Stimulus Differentiation by Preterm Infants Can Guide Caregivers

Author: Litovsky, Ruth

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Full Text: Headnote ABSTRACT: Advances in modern medicine in recent years have resulted in a remarkable increase in the number of human infants who survive a premature birth. Many of these infants undergo stressful perinatal and prenatal experiences, and require special care and attention in order for their physical and mental development to be optimal. If that goal is to be met, care-givers need to receive feedback from the infants, indicating how they are affected by treatment and stimulation. In this study, preterm infants displayed behavioral differentiation of various tactile stimuli. A number of behaviors are highlighted, which are indicative of physiological integration of environmental stimuli, and which can be used by care-givers as guides in their interaction with the infants. INTRODUCTION Due to advances in modern medicine in recent years, there has been a remarkable increase in the number of human infants who survive a premature birth. Many of these infants are expelled from the womb after only 6 month of gestational development. Not only do they undergo stressful prenatal and perinatal experiences, but in addition they often suffer postnatal complications which have been shown to adversely affect their development (Rose, 1980; Field, Hallock, Ting, George, Dempsey, Dabiri and Shuman, 1978; Fox, 1983). While some of these problems are short-lived, others persist throughout childhood, and sometimes into adulthood. The development of preterm infants resembles that of fullterms in some ways. But in other ways, preterms often lag behind their fullterm counterparts in physiological, motoric and intellectual capacities (Aylward, 1981; Berkson, Wasserman and Behrman, 1974; Dorros, 1977; Dreyfus-Brisac, 1968; Fox and Lewis, 1983; Gottfried, 1973), especially if they have experienced seizures and brain hemorrhaging (Volpe, 1981). The preterm infant is an organism which has been deprived of its last 2-3 months in the womb. Hence, the extrauterine environment into which it enters is one for which the infant may not be fully developmentally prepared. Not only are there demands made on the infant which are physiologically taxing and overwhelming, but often, preterm infants in the Neonatal Intensive Care Unit (NICU) do not receive the proper type of stimulation necessary to enhance their development. In some cases, they receive less than a third of the caregiving that fullterms receive at home (Lawhon, 1986), and are restricted to prone-lying, which limits self-generated tactile stimulation (Anderson and Aulster-Leibhaber, 1984). It is crucial that potential developmental problems in preterm infants be identified early, so that appropriate therapy may be administered to those infants who are at-risk for deficit. In this regard there are two primary issues to consider. First, appropriate measures of physiological and motoric integrity must be utilized in assessing preterm infants. The use of inappropriate measures could result in incorrect assessment of the infants, and consequently in administration of either insufficient or inappropriate therapeutic treatment. Conversely, appropriate therapy could enhance and bolster a preterm infant's progress and development, and has greater chances of ensuring optimal postnatal development (Lazzara, Ahmann, Dykes, Brann and Schwartz, 1980). Research on the growth achievement of preterm infants has become quite robust in the past 20 years, and has enabled us to highlight specific variables associated with developmental deficits at certain postnatal ages (Als and Brazelton, 1981; Anderson, 1986; Barnard and Bee, 1983; Brazelton, 1973; Mednick, 1977; Rose, Schmidt, Riese and Bridger, 1980). Initially, numerous investigators were primarily interested in examining discrete aspects of physiological and behavioral integrity and functioning, such as measuring heart rate and respiratory systems, (Bridger and Reiser, 1959; Cabal, Siass, Zanini, Hodgmman and Hon, 1980; Fox and Porges, 1985; Lacey and Lacey, 1980) as well as arousal and attention levels (Fox, 1983; Graham and Jackson, 1970). A more recent strategy has been to examine the infants' behaviors. An understanding of the naturally occurring behaviors of preterm infants can lead to the use of these behaviors as a tool in investigating infants' responses to environmental stimulation. Investigators of neonatal development such as Heidele Als and Berry Brazelton (1981) have proposed a unique model to explain the behavioral organization of young infants. Rather than treating the neonate as a passive organism which is simply impacted upon by its surrounding environment, this model treats the neonate as an active participant in its own development. Hence, neonates are viewed as intrinsically social beings that strive to survive and achieve self-regulation through feedback and interaction with their care-giving environment. In their assessment of preterm infants, Als and her colleagues (Als and Brazelton, 1981; Als, Lester and Brazelton, 1979) distinguish between two categories of behaviors: 1) "Self-Regulatory": Behaviors of approach and groping, seeking stimulation and interaction; stimulation eliciting relative increases of these behaviors is considered to be favorable for the infants and should be encouraged. 2) "Stress-related": Behaviors of avoidance and withdrawal; these usually result from overwhelming stimulation which the infant cannot integrate and which may be aversive. Utilizing this distinction, Als (1984) has developed a detailed behavioral examination for observation of newborn infants (fullterm and preterm), the Manual for Naturalistic Observation of Newborn Infants. Als' test classifies behaviors into 5 general categories: Autonomic, Visceral and Respiratory, Motor, State related, and Attention related. It must be noted though, that this test was developed as a clinical tool, to be used by nurses and care-givers who interact with preterm infants. It is used then in an "on-line" fashion, where the observer stands by the infant's bed and records behaviors which are emitted by the infant. However, in addition to understanding the infants' behaviors from a clinical, intuitive perspective, it is important to be able to evaluate the status of an infant on a quantitative basis. First, it is important because without a quantitative analysis of behaviors, the frequency of occurrence of various behaviors in relation to each other may not be clear. second, a quantitative analysis is crucial if we are to relate the behavioral findings and their indication about the state of an infant to those of other physiological systems, such as the cardiac system. With the author's permission I utilized aspects of her test in my investigation of preterm infants' responses to multimodal tactile stimulation. I explored whether preterm infants' behaviors can be quantified and analyzed, to yield an objective measure of whether the infant was more disposed to "self-regulate" or to express "stress" behaviors. The infants were presented with three different types of tactile stimuli, each of which had a unique qualitative characteristic, and I examined whether they displayed differential behaviors to each stimulus condition. If a relatively new test is to be avaluated, its results should be compared with those obtained using measures whose validity are fairly well established. Thus, in addition to evaluating the infants' behaviors, their heart rate responses to the multi-quality tactile stimuli were measured, since heartrate is a measure which has gained significant recognition and validity over the past couple of decades. In particular, it is a unique physiological function which has been widely used in the investigation of development of preterm infants (Berkson et al., 1974; Dorros Body and Rose, 1979; Field, 1979a; Fox and Lewis, 1980; Rose, Schmidt and Bridger, 1976; Rose Schmidt, Reise and Bridger, 1980; Rose, Schmidt and Bridger, 1978; Shulman, 1979; Vranekovic, Hock, Isaac and Cordero, 1974). Such research has frequently been grounded in the early work of Sokolov (1960; 1963), Lacey (1968; Lacey and Lacey, 1962) and Graham and Jackson (1970), investigators who initiated a vast field of research on early human sensory processing and its relation to physiological activity. Out of this early work, as well as later work, arose a predominant view of the mammalian body as having two extremes on its spectrum of arousal levels. On one end lies the orienting response (OR), which is involved in the perceptual mechanisms necessary for learning, and functions toward enhancement of perceptual capacity. The OR reflects sensitivity to changes in current stimulation and to novel stimuli. Cardiac deceleration has been suggested to be a main component of the OR (Graham and Clifton, 1966), and to indicate "stimulus intake." On the other end of the arousal system spectrum lies the Defensive response (DR); it is initiated by intense stimuli and characterized by heart rate increase (Graham and Clifton, 1966), indicating stimulus rejection. The DR is a protective component of the physiological system, which functions to lower perceptual sensitivity. These two components of the cardiac system may be analogous to the two components of the behavioral system, as has been described by Als. It will therefore be interesting to compare the infants' responses to stimulation with these analogous dichotomies in mind. Past research has shown that in preterm infants, cardiac responses to stimulation have been difficult to interpret. If the infants do display any detectable response to sensory stimulation, it tends to appear as that of cardiac acceleration above baseline (Rose et al., 1980). However, preterm infants during the first weeks of life have never been shown to display cardiac deceleration, in particular in response to tactile stimulation. What is common to these studies, is the repetitive, intense nature of the stimuli employed, which has commonly been a plastic filament presented phasically to the skin. The question thus remains as to whether newborn preterm infants are incapable of displaying orienting (heart rate decrease below baseline) responses to tactile stimulation, thus reflecting a predominant characteristic of stimulus rejection at this early stage in development, or whether they are not provided with stimulation appropriate to elicit an orienting response. To summarize, infants born prematurely often have their only mode of communication with their caretakers, that of behavior, misinterpreted. If these infants are to be provided with stimuli which will enhance their development, it is crucial that their responses to stimulation be understood, and that care-giving be modified to suit the needs of the infants. However, when we study the response of an organism to particular stimulation it is worthwhile to compare that response with another of a reliable system. In our case, when attempting to extrapolate answers about infant behavior as related to their internal state, it would help to compare these with the infants' heart rate responses to the same stimulation. Behavioral and cardiac responses have qualitative correlates with one another on the arousal spectrum. In both systems we have an "orienting" response (heart rate decrease and "self regulatory" behaviors), as well as a "defensive" response (heart rate acceleration and "stress" related behaviors). METHOD Subjects Eight preterm infants, 26-32 weeks estimated gestational age were tested a week after birth, while still patients at the neonatal intensive care unit (NICU) at St. Louis Children's hospital. All infants were determined by their physician to be in stable medical conditions at the time of testing. Stimuli Each infant was tested in his/her heating bed or isolette in the NICU. Behavioral and heart rate changes in response to stimulation were measured. Three types of tactile stimuli were used (see Table 1): Pressure (tonic), Brush (phasic), and Punctate (phasic). Tactile stimuli were manually delivered to each of the left and right perioral and abdominal regions of the body. The stimulus was a plastic filament, with and without a rubber tip, calibrated to deliver a constant pressure of 10.0 grams when applied to the skin. With pressure stimulation, a rubber tipped filament was applied to the skin for a full 5-sec interval at a constant pressure of 10.0 grams. With brush stimulation, the rubber tipped filament was applied in the form of 5 consecutive 1-sec strokes to the skin. Finally, a "bare" plastic filament was used to apply punctate stimulation, at a rate of 1 per sec over 5-sec, each contact with the skin actually lasting .25 sec.

TABLE 1
Stimulation Design

Types of Stimulation Conditions
Tactile stimuli
Punctate: bare filament, 10g, 1/sec (phasic)
Brush: rubber-tipped filament, 10g, 1/sec (phasic)
Pressure: rubber-tipped filament, 10g, 1/5 sec (tonic)
Control
Blank: bare filament, 10g, 1/sec; *no contact was made with the skin*
Stimulation Sites
Left Perioral; Right Perioral
Left Abdominal; Right Abdominal
Trial duration
5-second stimulation; 20-second post-stimulation interval.
Total stimulation
For each of the 3 stimulus conditions: 3 blocks of 4 trials; one trial at each body locus
For the control condition: 1 block of 4 stimulus trials; one trial at each body locus.
Total Test time
3 trials × 4 sites × 3 stimulus types (36) + 4 Blank trials = (36 + 4) × 25 sec = 1000 sec (16.7 minutes).
Total time of actual contact with the skin
36 trials × 5-secd = 180 sec (3 min)

Data-Recording Apparatus Throughout the experiment, the infants' heart rate was recorded with a polygraph interfaced with the heart monitors of the infants. In addition, their behavior was video-taped using a remotely controlled camera with an internal digital clock. Testing and Stimulation During the entire session, an infant was positioned supine with its head supported in the midline. Behavior and heart rate were recorded for 2 minutes prior to onset of tactile stimulation procedures. The stimulation phase of the study consisted of 40,25-sec trials and lasted a total of 16.7 minutes. Each trial consisted of a 5-sec period of stimulation followed by a 20-sec post-stimulation interval. Included in the 40 trials were 36, 25-sec tactile stimulation trials, and 4, 25-sec control "blank" trials. Every infant received stimulation with three different types of tactile stimuli (see Table 1). Each of the 3 stimuli (pressure, brush and punctate) was presented 12 times, 3 times to each of the 4 stimulus locations (left and right, each at the perioral and abdominal regions of the body). The order of presentation was randomized and pre-recorded on audio tape. The tape was played back through earphones to the administrating investigator to insure proper stimulation during the session. The 4 "blank" stimulations were randomized throughout the stimulation phase. In this control condition, the filament approached the infant, but made no actual contact with the infant's skin. Data Scoring Procedures The behaviors of the infants were scored and classified as either "Self-Regulatory" or "Stress", according to the criteria of Als (1984, Manual for the Naturalistic Observation of Newborn Behavior). Als has proposed that "Self-Regulatory" behaviors are strategies that infants use to internally synchronize their various physiological systems. On the other hand, "Stress" behaviors reflect an inability of the infant to process and manipulate environmental sensory stimulation. With these behaviors the infants reflect an avoidance of interaction with the environment. The behaviors are listed in Table 2.

TABLE 2
Self-Regulatory and Stress Behaviors

Behavioral Category		*Self-Regulatory Behaviors*	*Stress Behaviors*
Face		open frown "ooh" face "cooing" speech/mouthing smile sucking, suck-search	grimace gape face tongue-protrude twitch
	Eyes:	track	avert float
Visceral		....	spit up, gag, burp, hiccough, BM grunt, sounds, sigh, gasp.
Trunk		smooth trunk movements tuck trunk leg brace	tremors startle body twitch diffuse squirm stretch/drown arch flaccid trunk
Limbs	*Arms:* *&*	flexed smooth movement	flaccid extended
	Legs:	flexed smooth movement	flaccid extended
	Extremities: (hand & foot)	hand to mouth hand to face grasp/hold on hand clasp foot clasp	finger splay "airplane" salute fisting sitting on air
		Total = 20	Total = 30

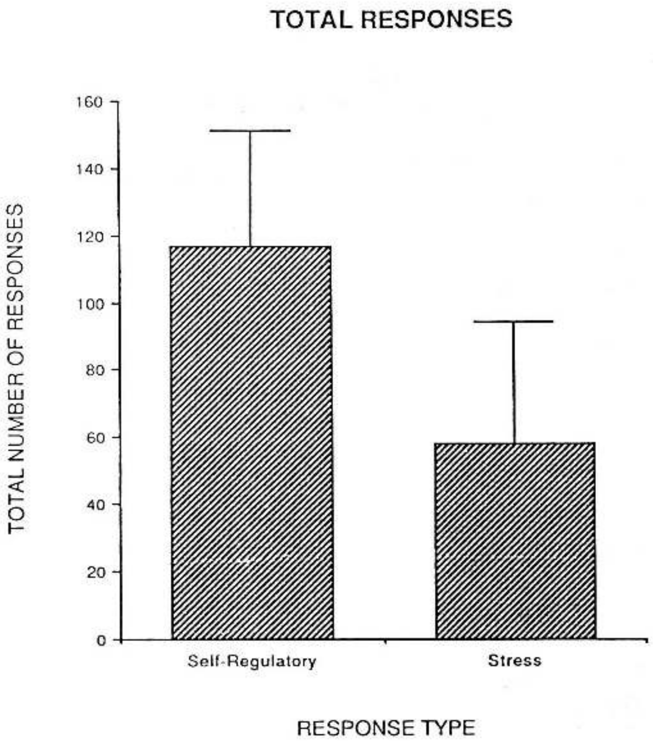
In the observation sheet used by Als there are 9 types of behaviors. These same behaviors were used in the present study, and were sub-grouped into four major categories based on the anatomical substrate of the behaviors: Face, Visceral, Trunk and Limbs (see Table 3). Infant behavior was scored from the video tapes onto data sheets (see Appendix A), using the descriptive criteria of Als (1984). Each of the 40 trials was scored on a single data sheet. Behaviors during each trial were scored into 5, 5-sec time bins and were coded in a checklist format.

TABLE 3
Behavior–Heart Rate Correlations

Behaviors 'r' with Heart Rate Decrease
Open Face
Mouthing
Suck-Search
Visual Tracking
Leg Brace
Airplane
Behaviors 'r' with Heart Rate Increase
Yawn
Grimace
Gasp
Eyes Closed, Avert, Float
Trunk: Tremor
Tuck
Squirm
Twitch
Finger Splay
Fisting

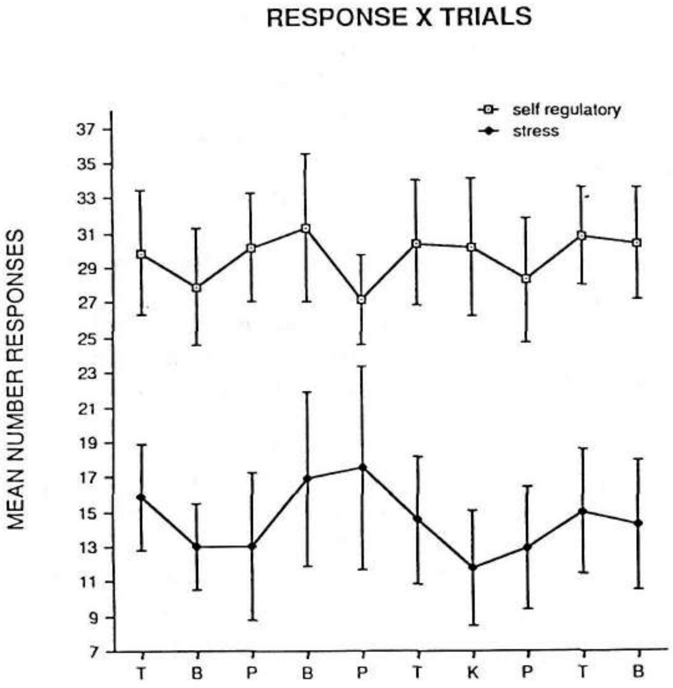
RESULTS Behavioral Responses Behavioral data for males and females, right and left stimulus sides, and for perioral and abdominal body sites were pooled based on no statistically significant differences between the pair-wise comparisons ($p > .05$). The first analysis was aimed at determining whether there was an overall effect of the stimulation procedure on the infant behaviors. Thus, the mean frequency of the two behavior types (Self-Regulatory and Stress) emitted during the test were compared. Each behavior type was summed across the 4 stimulus conditions (T, B, P and Control), and are presented in Figure 1. A significant difference was found between the mean number of Self-Regulatory (117 + 34) and Stress (58 ±36) behaviors [$t(7) = 8.15$, $p < .001$). Overall, the preterm infants displayed twice as many Self-Regulatory behaviors as Stress behaviors during the 40-trial (16.7 min) testing session.

FIGURE 1
Total Behavioral Responses to Stimulation: Self-Regulatory vs. Stress



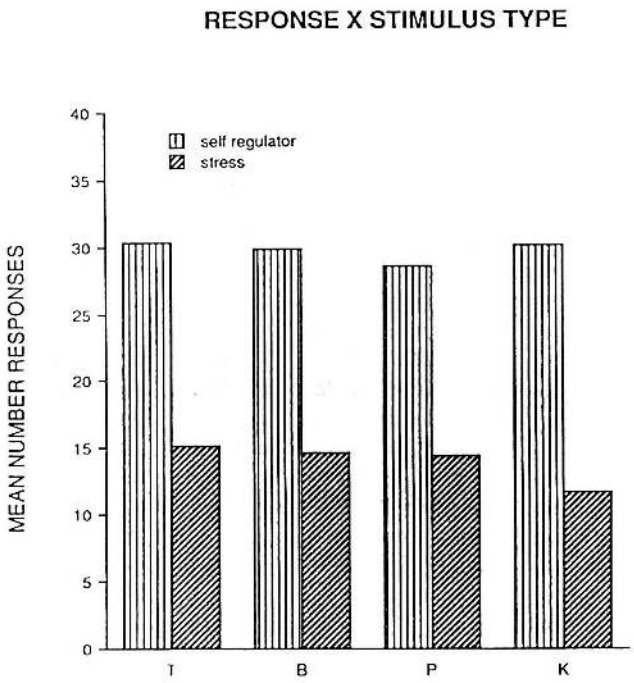
This significant difference was also persistent through time, lasting from beginning to end of the session. To illustrate this point, the 40 trials were divided into 10 blocks of 4-trial sequences, each block containing every one of the 4 stimulus conditions. A 2-way ANOVA (response type ×trial blocks) revealed a statistically significant main effect for response type [F(1,7 = 78.43, p <.001], by no effect for trials. This analysis shows that the number of Self-Regulatory or Stress behaviors did not change over the 10-block stimulation sequence, and that overall, Self-Regulatory behaviors predominated over Stress behaviors (see Figure 2). It is possible that although there were more Self-Regulatory than Stress responses during the test, when examined according to stimulus type, the 4 different conditions would yield differential levels of the two behavior types. Presented in Figure 3 are the mean behavioral responses plotted for the 4 stimulus conditions. A 2-way repeated measure ANOVA (2 response types ×4 stimulus conditions) revealed a significant main effect for response type [F(1,7) = 87.13, p <.001], but no effect for stimulus type, and no interaction between the two factors. As in the previous analyses, the preterm infants displayed consistently more Self-Regulatory than Stress behaviors. As was discussed in the Method section, the infants' behaviors were sub-grouped into 4 behavioral categories, "Face", "Visceral", "Body", and "Limbs". A 2-way repeated measures ANOVA (2 behavior types ×4 behavioral categories) revealed significant main effects for Response type [F(1,7) = 68.0, p <.001] and Category [F(3,21) = 62.0, p <.001], as well as a significant interactions of Response type x Category [F(3,21) = 51.0, p <.001]. T-tests revealed that the "Limbs" category had significantly more Self-Regulatory behaviors than did any of the other categories, as well as surpassing the other categories in the number of "Stress" behaviors displayed. Further, the "Limbs" category was the only one that significantly differentiated the numbers of Self-Regulatory and stress responses [t(7) = 8.8, p <.001]

FIGURE 2
Mean Number of Behavioral Responses, as a Funciton of Stimulation Trials



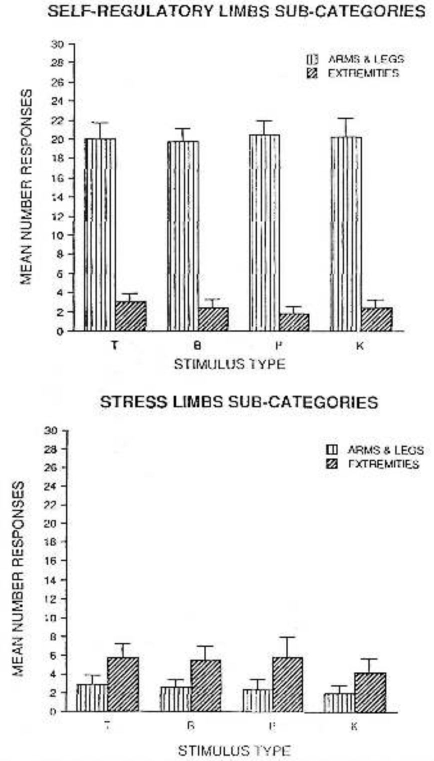
These results indicate that although Als' (1984) test is aimed at providing an overview of newborn infants' behavioral repertoire, not only were the majority of the behaviors that the infants displayed those involving activity of the limbs and extremities, but they were also the primary ones that contributed to differentiation of the Self-Regulatory and Stress behaviors. Out of the total number of behaviors that the infants displayed, 69.5% were in the "Limbs" category. Thus, to further delineate the source of high frequency Self-Regulatory behaviors displayed by the preterm infants, the "Limbs" category was separated into the 2 types of behaviors it consists of.

FIGURE 3
Mean Number of Self-Regulatory and Stress Behaviors Plotted as a Function of Stimulus Condition: (Punctate, Brush, Pressure and Blank)



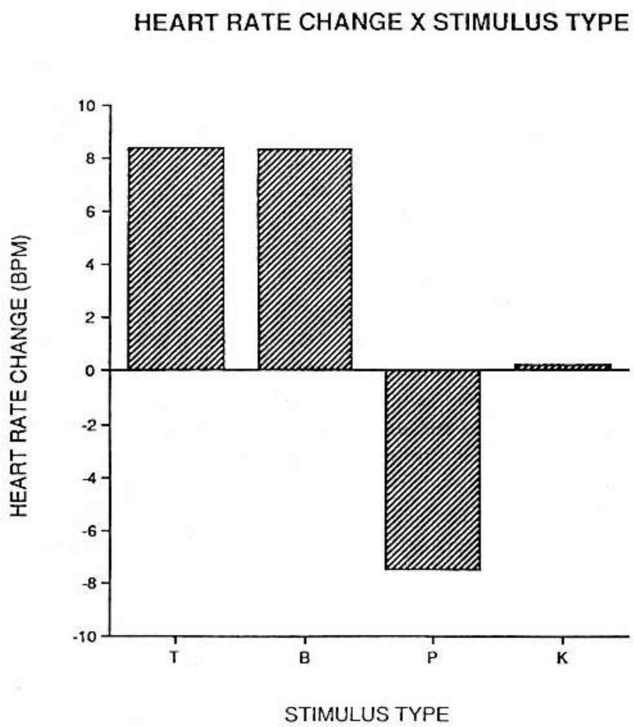
The scoring sheet I used displays the two types of behaviors that were scored under the "Limbs" category (see Appendix A). The "Arms and Legs" type includes behaviors related to the arms and legs, such as flexion, extention and flaccidity. Whereas, the "Extremities" subgroup consists of behaviors mainly displayed by the hands and feet, i.e., finger splay, grasp, foot clasp and fisting). Presented in Figure 4 are the mean number of behavioral responses (Self-Regulatory and Stress) of the 2 "Limbs" motoric behavior types, for each of the 4 stimulus conditions. A 3-way repeated measures ANOVA revealed a significant main effect for "Limbs" type [$F(1,7) = 75.97$, $p < .001$] and for Response type [$F(1,7) = 85.79$, $p < .001$], but no significant effect of stimulus type. T-tests revealed that within the "Arms and Legs" type there was a significantly higher number of Self-Regulatory than Stress behaviors [$t(14) = 4$, $p < .01$]. In addition, the "Arms and Legs" Self-Regulatory values were greater than both the "Extremities" Self-Regulatory [$t(14) = 10.5$, $p < .001$] and Stress [$t(14) = 7$, $p < .001$] behaviors.

FIGURE 4
Mean Number of Behaviors Displayed in the Two "Limbs" Sub-Categories, "Arms and Legs" and "Extremities". Self-Regulatory Behaviors Plotted on the Top; Stress Behaviors Plotted on the Bottom



These analyses reveal that the high frequency of Self-Regulatory behaviors compared with Stress behaviors, which was predominant throughout the testing session can be accounted for by the relatively high level of "Arms and Legs" motoric activity the preterm infants were engaged in. In fact, the Self-Regulatory behaviors of the "Arms and Legs" type represent 66% of the total behaviors in the "Limbs" behavioral category, which is 45.8% of the total behaviors emitted during the test (66% ×69.5%). The next interesting question dealt with what would the results be when the individual items on the test were each examined separately. In addition, how would these individual items compare with the heart rate changes. To answer these questions, the frequencies of each Self-Regulatory and Stress behavior during the test were analyzed on a correlation matrix with the heart rate responses. Displayed in Table 3 are the significant correlations that were yielded in the analysis, showing that out of the 52 behaviors in the test, 18 behaviors correlated with heart rate changes. There are 6 behaviors which correlate with heart rate decrease, indicating stimulus intake; these behaviors are classified as "Self-Regulatory". On the other hand there are 12 behaviors that correlate with heart rate increase, indicating stimulus rejection; these are behaviors classified as "Stress-related' (Als, 1984). It is evident from these analyses that some, but not all of the items on the behavioral test might be good indicators of stimulus intake or stimulus rejection by the infants. Thus, perhaps the test should not be used in its entirety for analysis of the infants' responses to stimulation, but selected items from the test should be concentrated on. Cardiac Responses The mean (± SE) heart rate changes (beats per minute) of the infants to the 4 stimulus conditions (punctate, brush, pressure and control) are shown in Figure 5. A 1-way ANOVA (4 stimulus types) yielded a significant main effect for stimulus type [$F(7) = 58.66$, $p < .001$]. Post testing with t-tests revealed that, in comparison with the control (K) condition, all three tactile stimuli elicited significant changes from baseline in heart rate: punctate-control [$t(7) = 4.6$, $p < .001$], brushcontrol [$t(7) = 14.9$, $p < .001$], and pressure-control [$t(7) = -7.4$, $p < .001$]. The infants displayed significant heart rate increases to punctate and brush stimulation, and significant heart rate decreases to the pressure stimulus. A number of things are evident. First, preterm infants are capable of displaying significant heart rate responses to tactile stimulation, even those of an orienting nature. Second, it is evident that preterm infants can differentialte tactile stimuli which are qualitatively different from one another. Lastly, since such capacities to demonstrate differential responses were not evident in the behavioral analysis of Self-Regulatory and Stress behaviors, it seems that there is a dissociation between the autonomic and skeletal systems of preterm infants during processing and modulation of multimodal sensory stimulation.

FIGURE 5
Mean Heartrate Change from Baseline (BPM), Plotted as a Function of the Four Stimulus Conditions: Punctate, Brush, Pressure and Blank



DISCUSSION Heart Rate Response to Stimulation Until recently preterm infants have been considered to be organisms virtually incapable of displaying organized responses to sensory stimulation. Where investigators have succeeded in eliciting reliable responses from preterm infants to sensory tactile stimulation, the responses have been primarily of a defensive nature. In this study heart rate changes from baseline, and the behaviors of preterm infants in response to multimodal tactile stimulation were scored, using the criteria of Als' (1984) Manual for Naturalistic Observation of Newborn Infants. Eight infants born at an EGA between 26-32 weeks were tested at 2 week postnatal. Each infant was presented with 40 trials of tactile stimulation, consisting of 3 different tactile stimulus conditions (punctate, brush, pressure) and a control condition. The infants displayed differential heart rate changes from baseline, depending on the stimulus condition. In comparison with the control (K) condition, which elicited no significant changes, the punctate (T) and brush (B) stimuli elicited cardiac acceleration above baseline, whereas the pressure (P) stimulus elicited cardiac deceleration below baseline. Previous studies with preterm infants have shown that cardiac responses to sensory stimulation are difficult to elicit, and that when elicited they are primarily those of acceleration above baseline. In addition these responses are considerably lower than those observed in fullterm infants, indicating a less mature physiological system in preterm infants (Rose et al., 1980). Maturation of cardiac system has been associated with factors such as respiratory distress, young postconceptional age and decreased parasympathetic influence on the heart. These are factors most commonly found in preterm infants (Fox and Porges, 1985). It has been suggested (Porges, 1974) that cardiac indications of "stimulus intake" and "stimulus rejection" are two different physiological responses, which are mediated by different brain structures, and which improve asynchronously with increased postconceptional age. Porges (1974) suggests that whereas "Stimulus intake" is mediated by higher, and less mature structures in the brain, "stimulus rejection" is mediated by lower structures which are more mature in the very young infant. This idea might explain results obtained with preterm infants which show reduced capacity by the infants to display cardiac deceleration. However, it cannot fully explain the results obtained in the present study. One major problem with most previous research paradigms has been the use of relatively intense levels of sensory stimulation, such as 20-30 grams of pressure (Rose et al., 1976; 1978; 1980), and buzzers of 85 dB or more as auditory stimulation (Berkson et al., 1974; Lawson, Daum and Turkewitz, 1977). The present study employed tactile stimuli which were much milder in nature (10 grams of pressure), but more important, the stimuli differed in the nature of their application. Two of the stimuli (punctate and brush) which were phasic in nature were the ones which elicited responses consistent with previous findings. The third stimulus (pressure) however, was tonic in nature. This stimulus, which is different than most stimuli employed in the past, is the one which elicited heart rate deceleration. Thus, when presented with very intense stimulation, the infants might be overwhelmed and incapable of displaying organized responses to stimulation. When presented with milder, but repetitive stimulation such as phasic punctate and brush, they appear to be capable of displaying an organized response, although the repetitive nature of the stimulus might be overwhelming or irritating, thus resulting in a "defensive" heart rate increase. Lastly, when introduced with mild tactile stimulation of a tonic nature, such as the pressure stimulus, the preterm infant can display an organized heart rate decrease, perhaps indicating "stimulus intake." The nature of this finding is consistent with an idea previously discussed by Field (1979b), who suggested that when preterm infants are presented with longlasting, tonic stimuli, they can orient to the stimulus and process it more easily. SELF-REGULATORY AND STRESS BEHAVIORS The first group of analyses conducted all yielded consistent findings regarding the numbers of Self-Regulatory versus Stress behaviors. The preterm infants consistently displayed greater numbers of Self-Regulatory than Stress behaviors. This predominancy was present during all stimulus types, body sites and body sides, across all trials and within trials. Thus, when utilizing Als' test in its complete format, whereas the infants' heart rate responses were indicative of a differentiation of the various stimulus conditions, the behaviors could not be similarly differentiated. The fact that the infants displayed differential heartrate response to stimulation is most interesting as a descriptive measure of their capacity to perceive environmental input. However, more helpful for caregivers would be a behavioral differentiation of stimulation. Behavior is a crucial aspect of infants' interaction with their environment. It is their primary "language" and mode of communication with their caretakers, hence, it is of utmost importance that caretakers learn how to interpret infants' behaviors (Als et al., 1979; Als, Lawhon, Brown, Gibes, Duffy, McAnulty and Blickman, 1986; Linn, Horowitz and Fox, 1985). Infact, what infants often benefit most from, are intervention procedures which are individually tailored. In order to provided such a procedure, one must assess each infant's response to various caregiving stimulation techniques. Thus, it is necessary to find reliable measures of preterm infants' behaviors, which would differentiate their responses to sensory stimuli; measures which caretakers could ideally use as on-line indications of how the infants are responding to intervention procedures. Intervention programs have evolved tremendously over the past few decades, primarily due to changes in the philosophies guiding such programs. Thus, the nature of stimulation procedures have evolved as well. A review of the literature on supplemental stimulation programs with preterm infants reveals disagreements among investigators in neonatal care, as to what is the most appropriate form of supplemental stimulation that preterm infants should receive, if any. About 20 years ago, there were those who claimed that preterm infants in the NICU did not receive enough supplemental sensory stimulation (Rothchild, 1967), while a decade later, others claimed that preterm infants might be overstimulated (Cornell and Gottfried, 1976). The prevailing view, which began to emerge in the late 1970's and has become increasingly acceptable, is that preterm infants are often exposed to sensory stimulation which is not too much nor too little, but simply inappropriate (Lawson et al., 1977). Intervention programs which provide supplemental stimulation to preterm infants, have treated the infants in one of two ways. Either the infants have been regarded as extra-uteral fetuses, and have thus received stimulation mimicking the intrauterine environment, or they have been looked upon as differing from the fetus, and have been provided with extra stimulation of the type that fullterm infants receive. Types of supplemental stimuli have ranged across the various sensory modalities. Many of these programs have differed in the types and combinations of stimulation. They have involved auditory stimulation (Katz, 1971); tactile-kinesthetic/vestibular stimulation, such as handling, rocking and stroking (Neal, 1968; Rose et al., 1976; Solkoff and Matuszak, 1975; White and Labarba, 1976); and multimodal stimulation, including tactile, auditory and visual (Barnard, 1978; Field et al., 1978; Kramer and Pierpont, 1976). The most consistent benefit evident across these various stimulation programs, has been that of improved performance on neonatal behavioral assessment scales, such as the Brazelton scale, and in particular on motor tasks, and on orienting and responsivity (Field, 1981). Although most supplemental stimulation programs have reported some benefits for the stimulated infants, there appears to be a tremendous amount of variability among the infants. I would speculate that such variability is mostly due to individual differences among the infants, who are each born with their own unique prenatal history, accompanied by its ailments and complications. This speculation leads me to suggest, as others have, that intervention with preterm infants should be highly individualized and geared toward the special needs of each infant. Recent observations of preterm infants' early environment conducted by Linn et al. (1985), described the sequential relationship between infant behaviors and the administration of stimulation by their caregivers in the NICU. The authors have concluded that the NICU environment does not reflect the rhythm of individual infants, that an infant is rarely given opportunities to control its own environment, in that intervention is administered based on hospital schedules and daily routines, rather than in contingency with the infant's behavior. However, it has been found that it is important for infants to be given opportunity to control environmental events, and to receive stimulation which is in response to their emitted behaviors (Finkelstein and Ramey, 1977). Barnard and Bee (1983) found that the introduction of heartbeat sound and rocking, contingent upon a period of infant inactivity, was related to more optimal newborn behavioral scores and Bayley mental Developmental indices at 2 years of age. With preterm infants, moreso, exposure to lying on waterbeds has been found to have positive effects (Korner, Kraemer and Haffner, 1975; 1978; Kramer and Pierpont, 1976). It seems that these effects may derive, in part, from the fact that waterbeds produce vestibular stimulation that is contingent upon the infant's own movements. It has also been shown that mothers of preterm infants who are taught how to interact with their infants can enhance the cognitive development of their infants. Widemayer and Field (1981) studied the interaction patterns of teenage mothers of low socioeconomic status with their preterm infants. The authors compared the development of those infants whose mothers were present during the administration of the Brazelton Neonatal Behavioral Assessment Scale, with infants whose mothers were not present. Their findings revealed how crucial it is for a mother to be made aware of her infant's capacities, in order to interact with the infant, and provide it with the type of care that is most appropriate for optimal development. Further, that if a mother can learn to become more sensitive to the unique capabilities and needs of her infant, by learning how to understand the infant's behaviors, she can play an active role in optimizing her infant's development. Linn et al. (1985) have emphasized the importance of contingencies in helping preterm infants to organize their interaction with, and responses to, their environment. They have further suggested that most intervention programs are designed such that the ability of individual infants to handle specific aspects of intervention has not been assessed prior to intervention procedures. Thus, rather than introducing a "pre-packaged" stimulation, from which the preterm infant cannot escape, care-givers should provide stimulation which is related to the infants' own behaviors. It must be insured that every infant receives stimulation which is appropriate for him or her. So how do we go about choosing behaviors which nurses, occupational therapists and physical therapists can use most optimally in understanding their young patients? In addition, out of the wide repertoire of behaviors emitted by the preterm infants which might be most helpful? The behavioral test which was constructed by Als (1984) is a valuable one, in that it stems from clinical validation and many years of experienced work with preterm and fullterm infants. The items which have been chosen for the test are even more useful however when their frequency of occurrence is known to be related to physiological functioning in the infants, i.e., to correlate with the infants' heartrate change, which is an established and reliable measure of response to stimulation. Thus a care-giver who would choose to increase the amount of attention paid to these particular behaviors, would be able to gain information about two of the infant's response systems simultaneously. Consequently a clearer understanding of whether the infant is in the process of "rejecting" or "accepting" the intervention procedure can be gained. This task was accomplished by the present investigation. In the Results section I highlighted 18 behaviors which seem to do exactly what I suggest, namely to correlate with the infants' cardiac changes during the test. As is shown in Table 3,18 of the 52 behaviors correlate with the heart rate responses to tactile stimulation. Thus when a caregiver is interacting with a young preterm infant she/he could benefit by having this truncated list of behaviors to concentrate on. It would imaginably be more difficult to have to pay attention to 52 behaviors, than to 18 behaviors. On the other hand, the task of evaluating the state of an infant is made easier when the evaluator can target her/his attention to particular domains of their patient's body. It is further interesting to note that of the 6 behaviors which correlate with heart rate decrease, 4 behaviors: "open face", mouthing, suck-search and visual tracking, are facial behaviors. Likewise, of the 12 behaviors which correlate with heart rate increase, 6 (50%) additional behaviors are related to the facial region: yawn, grimace, gasp, eyes closed, eyes averting and eye floatation. Since two thirds of the behaviors which correlate with heart rate changes during tactile stimulation are related to the facial region, this makes a care-giver's task even easier, by providing her/him with an optimal region of the body to concentrate their attention on. It is instinctive to look upon another organism's face for feedback concerning their response to a situation; this is especially true for humans. Hence, a care-giver's task might be aided by having a group of behaviors in mind when seeking feedback from an infant's face. In sum, the results described in this paper provide evidence about preterm infants' capacities to differentiate tactile stimulation of 3 different qualities. Whereas previously they have been thought to be incapable of doing so, when provided with appropriate stimulation which is not too intense or aversive, the infants seem capable of displaying differential responses. First, preterm infants can display cardiac decreases to pressure tactile stimulus, indicating an orientation toward to the stimulus. This type of a response might be indicative of an early analogue of attention in preterm infants. Such a result should encourage caretakers to provide infants with a tonic, not phasic stimulus in order to elicit and enhance orientation by the infants toward their environment, and minimize a rejection of the environment by the infants. second, when a behavioral test such as Als' (1984) is used in its entirety for evaluating the infants' behaviors, the results might lead us to think that the infants cannot display correlates of the heart rate with their behaviors. However, selected items of the test do correlate with the heart rate very highly, thus providing us with reliable indicators of the infants' "orienting" mechanism on a behavioral scale as well. It is of utmost importance that neonatal research progress in the direction of finding increasingly better methods of understanding preterm infants' response to their sensory environment. The better our methods of characterizing preterm infants are, the more hope we can have of aiding these infants in developing normally in their environment. References REFERENCES Als, H. (1984). Manual for the Naturalistic Observation of Newborn Behavior (Preterm and Fullterm Infants). Unpublished manuscript from the Children's Hospital, Boston, MA 02115. Als, H. and Brazelton, T.B. (1981). A New Model of Assessing the Behavioral Organization in Preterm and Fullterm Infants. Journal of the American Academy of Child Psychiatry, 20, 239-263. Als, H., Lawhon, G., Brown, E., Gibes, R., Duffy, F., McAnulty, G. and Blickman, J. (1986). Individualized Behavioral and Environmental Care for the Very Low Birth Weight Preterm Infant at Risk for Bronchopulmonary Dysplasia: NICU and Developmental Outcom. 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APPENDIX A
Behavioral Data Sheet

Name ________ S. # ________ Tape # ________ Date ________
Footage ________ Stim Type ________ Site ________ Trial # ________

Location: crib isolette held — State: 1 2 3 4 5 6 / A B — Tape Time at Start: ________
Posture: prone supine side
Head: right left middle

Respiration: regular irreg slow fast pause
color change: jaundice pink pale webb dusky blue comment: ________

	Time Interval				
	0.......5	6......10	11....15	16....20	21....25
Tape time:					
Heart rate:					
Resp. rate:					
Overall Condition:					
fussy					
yawn					
sneeze					
face: open					
grimace					
frown					
gape face					
"ooh face"					
"cooing"					
speech/mouth (S/M)					
smile					
tongue protrude					
twitch					
sucking					
suck search					
move head (R/L)					
eyes: avert					
float					
track					
closed					
Visceral: "spit up"					
gag					
burp					
hiccough					
BM grunt					
sounds					
sigh					
gasp					

Body: stick figure @ onset: ________ @ offset (if different): ________

APPENDIX A continued
Behavioral Data Sheet

smooth mvmnt trunk										
tuck trunk										
tremor										
startle										
twitch										
diffuse squirm										
stretch/drown										
arch										
leg brace										
flaccid trunk										
	R	L	R	L	R	L	R	L	R	L
Motor Movement:										
Arms: flaccid										
flexed: act/post										
extend: act/post										
smooth movem.										
Legs: flaccid										
flexed: act/post										
extend: act/post										
smooth movem.										
Extremities: finger splay										
airplane										
salute										
hand to mouth										
hand to face										
grasp/hold on										
fisting										
"sitting on air"										
hand clasp										
foot clasp										

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