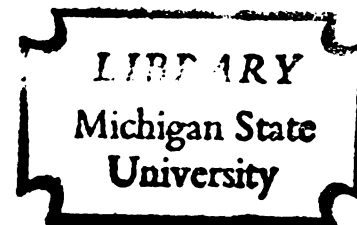




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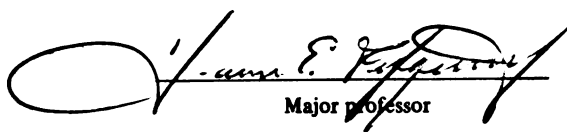


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DEVELOPMENTAL STATUS AS A CORRELATE
OF PSYCHOPHYSIOLOGICAL MEASURES OF ATTENTION
IN EARLY INFANCE

presented by
STEVEN GITTERMAN

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DEVELOPMENTAL STATUS AS A CORRELATE
OF PSYCHOPHYSIOLOGICAL MEASURES OF ATTENTION
IN EARLY INFANCY

By

Steven Gitterman

A THESIS

Submitted to
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ABSTRACT

DEVELOPMENTAL STATUS AS A CORRELATE OF PSYCHOPHYSIOLOGICAL MEASURES OF ATTENTION IN EARLY INFANCY

By

Steven Gitterman

The present study utilized a recent psychophysiological model of attention, the two component model, to assess the relationship between infants' relative developmental status and sustained cardiac attentional responsitivity. A separate analysis also was done to see if the model would differentiate cardiac responses to stimuli previously shown to elicit differential amounts of prolonged looking behavior. Results indicated strong support for previous studies showing cardiac orienting responses to nonaversive auditory and visual stimuli. However, there was little evidence distinguishing between high and low developmental status groups (assessed by the Bayley Scales of Infant Development). Similarly, cardiac responsitivity was unrelated to infant looking behavior. Infants' cardiac responses did discriminate between an aversive and a nonaversive auditory stimulus. Methodological factors which may have contributed to nonsignificant results are discussed.

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Introduction

Infant Attention

Recent methodological and technical advances in the study of infant attention (see Salapatek, 1975; Cohen & Gelber, 1975; Lewis, 1974 for reviews) have renewed interest in a field long hampered by inadequate and unquantifiable response measurement. These advances have allowed responses long noted by infant observers (i.e., Darwin, 1877) to be used in experimental paradigms directed toward an analysis of the processes which underlie cognitive development during infancy and early childhood.

In this expanding body of literature, the matter of defining attention acquires significance since the term has been used in a variety of contexts (c.f., Bakan, 1966; Lewis, 1971; McCall, 1970). Essentially, definitions of infant attention can be categorized into two rough classifications. The first definition uses an overt measure of attention on the strength of its apparent face validity. Examples of this approach are the use of looking time in habituation and paired comparison procedures to study recognition and memory (Fagan, 1977; Cohen & Gelber, 1975; Lewis, 1971). To be sure, in these and similar studies attention often is viewed as a necessary process. However, in many instances the specific question being scrutinized concerns the development of certain cognitive operations (Lewis, 1974) rather than the attentional process itself.

In contrast, the second definition of attention views it as a specific, albeit global, system that can be examined separately from other aspects of cognitive development. This latter viewpoint is characteristic of adult cognitive models (Kahneman, 1973), neurological models (Routtenberg, 1968), and syntheses of these two approaches

(Sokolov, 1963). Psychophysiological studies of attentional mechanisms in adults (Maltzman & Raskin, 1965; Zeiner & Schell, 1971), and in infants (see Graham & Jackson, 1970; Clifton, 1974 for reviews) are prominent examples of the latter approach. In many studies with infants, a cardiac measure is the primary psychophysiological dependent variable used to infer attention. This is due to the ease of measuring the cardiac response, the attachment of psychological significance to the directionality of the response (acceleration vs. deceleration) (Graham & Jackson, 1970), and the questionable reliability of commonly used adult measures (e.g., skin conductance; see Porges, 1974).

The foundation and relevance for the study of attention from a psychophysiological perspective is derived from the hypothesized importance of attentional mechanisms for cognitive development (Jeffrey, 1968; Furby, 1974). In its most molecular form, attention to the conditional stimulus is a necessary aspect of conditioning if a contingency between two environmental events is to be recognized. In studies using a two choice discrimination task with mentally retarded subjects, Zeaman and House (1963) plotted backward learning curves which appear to indicate that learning occurs rapidly once attention to a stimulus is established. A similar explanation has been mentioned by Gelber and Cohen (1975) to describe the backward learning curves they obtained in their studies of infant habituation, although these studies are more tentative. The rationale of a causal relationship between attentional processes and cognitive development underlies much of the extant research concerning attentional processes in infants. Although the exact mechanisms by which cognition and attention interact are still largely unknown, researchers have assumed and adopted a relationship between

these two processes to study both the cognitive capabilities of infants and strategies which maximize or minimize attentional response (Clifton, 1974; Graham & Jackson, 1970; Kagan & Rosman, 1964; McCall, 1970; Sameroff, 1971, 1972).

The present study attempted to investigate two aspects of the relationship between cardiac and behavioral responses of attention during infancy. The first question of interest concerned the concordance of cardiac and behavioral measures of attending, whether this relationship would discriminate between stimuli of different content. Previous investigators have examined this question by linking the reflexive cardiac OR to behavioral measures but have not attempted to link the sustained cardiac attentional response to behavioral indices of attention.

The second question of interest involved the relationship between cardiac attentional responses and measures of the infant's developmental status. Limited support for the existence of relationship between attention and development is derived from a small number of studies. However, to validly establish individual differences in cardiac attentional responsivity during infancy, the reliability of the measure under examination must be established. To achieve this prerequisite to the study of individual differences, the present study used two trials of very similar stimuli to establish intrasession reliability. As will be described, a variety of factors can dramatically affect these responses, and reliability is a necessary condition before analyzing the relationship between psychophysiological responses and other developmental measures.

The differentiation of individuals on the basis of attentional

responsitivity is a direct conceptual application that presents many methodological difficulties. The first problem, previously mentioned, is obtaining adequate and reliable dependent measures of infant attention. No less important for a study of this type is defining an adequate criterion measure to serve as an indicator of developmental status. For the latter difficulty, the Mental Development Scale, from the Bayley Scales of Infant Development (Bayley, 1969) was administered to each infant. For cardiac measures, a two component model was chosen to interpret attentional responses, and is described below. A description of the Bayley Scales is given later.

Literature Review

Psychophysiological Correlates of Infant Attention

In the Principles of Psychology, James (1962) constructed a three factor description of attention, where attention consisted of a focus (sensoral vs. associational), a rationale (immediate vs. associational), and a method (involuntary vs. active). Porges (1974) has identified two psychophysiological responses which are postulated to parallel a phasic, immediate response to stimulation and a tonic sustained response (analogous to James' involuntary and active responses, respectively).

Porges' model reflects the recent synthesis of two separate psychophysiological lines of research. The first is reflected both by the work of Sokolov and Lacey; the second primarily by the work of Porges. Each is discussed in turn.

Sokolov's Model. The study of reactive component of attention has a far longer history than the study of tonic response and, until recently, has been synonymous with attention in infant research, this despite the recognition of the active dimension cited by James for which the reactive component alone cannot account (Lynn, 1966). The reactive component can be identified as the "orienting-investigatory" or "What-is it?" reflex first described by Pavlov in 1927.

As another example of a reflex which is very much neglected we may refer to what may be called the investigatory reflex. I call it the 'What is it?' reflex. It is this reflex which brings about the immediate response in man and animals to the slightest changes in the world around them, so that they immediately orientate their appropriate receptor organ in accordance with the perceptible quality in the agent bringing about the changes, making full investigation of it. (Pavlov, 1927, cited by Lynn, 1966)

Sokolov (1960, 1963) systematically reviewed both the literature and empirical research on the orienting reflex (OR), concluding with a

activation of the EEG, i.e., desynchronization. (Lynn, 1966)

Elicitation of the OR or defensive reflex is not simply a function of qualitatively different stimuli: variations in the parameters that describe the physical characteristics and properties of a stimulus can alternatively lead to rejection or orientation to a stimulus (Graham, & Jackson, 1970; Lynn, 1966). Orientation reactions, similar to other behaviors, can become both conditioned (when the stimulus acquires signal value) or habituated (Floru, 1975).

The Laceys' Model. The Laceys' (Lacey, 1959, 1967; Lacey & Lacey, 1974) have developed a model of attention similar to that proposed by Sokolov which recognizes autonomic parallels to "stimulus intake" and "stimulus rejection" (specifically heart rate deceleration and heart rate acceleration, respectively). The autonomic response is moderated by situational stereotypy; that is by the set of environmental conditions interacting with the individual's history to produce the autonomic response. The Laceys' view the autonomic response as part of a feedback mechanism wherein the cardiac response facilitates the cognitive reaction (note the parallel to James' theory of emotion). Both aspects of the Lacey model (the response and its hypothesized mechanisms) have been criticized (see Elliot, 1974; Obrist, Webb, Sutterer, and Howard, 1970), but a number of these criticisms are inapplicable to infant subjects, as will be noted later.

Graham and Clifton (1966) synthesized the work of Sokolov and Lacey into a framework that equated stimulus intake with an orientation reaction and stimulus rejection with the defensive reaction. Nonhuman, human, adult, and infant studies were reviewed in order to support their interpretation. A more recent elaboration (Graham & Jackson, 1970)

cites an expanded base of research support for the previous position, while also noting the potential for studying cognitive development through the use of psychophysiological dependent measures.

In context of the Graham & Jackson hypothesis, the occurrence of a decelerative shift in early infancy is postulated to be of psychological significance. The decelerative shift is a well documented change in the ease of eliciting a decelerative response to a non-signal stimulus over the first six months of life. During the newborn period, responses to non-signal stimuli are predominantly accelerative (although recently a number of experimenters, i.e., Adkinson & Berg, 1976; Lipsitt & Jacklin, 1971; Kearsley, 1973; Parmeleau-Malcuit & Clifton, 1973, have elicited deceleratory responses by careful choice of stimuli and control for identified possible confoundations, e.g., state, prandial level). By six months of age, cardiac responses change to deceleration for the same stimuli that had previously elicited acceleration (Clifton & Meyers, 1969; Lipton, Steinschneider and Richmond, 1966).

Graham and Jackson emphasize strongly the possibility of this shift being indicative of a distinct change in the infant's interaction with the environment. A derivative view (Samaroff, 1971) accounts for poor conditionability in early infancy as a consequence of the inability to exhibit cardiac orienting reactions (although other authors, i.e., Fitzgerald & Brackbill, 1976, have disputed this view). In either case, much evidence indicates major psychological shifts in behavior during this period. Lewis (1971) has cited data from studies of visual responding to redundant stimuli, the loss of primitive reflexes, and changes in the EEG component waveforms to underscore change over this time. A recent review (Emde & Robinson, 1976) further documents behavioral and

neurobiological shifts during the first trimester of life.

Porges' Model. The study of psychophysiological parallel of the tonic component of attention has a more recent history, and is due primarily to the work of Porges and colleagues (Porges, 1972, 1973, 1974, 1977, 1978; Porges, Arnold & Forbes, 1975), although this factor had been noted previously (Lacey, 1967). Porges' two component model of heart rate response (Porges, 1974) is a psychophysiological model whose concomitants are empirically testable as cardiac responses. The phasic component can be identified as the OR discussed above whereas the active component is manifested as a reduction in heart rate variability. Heart rate variability responses are also quantifiable and testable in a paradigm examining individual differences. Porges (1974) has reported differences in newborns classified on the basis of their spontaneous heart rate responses, where high variability newborns were found to respond differently from low variability newborns to the offset of an auditory stimulus. Recent work with hyperactive children also indicates the applicability of heart rate correlates of attention for studying attentional processes (Porges, 1977), and further supports this model. Van Hover (1974) has added support for the model by reporting a study validating the existence of these two separate components of attention in an older sample of children.

The use of tonic measures of attention to distinguish among stimuli to which infants show equivalent amounts of overt attention (or looking time) appears to be virtually non-existent in the literature. Recent reports using a measure of coherence (the relationship between respiration and heart rate, Porges, 1978) appears to be a sensitive method of assessing this component. Many previous studies have demonstrated

redefinition of the OR that was more limited and restricted but one that, because it is specifically defined in terms of certain behavioral and autonomic responses, is empirically testable. Included as responses indicative of orienting were electroencephalographic changes, electrodermal activity, and certain vascular changes. However, it was evident from the work of Sokolov and others (e.g., Floru, 1975) that the OR could not lead to the far reaching consequences hypothesized by Pavlov for human development (c.f., Lynn, 1966). This is apparent in the following passage from Sokolov (1963):

By orienting-investigatory reflex, we mean the series of reactions bringing the animal into contact with the object and tuning the analyzers of the animal or man, so that perception of the stimulus takes place in the most favorable conditions. This definition of the orienting-investigatory reflex is, however, too wide. The orientation reflex in the restricted sense of the world should be distinguished in the reflex as the non-specific reaction resulting in the tuning of the analyzer when exposed to a new stimulus. This elementary reaction is quite distinct from the complex exploratory chain of reflexes, aiming at investigation of the object in detail and involving a whole series of conditioned orientation reflexes.

In this book, the orientation reflex is analyzed in the restricted sense. (Sokolov, 1963)

Sokolov further describes a defensive reflex which serves to psychologically detach the individual from contact with an aversive stimulus. In contrast, the OR is hypothesized to facilitate learning by heightening subject response and sensory intake to an environmental event. Lynn (1966) has described the orientation reaction components as follows:

Orientation has been indexed by a quieting of general behavior which permits the organism to attend to the environment. Typically the reaction has involved slowing of heart rate and respiration and cessation of gross activity. In addition, there is activation of perceptual systems, i.e., turning of sense organs towards the source of stimulation, and

phasic differences to stimuli (see Clifton, 1974), but these are primarily between stimuli of high and low signal value.

Previous Research

The application of psychophysiological techniques to differentiate between individuals in their rate of learning is restricted to only a few studies. All used a psychophysiological response as a measure of attention, and each related the magnitude of this measure (or groups formed on the basis of this response, i.e., high-low) to a performance measure. Using the narrow Sokolovian definition of orienting, Ingram and Fitzgerald (1974) reported a significant relationship between learning a conditional discrimination and the magnitude of the orienting reflex (defined as the skin potential response to an auditory stimulus) in 3-month-old infants. Ingram (1973) also found a similar effect in $3\frac{1}{2}$ month old infants where subjects with higher OR magnitudes (also defined by the skin potential response) exhibited more rapid learning during the conditioning of differential eyeblink responses. Nelson (1974), using a similar procedure, obtained virtually identical results with Down's Syndrome and mixed-etiology subjects ($\bar{x}$ C.A. = 11 years, 11 months; $\bar{x}$ M.A. = 1 yr., 5 months). In the Nelson study, significantly, the OR was determined by measurement of the cardiac responses of the subjects to an auditory stimulus.

More recently, Cousins (1976) has extended the Ingram & Fitzgerald finding to grade school children (9-11 years of age), also using a cardiac measure of orienting, and a conditioned discrimination paradigm. After a systematic review of the literature only these four studies appear to examine the question of the relationship between individual difference in psychophysiological measures of attention and learning

in infants and children. An older related study (Kagan & Rosman, 1964) reported greater deceleration for 1st and 2nd grade boys who exhibited an "analytic" attitude as opposed to those who showed a "non-analytic" cognitive mode; but unfortunately, this study only compared group effects and used questionable methods of computing the cardiac deceleration.

In addition to these few findings, a separate line of inquiry has examined the difference in the orienting responses between normal and retarded subjects. The majority of these studies are tests of Luria's (1963) suggestion that retardates should show a weaker OR than normals, and that this response habituates more rapidly in this population. A number of these studies (e.g., Powazek & Johnson, 1973) have found little support for Luria's suggestion, in fact finding no heart rate response difference between the two groups.

A more recent study (Porges & Humphrey, 1976) examined this same question from the two component model rather than from an analysis of heart rate alone. Using an approximate Mental Age matched design, Porges and Humphrey showed a decrease in the heart rate variability for the normal subjects during a task requiring sustained attention, and an increase in the variability for the retarded subjects during the same period. Although this study examined only gross group differences, the result further supports use of the two component model for examining individual differences.

The dearth of studies examining the relationship between psychophysiological measures and performance reflects the recent development of infant psychophysiology as a discipline. Despite this, theoretical and practical considerations signify the use of 2-4 month old subjects for a more powerful test of the possible influence of attentional

mechanisms. Newborn studies (i.e., Porges, 1974) are confounded by such factors as infant birth trauma and the effects of any labor medication which may depress infant responsitivity (Adkinson & Berg, 1976; Stechler, 1964; Freidman, Brackbill, Caron, and Caron, 1978). Reliability from the newborn period to the 3rd month is low (Lipton, Steinschneider, & Richmond, 1966; Clifton & Graham, 1968) owing possibly to the factors described above in addition to both the decelerative shift and the rapid maturation of the infant. In context of this and the results of the previous discussion, there appears to be a need for an evaluation of whether cardiac responses do have any developmental significance.

From the preceding literature review, it can be inferred that cardiac orienting is possibly a significant developmental variable. The goal of the method that will be described was to test whether a relationship could be found between measures of orienting and developmental level in early infancy. A specific difference between this and prior studies was to look at the global development of the infant rather than at a narrow criterion of infant performance, e.g., habituation. It was felt that if orienting or attentional vigilance was an important early variable, there should be differences between relatively advanced infants and less advanced infants on this dimension.

The instrument I chose to evaluate developmental status during infancy was the Mental Scale of the Bayley Scales of Infant Development (Bayley, 1969). These scales have a long history, being originally developed for the Berkeley Growth Study during the 1930's and recently restandardized. There are three separate scales in the instrument: a mental scale, a motor scale, and an infant behavior record. Neither the

motor scale nor the behavior record were administered, the former due to the small number of items present in early infancy, the latter because it has yet to be standardized.

The mental scale does have a relatively large pool of items, the exact number dependent on the level at which administration begins (in any case, the maximum number of items is 45 at four months). The mental scale is well standardized, and is highly reliable over short periods of time, even at three months of age (McCall, et al., 1972; Thomas, 1970). An additional reason for using the Bayley was a prior factor analysis of the mental scale content (Stott & Ball, 1965) which reported attentional factors present in the majority of the items analyzed.

The primary goal of the present study was to examine the relationship described above. As mentioned before, however, a number of additional questions could be examined to test the usefulness of cardiac measures as an index of infant attention. These questions were designed to assess whether the cardiac measures could differentiate between different stimuli to which the infants either showed or didn't show attending behavior (indexed by monitoring their looking behavior during visual stimulus presentation). This analysis is also unique by the application of a tonic measure of orienting.

Research Questions

The method to be described was used to allow examination of the following questions:

- 1) Can the two component model of heart rate response be used to differentiate between stimuli with unequal behavioral measures of attention? Previous work validating the two component model (Porges, 1974) has been restricted to the use of simple, nonsignal stimuli without the

use of a behavioral referent. Many previous investigators have cited the lack of a sensitive measure to establish individual differences in infant behaviors (e.g., Horowitz, 1974). It was hoped that the present study would yield progress toward the use of a more sensitive cardiac measure to discriminate between stimuli. If a distinction between two stimuli of greatly varying signal value (discussed later) could be realized, then a second test would be performed to see if cardiac measures could discriminate stimuli to which infants reactions are behaviorally equivalent. The main assumption for this question was that infants would show a relatively larger tonic reaction to signal or "salient" stimuli in these modalities with less attractive properties.

2) Are both the reactive and tonic components of the cardiac response reliable, i.e., are the heart rate functions similar to similar stimuli during the short term laboratory session? A prior study of the orienting response (specifically the phasic component) in a longitudinal study of infants from 2½ to 5 months of age (Lipton, Steinschneider, & Richmond, 1966) has indicated significant consistency of this response, but the stimulus chosen (a mild air stream to the abdomen) yielded a heart rate acceleration. In addition, the same study yielded a significant correlation for prestimulus heart rate ($r = .62$), and for certain measures of response magnitude. However, poor stimulus choice and possible misinterpretation of the response weakens this result. No other studies have examined the question of the reliability of the phasic heart rate orienting response.

3) Are psychophysiological responses correlated with the results of the Mental Development Index from the Bayley Scales of Infant Development? The preceding literature suggests that there should be a

relationship between the cardiac concomitants of orienting and scores on the Bayley Scale. Other authors (e.g., Crano, 1977) have hypothesized that the primary determinant of infant behavior on exams similar to the Bayley Scale is the biological maturation of the infant rather than a stable cognitive characteristic. The rationale for use of the Bayley has been described above; use of both signal and nonsignal stimuli will enable the test of whether an interaction exists between the reaction to a given stimulus type and the level of relative developmental precocity as indexed by the Bayley.

The procedure was therefore designed to explore these questions by exposing the infants to two different stimuli in both the auditory and visual modalities. One of each pair was chosen as a stimulus to which the infants would show prolonged looking behavior and hopefully a simultaneous tonic attentional response. After this, the Bayley Mental Development Scale was administered to see if the ability to show a prolonged tonic response was related to relative developmental status in the group tested. Two additional visual stimuli were used to see if the infant response was reliable over the short term laboratory session.

Method

Subjects

Subjects were full term, clinically normal infants ranging from 85 to 127 days at time of testing. Babies were solicited by a direct mailing to mothers whose names were obtained from the birth records of Ingham County, Michigan, and whose addresses were then taken from the most recent telephone book. Although an effort was made to recruit as many subjects as possible, the final sample analyzed consisted of 2 males and 10 females, from a total of 77 sessions in the laboratory. The

primary factor contributing to subject loss was the failure of the majority of infants to complete the experimental session.

All parents were asked to sign a release form before any testing was done (see Appendix A). Information to insure that the baby was full term and had no developmental difficulties was obtained by parent interview and by asking the parent to fill out a brief questionnaire on the child's history (Appendix A). The original intent was to obtain the subjects as close to ninety days as possible, but unfortunately, this was difficult to achieve in practice. The final mean age was 101 days, with 92% between 90 and 120 days of age at the time of final testing.

Apparatus and Stimuli

Cardiac responses were monitored on a Grass Model 7 Polygraph, with output recorded on both scaled paper and a Vetter FM tape recorder (1 7/8 ips). Three Beckman Ag/AgCl biopotential miniature electrodes were attached to the infant's chest to serve as direct input to the polygraph. The inside of each electrode was filled with Beckman Electrode paste to increase conductivity. Active electrode placements were symmetrical above the infant's nipples, with a third ground electrode placed 1/4 inch above the navel.

Stimuli were chosen to test each of the previously mentioned questions. Visual stimuli were:

- a) a blank slide which served as an illumination change to the infant
- b) two slide photographs of young infants (approximately three months of age, one male and one female)
- c) a 15 square by 15 square black and red checkerboard, each unit appearing as an approximately 1.75 cm square when projected.

Each of these stimuli was presented by a Kodak Carousel Model 500 slide projector onto a rear projection screen in the booth where the infant was located. The size of the two infant slides when projected was 21 cm by 31.5 cm on the screen. The blank slide filled approximately a 31.5 cm by 31.5 cm area, although this was diffuse rather than concentrated. The checkerboard was on a blue background with the red and black squares in the center of the slide; the entire slide was 21 cm by 31.5 cm. White noise was continually present during the experimental session to mask the sound of the projector changing. Between slide presentations a black slide to mask all light was used.

Two auditory stimuli were also presented:

- a) a 250 Hz sine wave, with a .5 second rise time
- b) a recording of an infant cooing (approximately four months of age)

These stimuli were recorded and then played back on a Wollensak cassette deck which was connected to an 8 ohm impedance speaker in the infant chamber. Playback in the chamber was at 75 db; ambient level was 65 db due to the white noise.

The stimuli were chosen across two dimensions of modality and salience in order to test the questions described earlier. The checkerboard was chosen as a stimulus that has previously been shown to elicit both behavioral (e.g., looking preference) and physiological orienting at a number of infant ages (Fantz, 1964; Kagan, 1972); the cooing sound was similarly chosen as a stimulus that contained signal properties. It was hoped that these stimuli would show both tonic and phasic differences in orienting when compared with the nonsalient stimuli (the light and the tone), although the test of primary interest involved the tonic

measure. An extension of the two component model would predict that there would be a continued response to these stimuli and none to the light or tone. Thus two dimensions of salience were defined in each of the two modalities (auditory and visual) of stimulus presentation to answer question 1. The baby slides were used to check reliability of the infant responses (question 2 above), and also to be used as a second salient stimulus if a comparison of the checkerboard and light proved significant. In this case a test of the baby versus checkerboard would be made to check if two salient stimuli could be distinguished. They were also used to examine the relationship between the Bayley Mental Scale score and cardiac responsivity, as were the two nonsalient stimuli (question 3 above). It should be noted that what I have defined as the salience of different stimuli could be considered synonymous with the characteristics of the checkerboard (i.e., contrast; Fantz, 1970) or coo (possibly spectral complexity; Clarkson & Berg, 1978) which elicit a behavioral reaction in addition to the physiological monitoring. For the visual stimuli in this study, salience was defined as the difference in looking time towards the screen. There does not appear to be an analogous measure for the auditory stimulus.

Procedure

All testing was done at the Developmental Psychobiology laboratory located in the Psychology Research Building, Michigan State University. Testing for the Bayley Scale was done in another room of the same building, where appropriate furniture and a crib were provided for both parental comfort and administration of the Bayley Scales.

Upon arrival at the laboratory the parents (and/or guardians) were

greeted by the experimenter and assistant. Parents were again explained the purpose and design of the study previously described in the mailing. After a brief tour of the laboratory, the parents were asked to sign the permission slip and to fill out the developmental questionnaire. They were also asked to fill out an address form so they could receive the results of the study, and thanked by the experimenter for participating in the study.

The child was then taken into the psychobiology laboratory where the experimenter or assistant undressed the child as much as necessary for the electrodes to be attached. The areas for electrode placement were lightly cleaned with an alcohol pad (70% ethanol) and the electrodes then attached. The parents were then asked to carry the infant into the research booth where the slides were presented, although in some cases it was necessary to use the infant's car seat rather than the laboratory seat to keep the child more comfortable.

The mother was seated behind the infant, and asked not to interfere with the infant's behavior in any way during the session, barring obvious infant discomfort, of course. For a minute or so the mother was engaged in conversation to acclimate both herself and the child to the experimental environment. (It should be noted that a large number of the infants were quite reluctant to accept not having the mother in visual contact.) The mother was asked not to communicate in any way with the infant, and also asked not to use any form of pacification.

If the child was sufficiently calm, the experimental procedure was started. The experimenter stayed in the equipment room of the laboratory where the polygraph was located and the presentation of stimuli was controlled. An assistant to the experimenter stayed where he or she was

able to monitor both the looking preference and state of the infant, this being done through a peephole below the center of the rear projection screen on the outside wall of the booth. The assistant was instructed to press two buttons, one to signify if the infant was looking or not looking towards the screen, the other to indicate to the experimenter that the infant was in a less than optimal state for continuing (assessment of infant state was based on the five level scale proposed by Brackbill and Fitzgerald [1969], where the acceptable states were either state 4 or 5, quiet or active awake). In addition, the experimenter in the equipment room could monitor a microphone that was in the experimental booth. During the session, if the infant wasn't in either of the acceptable awake states, the procedure was halted and appropriate decisions made on whether to continue.

The experimenter monitored both the polygraph and tape deck, in addition to controlling the stimulus presentations. Visual stimuli were presented for a minimum of 25 seconds, auditory stimuli for a minimum of 15 seconds with times calculated by using the polygraph timing mark. There was a variable intertrial interval of 30 to 40 seconds ($\bar{x} = 35$ seconds) to allow the infant's heart rate to return to baseline. Four different stimulus presentation orders were used, with the only requirement that the two infant slides always were in the same relative order. The male slide was presented after the female slide, regardless of its place in the order of stimuli.

After the session was completed, the electrodes were removed from the infant. Parents were now asked to carry the infant back to the crib room where the Bayley Mental Development Scale was administered. After this parents were invited to examine the polygraph record and to ask any

questions regarding the procedure. In no case, however, was any comparison between the present subject and previous subjects made to the parent.

Twenty parents were invited to the laboratory prior to the first physiological session for the experimenter to gain facility with both the Bayley and the handling of young infants in general. Learning of the Bayley was aided by the advice given by Dr. Thomas Taflan-Barrett of the Ingham County Community Mental Health Center, although in the author's opinion it was only after a good deal of practice that administration of the scales was considered to be accurate. (It should be noted that only the very first part of the scales needed to be used for this study--learning of the entire range of Bayley items would be a far more formidable task.) Similarly, the first six physiological sessions were disregarded, as they were used primarily to establish reliability in the assistants' monitoring of the infant eye movements. This was done by having two assistants at a time monitor the same infants and push two separate buttons, which afterwards were compared for similarity. A quantitative measure was never computed since the records were quite similar visually. Three additional sessions were disregarded during the course of the experiment due to experimenter error or equipment failure.

After the sessions were completed, the tapes were subsequently played back through the polygraph to get a final copy of the record. The polygraph was run at 50mm/sec for this record, and a Krohn-Hite Model II filter was used to reduce any noise present on the tape recording. These cardiac records were then hand scored by the experimenter and an assistant for the interbeat intervals (IBIs), the time between each

R-wave peak in the cardiac cycle (these were subsequently checked for reliability by the experimenter, $r=.97$). The IBIs were converted into a weighted average of heart rate in beats per minute for the five seconds prior to each stimulus through the five seconds after the stimulus by a program written for a Hewlett-Packard 2000 computer. A weighted average accounts for all the partial beats that fall in a one second interval by adding the proportion of each beat that falls in the interval, and then converting the average of all beat and partial beats from the interbeat interval measure of milliseconds to beats per minute. The analyses that will be reported in the results section are calculated using the beats per minute measure for each second of response time. Variability was scored for five second blocks from the five seconds pre-stimulus to the five seconds post stimulus. Each variability period was the variance of the five beats per minute values for that five second block.

Results

Separate analyses of variance were computed with heart rate as the dependent variable to test each of the previously mentioned questions. To accomplish this, a separate analysis was done for both the absolute changes in heart rate and the variability changes in the same measure. Absolute heart rate change was obtained by subtracting the rate for the last second prestimulus from the rate for each second of the stimulus period. The variability measure was the rate variance for the five second prestimulus period, each five second block during stimulus presentation, and for the five second post stimulus period. The alpha level for each test was set at $p=.10$. This was done in consideration of many methodological problems that most likely inflated the error variance, and

will be described later. All analyses of variance results are summarized in Appendix B.

Tests for discrimination between salient and nonsalient stimuli. To test whether infants could discriminate on this dimension, four separate analyses were done. The first two compared the blank slide and checkerboard (for absolute change and variability period change), the latter two similarly comparing the tone and coo. Each of these tests was a completely crossed repeated measure Anova ($A \times B \times S$; Keppel, 1973), where the subjects' factor was crossed by stimulus and either seconds (for rate) or period (for variability).

Discrimination of tone versus coo. For the absolute rate analysis, there was evidence of a significant difference in cardiac response to the tone and the baby sound ($F(1,11)=4.14$, $p < .07$). The main effect for seconds was nonsignificant ($p > .10$), as was the interaction for stimulus by time (this effect is illustrated in Figure 1). The variability analyses for the same stimuli yielded nonsignificant F-ratios for each of the main effects and a nonsignificant interaction for each (all p 's $> .10$).

Discrimination of blank versus checkerboard. In the rate analysis, there were nonsignificant effects for the stimulus differences and interaction, although there was a strong main effect for time ($F(24, 264)=2.19$, $p < .002$; see Figure 3). The variability analysis was similar to the comparison of auditory stimuli, with both main effects and interactions yielding nonsignificant F values (excepting a main effect for period for the response to the blank slide ($F(6, 60)=1.91$, $p < .10$); see Figure 2).

Reliability of Infant Slide Response

An analysis similar to the previous one, using the two infant slides as the independent variable yielded nonsignificant effects for the two slides and interaction, although there was a strong main effect for seconds ($F(24, 264)=1.95$, $p < .006$, graphed by separate slides in Figure 4). This was taken as evidence that the infants strongly oriented to both of the slides when the nonsignificant interaction is considered. The variability analysis yielded nonsignificant ratios for each test. Although more properly a generalizability coefficient should be computed (Cronbach, Gleser, Nanda, and Rajaratnam, 1972) rather than a simple ANOVA, it was felt that in consideration of the methodological problems to be described any computation of reliability would be misleading. This analysis will therefore be deemphasized, and the reliability of responses tentatively assumed.

Tests for the Relationship Between Bayley Scale Scores and Cardiac Responses

To test whether there was any relationship between the Bayley MDI Scale scores and the infant responses; the Bayley scores were first median split into high and low scale groups (the high group mean was 111, range 100-130; the low group mean was 93, range 85-96). This factor was then used in a mixed design repeated measures Anova (Keppel, 1973), where subjects were nested by group and then crossed with time [$Ax(BxS)$]. Although this factor could have been included by converting the prior analysis to the proper mixed design, computer considerations led the author to perform the analyses separately. The stimulus trials used for analysis were the first infant and blank slides for visual stimuli, and the coo and tone auditory stimuli (the choice of the infant slide was

arbitrary; both the infant slide and checkerboard were looked at for equivalent periods). A total of eight Anovas were therefore performed, four on the absolute rate and a similar four on the variability.

For each of these analyses, none of the interactions of group by time were significant, and thus these effects can be ignored. Tests for the main effect by Bayley group were also all nonsignificant, except for the analysis of the variability response to the tone ($F(1,10)=5.926, p < .04$ see Figure 5). A separate Mann-Whitney U test on the 25 seconds of baseline recording prior to the first trial was also nonsignificant for the Bayley median split.

The pattern of results thus strongly supports evidence of visual orienting as indicated by the prolonged deceleration to these stimuli. The pattern of looking during stimulus presentation showed prolonged looking only to the checkerboard and infant slide. Only one infant looked towards the screen less than 75% of the presentation time. Similarly, only one subject (a different infant) looked towards the screen more than 25% of the time the other stimuli were presented. Interpretation of the cardiac orienting effects and the nonsignificant effects by Bayley group are discussed below.

Discussion

The primary purpose of the present study was to determine whether individual differences in cardiac responsivity were related to individual differences in developmental level. The results of the analysis to answer this question were negative, despite yielding what appears to be strong evidence of cardiac and behavioral orienting in early infancy. As will be discussed below, however, problems during the data collection would have tended to mask differences between the Bayley groups if they

were present.

The results of the three analyses that compared two different stimuli for function differences (blank versus checkerboard, tone versus coo, and the comparison of two infant slides) indicated definite orienting responses to the visual pairs. This response, a rapid initial acceleration, prolonged deceleration, and return to baseline is similar to the response elicited by many previous studies of orienting (e.g., Berg, 1974) and the predicted response to nonaversive stimuli described by Graham and Jackson (1970). The differential response by the infants to the auditory pair is particularly interesting when interpreted by the Graham and Jackson model. During the playback of the tone, variation in the cassette recorder motor speed created a noticeable warble (unfortunately, no other equipment was available). Assuming that the tone was relatively noxious to the infant, the rapid return to baseline and acceleration to the tone could possibly reflect what Graham and Jackson interpret as analogous to a Sokolovian defensive reaction (relative to the prolonged orienting when the coo was presented).

As described in the introduction, previous studies have found definite signs of orienting in three-month-old infants; the present study replicates and supports these findings. Unfortunately, there were no significant differences between the blank and checkerboard, nor any significant discrimination when the subjects were separated by Bayley scores. Although the non-significant effects are possibly due to the true lack of main effects, the methodological difficulties in the study were such that any subtle effects were likely to be hidden by inflated mean square error terms (see Appendix B). These difficulties are discussed below.

Methodological problems. The problem of greatest concern in this regard was the poor reproducibility and scoring of the actual heart rate data. The EKG waveforms, as previously mentioned, were analyzed by playing back the recorded tape through a filter into the polygraph, operating at 50mm/sec. These resulting wave forms were then hand scored with a millimeter ruler by the experimenter. Even though the scoring was checked to establish reliability, the combined error from three sources (the tape deck, the drive motor of the polygraph, and the hand scoring) seems more than large enough to mask subtle main effects between either the visual stimuli or the two Bayley groups (as an estimate of the possible error magnitude, a 1cm error in scoring is translateable to approximately a 3 beat per minute difference after transformation). When originally designing the procedure and method for this study, the experimenter assumed the use of a LINC-8 computer to score the heart rate tapes and yield a relatively errorless digitized record. Mechanical difficulties precluded using this piece of equipment, and thus hand scoring was necessary.

This difficulty was intertwined with some further problems, these being the product of the relatively small number of babies in the analyzed sample. The final sample of twelve was chosen from the twenty babies completing the study because it was felt these records were least noisy and each experimental session was trouble free. (It was no coincidence that almost all of this sample were among the last babies to be run for the experiment.) In addition, as the experimenter became progressively more experienced with the Bayley as a tool, it was felt that the later scoring reflected more reliable differences between the babies on this dimension. The most apparent difficulty with this small number

is the significantly reduced power of the F-test used to define differences in the means between groups. By comparison to this sample, Cousins (1976) used 128 children, with trials blocked in groups of four. Research with infants always requires greater situational control than research with other subject populations, and also has a far greater experimental mortality. The experimenter, in recognizing this, made the decision to accept the reduced sample (and concomitantly reduced statistical power) in order to be confident that the results from the accepted sessions were obtained under as methodologically rigorous conditions as possible. As previously mentioned, the majority of infants in these sessions had previously failed to finish a prior session, and were judged to be a random sample on this basis. Another problem with the small number of sampled infants is the restriction of range on the Bayley Mental Scale scores. Even though the extremes of the sample differed greatly, the highest scores in the low group, and similarly the lowest in the high group, were quite close. One separate analysis was done excluding the score closest to the overall median in each Bayley group, but this result was also nonsignificant ($p > .10$) and no further analyses were done. A possible age confound is also due to the small number of infants. Originally, the goal was to obtain far more infants, as close to ninety days as possible. In the final sample, although the mean was close to this age, the infants ranged from 90 to 122 days of age. Infant maturation during this period is both rapid, and as the developmental shift from heart rate acceleration to stimulus presentation to heart rate deceleration highlights, qualitatively different over short periods. The time confound during this period is one that possibly could further affect the results obtained, although, as

the analyses show, there was clear evidence of orienting in the sample.

Despite the majority of negative results, there was one stimulus, the variability response to the tone, that discriminated between the high and low Bayley groups (see Figure 5). The interpretation of this lone significant result is difficult due to the inflated alpha level from running the large number of comparisons. (Similarly, interpretation of the one significant variability change over time must also await replication.)

When proposing this study, the author felt that one of its contributions was applying the use of variability analysis to the study of individual differences in infancy. Since it was felt that variability reflected a tonic rather than a phasic attentional response, it was anticipated that differences on this measure would be most likely present to stimuli that elicited a maximal tonic response, i.e., the infant slide or the baby coo. However, equally attractive is the possibility that this response is equivalent to stimuli with high elicitation potential, and that the true differences would appear to stimuli that do not elicit intrinsic attention by some property of the stimulus, e.g., contrast. A possible extension of this would be that infants with greater spontaneous attention would manifest greater environmental awareness and thus relative precocity.

As mentioned previously, since this area of inquiry is relatively recent, the experimenter decided to run a rate analysis and a variability analysis for Bayley group by each of two visual stimuli (the infant slide and blank) and by each of two auditory stimuli (the tone and the baby coo). The rationale for this was that the pair of results, either for the more salient or less salient stimuli, would offer stronger

evidence for this phenomenon than would a single results. However, the two less salient stimuli were most likely nonequivalent, since it was probable that the tone was noxious rather than nonaversive. In addition, the problem of an inflated alpha level is again prominent. Despite these problems, obtaining significance in consideration of the data collection problems strengthens this finding. In previous studies by Maltzman and associates (Maltzman, 1967; Maltzman and Raskin, 1965; Maltzman and Mandell, 1968), the investigators were able to distinguish differences in semantic conditionability by adult groups separated on the basis of their GSR response to an 110 db white noise burst which was clearly an aversive stimulus. Although their discussion is in terms of orienting responses, the result is possibly supportive of the present finding using this type of stimulus. A derivation from this could be that differences are reflected in the range of stimuli and environmental events to which infants can produce a response that will facilitate the "taking in" of a stimulus rather than its rejection. Obviously, this would require much empirical testing.

One last test was done to check if initial variability, as a measure of spontaneous variability, was related to differences in the Bayley score. When arranged by high and low Bayley groups, there was no relationship between these groups and the baseline variability (see Table 15). This could also be due to any of the problems described, to the different amount of time needed to acclimate infants, or, obviously, the lack of a true relationship. Again, variability analyses are more sensitive to measurement errors since random errors will inflate the variance without affecting the group means (and therefore the deceleration curves).

There are several ways in which either this or future studies could be adapted to provide a better examination of the interaction between biological and psychological variables during infancy. The Bayley Scales are probably not the best instrument for evaluating individual differences between young infants; the Brazleton Neonatal Behavioral Assessment Scale (Brazleton, 1973) has been used in a number of recent studies of infant behavior (e.g., Lester, Emory, Hoffman, and Eitzman, 1976), and appears to be a superior dependent variable for studies of this type. The test has been designed to evaluate more global characteristics of early infant behaviors, focusing mainly on a set of integrative behaviors more complex than the simple items on the early ranges of the Bayley scale. A recent paper (Lester, et al., 1976) reported an "attentional-orientation" factor present in a varimax factor solution on the Brazleton Scale administered to newborns (although in this sample of 54 infants, half were low birth weight children). An alternative approach to the use of a complex measure of many items (e.g., the Bayley scales) would be using a single well defined dependent measure. This approach has been advocated by Horowitz (1974) for the study of individual differences in habituation during various experimental manipulations (although Cousins [1976] study found no relationship between cardiac response and habituation to a tactile stimulus).

A review of the most recent literature leaves little doubt that studies of this type will become increasingly frequent in the future. With the decreasing cost of high technology digital processors and associated equipment, and the increasing sophistication of mathematical models for evaluating psychophysiological data, studies virtually impossible at the onset of the decade are becoming commonplace.

Psychophysiological techniques offer an excellent paradigm for the study of biological-psychological interactions in early infancy, as well as the study of developmental changes in maturation or certain psychological processes. An excellent synthesis of these techniques is the application of psychophysiological models to the problem of fetal monitoring during birth (Porges, 1978). Porges (1977) also has discussed the use of these models for evaluating the functional maturation of the autonomic nervous system, another useful application of these strategies.

In summary, the present study can only add little to the literature on individual differences in early infancy. It strongly reaffirms, however, the evidence for cardiac orienting in early infancy to a variety of stimuli, and supports a defensive-orienting difference in cardiac patterns. As mentioned above, many problems hampered this study, but technological improvements being undertaken currently should eliminate this problem for future studies in the Developmental Psychobiology Laboratory. This area of interest should long be a fertile source of valuable research.

APPENDICES

APPENDIX A

APPENDIX A

Parental Consent Form
Background Information Form
Parental Feedback Form

Permission Form for Testing Infant

Date: _____

Dear Parents:

This form is to request permission for us or members of our staff to examine your infant in tests of attention, and to administer the Bayley Scales of Infant Development.

You may withdraw permission at any time simply by informing us or our staff members that you wish to do so. The information collected is confidential; it will be available only to qualified personnel, and information on individual infants will be identified by number only. If you have any questions about the procedures to be used, please feel free to ask. The tests will not disrupt or in any way be harmful; however, participation in the study will not guarantee you or your infant any beneficial results.

Your signature on this form verifies that the specific tests and procedures to be used with your infant have been explained to your satisfaction, and that you have voluntarily agreed to allow us to test your infant. If at any time you wish to have the data for your baby withdrawn from the study, simply advise us and we will destroy all records relevant to your baby.

Any videotape record of the Bayley examination will not be viewed by anyone except the experimenter and an assistant. The only use of this will be to record the Bayley protocol, after which these records will be destroyed.

Sincerely,

Steven R. Gitterman
Research Director

Hiram E. Fitzgerald, Ph.D.
Professor of Psychology

Parent's Signature _____

Experimenter's Signature _____

BACKGROUND INFORMATION SHEET

The information requested in this form will be used to report the general characteristics of the infants used in our research. Only group results will be reported, and the identity of individual infants will remain anonymous. All information you provide on this form will be kept strictly confidential.

Infant Number _____ Stimulus Order _____

Date of Test _____ Time of Test _____

Tape Number _____ Room Temperature _____

Experimenters:

Parents:

Date of Birth _____ Sex: Male _____ Female _____
 Month Day Year

Place of Birth _____
 City or Town State Country

Weight at Birth _____ lb. _____ oz. Length at Birth _____ inches

Weight Now _____ lb. _____ oz. Length Now _____ inches

Due Date _____

Any complications during pregnancy? _____ If so, please briefly describe them.

Was medication used during labor and/or delivery (for example, local anesthetic, gas, saddle block)? _____ If so, please describe briefly.

Has your infant had any prolonged or general illness since birth? _____ If so, please describe briefly.

Has your infant received any medication since birth? _____ If so, please describe briefly.

Is your infant A _____ bottle fed _____ breast fed

_____ some combination, with bottle feeding _____ 75% _____ 50% _____ 25%

Is this your first child? _____ Yes _____ No If no, how many children do you have? _____

Dear Parents:

Please excuse the delay in my getting this letter out to you. Only just recently have I been able to complete the scoring of all the heart rate records, and then finish the laborious process of analyzing the data.

In sum, the analysis of the data didn't work out quite as well as I hoped. Most of the infants responded to the different stimuli with the cardiac response typical of 3 months per age (a rapid acceleration, then prolonged deceleration). Moreover, the cardiac responses clearly differentiated between the two auditory stimuli (the tone and the baby sound) when they were presented. I've included a graph of both these patterns on the second sheet.

Unfortunately, there was no relationship between the heart rate patterns and the items from the Bayley infant test. There are probably many reasons for this, not the least of which I'm sure was the amount of time spent in the booth when the different stimuli were presented. There are many ways in which this type of research can be improved, and from this experience I hope we can strengthen future research in the lab.

Again let me thank you for coming down to the lab with your child. As you might guess, it's very difficult to get subjects for this type of research, and your participation, along with many others, has helped to produce much successful work in this field. If there are any additional questions I can answer, please feel free to call me at 353-1651.

Sincerely yours,

Steve Gitterman

SG:sh

APPENDIX B

APPENDIX B

Analysis of Variance Summary Tables

Table 1

Analysis of Variance Summary Table for Heart Rate
to Blank Slide (seconds)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	144.075	.192	.671
Subject w. groups	10	750.584		
Within Subjects				
Time (B)	24	46.353	2.031	.004
B x Sub. w. grps.	240	22.818		
A x B	24	25.601	1.122	.320
Total	299			

Table 2

Analysis of Variance Summary Table for Heart Rate
to Baby Slide (seconds)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	23.297	.027	.873
Subject w. groups	10	867.404		
Within Subjects				
Time (B)	24	57.848	2.017	.004
B x Sub. w. grps.	240	28.681		
A x B	24	16.307	.569	.949
Total	299			

Table 3
Analysis of Variance Summary Table for Heart Rate
to Baby Sound (seconds)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	67.100	.137	.719
Subject w. groups	10	490.696		
Within Subjects				
Time (B)	14	27.455	.554	.896
B x Sub. w. grps.	140	49.549		
A x B	14	15.392	.311	.992
Total	179			

Table 4

Analysis of Variance Summary Table for Heart Rate
to 250 Hz Tone (seconds)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	1.168	.003	.958
Subject w. groups	10			
Within Subjects				
Time (B)	14	14.932	.708	.764
B x Sub. w. grps.	140	21.096		
A x B	14	19.480	.923	.536
Total	179			

Table 5

Analysis of Variance Summary Table for Heart Rate

Variability to Blank Slide (period)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	19.508	.026	.874
Subject w. groups	10	739.600		
Within Subjects				
Period (B)	6	417.849	1.905	.095
B x Sub. w. grps.	60	219.390		
A x B	6	33.032	.151	.988
Total	83			

Table 6

Analysis of Variance Summary Table for Heart Rate

Variability to Baby Slide (period)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	25.377	.044	.838
Subject w. groups	10	578.196		
Within Subjects				
Period (B)	6	309.969	.894	.505
B x Sub. w. grps.	60	345.671		
A x B	6	298.851	.865	.526
Total	83			

Table 7

Analysis of Variance Summary Table for Heart Rate

Variability to Baby Sound (period)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	47.277	.096	.763
Subject w. groups	10	491.067		
Within Subjects				
Period (B)	4	175.272	.686	.606
B x Sub. w. grps.	40	255.465		
A x B	4	164.896	.645	.633
Total	59			

Table 8

Analysis of Variance Summary Table for Heart Rate

Variability to 250 Hz Tone (period)

Source	df	MS	F	p
Between Subjects				
Bayley Group (A)	1	2162.88	5.926	.035
Subject w. groups	10	364.981		
Within Subjects				
Period (B)	4	118.728	.558	.695
B x Sub. w. grps.	40	212.926		
A x B	4	198.550	.932	.455
Total	59			

Table 9

Analysis of Variance Summary Table for Heart Rate

Differences to Checkerboard and Blank (sec.)

Source	df	MS	F	p
Stimulus (A)	1	132.446	.262	.619
Error (A x S)	11	505.141		
Time (B)	24	68.202	2.186	.002
Error (B x S)	264	31.199		
AxB	24	12.662	.745	.803
Error (A x B x S)	264	17.006		
Error (S)	11	1017.69		
Total	599			

Table 10

Analysis of Variance Summary Table for Heart Rate

Differences to Baby Sound and Tone (sec.)

Source	df	MS	F	p
Stimulus (A)	1	1163.52	4.139	.067
Error (A x S)	11	281.082		
Time (B)	14	22.596	.651	.818
Error (B x S)	154	34.708		
AxB	14	19.793	.606	.858
Error (B x S)	154	32.684		
Error (S)	11	539.306		
Total	359			

Table 11

Analysis of Variance Summary Table for Heart Rate Variability

Differences to Checkerboard and Blank Slide (period)				
Source	df	MS	F	p
Stimulus (A)	1	240.913	.556	.472
Error (A x S)	11	433.362		
Period (B)	6	555.880	1.500	.192
Error (B x S)	66	370.565		
A x B	6	133.975	.872	.521
Error (A x B x S)	66	153.707		
Error (S)	11	1339.88		
Total	167			

Table 12

Analysis of Variance Summary Table for Heart Rate Variability

Differences to Baby Sound and 250 Hz Tone (period)				
Source	df	MS	F	p
Stimulus (A)	1	116.427	.285	.604
Error (A x S)	11	408.172		
Period (B)	4	104.124	.509	.730
Error (B x S)	44	204.728		
A x B	4	189.695	.746	.566
Error (A x B x S)	44	254.150		
Error (S)	11	570.884		
Total	119			

Table 13

Analysis of Variance Summary Table for Heart Rate

Difference to Baby Slides (sec.)

Source	df	MS	F	p
Baby Slides (A)	1	822.979	1.059	.325
Error (A x S)	11	776.877		
Time (B)	24	50.260	1.945	.006
Error (B x S)	264	25.846		
A x B	24	22.846	.860	.657
Error (A x B x S)	264	25.597		
Error (S)	11	679.545		
Total	599			

Table 14

Analysis of Variance Summary Table for Heart Rate

Variability Differences to Baby Slides (period)

Source	df	MS	F	p
Baby Slides (A)	1	444.178	2.829	.121
Error (A x S)	11	157.045		
Period (B)	6	261.994	1.254	.291
Error (B x S)	66	208.984		
A x B	6	125.811	.521	.791
Error (A x B x S)	66	241.682		
Error (S)	11	534.9219		
Total	167			

Table 15

Menn-Whitney U Test for Differences
in Initial Variability by Bayley Group

$Z = 0.5, p > .10$

APPENDIX C

APPENDIX C

Figures

Figure 1. Heart rate change to the auditory stimuli. Second 1 is the first second after stimulus presentation.

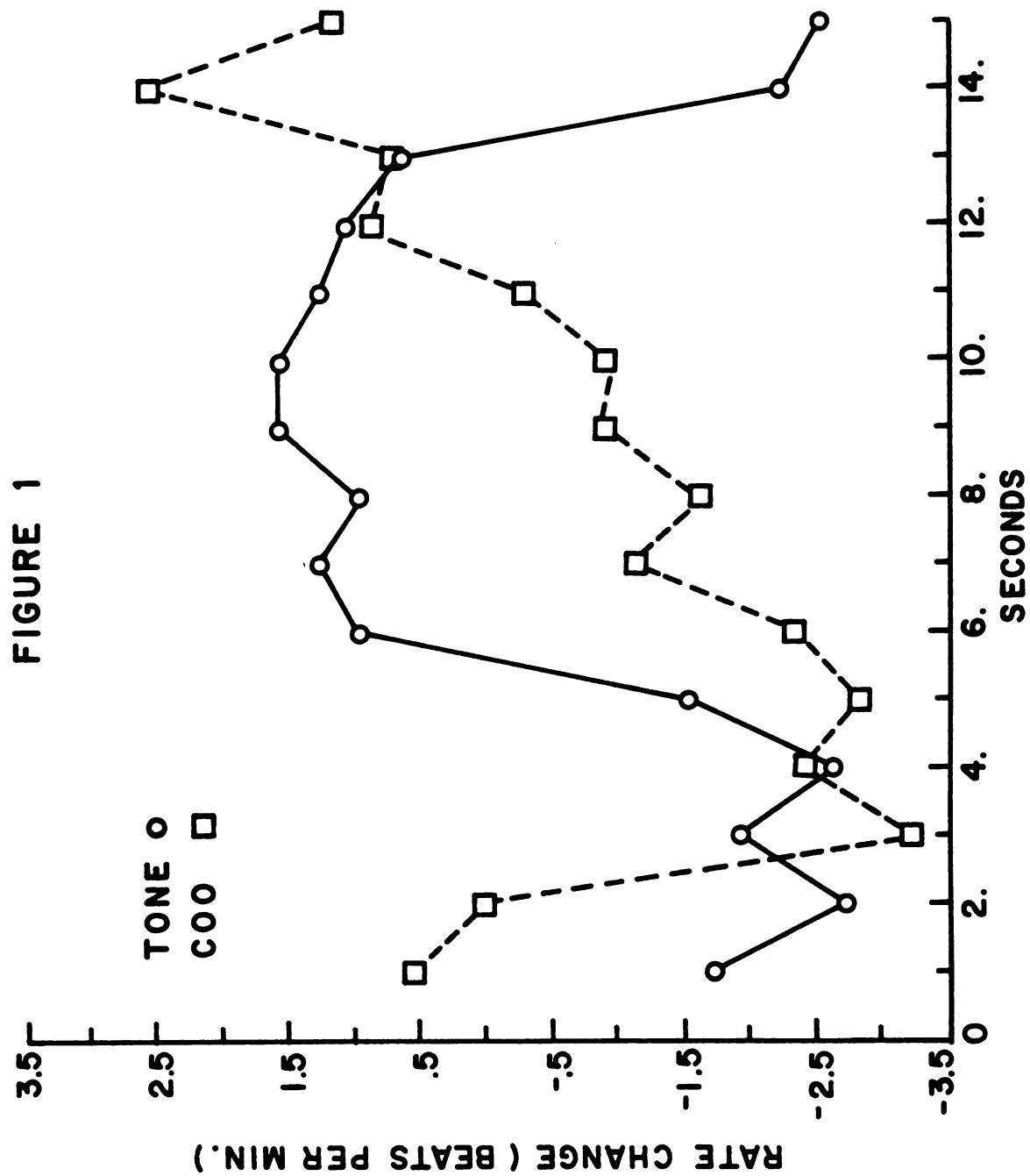


Figure 2. Variability change to blank slide presentation. Each period is a five second interval; the first interval is the five second interval prior to stimulus onset, the last interval is the five second interval after stimulus offset.

FIGURE 2

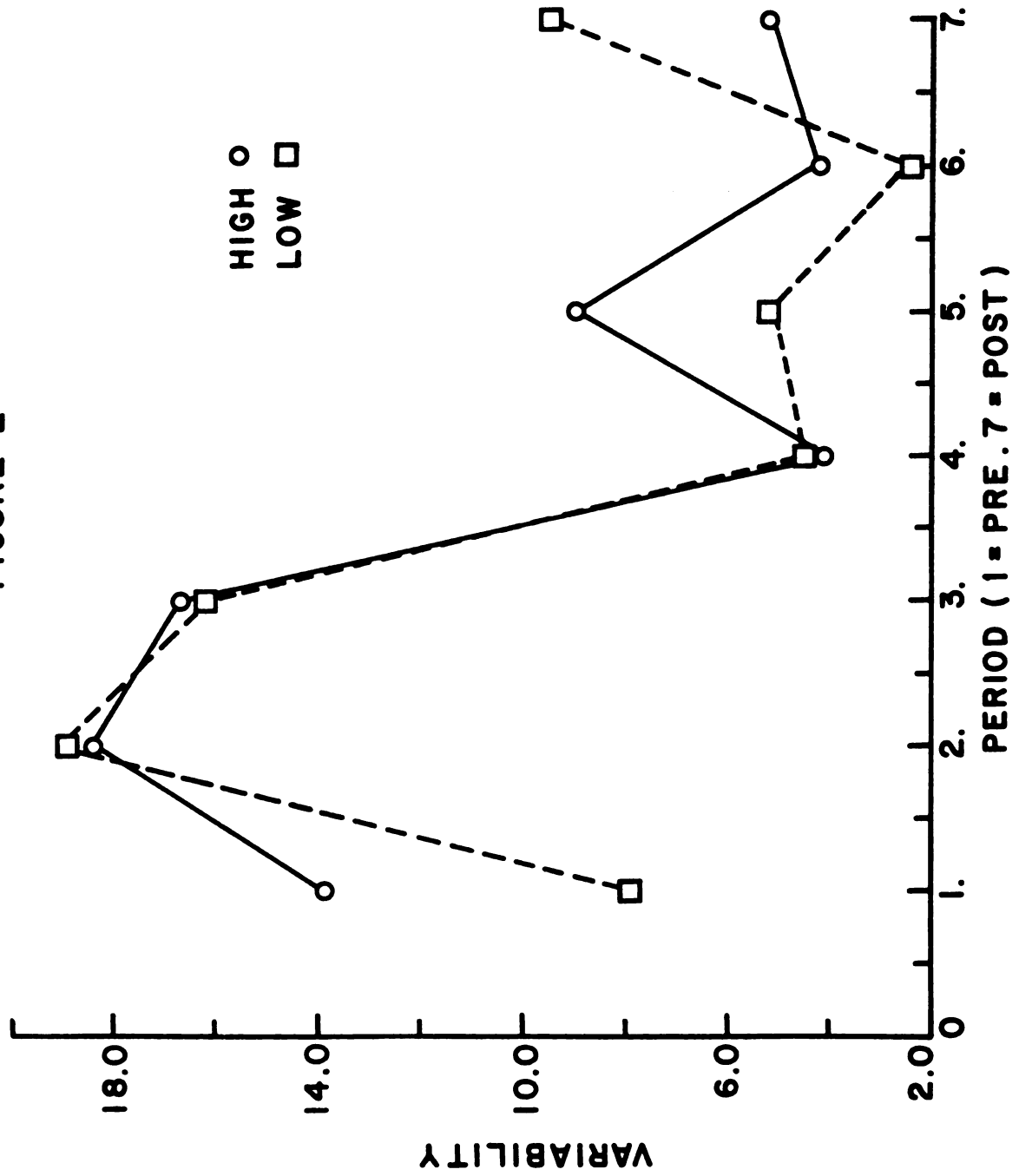


Figure 3. Heart rate change to the checkerboard and blank stimuli.

Second 1 is the first second after stimulus presentation.

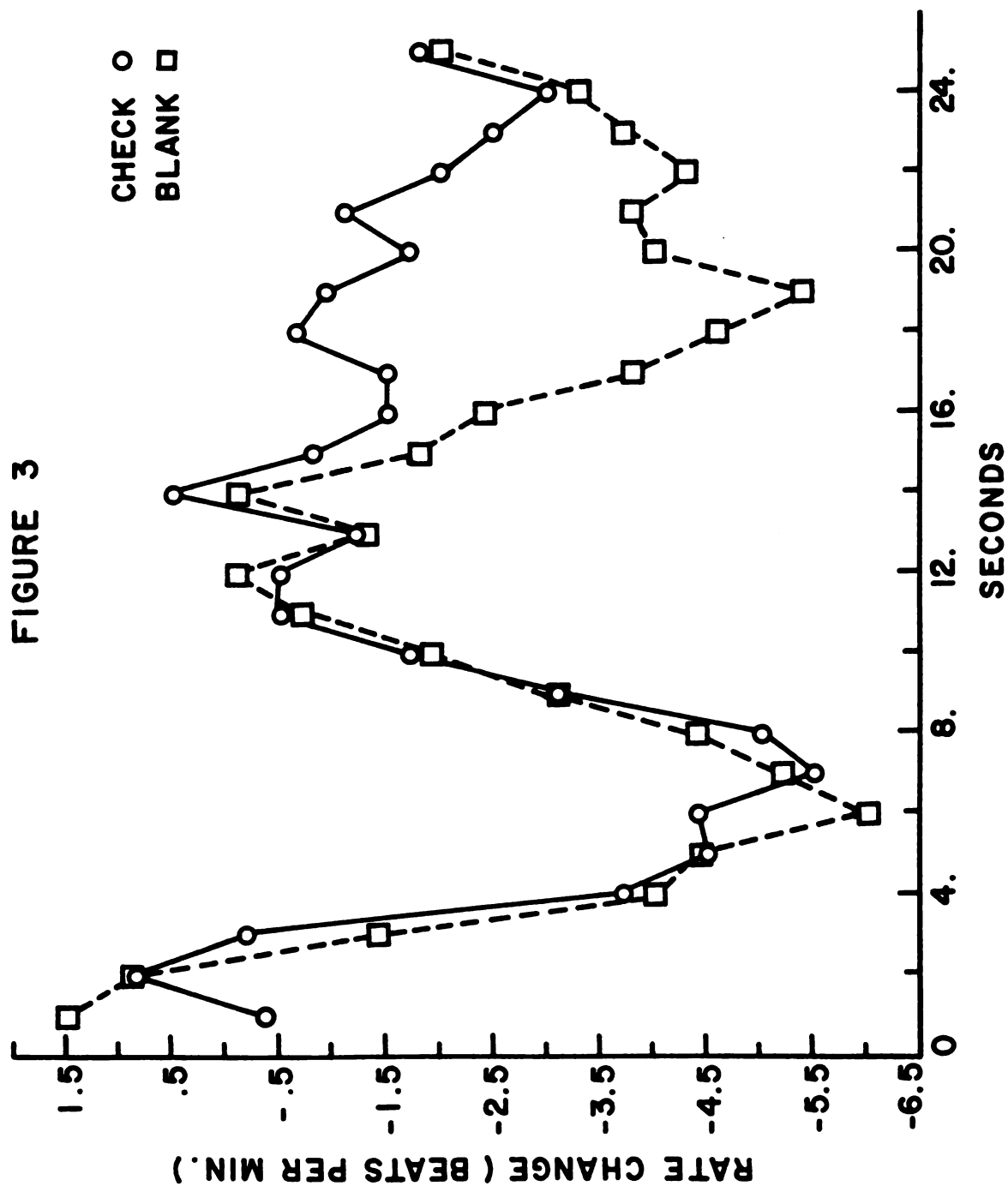


Figure 4. Heart rate change to the two baby slides. Baby A was always presented prior to Baby B. Second 1 is the first second after stimulus presentation.

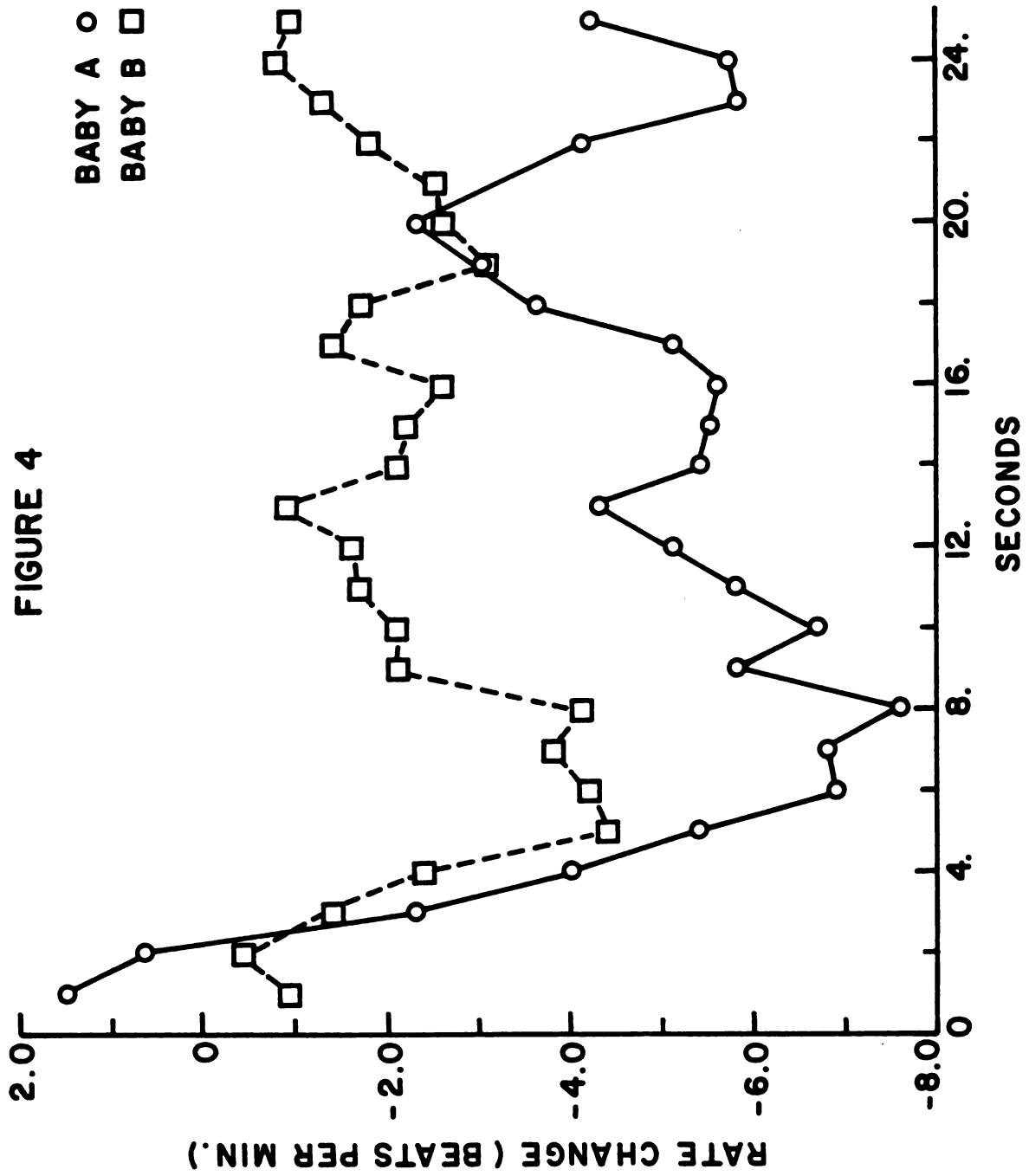
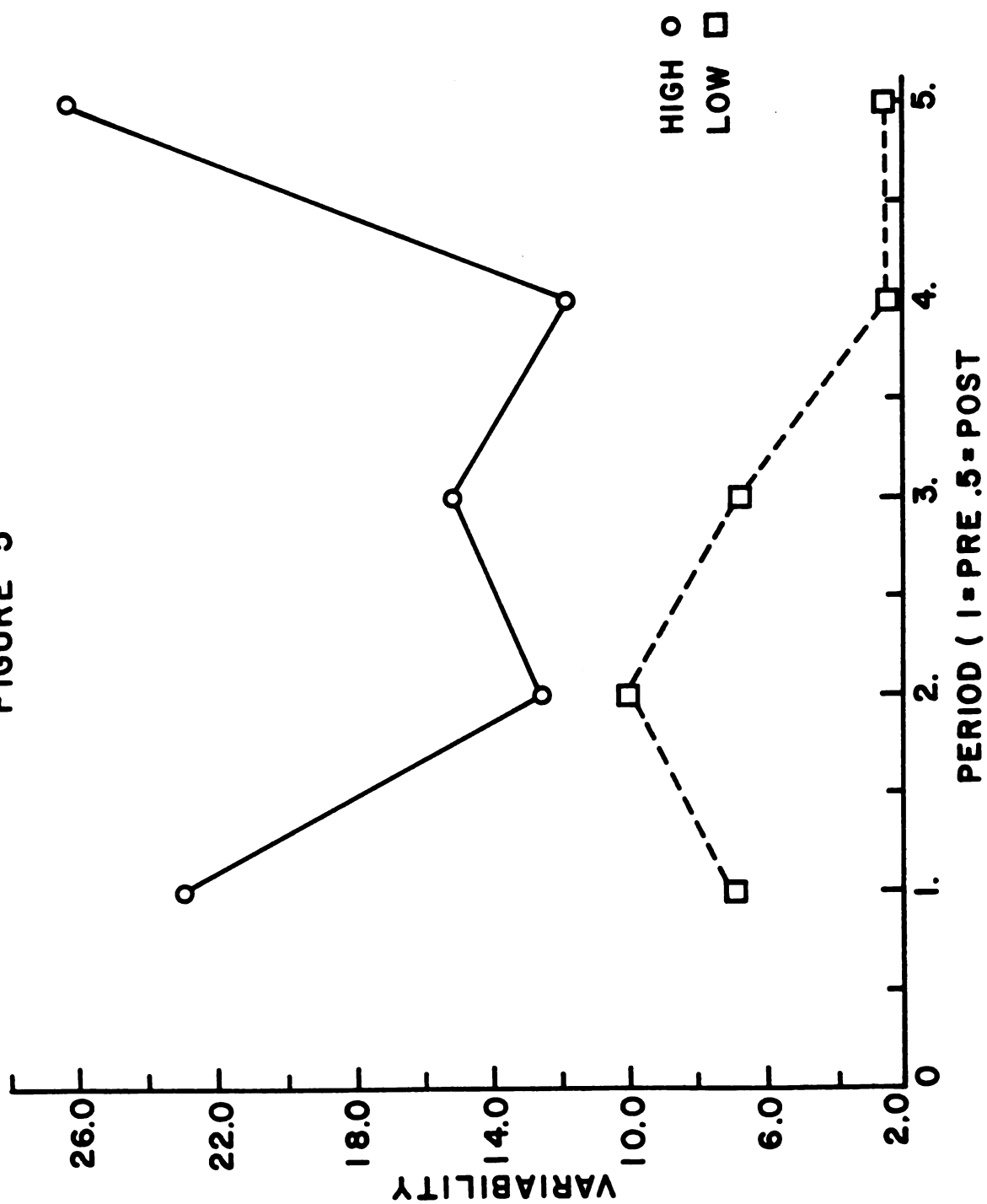


Figure 5. Variability change to the 250 Hz tone divided by Bayley group. Each period is a five second block; period 1 is the five second interval before stimulus presentation. Period 5 is the five second interval after stimulus presentation.

FIGURE 5



LIST OF REFERENCES

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