months and 18 months) were eliminated due to fussiness and their parents subsequent request to terminate their participation during the initial stages of the session. One child, a 10-month-old, was not included because he did not meet the age requirements for the three identified groups.

Each of the 21 participating subjects were assigned to one of three groups based upon their chronological age. These groups were one-year-olds (Year 1: 12 - 23 monhts), two-year olds (Year 2: 24 - 35 months), and three- and four-year olds (Year 3-4: 36 - 59 months). Table 1 provides a description of subjects by age and sex for each group. There were 7 subjects in Year 1 (Mean age = 16 months; Range = 12 - 23 months; M = 2, F = 5). There were 8 children in Year 2 (Mean age = 27.38 months; Range = 24 - 33 months; M = 4, F = 4). There were 6 children in Year 3-4 (Mean age = 43.83 months; Range = 36 - 51 months; M = 4, F = 2).

Table 1

Contingency Table for Subject Grouping Variables

	Age		Training Side (Contingent Panel)		Sex		
	$\bar{X}$	Range	Right	Left	Male	Female	N
Year 1	16 months	12 - 23 mos.	2	5	2	5	7
Year 2	27.38 mos.	24 - 33 mos.	4	4	4	4	8
Year 3-4	43.83 mos.	36 - 51 mos.	2	4	4	2	6
Total	28.29 mos.	12 - 51 mos.	8	13	10	11	21

Setting and Apparatus

All experimental sessions were conducted in a 3.7 m X 4.1 m room at the Family, Infant and Preschool Program (Western Carolina Center). The room was equipped with a one-way mirror and an intercom system. A relay rack used to control the presentation of stimuli and automatically record the children's manipulative responding was located in an observation room on the opposite side of the one-way mirror.

Visual stimuli were presented to the children by means of two carousel slide projectors which were housed in a single unit and projected slides onto two 33 cm. X 38 cm. plexiglass panels positioned side-by-side. The plexiglass panels were attached to simple switching devices which controlled the onset of slide presentation. A light touch on the front of either panel activated the carousel behind the panel which was touched.

The series of slides used in the study consisted of colorful pictures of animals and cartoon characters taken from young children's storybooks. Extremely popular cartoon characters (e.g., Care Bears, Smurfs) were avoided to prevent having a subsample of slides which were highly familiar to the children. Both projectors were loaded with an identical series of 80 slides (40 different slides repeated once).

<u>Experimental Design</u>

All children participated in at least three experimental phases: Training, Preference Testing, and a Reversal of Contingencies. Training consisted of a series of forced choice trials in which the children were presented with an opportunity to view response-dependent or response-independent slide advancement. Training was conducted to familiarize the children with the schedule of reinforcement associated with each of the two panels. Half of the training trials were response-dependent (i.e., contingent) and half of the trials were response-independent (i.e., noncontingent) stimulus presentation.

The Preference Testing and Reversal of Contingencies phases provided the children with a series of opportunities (trials) to select either contingent or noncontingent stimulus presentation by choosing the right or left panel. During the Preference Testing phase, the schedule of stimulus presentation for each panel was the same as it was during Training. The Reversal of Contingencies phase consisted of reversing the schedule of stimulus presentation associated with the two panels.

To control for preference based upon properties of the stimulus other than differences in "controllability" (e.g., rate, quantity, periodicity), each child served as his own yoked control. That is, noncontingent stimulus presentations were based upon the pattern of responding the child exhibited on the previous contingent trial (Training) or choice (Preference Testing, Reversal of Contingencies).

The position (i.e., right or left panel) of contingent and noncontingent stimulus presentations remained the same throughout the Training and Preference Testing phases. This was done to assist in the learning of the discrimination. Nevertheless, a possible position bias in responding over the course of Preference Testing was recognized. To control for this possibility, some of the children (N = 13) received contingent stimulus presentation on the left panel and noncontingent presentation on the right panel. The positions were reversed for the other children (N = 8). Moreover, the Reversal of Contingencies served as an additional control for a possible position bias.

The majority of children (N = 15) received 8 training trials (four contingent and four noncontingent). Only one child (S 14) received more than 12 training trials. The additional training trials for the other 6 S s were the result of the equipment not being switched quickly enough or a criterion of discrimination between contingent and noncontingent schedules based on rate of responding which was used early in the study to terminate training. This criterion was soon discarded. Appendix A indicates the number of Training trials received by each S.

The majority of childen received 10 trials in the Preference Testing phase and 10-15 trials in the Reversal Contingencies phase. Differences in number of Preference trials were, again, a result of equipment not being switched quickly enough (i.e., one or two additional trials) or a result of changes in criterion for switching to the next phase of the study. Following the running of several S s using a standard cut-off of 10 preference trials, it was decided to use a criterion of 5 out of 6 choices of the same panel (i.e., preference demonstrated) before switching to the Reversal phase.

At least 10 Reversal trials were attempted with each S. Two of the youngest children (S s 1 and 3) quit responding after 6 Reversal trials. If the children continued to show an interest in the apparatus after 10 trials, additional trials were run until they tired or additional reversals of contingencies were conducted. Six children received one additional reversal phase (Reversal 2) and four of these six received a third reversal phase (Reversal 3). The experimental conditions and number of trials received by each S within the three age groups are provided in chart form in Appendix A. The chart also indicates whether additional training was conducted subsequent to the Preference Testing phases to familiarize S s with the changing of schedules associated with the two panels.

Procedure

Experimental sessions were scheduled at a time of the day that was convenient for the parent and when the children were normally alert and content. Each child was escorted into the experimental room by his/her parent. The appartus sat on top of a child-height table and the child was seated in a small, child-sized chair facing the two plexiglass panels. The parent sat in a chair just to the right side of the child and slightly behind them. The E was also present in the room, sitting behind the child to the left.

The parents were instructed to speak only about the content of the slides with the child and to keep these comments and responses to the child brief. The parents were requested not to influence the child's choice of the right or left panel. They could, however, direct them to "Look at the lights." when the signal lights came on if the child was not attending. The children were allowed to wander around the room at will, but were occasionally prompted back to the apparatus by "Look at the lights!" The children were also allowed to sit or stand as they wished, however, they were prompted to remain in the center of the two panels. Each session consisted of at least three experimental phases: Training, Preference Testing, and Reversal of Contingencies.

Training. Training consisted of alternate presentations of contingent and noncontingent slide advancement. At the outset of each training trial, one of the two plexiglass panels was illuminated by a small yellow light. The other panel remained darkened for the duration of the trial. The yellow light served as a signal as to which of the two panels was operative on a given trial. The same type of slide advancement (i.e., contingent or noncontingent) appeared on the same panel throughtout all training trials. All that changed across training trials was which of the two panels was operative (i.e., right or left). Trials of contingent advancement and noncontingent advancement were alternated across training trials.

Following the onset of the signal light, a single touch of the illuminated panel resulted in the presentation of the first slide in the series. Slides were available for viewing for a 15-second period. At the end of the 15-second viewing period, both panels were darkened and then a new trial began. The critical difference between the stimuli provided by the two panels was the amount of control the children had in determining the rate and frequency of slide advancement during the 15-second viewing period.

When slide advancement was contingent, the first slide following the signal light remained on the panel until the child touched the panel again. Every subsequent response directed toward the panel during the 15-second viewing period resulted in an immediate advancement of the projector to the next slide in the sequence. Thus, the number and rate of slides presented on the panel were determined by the child's response rate. When slide advancement was noncontingent, touching the panel during the 15-second viewing period had no effect on slide advancement. Instead, slide advancement was automatically programmed according to the pattern of responding the child exhibited during the previous contingent trial (i.e., yoked).

In the event that a child did not touch the panel during the presentation of the signal light or during contingent trials, a prompting procedure was used. If no response was directed toward the operative panel within 10 seconds of onset of the signal light, the child was instructed or manually prompted to touch the panel. Similarly, if the child did not touch the panel during the first 10 seconds of a contingent trial, a single prompt was given. Prompting was used only during the first two training trials since prompting would not be used during the Preference Testing phase or the Reversal of Contingencies phase.

Preference Testing. Following the conclusion of training trials, the children were presented with a series of trials in which the two panels were concurrently illuminated with the yellows signal lights. Touching of either panel resulted in the viewing of slides according to the schedule formerly associated with that panel (i.e., contingent or noncontingent slide advancement). The length of the viewing period following a choice between the two discriminative stimuli was the same as it was during the training phase (i.e., 15 seconds). The yoked control procedure used during training was also in effect for the selection of noncontingent advancement in this phase.

Reversal of Contingencies. During this phase, the schedule in effect for the two panels was reversed. For example, if the right panel was associated with contingent slide advancement during training and preference testing, this schedule would now be switched to the left panel. The right panel would now be associated with noncontingent slide advancement. The same choice procedure used in the Preference Testing phase was employed during the reversal phase.

Measurements and Recording

Three dependent measures were taken for each child across all phases of the experimental session. These were (a) measures of CHOICE between contingent and noncontingent stimulus presentation, (b) measures of the FREQUENCY of panel presses directed toward the two panels during the viewing period, and (c) measures of ATTENTION directed toward the stimulus presentation provided by each of the two schedules.

Choice. Measures of choice between the two schedules of stimulus presentation were collected throughout the Preference Testing and Reversal of Contingencies phases of the study. The panel selected by the children on each choice trial was automatically recorded on response counters on the relay rack. Thus, a choice response to the right or left panel was recorded for each trial. Choice measures were then summarized across blocks of five trials for Preference Testing and Reversal of Contingencies.

Frequency. Frequency of panel pressing during 15-second viewing periods was automatically recorded on response counters located on the relay rack. This measure was taken for responding to both the contingent and noncontingent viewing panels and was recorded across all phases of the study. Frequency counts of panel pressing included all responses directed toward the operative panel following the initial touch of the signal stimulus which activated the panel. A separate frequency count was conducted for each 15-second viewing period (i.e., each trial). Frequency measures were summarized across blocks of four trials for the Training phase and across blocks of five trials for the Preference Testing and Reversal of Contingencies phases. Frequencies for each panel were then divided by the number of times that panel was selected during each block of trials to yield a mean frequency score for each panel per block of trials.

Attention. Videotapes of each session were made. These tapes were later viewed to obtain a measure of attention for each 15-second viewing period. This time period began when the child touched the yellow stimulus light and the first slide appeared on the panel and ended when the yellow light(s) appeared again to start a new trial. Thus, the child's behavior in the presence of the stimulus lights was not included. A child's attention to the operative panel during each 15-second viewing period was rated as falling in to one of three categories of attention: (a) attending, (b) mixed attention, or (c) nonattending. Definitions for the 3 categories of attention were as follows:

> ATTENDING (score = 3). The child is attending to the visual display for the majority of the 15-second viewing period (approximately 2/3 of time period or more). Attending is defined as the child's head oriented toward the visual display on the operative panel. Visual attending may or may not be accompanied by other overt signs of interest such as pointing to the pictures, touching the panel, or talking about the content of the pictures.

MIXED ATTENTION (score = 2). The child is attending to the visual display (i.e., head oriented toward the operative panel) for more than 1/3 but less than 2/3 of the viewing period. That is, the child shows some obvious attention to the display, however, for at least 1/3 of the viewing period the child is clearly not looking at the display (e.g., walks away, looks away, engaged with adult or other objects in room).

NONATTENDING (score = 1). The child is not attending to the visual display for the majority of the 15-second viewing period. The child's head is oriented toward the operative panel for less than 1/3 of the time period.

Attention ratings were summarized across blocks of four trials for Training and across blocks of five trials for Preference Testing and Reversal of Contingencies phases and were separated into attention ratings for the contingent and noncontingent panels. The summarized ratings were divided by the number of times each panel was chosen to obtain a mean attention rating for each panel (i.e., schedule of stimulus presentation) for each block of trials.

Reliability. A second observer independently viewed the tapes of seven randomly selected children and conducted ratings of attention using the definitions given above. Comparisons of the ratings of the two observers were conducted for each child across all experimental phases. Reliability was calculated using the formula:

$$\frac{\text{agreements}}{\text{agreements \& disagreements}} \times 100$$

Overall reliability between the two observers was 91% (Range 85% to 97%).

CHAPTER VIII

RESULTS

Statistical analyses of the data were conducted for the first three experimental phases only (Training, Preference Testing, and first Reversal of Contingencies). In addition, only two blocks of trials per experimental phase were subjected to statistical analyses. These blocks included the last eight trials in the Training phase, the first ten trials in the Preference Testing phase, and the first ten trials in the first Reversal of Contingencies phase. Data obtained beyond these blocks of trials for the three conditions were too sketchy (i.e., missing data) to be included in the analyses.

Separate ANOVA's were conducted for the dependent measures of (a) choice of contingent or noncontingent stimulus presentation and (b) mean frequency of responding during the 15-second viewing period. The factors involved in the analyses and the results are presented separately for these two dependent measures. Comparisons of attention measures between the two schedules of stimulus presentation and across experimental conditions are also provided.

Choice Measures

An analysis of variance was conducted using repeated measures of choice. The analysis consisted of two between factors and three within factors. These factors are listed in Table 2.

Table 2

Factors Used in Analysis of Variance for Choice

Source of Variance	Factor	Level	Names
Between S s	Age Group	3	Year 1 Year 2 Year 3-4
	T-Side * (Nested within Age Group)	2	Right Left
	Condition	2	Preference Reversal
Within S s	Block (Nested within condition)	2	Block 1 Block 2
	Contingency (Nested within blocks)	2	Contingent Noncontingent

* The panel which was contingent during training

The results of the ANOVA (See Appendix B) indicated no main effect for Contingency. Thus, the children showed no consistent preference in their choices of contingent ($\overline{X}$ = 2.54) or noncontingent ($\overline{X}$ = 2.35) stimulus presentation. A three-way interaction for Condition X Contingency X TSide was found to be significant ($p < .02$). The cell means and marginal means for this interaction are provided in Table 3. The cell means are suggestive of a right hand panel preference; however, this could not be directly tested in the ANOVA.

Table 3

Mean Choice of Contingent and Noncontingent Panel as a Function of Training Side and Experimental Condition

CONDITION	Preference		Reversal		
CONTINGENCY	C	NC	C	NC	
TRAINING SIDE: Right	Right Panel 3.20	Left Panel 1.80	Left Panel 2.13	Right Panel 2.54	C = 2.83 NC = 2.17
TRAINING SIDE: Left	Left Panel 1.62	Right Panel 3.38	Right Panel 3.19	Left Panel 1.68	C = 2.40 NC = 2.53
	2.41	2.59	2.66	2.11	Total C = 2.54 Total NC = 2.35

Note. The panel (right or left) which was contingent during Training and Preference was reversed in the Reversal phase. Panel side (right or left) on which the schedule (C or NC) appears is indicated in the upper right hand corner of each cell.

The procedure of forced choice between contingent and noncontingent stimulus presentation prevented the direct testing of other main effects in this first ANOVA. Consequently, separate ANOVAs for contingent choice and noncontingent choice were conducted using the same factors that were used in the first ANOVA. The results of these ANOVAs are provided in Appendix B. No main effects were found in the analyses. A Condition X TSide interaction was found to be significant ($p < .02$) for both contingent and noncontingent choices. This was, again, suggestive of a right hand panel preference.

Subsequent t-test comparisons were conducted to determine if, in fact, a significant right panel preference occurred. These comparisons showed no significant differences in choice as a function of right versus left panel position.

Frequency Measures

An analysis of variance was conducted using repeated measures of mean frequency of responding to the operative panel during the 15-second viewing period. The ANOVA consisted of two between variables and three within factors. These factors are listed in Table 4.

Table 4

Factors Used in Analysis of Variance for Frequency of Responding During Viewing Periods

Source of Variance	Factor	Levels	Names
	Age Group	3	Year 1 Year 2 Year 3-4
Between S s			
	T-Side * (Nested within Age Group)	2	Right Left
	Condition	3	Training Preference Reversal
Within S s			
	Block (Nested within condition)	2	Block 1 Block 2
	Contingency (Nested within Block)	2	Contingent Noncontingent

* The panel which was contingent during Training.

The results of the ANOVA are provided in Appendix B. A main effect for Condition ($p < .03$) was found. The highest rate of responding during the 15-second viewing period occurred during the Preference Testing phase of the study and the lowest rate occurred during Training ($\bar{X}$ Training = 3.12; $\bar{X}$ Preference = 4.73; $\bar{X}$ Reversal = 3.91).

A significant three-way interaction ($p < .05$) for Condition X Contingency X TSide was also found. The cell means and marginal means depicting this interaction are shown in Table 5. The marginal means show that, in addition to the main effect of Condition, response rates on the contingent panel are higher than those on the noncontingent panel within each experimental condition and across right and left training side. Nevertheless, the overall main effect for Contingency was not significant. Closer examination of cell means reveals that response rate is more consistently related to panel side (right or left position) than to the contingency which is in effect on the panel. This overall higher rate of responding to the right panel is similar to the effects of panel side on choice.

Table 5

Mean Frequency of Responding During 15-Second Viewing Periods as a Function of Condition, Training Side, and Contingency of Operative Panel

CONDITION	Training		Preference		Reversal			
CONTINGENCY	C	NC	C	NC	C	NC		
TRAINING SIDE: Right	Right Panel 3.61	Left Panel 2.96	Right Panel 5.19	Left Panel 4.24	Left Panel 3.54	Right Panel 3.97	C = 4.12 NC = 3.73	3.92
TRAINING SIDE: Left	Left Panel 2.84	Right Panel 3.07	Left Panel 4.37	Right Panel 5.13	Right Panel 4.62	Left Panel 3.49	C = 3.94 NC = 3.90	3.92
	3.23	3.01	5.29	4.69	4.08	3.72	TOTAL C = 4.03 TOTAL NC = 3.81	
	3.12		4.73		3.91			

Note. The panel which was contingent during Training and Preference changes during Reversal condition. The panel (right or left) on which contingent or noncontingent stimulus presentation occurs is indicated at the top of each cell.

Subsequent comparisons of cell means (t-tests) for right and left panel responding were conducted. These comparisons showed no statistically significant difference between responding on the two panel sides.

Finally, a significant ($p < .04$) four-way interaction for Condition, X Blocks, X Contingency, X Age Group was found. Tables 6 and 7 show the various cell means for this interaction. Table 6 shows that,

Table 6

Mean Frequency of Responding During 15-Second Viewing Periods as a Function of Condition, Blocks, Age Group, and Training Side

CONDITION		Training		Preference		Reversal			
BLOCKS		1	2	1	2	1	2		
AGE GROUP	TRAINING SIDE								
YEAR 1	Right	3.51	4.19	4.24	3.19	2.10	5.21	3.71	3.59
	Left	2.65	3.60	3.41	4.66	3.16	2.93	3.44	
YEAR 2	Right	2.31	3.03	3.50	3.17	2.90	2.36	2.88	3.86
	Left	3.28	3.38	7.26	7.00	4.61	3.71	4.87	
YEAR 3-4	Right	3.31	3.38	7.13	7.08	4.38	5.58	5.14	4.30
	Left	2.19	2.41	2.57	3.71	5.35	4.59	3.45	
		2.88	3.36	4.66	4.79	3.75	4.05	TOTAL BLOCK 1 = 3.76	
		3.12		4.72		3.90		TOTAL BLOCK 2 = 4.24	

overall, higher rates of responding occurred in the second block of trials ($\bar{X}$ = 4.24) than in the first block of trials ($\bar{X}$ = 3.76). This effect was consistent across Training ($\bar{X}$ Block 1 = 2.88; $\bar{X}$ Block 2 = 3.36), Preference ($\bar{X}$ Block 1 = 4.66; $\bar{X}$ Block 2 = 5.31), and Reversal conditions ($\bar{X}$ Block 1 = 3.75; $\bar{X}$ Block 2 = 4.05). As can be seen, however, this effect varied with age groups and T-side. A consistent pattern is not obvious.

Table 7

Mean Frequency of Responding During 15-Second Viewing Periods as a Function of Contingency, Age Group, and Panel Side

		Contingent	Noncontingent		
Right Panel	Year 1	4.69	3.91	4.30	
	Year 2	3.78	4.76	4.27	4.27
	Year 3-4	4.96	3.50	4.23	
	Total Right Panel	4.12	3.73		
Left Panel	Year 1	3.37	2.38	2.88	
	Year 2	3.96	3.00	3.48	3.57
	Year 3-4	3.41	5.31	4.36	
	Total Left Panel	3.94	3.90		
		4.03	3.81	Total Year 1 = 3.59 Total Year 2 = 3.88 Total Year 3-4 = 4.30	

Note. Right and left panel are the actual panel positions and not just training side.

Table 7 shows that overall mean rates of responding to the operative panel increased with age ($\bar{X}$ Year 1 = 3.59; $\bar{X}$ Year 2 = 3.88; $\bar{X}$ Year 3 = 4.30). Also shown are the effects of age in interaction with response rates to the contingent and noncontingent panel and with the panel (right or left) on which each schedule was operative. The marginal means on Table 7 show that one-year-olds displayed the greatest difference in response rates to the right and left panels. Responding to the right panel ($\bar{x}$ = 4.3) was higher overall than responding to the left panel ($\bar{x}$ = 2.88). Nevertheless, the cell means indicate that the response rates of one-year-olds were higher for the contingent schedule than for the noncontingent schedules on both the right panel ($\bar{X}$ C = 4.69; $\bar{X}$ NC = 3.91) and the left panel ($\bar{X}$ C = 3.37; $\bar{X}$ NC = 2.38). The pattern of responding is less clear for two-year-olds and three-to-four-year olds. For example, the two-year-olds had higher response rates to noncontingent ($\bar{X}$ = 4.76) than to contingent ($\bar{X}$ = 3.78) on the right panel and slightly higher response rates to contingent ($\bar{X}$ = 3.46) than to noncontingent ($\bar{X}$ = 3.00) on the left panel. The opposite interaction between panel side and contingency was shown by three-to-four-year olds.

Attention Measures

Table 8 presents the mean attention ratings for contingent and noncontingent stimulus presentations across all three experimental conditions. The highest levels of attention occurred during the Training phase and attention waned somewhat over the course of the next two experimental phases. Most important, attention to contingent and noncontingent stimulus presentations were comparable within the Training ($\bar{X}$ C = 2.68, $\bar{X}$ NC = 2.61), Preference Testing ($\bar{X}$ C = 2.38, $\bar{X}$ NC = 2.44), and Reversal of Contingencies conditions ($\bar{X}$ C = 2.19, $\bar{X}$ NC = 2.18). This indicates that the actual amount of reinforcement received by the Ss during the contingent and noncontingent stimulus presentations was equivalent.

Table 8

Mean Ratings of Attention to Contingent and Noncontingent Panel Across Conditions

Contingency	Condition		
	Training	Preference	Reversal
Contingent	2.68	2.38	2.19
Noncontingent	2.61	2.44	2.18

It is interesting to note that although the levels of attention were higher in the Training phase than in the Preference phase, the mean frequency of responding was the opposite. Thus, although the children engaged in fewer panel presses during Training than during Preference Testing, they actually attended to the stimuli more during Training than Preference.

CHAPTER IX

DISCUSSION

Previous studies of operant conditioning with infants have suggested that control over environmental events is reinforcing. Interpretations of the pleasure derived from controlling stimuli have been largely based upon observation and anecdotal reports of increased attention and positive affect (e.g., smiling, cooing) under conditions of infant-controlled stimulation and observations of negative affect (e.g., fussing, crying) when control is taken away.

The purpose of the present study was to empirically validate whether infants and young children do, in fact, prefer contingent over noncontingent stimulation. To accomplish this, the children were provided with a series of opportunities to choose between contingent and noncontingent visual stimuli. Choice, then, was used as a measure of preference. Rates of responding (i.e., panel pressing) to the two schedules following each choice were also analyzed.

Statistical analyses of child data indicated no preference for contingent over noncontingent stimulation based upon measures of choice responding to the two schedules. Differences between rates of responding to the two schedules following each choice were also found to be nonsignificant. Unexpectedly, the position of the stimuli (right or left side) appeared to have some impact on the children's choices. That is, the children tended to select the right side over the left. This effect, however, was not statistically significant.

These findings could be intrepreted in several ways. Most obvious, it might be said that the contingent and noncontingent stimulus presentations were equally reinforcing to the children. An equally plausible explanation, however, would be that the children could not discriminate between the two schedules and therefore had no preference. Anecedotal observations of the children during the experimental session helps to shed some light on the confusion.

Anecdotal Observations

When switching from the contingent panel to the noncontingent panel, many of the children hit the noncontingent panel in a series of rapid bursts until the panel changed automatically and then ceased responding. Several children were more creative and would press the contingent panel (which was not operative) while looking at the noncontingent panel as if they were trying to control the noncontingent panel through pressing the contingent panel. Even the youngest child in the study (12 months) engaged in this behavior.

Some of the older two-year-olds and three-and four-year-olds would press the noncontingent panel very quickly when they saw it change, as if to "control" it post hoc. One of the oldest (51 months) children in the study very methodically alternated back and forth between the two panels, regardless of the condition, and concentrated very hard on "matching" panel presses on the noncontingent panel to the rate of slide advancement. He actually did quite a good job of it! His only burst of responding above a rather steady pace was the third time he selected the noncontingent panel in the first Reversal phase when he appeared to recognize that he had "lost control."

Another older child spontaneously made several verbal statements throughout the second and third reversal to indicate that he could discriminate between the contingent and noncontingent panels. While pressing the contingent panel he said: "This is the good one." followed by "This one doesn't work!" when he selected the noncontingent panel on the next trial. Later (Reversal 3), while engaged in a series of selecting the noncontingent panel he said: "What's wrong with this?", "Hey, this thing is weird because it won't change." Finally, he held the panel down and stated: "It won't turn because I'm pushing it." Still another child (Year 3-4) had a different idea and tried to press the noncontingent panel while straining to look around into the "guts of the machinery" to resolve the "broken" panel. Thus, many of the older children and a few of the younger (Year 1) children engaged in behavior indicative of being able to discriminate between the contingent and noncontingent panel. Even so, they continued to select and respond to both the contingent <u>and</u> the noncontingent panel.

Based upon these observations, still other interpretations of the findings are possible. For example, it may have been that the children could discriminate between contingent and noncontingent stimulus presentation, but they were trying to gain control over the noncontingent panel. Some of the children's rapid bursts of responding on the noncontingent panel and other children's "pacing" of responding to noncontingent stimulus presentation or immediate responding following noncontingent stimulus change may be indicative of attempts to control.

For at least some of the children it may have been that they did not view the equipment as having two independent schedules. That is, they may have dealt with the equipment as one large unit to control. The children's responding on the inoperative contingent panel during noncontingent stimulus presentation may, at least partially, support such a notion.

Methodological Issues

Selection of any one of the above explanations as being more plausible than the other is not possible based upon the present results. More important, the present results oppose previous suggestions of control over stimulus presentation as a reinforcing event for young infants and children. The results are also in opposition to objective evidence of preference for contingent over noncontingent reinforcement found with animals (Jensen, 1963; Neuringer, 1969b; Singh, 1970) and older children (Singh, 1970). Differences in methodology between previous research and the present investigation may be partially responsible for the contrasting findings. Comparisons of methodologies with previous infant research and with previous preference studies (animals and older children) are discussed separately below.

Infant Research Methodologies. Traditionally, studies of operant conditioning with infants and young children have presented contingent and noncontingent stimulus presentation in a series, that is, all of one schedule first followed by the other type of schedule. In contrast, the present study allowed the children to select the type of schedule in effect. For most children, this resulted in at least some alternations between contingent and noncontingent stimulus presentations. Even if this did not occur, the initial training phase and the training on the reversal of contingencies used forced choice alternation between the two schedules. Thus, the children were at least periodically "reminded" of the controllability of slide advancement.

An enhancement effect of prior exposure to contingent stimulation has been documented by others. That is, experience with contingencies has been demonstrated to facilitate the acquisition of future contingencies. In the present study, repeated exposure to contingent slide advancement may have resulted in attempts to learn the "contingency" on the noncontingent panel.

A large portion of investigations of infant instrumental learning have used nonreinforcement as a control as opposed to noncontingent stimulus presentations. Those studies which have used noncontingent stimulation have typically used periodic presentations of the stimulus (e.g., standard mobile rotation). Several have used a yoked control across groups where a child in the control group receives the same rate or pattern of noncontingent stimulus presentation as the child in the experimental group obtained through responding.

In the present study the children served as their own yoked controls. Furthermore, the rate of noncontingent stimulation could change from trial to trial dependent upon their switching to the contingent panel and their rate of responding on the previous contingent trial. This yoking procedure resulted in changing and aperiodic stimulus presentation on the noncontingent panel. Consequently, the children could not predict the pattern of noncontingent stimulus presentation. Previous studies have demonstrated that both changes in the reinforcer and aperiodic stimulus presentation result in increased attention and (in the case of response-contingent reinforcement) response recovery.

Preference Research Methodologies. Jensen's (1963) and Neuringer's (1969b) work with rats involved a choice between continuously available free food and lever pressing for pellet delivery. Singh's (1970) research is more comparable to the methodology employed in the present study, in that, his free food (noncontingent) choice consisted of pellets dispensed at the same rate the each rat had received through lever pressing. Singh (1970) employed a similar yoking procedure with 5 and 6 year old children. Their choice involved sitting in one chair and pressing a lever which resulted in marble delivery (contingent) or sitting in another chair and receiving marbles that dropped automatically from a dispenser at the same rate that the child produced on the response-contingent side.

Although Singh's yoked control is comparable to the schedule of noncontingent stimulus presentation used in the present study, there are two points of departure in methodology between Singh's work and the present study. First, in Singh's studies the subjects (rats and children) could switch between contingent and noningent reinforcement at will by physically moving in front of the other presentation. Second, under conditions of noncontingent reinforcement, there was no response manipulandum present. That is, responding in the presence of noncontingent stimulus presentation was not possible. It is uncertain just how critical these two points of departure are; however, they appear different enough to merit consideration.

Differences between studies in terms of the ability to switch schedules at will brings up the issue of differences in the definition or measurement of preference. Singh's measure of preference was the difference in the number of reinforcers received by subjects under the two schedules of delivery. Looked at from a different angle, it may be seen as the difference in time spent (i.e., duration measure) in the presence of the two schedules. The measure of preference employed in the present study was more of a frequency measure, that is, differences in the number of times each schedule was chosen. Once chosen, the children were "stuck" with the schedule for the duration of the 15-second viewing period. Although it might be said that the children had control over extending the duration of a schedule through repeated selection (choice) of it, they did not have the capability of getting out of a schedule once it was selected until the pre-established viewing period was finished. Perhaps more important, the children's experience with each schedule in the present study was interrupted by the repeated choice procedure. It may be that they didn't have a prolonged enough exposure to each schedule to determine whether a contingency existed.

The availability of a response manipulandum seems to be a more crucial difference between studies. First, it brings up the question of whether or not responding (lever pressing or panel pressing) is reinforcing in its own right. That is, in Singh's studies, did the subjects prefer doing something (physical activity) over merely waiting for the dropping of the reinforcer? In the present study, was the availability of a response on both schedules enough to result in no preference? Related to this issue, Antonitis (1978) has previously demonstrated that preschoolers pressed a lever in the presence of a noncontingent stimulus even when there had been no history of lever pressing being involved in a contingency.

Second, it may be that the availability of a response under noncontingent stimulus presentation in the present study served to preclude discrimination between the two schedules. Perhaps Singh's nonavailability of a response under noncontingent reinforcement facilitated the discriminability of the two schedules and the subjects preferred controlling reinforcement. If the availability of a response manipulandum plays a critical role in determining outcome, it will need to be determined which, if any, of the above notions is correct. That is, does response availability under conditions of noncontingent reinforcement (a) preclude discrimination between schedules and (b) does it enhance the reward value of the reinforcer (i.e., responding is reinforcing)?

Future Research

As described above, differences in methodology between this study and other studies points to a need for further research to investigate the relative importance of these differences to outcome. Among those methodological variables and issues requiring further investigation are:

- o The availability of a response manipulandum under conditions of noncontingnet stimulus presentation.
- o The ability to switch from one schedule to another at will.
- o Measures of preference (e.g., duration, number of reinforcers, frequency of selection).
- o Reinforcing aspects of the stimulus characteristics inherent under contingent reinforcement (e.g., aperiodic, changing).
- o Length of time subjects are exposed to each schedule.
- o Determining the subject's ability to discriminate between the two schedules.

Within the context of the present experiment, several methodological changes may have assisted in obtaining clearer results. First and foremost, it would have been helpful to eliminate the potential influence of position preference. Although the right sided preference was not statistically significant, it did appear to exert some influence over choice and it would have been helpful to avoid this potential bias. Perhaps this could have been accomplished by having one presentation screen and two attached choice manipulanda. Even simpler, perhaps the two sources of stimulus presentation could have been stacked on top of one another.

Procedural changes aimed at aiding in the discriminability of contingent and noncontingent stimulus presentation would also have been helpful. At the very least, it would have been beneficial to insure that the procedures did not in any way <u>encourage</u> responding during noncontingent presentations. Potential variations in procedures to achieve these outcomes are as follows:

- o Use of a different response for choice and responding during viewing period. At the very least, this change would eliminate the initial contingency during noncontingent presentation when the choice response activated the first slide during the viewing period.

- o Tighten up the contingency between responding and stimulus presentation. That is, there was a very brief lag between panel press and stimulus presentation due to the use of slide projectors. The use of a response which took more time to perform may have helped to slow responding down and insure a better correlation.

- o The physical spacing of the two panels may have been assistive in insuring that the subjects perceived the two schedules as being independent (i.e., not viewed as one unit).

- o It may have been helpful to provide a longer exposure to each schedule per trial during training to assist in discrimination.

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APPENDIX A

Description of Experimental Conditions for Individual Subjects

Description of Experimental Conditions for Individual Subjects

YEAR 1	TRAINING		PREFERENCE		REVERSAL			REVERSAL 2			REVERSAL 3		
S	Contingent Panel	Number of Trials	Contingent Panel (Rt./Lft.)	Number of Trials	Contingent Panel (Rt./Lft.)	Number of Trials	Additional Training (Yes/No)	Contingent Panel (Rt./Lft.)	Number of Trials	Additional Training (Yes/No)	Contingent Panel (Rt./Lft.)	Number of Trials	Additional Training (Yes/No)
1	R	9	R	13	L	6	Y	•	•	•	•	•	•
2	L	12	L	10	R	10	N	•	•	•	•	•	•
3	L	12	L	11	R	6	N	•	•	•	•	•	•
4	R	8	R	10	L	12	N	•	•	•	•	•	•
5	L	8	L	10	R	15	Y	•	•	•	•	•	•
6	L	8	L	10	R	13	Y	•	•	•	•	•	•
7	L	8	L	10	R	13	Y	•	•	•	•	•	•
YEAR 2													
S													
8	L	8	L	10	R	10	Y	L	18	N	•	•	•
9	L	8	L	10	R	15	Y	•	•	•	•	•	•
10	R	8	R	10	L	10	Y	•	•	•	•	•	•
11	R	8	R	10	L	12	N	R	5	N	L	27	Y
12	L	8	L	10	R	17	Y	•	•	•	•	•	•
13	R	8	R	11	L	15	Y	•	•	•	•	•	•
14	L	20	L	16	R	12	Y	•	•	•	•	•	•
15	R	8	R	14	L	21	Y	R	18	N	•	•	•
YEAR 3-4													
S													
16	L	8	L	10	R	18	Y	L	16	Y	R	9	N
17	L	11	L	13	R	10	Y	•	•	•	•	•	•
18	R	8	R	10	L	27	Y	•	•	•	•	•	•
19	L	8	L	14	R	11	Y	•	•	•	•	•	•
20	R	8	R	21	L	10	Y	R	16	Y	L	15	N
21	L	10	L	27	R	15	N	L	10	N	R	10	N

APPENDIX B

Analysis of Variance for Dependent Measures

Analysis of Variance of Children's Choice of Schedules for Conditions, Blocks, Age, Contingency, and Training Side

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
A	See ANOVAs for Selection of Contingent and Selection of Noncontingent Schedules of Stimulus Selection.			
B				
C				
E				
D	1.29808	1	1.29808	0.64
D X C	0.65625	2	0.32812	0.16
D X E	3.60577	1	3.60577	1.77
D X C X E	0.32625	2	0.16312	0.08
Error	30.62500	15	2.04167	
A X D	4.85192	1	4.85192	0.57
A X D X C	1.28625	2	0.64312	0.08
A X D X E	60.41603	1	60.41603	7.12*
A X D X C X E	14.58625	2	7.29313	0.86
Error	127.22500	15	8.48167	
B X D	0.87756	1	0.87756	0.23
B X D X C	10.47625	2	5.23813	1.37
B X D X E	0.33910	1	0.33910	0.09
B X D X C X E	4.55625	2	2.27812	0.60
Error	57.22500	15	3.81500	
A X B X D	1.93910	1	1.93910	1.09
A X B X D X C	0.03625	2	0.01812	0.01
A X B X D X E	0.40064	1	0.40064	0.23
A X B X D X C X E	0.38625	2	0.19313	0.11
Error	26.62500	15	1.77500	

* $p < .02$

Variable Names

A = Condition
B = Blocks
C = Age Group
D = Contingency
E = Training Side

Analysis of Variance of Children's Choice of Contingent Schedule for Conditions, Blocks, Age, Contingency, and Training Side.

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
Age	0.64313	2	0.32156	0.26
TSide	1.27212	1	1.27212	1.03
Age X TSide	0.38813	2	0.19406	0.16
Error	18.61250	15	1.24083	
Condition	1.11571	1	1.11571	0.25
Condition X Age	1.93812	2	0.96906	0.22
Condition X TSide	32.61571	1	32.61571	7.36*
Condition X Age X TSide	7.87812	2	3.93906	0.89
Error	66.51250	15	4.43417	
Blocks	0.02596	1	0.02596	0.01
Blocks X Age	3.94313	2	1.97156	0.94
Blocks X TSide	0.03878	1	0.03878	0.02
Blocks X Age X TSide	2.89312	2	1.44656	0.69
Error	31.51250	15	2.10083	
Condition X Blocks	0.23365	1	0.23365	0.24
Condition X Blocks X Age	0.40312	2	0.20156	0.21
Condition X Blocks X TSide	0.05417	1	0.05417	0.06
Cond.X Blcks.X Age X TSide	0.02813	2	0.01406	0.01
Error	14.61250	15	0.97417	

* $p < .02$

Analysis of Variance of Children's Choice of Noncontingent Schedule for Condition, Blocks, Age Group, and Training Side.

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
Age	0.99313	2	0.49656	0.51
TSide	2.42596	1	2.42596	2.49
Age X TSide	0.11812	2	0.05906	0.06
Error	14.61250	15	0.97417	
Condition	4.23878	1	4.23878	1.00
Condition X Age	0.32812	2	0.16406	0.04
Condition X TSide	27.89263	1	27.89263	6.61*
Condition X Age X TSide	6.88812	2	3.44406	0.82
Error	63.31250	15	4.22083	
Blocks	1.35417	1	1.35417	0.72
Blocks X Age	7.51313	2	3.75656	1.99
Blocks X TSide	0.39263	1	0.39263	0.21
Blocks X Age X TSide	1.84312	2	0.92156	0.49
Error	28.31250	15	1.88750	
Condition X Blocks	2.20801	1	2.20801	2.27
Condition X Blocks X Age	0.61313	2	0.30656	0.31
Condition X Blocks X TSide	0.43878	1	0.43878	0.45
Cond.X Blcks.X Age X TSide	0.53813	2	0.26906	0.28
Error	14.61250	15	0.97417	

* $p < .02$

Analysis of Variance of Children's Mean Frequency of Panel Presses During 15-second Viewing Periods for Condition, Blocks, Age, Contingency, and Training Side

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
C	17.43487	2	8.71744	0.27
E	0.00617	1	0.00617	0.00
C X E	138.01954	2	69.00977	2.10
Error (Between S s)	492.04333	15	32.80289	
A	97.85964	2	48.92982	4.07***
A X C	54.74428	4	13.68607	1.14
A X E	3.37405	2	1.68703	0.14
A X C X E	85.12834	4	21.28209	1.77
Error	360.31640	30	12.01055	
B	5.73992	1	5.73992	1.07
B X C	11.13226	2	5.56613	1.04
B X E	0.84138	1	0.84138	0.16
B X C X E	0.04248	2	0.02124	0.00
Error	80.65930	15	5.37729	
A	1.33053	2	0.66526	0.13
A X B X C	9.27163	4	2.31791	0.46
A X B X E	22.49439	2	11.24719	2.24
A X B X C X E	12.51528	4	3.12882	0.62
Error	150.73329	30	5.02444	
D	2.91313	1	2.91313	0.39
D X C	12.77281	2	6.38640	0.86
D X E	1.85458	1	1.85458	0.25
D X C X E	1.84257	2	0.92128	0.12
Error	111.52872	15	7.43525	
A X E	0.58977	2	0.29488	0.07
A X D X C	38.09543	4	9.52386	2.26
A X D X E	27.14380	2	13.57190	3.23*
A X D X C X E	24.94989	4	6.23747	1.48
Error	126.15232	30	4.20508	
B X D	10.25977	1	10.25977	2.88
B X D X C	10.40101	2	5.20051	1.46
B X D X E	0.00056	1	0.00056	0.00
B X D X C X E	17.10479	2	8.55239	2.40
Error	53.36844	15	3.55790	
A X B X D	9.13844	2	4.56922	1.37
A X B X D X C	37.82337	4	9.45584	2.84**
A X B X D X E	1.97959	2	0.98979	0.30
A X B X D X C X E	20.07425	4	5.01856	1.51
Error	99.85333	30	3.32844	

* $p < .02$
** $p < .04$
*** $p < .03$

A = Condition
B = Blocks
C = Age Group
D = Contingency
E = Training Side