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CARDIAC CHANGE TO AN AUDITORY SIGNAL
AND EXPLORATORY BEHAVIOR
IN NORMAL AND DEVELOPMENTALLY DELAYED INFANTS

by

Sharon Bradley Johnson

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Doctor of Education

Western Michigan University
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Sharon Bradley Johnson

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TABLE OF CONTENTS

CHAPTER		PAGE
I	INTRODUCTION	1
	Attention and Cognition	2
	Attention and the Orienting Response	2
	Cognition and Exploratory Behavior	5
	Purpose of the Current Investigation	8
II	EXPERIMENT 1	10
	Method	10
	Subjects	10
	Procedure	12
	Cardiac measure	15
	Results	15
	Habituation	15
	Patterning	16
	Stimulus intensity	21
	Discussion	33
	Habituation	34
	Patterning	37
	Amount of heart-rate change	38
	Stimulus intensity	40
III	EXPERIMENT 2	42
	Method	42
	Subjects	42
	Procedure	42
	Results	44
	Discussion	44

CHAPTER	PAGE
IV EXPERIMENT 3	47
Method	47
Subjects	47
Procedure	47
Results	50
Manipulation of the familiar object	50
Manipulation of the novel objects	53
Preference for novelty	53
Amount of vocalization	55
Discussion	55
V GENERAL DISCUSSION	59
References	66

INTRODUCTION

This is a study of infant characteristics that influence cognitive functioning. If more were known about the personal characteristics that influence cognitive development then the assessment of these characteristics might be useful for the identification of infants who are at-risk in terms of later cognitive development. Knowledge of these characteristics might also contribute to the planning of effective intervention strategies to prevent or minimize cognitive impairment.

Present techniques of assessment of infant cognitive functioning are of little help in the identification of at-risk infants (Bayley, 1933; Lewis, 1973; Parmelee & Haber, 1973; Sigman, 1976). It remains unclear what characteristics displayed during the period of infancy correlate with later cognitive development (McCall, Hoharty & Hurlburt, 1972; Sigman, Beckwith, Cohen, Kopp, Littman & Parmelee, 1977).

Parmelee, Sigman, Kopp and Haber (1974) have proposed the use of multiple measures to identify the at-risk infant. These investigators suggest that a cumulative risk score, composed of multiple measures, may be a better predictor of functioning level than a single score on a standardized test. Preliminary results from the use of this cumulative risk score system suggest the advantage of multiple measures in assessment (Sigman, et al, 1977). However, considerably more research is required to determine what multiple measures can be used to improve the validity of early judgments.

Attention and Cognition

Measures of attention seem worthwhile for assessing development during infancy. Lewis (1974) has emphasized the importance of the relationship between attention and infant cognitive development. He suggests that since attending is a prerequisite to learning, individual differences in attending may be predictive of differences in later cognitive functioning. For example, an infant adept at attending would have an advantage in learning over an infant whose attending skills were not so well developed. Attention necessarily has a significant relationship to cognition and therefore seems to be a worthwhile area of investigation.

Attention and the Orienting Response

Attention is a covert process and cannot be measured or observed directly. Currently there is no consensus on a definition of attention. One definition which seems to be in agreement with what is known about attention is that it at least reflects an individual's readiness to receive and process information (Ross, 1976). Conditions that accompany attention can be measured by physiological changes which occur in response to repeatedly presented information. One physiological variable which correlates with attention is cardiac change in response to a moderate-level of stimulation. This cardiac change is generally referred to as a component of an orienting response (Crowell, Jones, Nahagawa & Kapuniai, 1972).

The orienting response was first described by Pavlov (1927). He observed that the dogs in his laboratory stiffened their ears and

inhibited ongoing activity when a novel stimulus was presented. Pavlov referred to this behavior as an unconditioned orienting reflex or the "what-is-it?" reaction. Extensive work with the orienting reflex and its parameters, with both animals and humans, was carried out in Russia. This work was largely ignored by Western psychologists until there was a demonstration of distinctive electrophysiological changes that took place with the orienting reflex in all types of learning settings (Grossman, 1967).

Researchers in psychophysiology in the United States have shown a renewed interest in the orienting response. This interest is to a large extent a function of an information processing model, based on the orienting reflex, which was proposed by Sokolov (1963). In this model Sokolov described two types of generalized responses to stimulation. One type of response is the orienting response which enhances the effects of stimulation and assists the organism in processing information. The other type of response is a defensive response which limits its stimulation effects and functions to protect the organism. The model suggests that different physiological changes are associated with the orienting and the defensive responses.

One difference between the orienting response and the defensive response seems to be based on the direction of the heart rate change; a decrease for the orienting response and an increase for the defensive response. A substantial amount of data tends to support this interpretation. Graham and Clifton (1966), Lacey (1967) and Graham and Jackson (1970) have interpreted heart rate deceleration as indicative of the orienting response and heart rate acceleration as demonstrating

the defensive response. This differentiation of the orienting and defensive responses, based on the direction of heart-rate change, has been shown with infants (Rewey, 1973; Berg, 1974) and also with adults (Berg & Chan, 1973; Jackson, 1974). Thus, the cardiac orienting response, indicated by heart-rate deceleration, is assumed to reflect receptivity to novel stimuli.

Porges (1977) has proposed a model of attention as indicated by the heart-rate response. This model is based upon results from several studies (Porges, 1972, 1974; Porges & Raskin, 1969; Porges, Walter, Korb & Sprague, 1975) where different components of the heart-rate response were associated with different types of attention. The two components of the heart-rate response are the reactive and sustained. The reactive component is made up of two responses; the first, a short latency response, occurs within two seconds following the onset of the novel stimulus and the second, a long latency response, occurs approximately two to six seconds following onset. Porges has suggested that the first part of the reactive component may be analogous to Sokolov's (1963) view of the orienting reflex as an intensity sensor. The second part of the reactive component (the long-latency response) may last for four or five seconds and be a function of the qualitative nature of the stimulus. Porges, Stamps and Walter (1974) proposed that the short-latency response may be reflexive and the long latency response more cognitive in nature. The second component, the sustained component, is distinguished by a decrease in heart-rate variability and reduced or temporary cessation of motor and respiration responses. This component continues for the duration of time

the subject attends. According to this model, measures of cardiac change reflect attentional responsivity.

Use of cardiac change as a measure of attention in infancy has several advantages. Only a minimal involvement of the child is required and an objective measure (cardiac rate change) is obtained. In addition, numerous studies have been undertaken with normal infants to demonstrate the use of a physiological measure of the orienting response to a variety of stimuli including auditory, tactile, visual and olfactory (Bronstein, Itina, Kamenetskaia & Sytova, 1958; Bridger, 1961; Keen, 1964; Egan & Lipsett, 1965).

In summary, the distribution of infants' attentional responses to repeated stimulation, or receptivity to novel stimuli, can be assessed by the use of the cardiac orienting response. This method has some advantages over standardized tests in infant assessment and the response occurs to several different types of stimuli. The cardiac component of the orienting response is an important phenomenon for investigation since it is a crucial factor in cognitive development (Crowell, et al, 1972).

Cognition and Exploratory Behavior

Another factor which may be related to cognitive development in infancy is exploratory behavior. Yarrow, Klein, Iomanaco and Morgan (1975) have emphasized that it is not sufficient to try to change an at-risk child's I.Q. score. Rather, the competent child is one who freely explores the environment and persists even on difficult tasks. The authors indicate that these cognitive-motivational factors may likely be prerequisites to sustained intellectual functioning.

Evidence for the relationship of exploratory behavior and cognition has been demonstrated in a study by Yarrow, et al, (1975). Performance at 3½ years on the Stanford-Binet was found to be significantly correlated with the length of exploration of novel objects in six-month-old infants. This finding is not surprising since an infant who actively explores novel objects has more opportunities to learn about them and therefore, would probably function at a higher cognitive level than an infant who is passive and rarely explores.

Infants' exploratory behavior can be measured in several ways. One method is to present the child with a novel object and to record the length of time the object is manipulated and visually explored (Rubenstein, 1967). Another procedure to measure exploratory behavior is to examine infants' preference for novelty. This can be done by presenting the child with a novel and a familiar object simultaneously and by observing which object is manipulated or visually explored for a longer period of time (Rubenstein, 1967; Sigman, 1976).

Piaget (1952) describes the importance of novelty or variety to the development of knowledge. Variety allows schemata to be differentiated through the processes of assimilation and accommodation. A schema is a structure underlying a child's actions. Assimilation is the process whereby the child takes in information and adds that information to knowledge that already exists. The process of changing the knowledge that already exists to meet the demands of a new situation is accommodation. As an infant develops different schemata, he becomes capable of interacting with novel objects in different ways resulting in even more of a variety of stimulation for the child. The production

of this variety, or novel stimulation, is pleasurable for the infant and he continues exploring and learning about the environment.

The human infant actively seeks stimulus change (Sigueland, 1969). Rheingold and Samuels (1968) found that the lack of stimulus change becomes aversive for ten-month-old babies.

The work of several investigators (Fagan, Fantz & Miranda, 1971; Weizman, Cohen & Pratt, 1971; Wetherford & Cohen, 1973) suggests that this preference for novelty over familiarity in the exploration of the environment has a developmental component. Though infants show a preference for novel two-dimensional visual stimuli at least as early as ten weeks of age (Wetherford & Cohen, 1973), differential manipulation of objects does not occur until about eight months of age (Schaffer, 1975). As the infant matures and acquires more information about the environment through the acquisition of differentiated schemata, his preference for the familiar seems to change to a preference for novelty. This preference would be expected to facilitate further cognitive growth.

Additional evidence regarding the relationship between preference for novelty and cognition is provided in a study by Miranda and Fantz (1974). Down's syndrome infants displayed a visual preference for novel two-dimensional objects at later ages than normal infants. Down's syndrome infants are a cognitively delayed group, at least after one year of age (Kopp, 1977). In addition, Sigman (1976) found that when eight-month-old premature and fullterm infants of equal conceptual age were assessed for exploratory behavior, different patterns of preference for novelty were evident. Although all of the infants in her

study showed a preference for novelty, the degree of preferential attention was greater for fullterm infants. In this same study it was found that when high- and low-risk infants were compared on preference behavior, low-risk infants also displayed greater preference for novelty. This type of exploratory behavior necessarily involves cognition since the infant must recognize the familiar to demonstrate a preference (Sigman, 1976).

Purpose of the Current Investigation

The substantial role of attention and exploratory behavior in cognitive development is supported by considerable research evidence. Differences on a measure which is correlated with attention and on measures of exploratory behavior would therefore, be expected to vary with different levels of cognitive development. Research which examines the relationship of both attention and exploratory behavior to cognition could provide much needed information in the area of infant development.

The purpose of this investigation was to determine whether two groups of infants differed on a measure of a physiological response which accompanies attention and on two measures of exploratory behavior. One group of infants was developing normally and the other, due to prenatal complications, was developmentally delayed. The physiological measure which accompanies attention was cardiac change in response to a repeatedly presented auditory signal. Exploratory behavior was measured by duration of manipulation of a novel object and also by differential manipulation of novel and familiar objects. The research

hypothesis was that there would be a difference between the normal infants and the developmentally delayed infants on all three measures. It was expected that the normal infants would show greater cardiac deceleration to the auditory signal, longer duration of manipulation of a novel object and greater preference for novel objects than the developmentally delayed infants. Since attention and exploratory behavior are related to cognitive functioning, differences in the three measures used would be expected to vary with different levels of cognitive development.

All infants in the group that was delayed in development had suffered some type of prenatal condition associated with mental impairment in childhood. These prenatal factors included: hydrocephaly, microcephaly, Down's syndrome and Conrade's syndrome. These children were likely to be functioning at lower cognitive levels than the normally developing children during infancy, as well. Evidence for this difference in developmental level in these infants was shown by slower rates of development of motor, social and pre-language skills.

Three experiments were included in this study. Experiment 1 examined cardiac change to a repeatedly presented auditory signal. Experiment 2 investigated exploratory behavior measured by duration of manipulation and visual exploration of a novel object. Experiment 3 examined exploratory behavior indicated by differential manipulation and visual exploration of novel objects. Amount of vocalization was also observed during experiments 2 and 3.

EXPERIMENT 1

The purpose of this experiment was to examine the cardiac response of normal and developmentally delayed infants to a repeatedly presented auditory signal.

Method

Subjects

Ten infants from the Bronson Methodist Hospital Follow Along Clinic in Kalamazoo, Michigan were the subjects for this study. All children involved in the Clinic had been in the Bronson Special Care Nursery because of some problem which occurred before, during or shortly after birth. Five of the infants had experienced some type of difficulty, such as prematurity, but were diagnosed by their physicians as developing as healthy normal babies. Clinic records indicated that these infants were developing at a normal rate in terms of physical growth and motor, social and pre-language skills. The other five infants were diagnosed by their physicians as developmentally delayed due to some prenatal condition associated with mental impairment in childhood. These prenatal conditions included Conrade's syndrome, Down's syndrome, arrested hydrocephaly and microcephaly. For these five infants the clinic records all contained a history of delayed development in motor, social and pre-language skills.

The infants were selected on the basis of the following criteria:

- (a) age at time of assessment between 8 and 24 months (One child with

Conrade's syndrome was 31 months old.) (b) no physical impairment that would interfere with performance (c) family residing within a 40-mile radius of Kalamazoo (d) permission given by the child's physician (e) permission given by the child's mother.

The group of infants developing normally contained one girl and four boys and in the developmentally delayed group there were three girls and two boys.

Age mean, median and range scores for each group are presented in Table 1 (see page 12). No difference in age was found for the two groups of subjects (t , 8 = 1.14, NSD).

Originally there were 14 subjects selected for the study. However, three subjects in the normal group fell asleep during the assessment and one subject in the developmentally delayed group cried the entire time and the session was terminated.

Clinic records were screened for infants who met the criteria for the study. The local physician for each infant selected was contacted and the purpose and procedures for the study explained to him. A total of seven physicians were contacted and all agreed to participate. After receiving the physician's written permission, the examiner contacted the mother and described the study to her. If the mother indicated a willingness to participate the examiner made an appointment to visit the home. On the home visit the examiner described the study in detail, answered any questions the mother had and asked her to come to the hospital with the infant for the assessment. Of 16 families contacted, 13 agreed to participate and showed up for the appointment (two infants were from one family), three agreed to come and did not

Table 1
Ages in Months

Group	<u>n</u>	Mean	Median	Range
Normal Infants	5	14.7	16.0	10.8 - 18.6
Developmentally Delayed Infants	5	18.8	16.5	12.4 - 31.4

show up for their appointments, one moved out of town before the scheduled appointment and one refused to participate. For the mothers who agreed to participate, an appointment was scheduled for a two-hour session. As much as possible, this appointment was arranged so as to avoid the infant's feeding and nap times.

Procedure

When the mother and child arrived at the hospital the mother was asked to sign an informed consent form. This form was read to her and she was given an opportunity to ask any questions she might have about the procedures. This part of the session was tape recorded to provide a record of the questions and answers.

The experiment was conducted in a 10' x 14' room in the Clinical Investigational Unit of Bronson Hospital. The room contained only a desk, two chairs and the equipment for the study. The child was seated on the mother's lap facing a blank wall. The mother was instructed that when the session started she was to remain as still as possible and not interact with the child in any way. A toy with which the child was to play was attached to a string and the string was placed around

the mother's wrist (See Figure 1, page 14). The mother was told to hold the toy within the child's reach.

Three Beckman miniature skin electrodes were attached to the infant's body; one to the front of the right shoulder just below the collar bone, another on the left side at the midpoint of a line between the armpit and the bottom of the rib cage, and the third at the same point on the right side. A double sticky-sided annulus held the electrode in place and standard electrode paste was used. The electrode wires were hidden under the child's clothing to prevent the child from playing with them. Several minutes were allowed for the child to adapt to the situation.

Heart rate was recorded on a Grass polygraph, Model 79 PCP A. Beat-to-beat intervals were converted to beats-per-minute by a Grass tachograph. Heart-rate amplitude was recorded on the second channel of the polygraph.

A six-inch speaker was located approximately three feet behind the infant and the mother at the level of the child's head. The speaker was connected to a Heathkit Model 1 G-82 Sine-square Wave Generator and two Hunter Decade Interval Timers, Model 11-B. This apparatus was used to deliver a 65 db pure sine tone at 350 cps for 30 seconds. A B & K Sound Level Meter was used to measure the level of the pure tone and of the ambient noise. The ambient noise level at the height of the child's head was 45 db. The pure tone was presented for 15 trials with 20 second interstimulus intervals. Presentation began once a stable baseline, established by visual inspection of the heart-rate record, was obtained. An automatic counter recorded the number

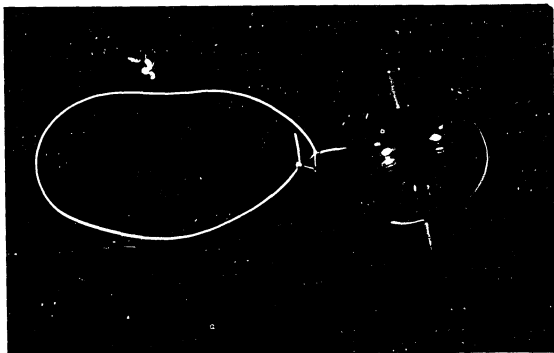


Figure 1. The Toy with which children played.

of trials. A six-foot metal screen separated the mother and child from the equipment. Two examiners were present for all sessions to operate and monitor the equipment.

Following the 15 trials of the pure tone there was a second stimulus presented for two trials. The second stimulus was a 65 db pure tone at 650 cps. This paradigm was used to determine whether any decrease in responding might be attributed to fatigue. Two of the infants in the developmentally delayed group had hearing problems and for these subjects the db levels for both stimuli were 65 db of 400 and 700 cps respectively.

Cardiac measure

The average number of beats per minute for each one-second interval was calculated. The one-second interval included all full beats and beats of which 50 percent or more fell within the interval. The data were analyzed over one-second prior to stimulus onset and nine seconds following stimulus onset. This interval was selected on the basis of previous studies which indicated that the deceleratory response of the heart to stimulus presentation was included within this nine-second interval (Pomerleau-Malcuit & Clifton, 1973; Adkinson & Berg, 1976). The heart-rate data were hand scored.

Results

A linear regression of poststimulus heart rate upon prestimulus heart rate revealed a beta of .99. If results of a linear regression indicate that the beta is within a range of .99 to .85, previous research has shown that the prestimulus level accounts for little of the variance (Graham, 1977). Therefore, no adjustment of the heart-rate measures was made.

Habituation

A 2 (infant group) x 15 (trials) x 9 (intervals: seconds following onset) analysis of variance resulted in no significant effect of trials (See Table 2, page 16.).

The expected habituation over trials was not shown in the data, but there was a fluctuation in the heart-rate response to the tone for both groups of infants. The fluctuation is represented in Figure 2.

Table 2

Analysis of Variance Summary Table

Source	Sum of squares	Degrees of freedom	Mean square	F
Mean	740.44	1	740.44	3.88
Group	1304.00	1	1303.99	6.83*
Error	1527.50	8	190.94	
Trial	2921.86	14	208.70	.64
Trial x group	6386.83	14	456.20	1.41
Error	36263.29	112	323.78	
Interval	260.37	8	32.55	1.37
Interval x group	648.80	8	81.10	3.41**
Error	1522.83	64	23.79	
Trial x interval	2829.43	112	25.26	.99
Trial x interval x group	2323.92	112	20.75	.82
Error	22690.87	896	25.32	

* $p < .03$ ** $p < .003$

Both the normal and the developmentally delayed infants showed three phases of deceleration or fluctuation. The first two fluctuations for the developmentally delayed babies seemed to occur on somewhat later trials than the fluctuations for the normal infants. For trials two through seven, the data for the developmentally delayed infants are a mirror image of the data for the normal infants (See Figure 2, page 17.).

Patterning

Figure 2 also shows that the normal infants appeared to exhibit heart-rate deceleration more frequently than the developmentally delayed infants. Individual analysis of the intervals within a group, summed across trials, indicated that the normal infants showed a

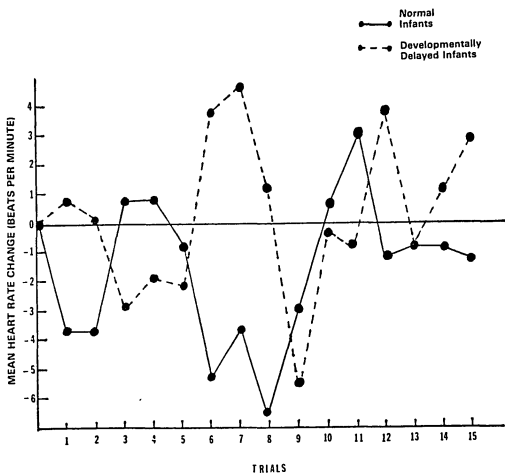


Figure 2. Heart Rate Change for Nine-Seconds Post Onset.

significant heart-rate deceleration 4, 5, 6 and 7 seconds following stimulus onset. The developmentally delayed infants did not demonstrate significant heart-rate change on any of the one-second intervals (Tukey HSD Test). (See Table 3, page 19.)

Normal infants maintained the deceleration in heart rate from two to five consecutive trials and the developmentally delayed infants from one to three trials. (See Figure 2.)

An analysis of variance indicated a significant group x interval interaction. (See Table 2.) Figure 3 (page 20) shows that the normal babies evidenced a deceleration in heart rate after the first one-second interval. In contrast, after the first one-second interval, the developmentally delayed infants demonstrated an acceleration on five intervals following the onset of the tone. Some deceleration in heart rate became evident for those infants on the ninth interval.

Individual analysis of the groups at each of the nine intervals indicated that there were significant differences between the groups for 3, 4, 5, 6 and 7 seconds following the presentation of the tone. (See Table 4, page 19).

The strong deceleration in heart rate for the normal infants was also evident in the data for the individual babies. The individual data for the developmentally delayed infants show either a relatively weak deceleration or an acceleration in heart rate. These data are displayed in Table 5 (page 21). The range in heart-rate change on the 15 trials for the normal babies was -84.0 to -155.7 beats per minute and for the developmentally delayed infants -66.2 to +153.1 beats per minute.

Table 3

Mean Heart Rate Change Scores Summated over Trials
for Each Interval Following Onset of the Tone
(beats per minute)

Interval following stimulus onset	Amount of Cardiac Change	
	Normal infants	Developmentally delayed infants
1	.5	-.4
2	-.3	.1
3	-1.9	.5
4	-2.4*	.6
5	-3.0*	.8
6	-2.9*	.4
7	-2.5*	0
8	-1.8	-.1
9	-1.6	-.2

*p < .05

Table 4

Between Group Comparison of Cardiac Change Scores
Summated over Trials
(beats per minute)

Interval following stimulus onset	Mean for normal infants	Mean for developmentally delayed infants	Difference between groups
1	.54	-.32	.86
2	-.31	.13	.44
3	-1.83	.58	2.41*
4	-2.35	.63	2.98*
5	-2.95	.88	3.83*
6	-2.82	.46	3.28*
7	-2.43	.03	2.46*
8	-1.79	-.03	1.76
9	-1.58	-.20	1.38

*p < .05

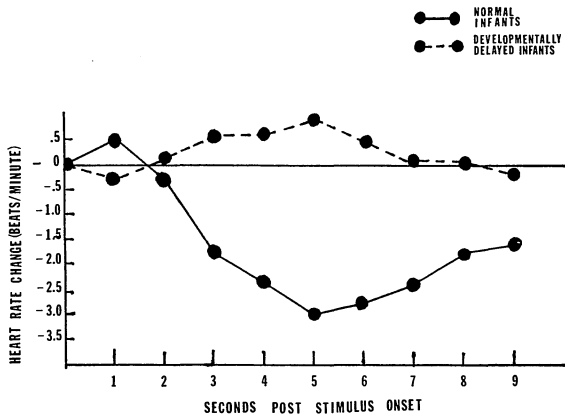


Figure 3. Cardiac Response over 15 Trials

Table 5

Heart Rate Change for Individual Infants
Summated Over 15 Trials
(beats per minute)

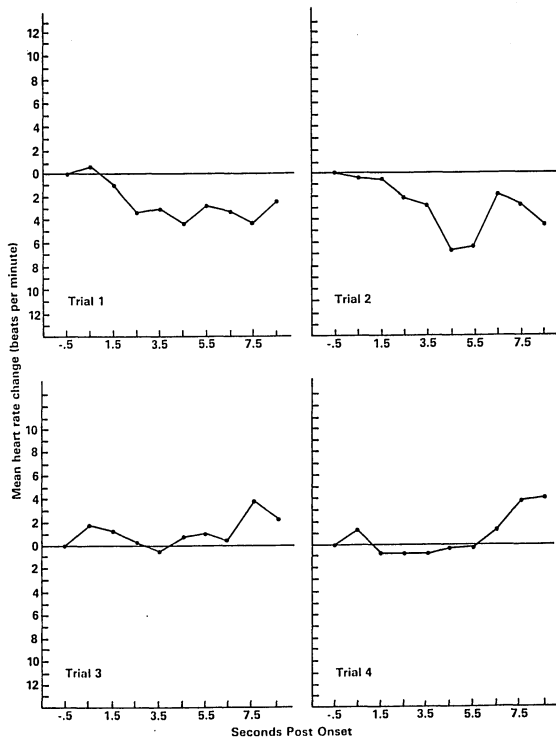
Normal infants	Developmentally delayed infants
-155.7	- 66.2
-140.2	- 39.2
-115.8	- 3.6
- 91.5	+ 81.3
- 84.0	+153.1

The data for each of the one-second intervals for each trial are presented in Figures 4 through 20 for the normal infants and Figures 21 through 37 for the developmentally delayed infants. (See pages 22 - 31.)

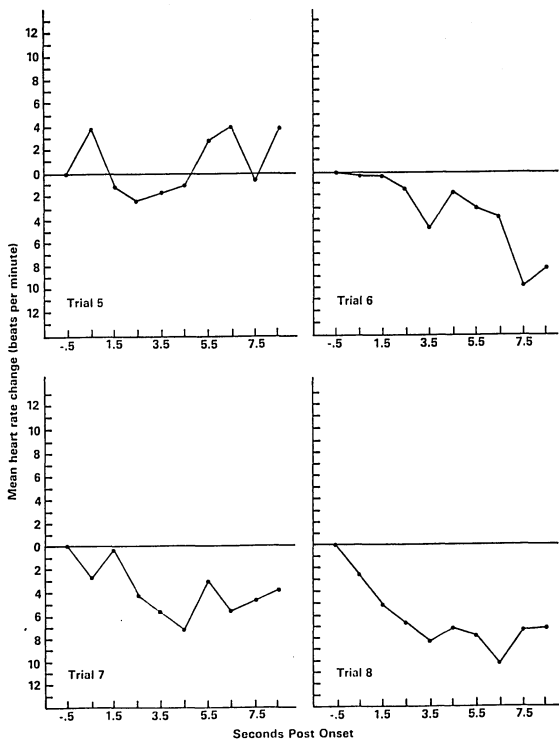
Stimulus intensity

On the first two trials of the first stimulus the normal infants seemed to show a greater amount of heart-rate deceleration than the developmentally delayed infants. The amount of heart-rate change for the normal infants on these two trials was -51.7 beats per minute and for the developmentally delayed infants was +26.3 beats per minute. (See Figure 38, page 32.) However, no significant difference was found between the groups. (See Table 6, page 33.) The lack of significance seems to be due to the small amount of data obtained with only five subjects and the large standard deviations which existed for these data.

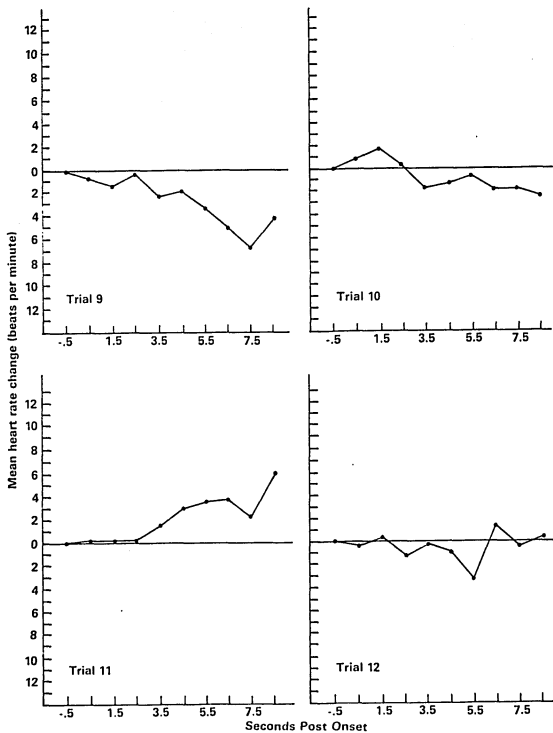
On trials 16 and 17, where the second stimulus was presented



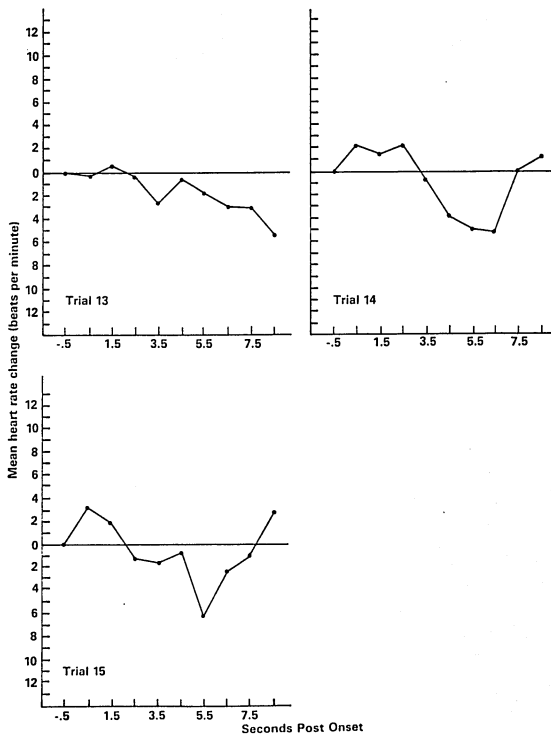
Figures 4, 5, 6 and 7. Cardiac change of the 5 normal infants



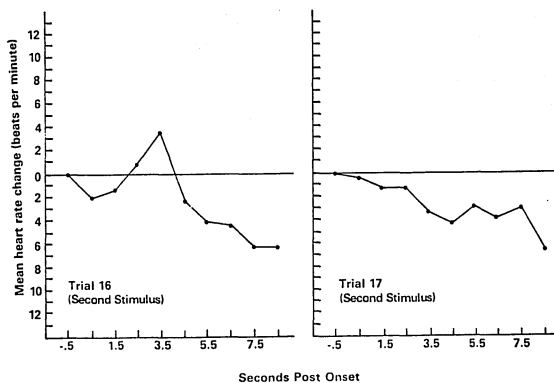
Figures 8, 9, 10 and 11. Cardiac change of the 5 normal infants



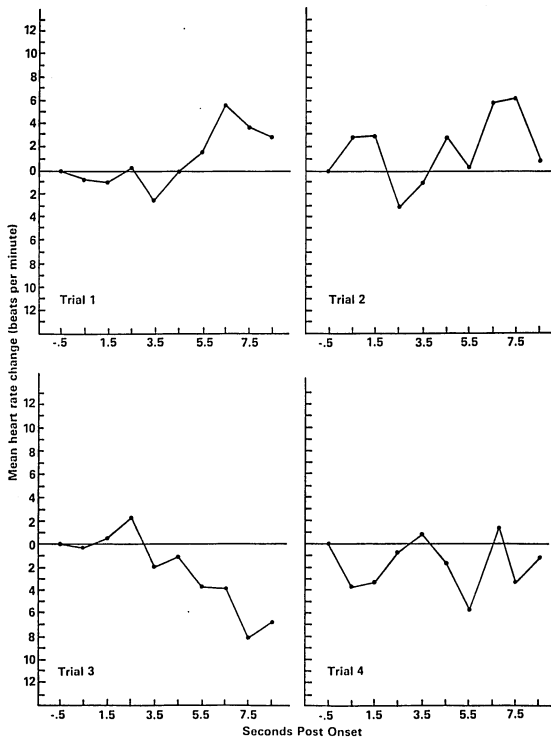
Figures 12, 13, 14 and 15. Cardiac change of the 5 normal infants



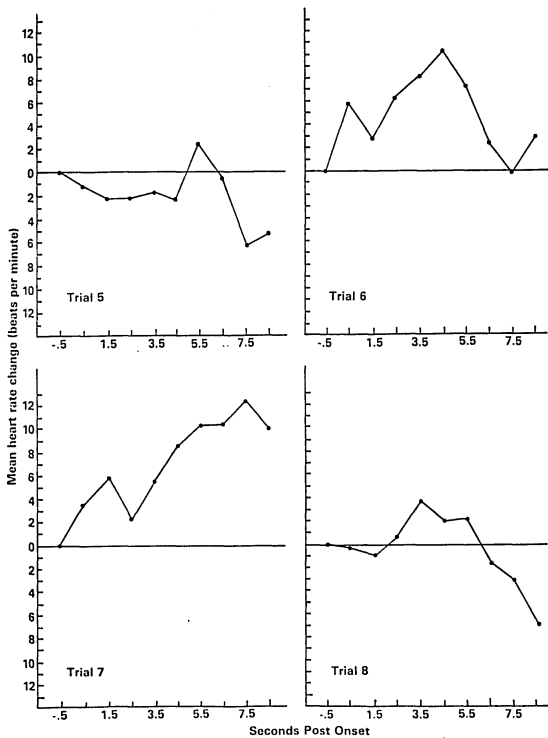
Figures 16, 17 and 18. Cardiac change of the 5 normal infants



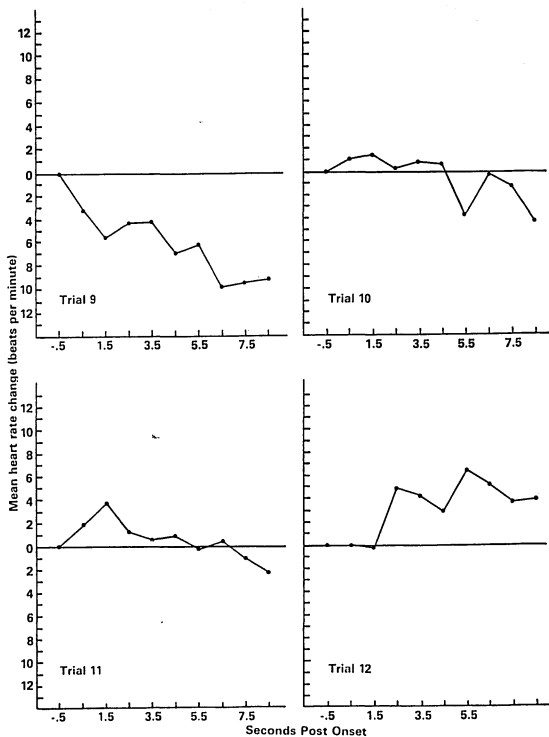
figures 19 and 20. Cardiac change of the 5 normal infants
Dishabituation trials



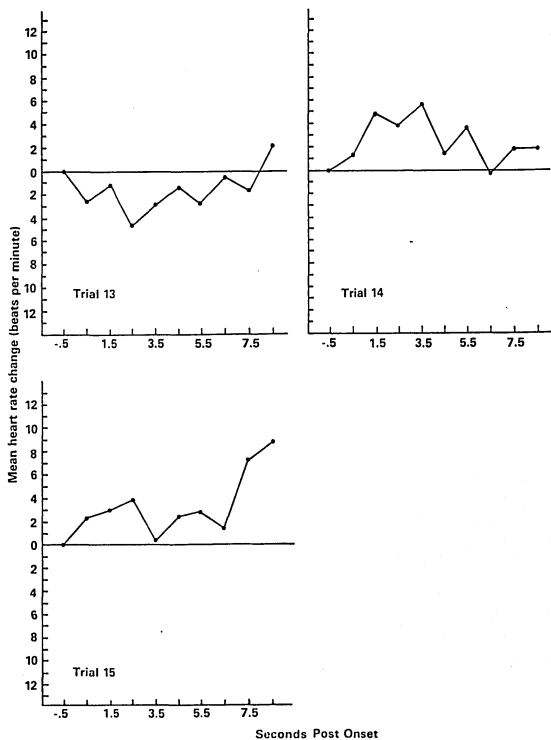
Figures 21, 22, 23 and 24. Cardiac change of the 5 developmentally delayed infants



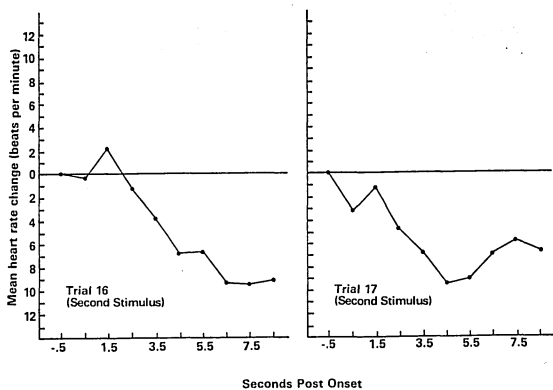
Figures 25, 26, 27 and 28. Cardiac change of the 5 developmentally delayed infants



Figures 29, 30, 31 and 32 Cardiac change of the 5 developmentally delayed infants



Figures 33, 34 and 35 Cardiac change of the 5 developmentally delayed infants



Figures 36 and 37. Cardiac change of the 5 developmentally delayed infants
Dishabituation trials

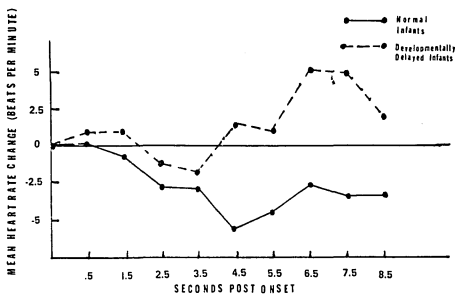


Figure 38. Cardiac Response for Trials 1 and 2 (First Stimulus)

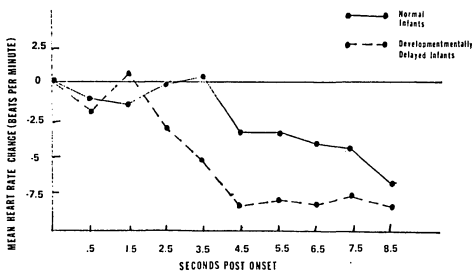


Figure 39. Cardiac Response on the two Dishabituation Trials (Second Stimulus)

Table 6
Analysis of Variance Summary Table

Source	Sum of squares	Degrees of freedom	Mean square	F
Mean	951.27	1	951.27	.85
Group	1545.88	1	1545.88	1.38
Error	8942.97	8	1117.87	
Interval	517.37	8	64.67	.80
Interval x group	744.91	8	93.11	1.15
Error	5178.42	64	80.91	

(a 300 cps increase in frequency), the developmentally delayed infants appeared to demonstrate a greater amount of heart-rate deceleration than the normal infants. The amount of heart-rate change for the normal infants was +49.2 beats per minute for the two trials and was -98.3 beats per minute for the two trials for the developmentally delayed infants. Figure 39 (page 32) displays these data. No significant difference was found between the groups, however. (See Table 7, page 34.) This lack of significance also seems to be due to the small amount of data obtained and the large standard deviations for these data.

Discussion

Differences between normal and developmentally delayed infants were found in cardiac response to a moderate level, repeatedly presented, pure-tone auditory signal. The differences were shown when several characteristics of the cardiac response were examined; habituation, patterning and amount of heart-rate change.

Table 7

Analysis of Variance Summary Table

Source	Sum of squares	Degrees of freedom	Mean square	F
Mean	4488.75	1	4488.75	2.07
Group	593.93	1	593.93	.27
Error	17319.51	8	2164.94	
Interval	1663.31	8	207.91	2.48*
Interval x group	647.12	8	80.89	.96
Error	5364.78	64	83.82	

* $p < .02$ Habituation

On the basis of prior research, habituation of the heart rate deceleration response to the signal was anticipated (Adkinson & Berg, 1976; Graham & Clifton, 1966). Thorpe (1956) defines habituation as a relatively permanent waning of the response as a function of repeatedly presented stimulation not followed by reinforcement. Several studies carried out with normal infants have shown habituation over trials (Kagan & Lewis, 1965; Bartoshuk, 1962; Adkinson & Berg, 1976). Other studies comparing normal infants and infants who suffered some type of trauma at birth found habituation with normal infants and minimal evidence of habituation, or no habituation at all, with the infants suffering trauma (Bronstein, Antonova, Kamenetskaya, Luppova & Sytova, 1958; Eisenberg, Coursin & Rupp, 1966). Conversely, Luria (1963) has proposed that the mentally retarded cannot maintain an orienting response to a change in stimulation and that the orienting response of these subjects habituates quickly.

It is difficult to draw conclusions from the current literature since the studies have employed different measures (GSR, EEG, EKG, and head and finger blood volume measures), different types of stimuli (visual, auditory and tactile), different stimulus parameters (such as duration and intensity) and different populations.

Another variable which may account for seemingly conflicting results in the literature was observed in the present study. The number of trials administered may affect the results in terms of habituation of the heart rate response. Rather than habituation, a fluctuation of the decelerating heart rate response occurred over trials for both groups of infants. In other words, some of the previous studies which demonstrated habituation of heart-rate deceleration might have found fluctuation of the response if more trials had been run. Several studies blocked trials in the analysis procedure or sampled the lowest or highest beats in an interval, rather than examining each beat-per-minute. Either of these procedures could mask the response form, particularly the fluctuating aspect of the response. Examining each beat-per-minute without averaging by trial blocks may more accurately describe the change which occurs in the response.

Fluctuation of heart-rate deceleration was found in this study. This is shown in Figure 2. These results are similar to results of research carried out by Frieberg (1937). In Frieberg's study, subjects were required to press a key upon hearing a signal. Results indicated that the subjects' performance fluctuated with both pure and complex tones of liminal intensity; the most rapid fluctuations occurring with tones perceived about half of the time. Adaptation did not occur.

The auditory signal in the present study was approximately equivalent to the level of normal conversation (65 db). This level did not appear to be at a threshold level and a strong response was obtained by both groups on a number of trials. For example, a mean heart-rate decrease of six beats was noted eight seconds following stimulus onset for the normal group. Nine seconds after the onset of the tone a mean heart-rate deceleration of five beats was observed for the developmentally delayed babies. Moderate, as well as low level stimuli may result in a fluctuation of heart-rate responses.

Whether or not heart-rate deceleration to stimulation indicates that the individual is attending to the stimulus is unclear. Karrer (1976) warns that inferring a behavioral state (such as attending) from a physiological measure (such as heart-rate deceleration) is currently a weak position. He suggests that it is necessary to confirm this inference using a direct test of behavior. A study using a measure of behavior, reaction time, and heart-rate response to stimulation has been carried out by Krupski (1976). She found that for both normal and mentally retarded young adults heart-rate deceleration seemed to reflect an individual's maximum preparedness to respond. Other studies have shown that cardiac deceleration accompanies attention to visual and auditory stimuli in adults (Lacey, 1959; Lacey, Kagan, Lacey, & Moss, 1963) and in first graders (Kagan & Rosman, 1964).

The examination of heart-rate deceleration revealed that for both the normal and developmentally delayed infants a fluctuation of the heart-rate deceleration response occurred, rather than habituation.

It is questionable whether heart-rate deceleration to a signal reflects the individual's attention to the stimulus. It seems reasonable to assume, however, that the deceleration in heart rate at least corresponds to a preparedness of the individual to respond to the stimulus.

Patterning

The patterning of the heart-rate response to the pure tone indicated a large difference between the normal and the developmentally delayed infants. This difference is displayed in Figure 3. When the data were collapsed over trials, the normal infants showed a strong heart-rate deceleration to stimulation. In contrast, the developmentally delayed infants displayed an acceleration in heart rate to the tone. Individual data for normal infants showed a strong deceleration, also, while data for individual infants in the developmentally delayed group showed a relatively weak deceleration or an acceleration in heart rate. A number of factors, or the interaction of several factors, may account for this difference. Karrer (1976) suggests that finding a reliable and valid difference between individuals does not necessarily mean that an "organic lesion" exists. The difference found may not be related to etiology. Karrer emphasized that the difference reflects the complex interaction of biological developmental, genetic and experience factors. This is not to deny that the difference may be a sign of a lesion of some physiological process, but to stress that the interaction of many variables may be responsible for the difference.

Several studies have demonstrated that a relationship exists

between heart-rate acceleration and "rejection" of a stimulus and heart-rate deceleration and "acceptance" of the stimulus (Lacey, 1963; Graham & Clifton, 1966). On the basis of these studies it has been postulated (Karrer, 1976) that acceleration may be related to cognitive processing and stimulus blocking and that on a passive stimulus reception task, retarded subjects would be expected to show similar or more deceleration than normals. In the present study, which employed a simple stimulus reception task, the results were the opposite to those expected on the basis of this hypothesis. The developmentally delayed infants showed much more acceleration than the normal infants. It may be that if acceleration indicates stimulus rejection and deceleration stimulus acceptance, then the normal infants did not reject the stimulus. Therefore, they had more opportunities to learn about it, especially on early trials. The greater heart-rate deceleration (possibly stimulus acceptance) of the normal children may, at least partially, account for the faster learning which typically occurs on tasks with normal individuals. Even a simple stimulus needs to be processed.

Amount of heart rate change

The amount of heart-rate deceleration, determined by magnitude and frequency of the response, was different for the normal than for the developmentally delayed infants, also. The difference in magnitude is shown in Figure 3 and Table 4. The difference in frequency is displayed in Figure 2 and Table 3. (Figures 4 through 37 show the distribution of the data for each group on each trial.) In this study a moderate level stimulus (65 db, 350 cps tone) was selected; and

approximately the decibel level of normal conversation. Since many learning situations involve verbalization, this seemed an important level of auditory stimulation to investigate.

Regarding stimulus intensity and heart rate deceleration, Luria (1963) has suggested that the mentally retarded emit fewer orienting responses than normal individuals to moderate or low levels of stimulation. Moskowitz and Lokman (1970) found it necessary to use an intense level of stimulation to evoke an orienting response with Down's syndrome subjects. When the data for each trial in this study are examined it is evident that both the normal and developmentally delayed infants demonstrated an orienting response to this moderate level stimulation.

Though both groups exhibited heart rate deceleration when the amount of deceleration is examined there is a considerable difference between the groups of infants as shown in Figure 3. The total amount of deceleration was greater for the normal than for the delayed infants. During any fluctuation phase the normal infants appeared to maintain a deceleration in heart rate for more consecutive trials than the developmentally delayed infants (two to five trials and one to three trials respectively). (Refer to Figure 2.) If heart rate deceleration is correlated with attention, then these data are consistent with the literature on mental retardation. Denny (1964) suggests that the mentally retarded have a deficit with respect to duration of attention. Luria (1963) contends that the mentally retarded cannot maintain an orienting response. This deficit may be evident during infancy by amount of heart-rate deceleration and its maintenance over consecutive trials.

The fluctuation of the deceleratory heart-rate response seemed to take place on later trials for the developmentally delayed babies than for the normal babies. This is displayed in Figure 2. For the first seven trials the response distribution of the developmentally delayed group was the mirror image of the normal group of babies. Assuming heart-rate deceleration corresponds to preparedness to respond, this finding is consistent with the fact that the mentally retarded show a delayed response and delayed reaction time compared to normal subjects (Denny, 1966).

Thus, both normal and developmentally delayed infants demonstrated heart-rate deceleration to a moderate level auditory signal. The normal infants showed a greater amount of deceleration, a greater frequency of the response and seemed to maintain the cardiac deceleration over more consecutive trials than the developmentally delayed infants. The cardiac deceleration seemed to occur on later trials for the developmentally delayed babies. If heart-rate deceleration is correlated with attention then these results seem consistent with the literature on attention and mental retardation.

Stimulus intensity

The importance of assessing various stimulus parameters was evident in this study. Karrer (1976) notes that the retarded are repeatedly less responsive to low intensity stimulation but are equal to or more responsive with higher level stimuli. During trials 1 and 2 of the first stimulus (65 db, 350 cps) the normal infants seemed to show greater heart-rate deceleration than the developmentally delayed infants.

(See Figure 38.) Since habituation was anticipated, a dishabituation paradigm was used on trials 16 and 17. For these trials a second stimulus at 65 db, but increased to 650 cps, was presented. On these two trials the developmentally delayed infants seem to display greater deceleration than normal infants. (See Figure 39.) The increase in frequency of the tone may have functioned as an increase in intensity, even though the db level remained unchanged. The results are consistent with previous studies where developmentally delayed individuals were more responsive than normal individuals to intense stimulation. Future research should investigate the effect of different frequencies, as well as db levels on heart-rate deceleration.

Many questions can be raised regarding psychophysiological measures and mental retardation. Yet heart-rate response seems to have considerable potential as a measure to differentiate between normal and developmentally delayed infants. Further investigation is needed in many areas including the effect of various stimulus parameters and various types of stimulation. Analysis of heart-rate response to onset and to offset of stimulation would provide more data on each individual than is provided by this study. Studies on heart-rate response to a repeatedly presented stimulus should use many trials, for example 10 to 15 trials, to clarify the issue of fluctuation versus habituation. Examination of data on individual trials, and sampling each beat per minute, seem necessary to accurately describe the response. Finally, studies using larger numbers of subjects and different subgroups of the mentally retarded would provide critical information regarding the usefulness of this measure.

EXPERIMENT 2

This experiment was conducted to assess duration of manipulation of a single novel object by normal and developmentally delayed infants.

Method

Subjects

The infants who participated in experiment 1 also participated in this study. The infants who cried and who fell asleep in experiment 1 responded without difficulty in this experiment, making 6 infants in each group. The sixth infant included in the developmentally delayed group was diagnosed as having cerebral hypotonia.

Age mean, median and range scores for each group of babies are presented in Table 8 (page 43). No difference in age was found for the two groups of infants ($t, 10 = 1.8$, NSD).

Procedure

Upon completion of experiment 1 the mother and infant were given about a 10 minute break. Then experiment 2 was begun.

The study was conducted in a 10' x 14' room in the Clinical Investigational Unit of Bronson Hospital. The procedure used was Rubenstein's Bell Test (1967). The infant was seated on the mother's lap at a table covered by a white cloth. The examiner sat across the table. A one-minute adaptation period was allowed. The mother was instructed to give the child support to remain upright, but not to interact with the

Table 8
Ages in Months

Group	<u>n</u>	Mean	Median	Range
Normal Infants	6	11.7	11.6	8.0 - 16.9
Developmentally Delayed Infants	6	18.3	16.5	12.4 - 31.4

child in any other way during the session. The child was then presented with a single novel stimulus, a bell with a red wooden handle. A string was attached to the handle. The examiner held the other end of the string so that if the bell fell off the table it could be quickly replaced. The examiner rang the bell and placed it on the table within reach of the child for a ten-minute interval. In Rubenstein's procedure data were collected using an event recorder. In this study the examiner used a stop watch to record the amount of time the child made tactile or oral contact with the bell. A sweep hand timer measured the ten-minute interval. At the end of the session the amount of the child's visual exploration and vocalization were recorded on a three-point scale. A score of 1 indicated that the behavior did not occur, a 2 that the behavior was displayed infrequently and a 3 represented frequent occurrence of the behavior. If the child began to cry or become restless, the session was terminated until the mother quieted the child. This was necessary with only two children who quieted quickly and the session resumed without further problems.

Results

The data revealed that the duration of manipulation of the bell varied significantly between the normal infants and the developmentally delayed infants. (See Table 9, page 45.) Table 10 (page 45) presents the mean, standard deviation and range scores for each group. The normal infants manipulated the novel object for a longer period of time (mean = 505.3 seconds) during the ten-minute interval than the developmentally delayed infants (mean = 358.7 seconds).

The three-point rating scale used to describe visual exploration and amount of vocalization resulted in a clustering of the data around the middle score (2). Thus, the results for these measures were obscured by the lack of sensitivity of the rating scale.

Because Rubenstein found that sex differences were not significant for the Bell Test the data were combined for both sexes.

Discussion

The hypothesis that differences in exploratory behavior, measured by duration of manipulation of a novel object and amount of visual exploration and vocalization, would vary between normally developing infants and infants delayed in development was supported. The differences were in the predicted direction with the normal infants displaying more exploratory behavior. (See Table 9.)

Inhelder (1974) points out that a child can be mentally active without engaging in manipulation of objects and that he can also be mentally passive while manipulating objects. Though a child's manipulation of a novel object does not necessarily mean he is mentally

Table 9

Analysis of Variance Summary Table

Source	Sum of squares	Degrees of freedom	Mean square	F
Between	64,533.2	1	64,533.2	5.42*
Within	119,136.8	10	11,913.7	
Total	183,670.0	11		

*p < .05

Table 10

Duration of Manipulation of the Bell in Seconds**

Group	<u>n</u>	Mean	Standard Deviation	Range
Normal Infants	6	505.3	81.94	409 - 599
Developmentally Delayed Infants	6	358.7	130.82	146 - 507

**600 seconds maximum

active, the manipulation at least increases the probability that he will receive more varied information about the object than if he had not manipulated it. In other words, when an infant manipulates novel objects he increases the opportunities available for learning.

Rubenstein (1967) used the Bell Test with infants who varied in the amount of maternal attentiveness they received. She found significant differences in manipulation, looking and vocalization between children whose mothers were rated as high and low in attentiveness. No significant differences were found on any of the measures for children whose mothers were rated as high and medium or medium and low in

attentiveness. In the present study, the Bell Test discriminated between infants with a relatively large difference in cognitive level. It may be that the measure is not sensitive enough to differentiate between infants with considerably less severe discrepancies in cognitive development.

If the higher scores for exploratory behavior observed with the normal infants reflect a longer duration of attention, then the results are consistent with the literature on mental retardation. One of the most basic deficits of the mentally retarded appears to be duration of attention (Zeaman & House, 1963; Denny, 1964). In a review of the literature Denny (1966) has pointed out that the mentally retarded have difficulty maintaining attention for an appreciable length of time. During infancy this shorter duration of attention may be reflected in such measures as those used in the Bell Test.

Future research on the Bell Test might use video taping procedures which would make it possible for observers to record the duration of visual exploration and vocalization. Duration measures would describe these behaviors more accurately than a rating scale.

Additional research might well examine these measures of exploratory behavior as a function of different types of impairment categories and also with larger numbers of subjects. The measures appear to account for some of the differences between varying levels of cognitive development during infancy.

EXPERIMENT 3

This experiment was carried out to examine exploratory behavior in normal and developmentally delayed infants. Exploratory behavior was measured by duration of manipulation of a familiar object and of novel objects, amount of visual exploration of a familiar object and of novel objects, and by amount of vocalization during the session.

Method

Subjects

The infants were the same infants who participated in experiment 2.

Procedure

The study was conducted in a 10' x 14' room in Bronson Hospital's Clinical Investigational Unit. Upon completion of experiment 2, experiment 3 was begun. The infant remained seated on the mother's lap at the table which was covered by a white cloth. The same examiner sat across the table. The mother was again instructed to give the child support to remain upright, but to not interact with the child in any other way during the session.

The procedure used was similar to Rubenstein's Pairs Test (1967). Because of the infant's exposure to the bell for 10 minutes in experiment 2, it was now a familiar object for the infant. In the present study the bell was paired with ten novel objects, each for one minute.

The position of the objects, on the infant's left or right, was determined by use of a random number table. The order and position of the objects was the same for all of the infants. Because the bell was capable of providing auditory and visual feedback, the ten novel objects were selected so as to provide feedback via the two modalities. This selection was an attempt to equalize differences between the objects. Each of the objects was of a shape and size that an infant could easily grasp with one hand. Figure 40 (page 49) shows the 10 novel objects.

A sweep hand timer was used to record the one-minute intervals. The examiner used two stop watches to measure the duration of manipulation of each of the objects. At the end of a presentation the examiner rated the amount of visual exploration of each object and the amount of vocalizing which occurred. The rating was done on a three-point scale. The rating of 1 indicated that the behavior did not occur, a 2 that the behavior was displayed infrequently, and a 3 represented frequent occurrence of the behavior. Six final scores were obtained on each child: (1) total duration of manipulation of the familiar bell for 10 trials (2) total duration of manipulation of the 10 novel objects (3) a preference for novelty score (a generated measure; total duration of manipulation of novel objects minus total duration of manipulation of the bell) (4) a rating of amount of visual exploration of the bell for the 10 trials (5) a rating of the total amount of visual exploration of the 10 novel objects and (6) a rating of the amount of vocalization which was displayed during the session.

After experiment 3 was completed each infant was given a complete



Figure 40. Ten Novel Objects

physical examination by the pediatrician from the Bronson Clinical Investigational Unit or the pediatrician from the Bronson Follow Along Clinic. This examination was given to be sure the child did not have any illnesses that might have interfered with performance, such as a cold or sore throat. The examination was also done for the benefit of the infant and mother. The report was placed in the child's medical file as a record of development.

Results

A 2 (infant group) \times 10 (trials) \times 2 (type of object: novel or familiar) analysis of variance revealed a significant trial by object type interaction for duration of manipulation. The group factor, normal or developmentally delayed, approached significance on this measure. See Table 11 (page 51).

Manipulation of the familiar object

Individual analysis of the familiar object on each trial revealed a significant difference between trials 3 and 10 only. The infants manipulated the bell for more time on trial 3 than on trial 10, $q(20, 180) = .998, p < .05$ (Tukey, 1949).

Figure 41 (page 52) shows that the normal infants exhibited a decreasing manipulation time with the familiar object (bell) beginning on trial 7. A Dunn test (Dunn, 1961) revealed a significant difference between trials 1 through 6 and trials 7 through 10 for the normal infants, $t(2, 180) = 3.62, p < .01$. No significant difference was found on these trials for the developmentally delayed infants, $t(2, 180) = 1.25, \text{NSD}$.

Table 11

Analysis of Variance Summary Table

<u>Source</u>	<u>Sum of squares</u>	<u>Degrees of freedom</u>	<u>Mean square</u>	<u>F</u>
Mean	654.18	1	654.18	184.38
Group	14.00	1	14.00	3.95
Error	35.48	10	3.55	
Type (object)	62.06	1	62.06	25.45*
Type x group	.18	1	.18	.07
Error	24.38	10	2.44	
Trial	3.06	9	.34	1.53
Trial x group	3.00	9	.33	1.51
Error	19.96	90	.22	
Type x trial	10.98	9	1.22	2.24**
Type x trial x group	2.15	9	.24	.44
Error	48.95	90	.54	

*p < .001

**p < .026

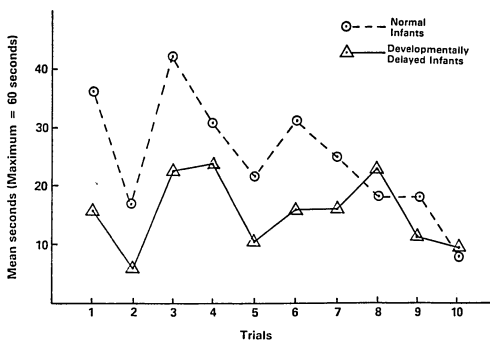


Figure 41. Duration of manipulation of a familiar object

Because a three-point scale was used for visual exploration, a clustering of the data occurred around the middle score (2). Thus, the results for this measure were obscured by the lack of sensitivity of the rating scale.

Manipulation of the novel objects

Figure 42 (page 54) displays the data for duration of manipulation of the novel objects. Individual analysis of manipulation of each of the objects indicated no significant difference between any of the objects. Thus, the infants did not exhibit a preference for any of the novel toys.

Preference for novelty

Preference scores were measures generated by subtracting the total duration of manipulation of the familiar object from the total duration of manipulation of 10 novel objects. A positive score indicated a preference for novelty. There was no difference in the degree of preference between the two groups of infants, $F(1, 10) = .07$, NSD.

Analysis of the type of object (novel or familiar) on each trial indicated that on trials 2 and 9 the infants manipulated the novel objects longer than the familiar object, $q(20, 180) = 1.58$ and 1.46 respectively, $p < .05$ (Tukey, 1949). A sign test showed that if in fact there is no difference in the duration of manipulation of the novel objects over the familiar objects, the probability of obtaining such a difference is $= .001$. Consequently, the tendency of the data is in the direction of preference for the novel over the familiar object for the infants.

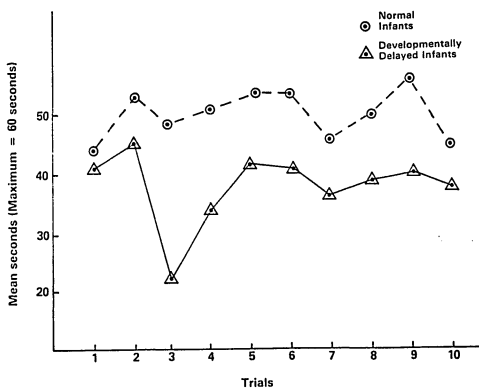


Figure 4.2. Duration of manipulation of a novel objects

Amount of vocalization

The lack of sensitivity of the three-point rating scale resulted in a clustering of the data around the middle score which obscured the results.

Discussion

Normal infants showed a decrease in duration of manipulation of a familiar object over trials, while developmentally delayed infants did not demonstrate this tendency. The normal infants appeared to habituate to the repeated presentations while the infants delayed in development did not. (See Figure 41.) Bridger (1961) suggests that habituation is a decrement and cessation of a response to the repeated presentation of a constant stimulus. Jeffery and Cohen (1971) stress that response decrement is not sufficient evidence of habituation. The latter authors indicate that demonstration of response recovery to a novel stimulus is needed to rule out situational and effector fatigue. In this study the normal infants did demonstrate response decrement to a repeatedly presented stimulus (the bell), which became close to a lack of response on trial ten (mean duration of manipulation on trial ten = 8 seconds, maximum possible = 60 seconds). The normal infants also showed continued response strength to the novel stimuli which were presented simultaneously, thus ruling out situational or effector fatigue. Consequently, the normal infants did appear to habituate over the ten trials.

In addition, the normal infants manipulated the bell longer than the developmentally delayed infants in experiment 2, and slightly longer in experiment 3 on the first seven trials.

The longer manipulation of the bell on initial trials and the demonstration of habituation by the normal infants, not shown by the developmentally delayed infants, seem consistent with the data on performance of mentally impaired individuals. The mentally impaired have difficulty maintaining attention to a task for an appreciable length of time and demonstrate an attention deficit (Denny, 1964). Stone, Smith and Murphy (1973) suggest that habituation or "disattending" may be the opposite side of the coin to the study of attention and the effects of novelty, and that, with a repeated presentation, memory is clearly implied. Habituation may be a measure of the ability to recognize the "old hat" situation. If manipulation of the bell can be considered a type of attending, then the Pairs Test seems to demonstrate a deficit in attention with the developmentally delayed infants.

These impaired infants may not have habituated as the normal infants did because they were not attending as long on any trial. If a minimal amount of attention to a repeatedly presented stimulus is necessary for habituation, it may be that the developmentally delayed infants require more trials to reach this total minimal amount of attention to the stimulus. Thus, for developmentally delayed infants more trials are probably necessary for the recognition of the "old hat" situation to take place. Some research (Bronstein, Itina, Kamenetskaia & Sytova, 1958; Polikania, Polikania and Probatova, 1958) suggests that newborns with birth injury to the brain often show no evidence of response decrement or require many trials to demonstrate a decrement. Luria (1963), on the other hand, suggests that the mentally retarded demonstrate faster habituation. Since Luria's studies utilized

physiological measures, different populations and different stimuli, it is difficult to draw any conclusions. More research is needed before this issue can be clarified.

The hypothesis that the normal infants would show a greater preference for novelty was not supported. No difference was found between the two groups of infants. (See Figure 42.) These results seem to contrast with the results obtained by Sigman (1976) with eight-month-old infants. Sigman's study involved infants who were classified as high- or low-risk on the basis of multiple performance measures. The low-risk infants showed a greater preference for novelty than the high-risk infants on a task similar to the Pairs Test. Duration of manipulation and of visual exploration were combined into one measure of preference. The combination of the duration measures could have resulted in a more sensitive measurement. Another possible reason for the conflict in results could be an age factor. The Sigman study involved eight-month-old infants; the youngest child in the present study was eight-months-old and the range extended to 31 months. It is possible that differences in preference for novelty on the Pairs Test disappear at later ages.

Sigman also found that performance was affected by socio-economic status. High socio-economic status premature infants demonstrated less exploration of novel objects than did low socio-economic status premature infants. In the present study, this environmental factor was not controlled. Since if there were a difference in preference between normal and developmentally delayed infants, on the basis of Sigman's work, the normal infants would be expected to show greater

preference. It is unlikely that the developmentally delayed infants in the present study were from a high socio-economic class. From the visits to the homes it appeared that if there were a difference, then the difference was just the opposite. Therefore, socio-economic class would not be expected to account for the results obtained in this study.

The problems encountered with the three-point rating scale used to describe amount of visual exploration and vocalization could be avoided by use of video taping procedures. Duration measures could be used and would more accurately describe the behavior. This would provide a better means of carrying out reliability checks, too.

Although preference scores did not seem to be associated with different levels of cognitive development, at least with this age range of infants, there are many questions to be answered regarding the utility of the procedure. The duration of manipulation of the familiar object in the Pairs Test certainly seems worthy of further research. Studies with larger numbers of subjects, and which include information related to environmental factors (such as socio-economic class) are needed. Examination of performance on the measures as a function of different types of adverse prenatal factors might provide answers to some of the many questions regarding identification of risk factors in infancy.

GENERAL DISCUSSION

This project examined the hypothesis that two groups of infants, one group developing normally and the other developmentally delayed, would differ on three characteristics that are related to cognitive development. Infants in the developmentally delayed group had all experienced some type of prenatal complication associated with cognitive impairment in childhood. These prenatal conditions included hydrocephaly, Down's syndrome, Conrade's syndrome, microcephaly and cerebral hypotonia. The age range was 8 to 16.8 months, with one developmentally delayed infant who was 31 months old. The three characteristics examined were cardiac response to a repeatedly presented auditory signal, duration of manipulation of a novel object and preference for novelty.

Cardiac change to stimulation is a physiological variable which correlates with attention. Since attention is a prerequisite to learning, the relationship of cardiac change and cognitive development appeared to be an important area to investigate. The other two characteristics, duration of manipulation of a novel object and preference for novelty, are measures of infants' exploratory behavior. Exploratory behavior is likely to be a prerequisite to sustained intellectual functioning (Yarrow et al., 1975) and therefore also a potentially valuable area to explore.

The first study examined the cardiac response of normal and developmentally delayed infants to a repeatedly presented 65 db, 350 cps pure sine tone. The tone was presented for 15 trials while the infant was seated on the mother's lap. Duration of the tone was 30 seconds

and the interstimulus interval was 20 seconds. Upon completion of the 15 trials, two additional trials with a second stimulus were presented to control for state of the infant. In other words, the second stimulus was used to determine whether or not any decrease in responding could be attributed to fatigue. The second stimulus consisted of a 300 cps increase (650 cps) over the first stimulus. Data were analyzed over one second prior to stimulus onset and nine seconds following onset of the stimulus.

Differences between the normal and the developmentally delayed infants were observed when several components of the cardiac response were examined. In addition some interesting similarities between the two groups of infants were noted.

A deceleratory heart-rate response, a component of the orienting response, was demonstrated by both the normal and the developmentally delayed infants. Habituation of this deceleratory heart-rate response to repeated stimulation had been shown in previous research. In the present study, however, a fluctuation of the deceleratory heart-rate response was observed. Over the 15 trials, both groups of infants showed three phases of fluctuation. This fluctuation in responding is consistent with a study on attention by Frieberg (1937). This fluctuation may not have been evident in previous studies because often the data in these studies were blocked over trials or intervals which would mask the fluctuation. Also, some studies did not include enough trials to allow the fluctuation to occur.

A large difference was evident between the normal and the developmentally delayed infants in the patterning of the heart-rate response

to the pure tone. The normal infants showed a strong deceleration in heart rate and the developmentally delayed infants, after the first trial, demonstrated an acceleration to the tone. The difference in patterning was also apparent in the infants' individual data. These results support the hypothesis that there would be a difference between the two groups of infants on this measure. If acceleration represents stimulus rejection and deceleration stimulus acceptance, the normal infants would have had more opportunities to learn about the stimulus.

Differences between the two groups of babies were observed in the frequency and the magnitude of the cardiac deceleration to the tone. Deceleration in heart rate was of greater magnitude, occurred more frequently and seemed to be maintained over more consecutive trials with the normal infants than the developmentally delayed infants. The heart-rate deceleration appeared to take place on later trials with the developmentally delayed babies than for the normal babies, also. These results are in agreement with research on normal and mentally impaired individuals for attention (Zeaman & House, 1963; Denny, 1964) and reaction time (Krupski, 1976).

This study raises numerous questions about infants' cardiac response to stimulation. Further investigation is needed to examine the effects of various stimulus parameters, different types of stimulation and different number of trials on the cardiac response. Studies employing larger numbers of subjects and different subgroups of mentally impaired individuals are also necessary. Cardiac response to stimulation seems to have considerable potential as a measure to discriminate

between normal infants and infants at-risk in terms of cognitive development. Its usefulness can be determined only by further research.

The second experiment assessed duration of manipulation of a novel object by the normal and the developmentally delayed infants. Each baby was seated on the mother's lap at a table covered by a white cloth. Rubenstein's Bell Test (1967) was used. This test involved presenting the infant with a bell with a red wooden handle for 10 minutes. Duration of manipulation of the bell was measured and the amount of visual exploration and vocalization during the 10 minutes was rated on a three-point scale. The results indicated that the normal infants manipulated the bell for a longer period of time than the developmentally delayed infants. Thus, the second hypothesis was supported. If a longer duration of manipulation accompanies longer attention to the object, then the results are in accordance with the literature on mental retardation. The mentally retarded seem to have difficulty maintaining attention for an appreciable period of time (Zeaman & House, 1963; Denny, 1964). The Bell Test may reflect this difficulty during infancy. A longer duration of manipulation at least increases the baby's opportunities for learning about the object.

The three-point rating scale confounded the results obtained on amount of vocalization and visual exploration. Use of video taping procedures, in future research, would circumvent this problem and make it possible to obtain duration measures on these behaviors. If duration measures for vocalization and visual exploration were combined with duration of manipulation scores a more sensitive measure for both groups of infants might be obtained.

More research with larger numbers of subjects and with different subgroups of mentally impaired is necessary before the value of this test for early identification of high-risk infants can be determined.

For the third study the infant remained seated on the mother's lap at the table. Rubenstein's (1967) Pairs Test was employed. The baby was presented with the bell that was used in the Bell Test and a novel object for one minute. This procedure was used ten times, each time with a different novel object. Duration of manipulation of each object was recorded and amount of visual exploration and vocalization were rated on a three-point scale. Preference for novelty, a generated score (duration of manipulation of the novel object minus duration of manipulation of the bell) was also calculated.

The difference between the normal and the developmentally delayed infants on duration of manipulation of the bell approached significance, with the normal infants manipulating the bell for a longer period of time. No difference was observed between the two groups of infants on duration of manipulation of the novel objects or on preference for novelty. Thus, the third hypothesis, that there would be a difference between the two groups on preference for novelty, was not supported.

However, the normal infants demonstrated a decreasing manipulation time for the bell. This decrease in manipulation was not shown by the developmentally delayed infants. These results were interpreted as reflecting habituation of the manipulative response to the familiar object. No habituation was evident for either group with the familiar object, indicating that fatigue would not account for the decrease in the normal infants' manipulation of the bell. These results seem to

demonstrate that the developmentally delayed infants did not habituate because they were not attending to the bell as long on any trial. If a certain amount of attention to an object is necessary for habituation to take place, then the developmentally delayed infants may require more trials to reach this cumulative amount of attention. Further research is necessary to test this hypothesis.

In this study the three-point rating scale confounded the results obtained to describe visual exploration and also vocalization. Use of video taping procedures could eliminate this problem.

As with the other two studies, more research with larger numbers of infants from different subcategories of mentally impaired are required before conclusions can be drawn regarding the utility of the Pairs Test and rate of habituation as a measure of risk during infancy.

In conclusion, this investigation found three different characteristics related to cognition which discriminated between a group of normally developing infants and infants delayed in development. One characteristic, cardiac deceleration to a repeatedly presented auditory signal, is one component of an orienting response. The orienting response accompanies attention. Since attention is a prerequisite for learning, cardiac response to stimulation is an important variable to consider in the assessment of cognitive functioning. Cardiac response to stimulation has several advantages over the use of standardized tests in the assessment of cognitive functioning during infancy. It is an objective physiological measure, requires little participation by the infants and seems to be a sensitive measure for discriminating between those infants at high- and low-risk.

Piaget (1952) and Yarrow et al. (1975) have emphasized the importance of the relationship between exploratory behavior and sustained intellectual functioning. In the present study one characteristic of exploratory behavior, duration of manipulation of a novel object did discriminate between normal and developmentally delayed babies. This was measured by the Bell Test. Another measure, preference for novelty failed to show a difference between the two groups of infants. However, habituation of the manipulative response to the familiar object in this test did discriminate between the two groups of babies. Both of these measures of exploratory behavior may be more sensitive if duration measures of visual exploration and vocalization are combined with duration of manipulation scores.

Parmelee et al. (1974) have demonstrated the need for, and usefulness of, multiple measures in early identification of at-risk infants. The three measures investigated in this project appear to have potential as sources of information, when used in a battery of measures, to increase the validity of judgments regarding risk conditions during infancy. All of the measures seem to be necessary characteristics for sustained intellectual functioning. A great deal more research is necessary to determine the effectiveness of these three procedures, however.

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