THE RELATION BETWEEN PSYCHOPHYSIOLOGICAL RESPONSES TO LOW- AND HIGH-RISK INFANT CRIES AND INTROVERSION-EXTRAVERSION

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Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE
in
Psychology

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July, 1983

Blacksburg, Virginia

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(ABSTRACT)

The unusual high-pitched cry of the high-risk infant has been shown to be rated as generally more aversive than low-risk infant cries. Because psychophysiological measures may provide sensitive indicators of perceptual differences which occur as a function of the listener's personality, the relation between heat rate (HR) to low-and high-risk infant cries and introversion-extraversion was examined. Introverts were predicted to show a greater amount of HR acceleration to infant cries than extraverts due to the introvert's lower threshold for psycho-physiological activity. Extraverts were predicted to show a greater amount of HR deceleration to infant cries due to the extravert's high threshold for psychophysiological activity.

A between groups design was used in which 40 introverts and 40 extraverts listened to a series of low-or high-risk infant cries while their HR was monitored. A significant personality by cry type interaction was found for HR acceleration but no significant differences were revealed in the post-hoc tests. Nonparametric analysis, however, revealed that introverts gave reliably more responses of greater HR acceleration to high- than to low-risk infant cries, suggesting that high-risk infant cries are perceived as more aversive. Heightened

perceptual awareness by the introvert may be resulting in the greater differentiation of HR responses between cry types. Implications of these findings with child abuse and neglect are discussed.

ACKNOWLEDGEMENTS

First and foremost, the author gratefully thanks Dr. Philip Sanford Zeskind for his neverending support, patience, sensitivity and friendship during the course of this study. His editorial comments, general instruction and enthusiasm for new ideas not only helped to shape and solidify the thesis itself but aided in my development as a more competent researcher and writer. Special thanks go to Dr. David Bownas, for his statistical assistance, comments and readiness to help, and to Dr. Constance Schmidt, for her insightful comments on the manuscript which clarified many an elusive point. The author gratefully acknowledges her research assistants, Christi Hadley, Gene Kastelberg, Phil Peacock, Julie Weisemann, and Trina Worrell, for their faithfulness, diligence and neverending offer of assistance. Thanks also go to Vickie Carroll for her uncomplaining and helpful attitude in the typing of the manuscript. Finally, special thanks go to Ken Israel for his friendship, loyalty and the many long nights shared together over a typewriter.

This thesis is dedicated to my parents, George and Florence Pocius.

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Introduction

The infant at risk is defined as any infant having a propensity toward the development of motoric, intellectual or behavioral deficits in later life. These infants may range from those with severe pediatric complications to those with relatively healthy constitutions. For example, prematurity (gestational age 37 weeks or less) and low birthweight (between 1500 and 2500 grams) are two very common risk conditions among infants which may result in a wide variety of outcomes. In their review Caputo and Mandel (1970) found that "low birthweight is relatively frequent in the histories of mental retardates, institutionalized individuals,... high school dropouts,... deviant behaviors such as hyperkinesis, autism, and involvement in childhood accidents along with difficulties in language development and in various areas of academic achievement" (p. 363). There is also evidence that these infants are at increased risk for child abuse and neglect (Lynch, 1979) and Sudden Infant Death Syndrome (SIDS) (Lipsitt, 1979).

In addition to these conditions, there are a number of other pre- and perinatal events that may place the infant at risk. Lower scores of optimality based on Prechtl's (1968) scale of 42 optimal maternal, parturitional and fetal conditions have been used as indicators of the degree of risk to the infant's nervous system. Infants with pre- and perinatal complications appear to have an increased probability for later developmental deficits (Prechtl, 1968). In summary, identifying the

infant at risk encompasses a wide range of physical conditions and obstetric events affecting the infant.

Many attempts have been made to assess which infants are at risk. Pasamanick and Knobloch (1966) proposed a continuum of reproductive casualty to include such defects as mental retardation, cerebral palsy, deafness and other neurosensory defects to account for later problems in the infant's development. However, this continuum of reproductive casualty did not encompass environmental factors in the prediction of poor developmental outcome. Sameroff and Chandler (1975) expanded upon this continuum of reproductive risk by proposing a continuum of caretaking casualty that would incorporate environmental factors causing abnormal development. Prediction of developmental outcomes does not emerge from an analysis of the physical condition or the obstetric history of the infant alone, but is also determined by the type of caretaking the infant is destined to receive (e.g. Zeskind & Ramey, 1978, 1981). Although much work studied and identified various early risk factors, there remain many infants sustaining complications who do not succumb to any later developmental problems. Thus, although the infant at risk can be recognized a posteriori, predicting which risk infants are actually going to develop problems has met with little success.

Identification of Infants at Risk

Identifying the infant at risk through his or her physical condition or obstetric history does not allow for the dynamics of the biological functioning or the environment of the infant. Within the last few

decades research in this area has expanded. In addition to the physical condition and the obstetric history of the infant, developmental psychologists have begun to look at the behavioral characteristics of the infant which may reflect the dynamic and bidirectional relationship occurring between the biological functioning of the infant and its environment. It is these transactions which may influence the direction of developmental outcome.

A recent focus in newborn research has been on one of the more salient of infant behaviors - crying. This behavior may be tapping into both the biological functioning and the environmental factors of the infant. In particular, in neurological examinations a high-pitched cry has been recognized as supporting the previous diagnosis of pathology in neurological examinations (Prechtl & Beintema, 1964). Zeskind and Lester (1978) speculate that higher numbers of pre-and perinatal complications may reflect an "intrauterine compromise that acts as a mild stress to the developing CNS and that this stress is reflected in changes in certain features of the cry" (p. 586). Thus, it is these CNS changes which may be affecting the pitch of the cry.

Cries may vary quite dramatically in pitch. Infants with pathological disorders such as "maladie du crie du chat" (cry of the cat) and infants with 13-15 trisomy (Ostwald, Peltzman, Greenberg & Meyer, 1970; cited in Zeskind & Lester, 1978) have a higher fundamental frequency cry than the cries of normal infants. This high-pitched frequency may range from 1000 to 2000 hertz in comparison with the 400-600 hertz range of normal infant cries. In effect, studies have

found that the cries of abnormal babies are higher (e.g. maladie du crie du chat, Vuorenkoski, Lind, Partenen, Lejeune, Lafourcade & Wasz-Hockert, 1966) or lower (e.g. Down's Syndrome, Lind, Vuorenkoski, Rosberg, Partenen & Wasz-hockert, 1970) in pitch than normal cries, have greater variability, and have different temporal patterns evidenced by either shorter or longer cry durations and cry intervals (see Wasz-Hockert et al, 1964).

Underweight- and overweight-for-length infants have also been found to exhibit a high-pitched cry sound (Zeskind, 1981). In addition, several distinguishing characteristics between the cry of the healthy infant who experiences few complications at birth and the healthy infant who experiences a high number of complications at birth have been noted (Zeskind & Lester, 1978). In most cases infants with a high number of obstetric complications emit a cry very similar in pitch to that of an infant with an overt pathological disorder. In summary, it is apparent that a wide range of infants emit this high-pitched cry sound.

Cry Perception

Crying may indicate some form of distress for the infant, but the ramifications of the infant's behavior upon its environment will determine whether its needs will be met. In a review by Murray (1979), two models of the nature of the infant cry were examined. The first model proposed the evolutionary significance of the cry as a releaser of parental behavior. The second model advocated the cry as an activator of motives within the listener of either an egoistic or altruistic nature. This represents an empathy model which implicates both motivational and

cognitive factors in response to the presentation of a cry. Evidence of contagious crying in newborns, the suggestion that deaf parents do not show an urgency about responding to crying although cognizant of the presently occurring event, and the almost universal use of interventions that involve close physical contact (see Murray, 1979) provide support for the view of the cry as a releaser. Murray states however, that the "cry signal does not appear to be a simple and discrete stimulus with a single meaning, but rather its meaning depends upon intensity cues and contextual factors" (p. 202). She argues to the contrary that the model of the cry as an activator of egoistic or altruistic motives "contributes to an understanding of both the compelling releaserlike effects of the cry as well as the wide variations observed within and between cultures in the nature and extent of caregiver responsiveness" (p. 191). In summary, the behavior of the infant, particularly crying, may reflect some form of distress for the infant, but its interaction with the contextual factors of its environment will affect the type of caregiving the infant will receive.

In addition to contextual factors, the sound of the cry may determine the type of caregiving response the infant will receive. Thus, it is important to understand of the distinguishing characteristics of the cries. Early attempts to differentiate acoustically among newborn infant crying were based on the cry characteristics associated with the emotional or physical state of the infant (Wasz-Hockert, Lind, Vuorenkoski, Partenen, and Valanne 1968; Wolff, 1969). Wolff distinguished three cry types based on their temporal parameters: the

hunger cry, the mad/angry cry, and the pain cry. Using a sound spectrograph, Wasz-Hockert et al identified four cry types: birth, pain, hunger, and pleasure. The distinction between the characteristics of these cry types implicated that these differences could be attributed to the emotional or physical state of the infant.

Instead of reflecting different stimuli, different cry sounds may be elicited by the same stimulus. Three types of pain cries were obtained from 1 to 12-day old infants who were all pinched to provide a standard stimulus to cry (Truby & Lind, 1965). These pain cries were differentiated into three categories on the basis of sound spectrograms: phonation--the basic cry pattern characterized by a harmonic structure, symmetry, and smoothness of the spectrogram; dysphonation--"effortful" cries, characterized by turbulence which disrupt the harmonics of the basic cry pattern; and hyperphonation--cries characterized by an abrupt shift from or to a very high "whistle-like" pitch. Wolff's description of the hunger cry, which is actually a basic rhythmical pattern, and the mad/angry cry was similar to the phonated and dysphonated cry, respectively. The pain cry was differentiated more on the basis of temporal patterns of the first two or three expiratory cries, following which it settled down to the basic temporal pattern. According to Wolff, the basic cry has no causal connection with hunger, and the mad/angry cry is described as just a more "effortful performance" of greater discomfort. Similarly, in a multivariate study of the characteristics of their four cry types, although Wasz-Hockert et al. find that a rising-falling melody is associated with hunger cries, few of their other

measures are predictive of a particular cry type. Murray (1979) concludes from these results that cries are not uniquely different by what causes them but rather by their degree of intensity, based on the degree of discomfort being experienced by the infant.

Depending upon the sound of the different cries, perceptual rating studies of infant cries reveal that cries are rated by listeners as being qualitatively different and as possessing particular demand characteristics. Frodi, Lamb, Leavitt, Donovan, Neff and Sherry (1978) presented a videotape with the dubbed cry of a premature and normal infant to parents. Whether the premature cry was paired with the videotape of a normal or premature infant, it was rated as more aversive. Zeskind and Lester (1978) presented the cries of clinically healthy, normal newborns to a group of naive adults, in which they were asked to rate certain perceptual qualities of these cries. The cries were differentiated however, in that half of these cries were from infants with an obstetric history of a low number of pre- and perinatal complications (low-risk infant cries) while the other half experienced a high number of these pre- and perinatal complications (high-risk infant cries). Adults rated the high complications infant cries as more "aversive", "grating", "sick", "urgent", "distressing", "piercing", "discomforting" and "arousing" than the cries of the infants experiencing a low number of complications. The perceived characteristics of these cries also appear to influence the type of caregiving responses of the listener. Zeskind (1980) examined the responses parents and nonparents might give to cries of healthy low-risk and high-risk infants. In

responses to the high-risk cries, parents, but not nonparents, gave responses which were more "tender and caring" and more "immediately effective at terminating the crying" than the responses toward the low-risk infant cries. It is interesting to note from the Zeskind and Lester (1978) study that although both types of cries were described along a dimension of discomfort, a second factor emerged which described a "sick" nature in the sound of the high-risk infant. This cry sound may perhaps be eliciting a greater protective nature within the caregiver or parent by signaling a "need for special care in the absence of other signs" (Zeskind, 1980, p. 175). In addition, cross-cultural differences appear to be found in the maternal perceptions of low- and high-risk infant cries (Zeskind, 1983).

These perceptual studies have also involved the perceived "temperament" of the infant. In a study involving the pitch and temporal patterning of the cry, Lounsbury and Bates (1982) examined the ratings of primiparous mothers who listened to cry tapes of infants rated as having a difficult, average or easy temperament according to the Infant Characteristics Questionnaire (Bates, Bennett-Freeland & Lounsbury, 1979). Subjects rated difficult infant cries higher on "anger/ irritation" and "spoiled" ratings, and perceived these same infants as crying for more "psychological/emotional" reasons, in contrast to easy temperament infants, who were seen as crying because of "routine physical discomfort". Using the same cries, Boukydis and Burgess (1982) studied the self-report measures of three populations: nonparents, primiparous parents, and multiparous parents. As in Lounsbury and Bates' study,

difficult infant cries received a greater number of irritation and spoiled ratings, and were rated as more "aversive", "grating", "sick", "urgent", "distressing", "piercing", "discomforting" and "arousing" on the Zeskind and Lester (1978) scales. Parents also perceived these cries as being less similar to their own infants' cries. In addition, these cries were perceived as being caused more frequently by frustration rather than routine physical discomfort. In summary, perceptual rating studies of infant cries emphasize the fact that the infant does not live in a vacuum, but that its behavior will have a distinctive impact upon its surrounding world.

Psychophysiological Responses to Cries

One problem with perceptual rating studies of infant cries involves the presence of social acquiescence factors (i.e. rating cries as less "aversive" than they are actually perceived). Psychophysiological responses based on the perception of these cries may be valuable indices from which these social acquiescence factors may be eliminated. Donovan, Leavitt and Billing (1978) found that when mothers were presented with a 10-second silent image on a videotape monitor of a three-month-old infant exhibiting either a smiling or crying infant expression, those mothers who described their infants as more difficult (according to the Carey Infant Temperament Questionnaire) were physiologically less sensitive to changes in infant expressions. In addition to Frodi et al.'s (1978) ratings of premature and normal infant cries, skin conductance and heart rate analysis indicated a greater autonomic arousal when subjects were presented with the premature infant cry. Frodi and Lamb (1980) looked at

child abusers' and a matched group of nonabusers' responses to videotapes of smiling and crying infants. Although the crying infant elicited heart rate acceleration and increases in skin conductance and diastolic blood pressure for both groups, the abusers experienced greater arousal on all these measures, and expressed less sympathy. Nonabusers responded to the smiling infant with no change or a decline in arousal, while abusers maintained a psychophysiological arousal to both the smiling and crying infants similarly.

Boukydis and Burgess (1982) found that, as expected, nonparents and multiparous parents showed increasing arousal as reflected by skin potential response from easy to difficult infant cries; however, primiparous parents had the highest levels of arousal to average infant cries. Boukydis and Burgess interpreted this unexpected result on the basis of Lounsbury and Bates' (1978) research indicating that average infant cries are most representative of typical hunger cries. Thus the still novel status of the primiparous parent in relation to infant feeding may have sensitized the parent to a "perceived immediacy" of the cry.

Wiesenfeld and Klorman (1978) measured mothers' autonomic reactions to smiling and crying videotapes of their own infant and an unfamiliar infant. When subjects viewed their own infant smiling or crying, cardiac acceleration and a large skin conductance were evoked. While the unfamiliar crying infant elicited no significant effects, the infant did elicit a cardiac deceleration and smaller skin conductance responses. Heart rate acceleration was greatest for scenes depicting the subjects'

own child smiling, whereas stimuli portraying an unfamiliar crying infant evoked the largest cardiac decelerations.

In a recent study (Zeskind, Huntington & Pocius, Note 1) subjects were found to have heart rate responses of an acceleratory, deceleratory and "flat" direction to presentation of both low- and high-risk infant cries. Although low-risk infant cries predominantly elicited acceleratory heart rate patterns, the high-risk infant cries elicited both acceleratory and deceleratory heart rate patterns. Because of the complex nature of these responses to infant crying, psychophysiological indices will be the focus of the remainder of the paper.

Different responses to infant cries in these past studies may be the result of two different processes: the physical dimensions of the cry, such as the pitch, intensity, and pauses; and the demand characteristics which are attributed to the cries due to the experiental and cognitive factors of the listener. Lacey's (1967) revision of activation theory proposed the concept of situational stereotypy which suggests that "the activation processes do not reflect just the intensive dimension of the behavior but also the intended aim or goal of the behavior...in other words...the nature of the transaction between the organism and its environment" (Lacey, 1967, p. 25).

Because of these physical dimension and demand characteristics, stimulus responses tend to be complex. Although many of these studies report significant effects on heart rate responses to infant cries, this significance is based on only a few seconds of the cry. For example, when a crying infant is viewed before a smiling infant, responses to seconds eight through ten deviate significantly from prestimulus

second in trial 1. Theseresponses are reflected as a deceleratory response. When the cry expression is presented second, these responses are consistently deceleratory for Trial 1 and are significant at seconds three, seven and eight (Donovan et al, 1978). Frodi et al (1978) found significant effects on heart rate for cries on seconds six, seven, and ten and inspection of the data revealed a more rapid acceleration to the premature than to the normal infant cry.

Trend analysis of heart rate response to visual infant signals has revealed a response which consists of a "brief deceleratory component followed by an acceleration/deceleration curve which eventually returns to baseline" (Donovan et al, 1978). In addition, acceleratory and deceleratory heart rate responses to some infant cries are seen in other studies (Zeskind et al, Note 1). Given just a few examples, traditional heart rate analysis reveals that categorization of responses to infant cries is not clear cut. Responses tend to be complex, with second by second analysis resulting in significance for only a few seconds of the cry sequence. In addition, analysis has revealed varying acceleratory and deceleratory responses to cries across studies.

Characteristics of Listener

In all psychophysiological response analyses, characteristics of the listener must be considered. First of all, direction of heart rate change and habituation rate are thought to be a function of increased attentional processes resulting from an orienting response (heart rate deceleration), or defensive response (heart rate acceleration), which are thought to be due to disruptive or noxious stimulation (Graham & Clifton,

1966). This has been qualified by some studies in which stimuli that are attention-provoking and elicit cardiac deceleration may still be labeled as noxious or unpleasant (e.g. Hare, Wood, Britain & Shadman, 1971). A second issue is the finding that many individuals have a propensity to respond consistently in a certain direction. For example, Lawler (1980) has found that subjects consistently exhibit one of two characteristically different patterns of responding - heart rate reactive (accelerators), and heart rate nonreactive (decelerators) - when confronted with psychological stress. Electrodermal lability is another psychophysiological trait which seems to be relatively consistent across individuals. Lacey and Lacey (1958) distinguished between electrodermal "labiles" and "stabiles" - defined by the frequency of spontaneous bursts of activity in skin resistance recordings. This raises the question of which characteristics of the individual may be playing a part in the psychophysiological responses to infant cries. What is behind this complexity of acceleratory/deceleratory responses to these cries?

One personality characteristic which employs the concept of autonomic reactance is the Introversion/Extraversion (I/E) diminish. H. J. Eysenck's (1967) theoretical formulation states that introverts have lower thresholds for psychophysiological activity than extraverts, and thus react to given levels of stimulation with higher degrees of cardiac and electrodermal activity. He postulates that the source of these individual differences resides in the functioning of the reticular activating system. This structure is thought by neurophysiologists to be

responsible for producing nonspecific arousal in the cerebral cortex in the presence of external stimulation. As a result of this higher threshold level of arousal for extraverts, it is thought that extraverts have a certain degree of "stimulus hunger". This idea has been used in support of why certain individuals consistently seek arousing or stimulating situations, such as parties or loud music. Introverts, on the other hand, have a certain degree of "stimulus aversion", and avoid these same situations (e.g. Weisen, 1965). Hypothetically the inhibited behavior of the introvert results from the cortex exercising control over the more "primitive and impulsive" lower brain centers. In addition to his theory, Eysenck (1957) supports another contention that the build up of reactive and conditioned inhibition over a constant period is faster and greater in extraverts than in introverts (i.e. GSR adaptation).

Eysenck interpreted the results of several past studies as consistent with the existence of the I/E personality dimension. In 1948 Theron carried out a factor analytic study of autonomic responses made by fifty normal students. The second factor, which Theron labeled "basic emotional tension", was of great interest to Eysenck. This factor was found to discriminate between hysteric and dysthymic patients, whose mean scores fell on opposite sides of the scores of the normal group. Although admitting such interpretations of "considerable complexity to be of doubtful value", he suggested that "these findings could be interpreted to mean that hysterics (extraverts) show a shift to parasympathetic predominance, while dysthymics (introverts) show a shift to sympathetic predominance" (Eysenck, 1967, p. 168). Jones (1950)

compared a high-reactive and a low-reactive group chosen from 100 adolescent boys and girls in which reactivity was measured in terms of mean resistance change in ohms and log conductance change. Based upon psychologists' and peer ratings of the social behavior of these two groups, "high-reactives" were introverted, while "low-reactives" were extraverted.

An abundance of studies has been conducted on the relationship between different psychophysiological variables and extraversion. For example, in a visual vigilance task, introverts detected more signals, exhibited more spontaneous fluctuations and exhibited a greater heart rate than extraverts, although, contrary to expectations, introverts did not have a greater skin conductance than extraverts (Gange, Geer & Harkins, 1979). In Lacey's "labile" and "stabile" personality dimension, frequency of spontaneous bursts of skin resistance activity has been consistently inversely related to the speed of habituation of the electrodermal orienting response to serially presented stimuli (cited in Crider & Lunn, 1971). Crider and Lunn also found that spontaneous fluctuation rate and habituation speed were negatively correlated with extraversion. Thus, there is evidence to support Eysenck's theory of a higher arousal threshold and a more rapid buildup of inhibition for extraverts.

Several studies have related GSR reactions and personality, and although not all findings are significant, correlations are in a negative direction for extraversion (Bronzaft, Hayes, Welch, & Koltur, 1960; Burdick, 1965). Scott and Wilkinson (1962) found that the correlation between adaptation on the GSR and extraversion was highly significant.

Eysenck has also pointed out the relationship between the extraverted nature of the sociopath and the attenuated responsiveness on GSR of this group in comparison to nonsociopathic disorders and normal controls (Fox & Lippert, 1963; Hare, 1965). Again, however, the relationship is only tangential; it would have been of benefit if some of these studies could be replicated with the addition of the I/E personality inventory.

Although many studies have been conducted on the relationship between different psychophysiological variables and extraversion, results have been equivocal; some experiments yield evidence for higher arousal in introverts, other experiments yield evidence for higher arousal in extraverts, and finally, some experiments yield evidence for no difference between the two (see Rust, 1974; cited in Wilson, 1977). Because results of these studies have been equivocal, Gale (1973) has suggested that these seemingly conflicting results may be situation specific. For instance, experimental situations which may be "tedious or excruciatingly boring" to extraverts may cause them to raise their level of arousal above that of the introverts by "imagination, fidgeting", etc., confounding any attempt to demonstrate that they are "chronically less aroused than introverts". Many studies indicate that introverts do have lower sensory thresholds than extraverts. For example, according to Gange, Geer, and Harkins (1979), there is evidence showing that: 1) introverts are superior to extraverts in signal detection, and 2) improved signal detection is correlated with increased psychophysiological activity. Thus, it is possible that this same personality dimension may be tapping into the acceleratory/deceleratory

nature of heart rate of individuals when presented with infant cries.

Summary

Several studies indicate that, given certain stimuli, individuals will tend to respond consistently in a particular direction with heart rate (e.g. Lawler, 1980) and skin conductance (Lacey, 1958). Eysenck has suggested that introverts have a lower threshold for psychophysiological activity, and will thus react to stimuli with higher levels of cardiac and electrodermal activity than extraverts. There are a number of studies which suggest that this is the case (e.g. Crider & Lunn, 1971).

The present study attempts to account for the complexity of psychophysiological responses to infant cries in two ways. First, it is conceivable that the infant cry may be evoking responses influenced by the personality characteristics of the individual. If this is so, psychophysiological responses to infant crying in past studies may be reflecting not only differences between cries, but also personality differences in cry perceivers which affect their psychophysiological responses. Controlling for the introversion/extraversion personality dimension may account for some of the differences in acceleratory/ deceleratory directions of responding across infant cry studies. Second, because of the complex physical and psychological dimensions of the infant cry, and the relatively short duration of the trials presented to each subject, this study sought to eliminate any potential confounding due to extraverts raising their level of arousal to avoid a tedious situation (Gale, 1973).

The purpose of this study is to explore the psychophysiological responses to cries of low- and high-risk infants. Based on Eysenck's personality theory of differing thresholds for psychophysiological activity, it is predicted that introverts will maintain a greater level of cardiac acceleration than extraverts. It will be assumed that heart rate acceleration is indicative of a defensive response (DR) while heart rate deceleration represents an attentive or orienting response (OR). Extraverts, on the other hand, will maintain a greater level of heart rate deceleration than introverts. Intuitively this deceleratory response would be expected due to an orienting response to "seek stimulation". Because of the aversive quality of the high-risk infant cry it is expected that both introverts and extraverts will exhibit a greater level of cardiac acceleration to the high-risk than to the low-risk cries.

Method

Subjects

Eighty volunteer psychology students attending Virginia Polytechnic Institute and State University were selected from the upper and lower 25th percentile of the Eysenck Personality Inventory (EPI), representing 40 extraverts and 40 introverts respectively. Scores ranged from 17 to 22 for extraverts, and 2 to 9 for introverts. Subjects were tested either individually, in small groups, or at a common examination time. Subjects had no prior professional experience with infants. The two groups were balanced for subjects' sex.

Stimulus Tapes

Two stimulus tapes were used. The first stimulus tape consisted of the pain cries of ten newborn infants. These cries were selected on the basis of a high pitched frequency (ranging from 1000 - 2000 hertz), and were operationally defined as high-risk infant cries. The second stimulus tape consisted of the selected pain cries of ten newborn infants who had a normally pitched infant cry sound (ranging from 400 -600 hertz). These cries were operationally defined as low-risk infant cries. Cries were selected from the Zeskind (1981) study in which cries were elicited from 39 two-day-old infants housed in a normal newborn nursery at a teaching hospital in North Carolina. All infants were normal and healthy according to routine standard pediatric physical and neurological examinations. Infants, however, could be at risk based on the signal of

the cry sound, which may be indicating possible insult to the functional integrity of the ANS of the infant even in the absence of other signs. The pain cries were elicited by snapping the heel of the infant's foot with a rubber band stretched 15 centimeters along the edge of a ruler. Preceding the first cry was a 60-second silent period. Each cry lasted ten seconds with a 20-second silent period between cries.

Procedure

Design. A two (Personality Type: introvert, extravert) by two (Cry Type: high-risk, low-risk) factorial design was employed. Both factors were manipulated between-subjects.

A research assistant greeted the subject and obtained written consent and information regarding the subject's history of infant experience. Subjects were introduced to the experimenter, briefly shown the polygraph equipment, and conducted to a small adjoining lab for electrode placement, where they would hear the infant cries. After each subject was seated in a large armchair Beckman biopotential miniature electrodes were attached to the right collarbone and lower left rib of each subject. A set of written instructions then was presented in which the subject was instructed to attend to the tapes and to remain as still as possible; instructions were re-emphasized orally. Following the opportunity to ask any questions, subjects were fitted with a set of Veritas V372 stereo headphones and told approximately when the cry tape would begin. After an acclimation period of ten minutes in which the subject rested quietly, the cries began. Cries were played at a constant volume on a Marantz PMD-360 stereo tape deck. Heart rate was recorded

via a Grass model 8B polygraph during the presentation of the recording. Subjects were given a written debriefing and the opportunity to ask questions at the end of this time.

Heart rate analysis. Heart rate was chosen because it is a measure capable of discriminating between the orienting (attentive) and defensive reactions (Lacey, 1967). A cardiotachometer on the polygraph translated the beat-to-beat intervals to a beat-per-minute heart rate. Because of the complex nature of the cry signal, a subject may show a heart rate response consisting of both an acceleratory and deceleratory component to a single infant cry. As a result of this, traditional heart rate analyses in which these acceleratory and deceleratory responses would be summed and averaged across all cries per subject may functionally result in little or no differential heart rate change. Thus, a traditional analysis of the heart rate responses was not used.

Instead, three heart rate change scores were created which reflected the total amount of absolute heart rate change (TOTHRC), the total amount of acceleration (TOTA), and the total amount of deceleration (TOTD) for each subject. These were calculated by subtracting baseline HR from observed HR at each of the ten stimulus seconds. Baseline was defined as the average of the five seconds preceding stimulus onset. All positive difference scores were summed across all seconds across all cries for each subject, resulting in the TOTA per subject. All negative difference scores were summed and averaged across all seconds across all cries per subject, resulting in the TOTD for each subject. Positive difference scores and the absolute values of the negative difference scores were summed to obtain the TOTHRC score.

Results

The means and standard deviations of total absolute HR change, total amount of HR deceleration and total amount of HR acceleration are shown in Table 1. An analysis of variance was conducted on each HR change score. No significant effects were found for the total absolute HR change or the total amount of HR deceleration. However, a two-way analysis of variance indicated a significant interaction for personality by cry type for the total amount of HR acceleration, $\underline{F}$ (3,77) = 3.88, $\underline{p} < .05$. The results of these analyses of variance are shown in Table 2. A post-hoc Newman-Keuls Multiple-Range Test indicated that none of the pairwise cell differences was statistically significant.

A χ^2 analysis was conducted to further explore the hypotheses of this study. Subjects were divided into two categories: those with responses of their total amount of HR acceleration greater than 233 and those with responses of their total amount of HR acceleration less than or equal to 233. This number was arbitrarily chosen to approximate the middle of the range of the distribution of total amount of HR acceleration. Two post-hoc χ^2 analyses were conducted comparing the HR responses to high- and low-risk infant cries made by extraverts and introverts, respectively. The distributions of the HR classification (greater than 233 or less than or equal to 233) for responses to low- and high-risk infant cries for both groups are shown in Table 3. Following a Yates' correction for continuity, the distribution in HR responses to

low- and high-risk infant cries for extraverts did not depart from the distribution expected by chance, $\chi^2(1) = .57$, $p < .50$. Similarly, the distribution in HR responses to low- and high-risk infant cries for introverts, as can be seen in the distribution presented in Table 3, departed from the distribution expected by chance, $\chi^2(1) = 5.16$, $p < .025$. Thus, the basic premise of our hypotheses was supported in this nonparametric analysis.

In addition, two χ^2 analyses were conducted comparing the HR responses of introverts and extraverts to high- and low-risk infant cries, respectively. Following a Yates' correction for continuity, the distribution in HR responses between extraverts and introverts for high-risk infant cries did not depart from the distribution expected by chance, $\chi^2(1) = 2.00$, $p < .25$. Similarly, the distribution in HR responses for low-risk infant cries did not depart from the distribution expected by chance, $\chi^2(1) = 2.77$, $p < .10$. The distribution of HR classification of responses between introverts and extraverts to high- and low-risk infant cries, respectively, are also shown in Table 3.

In addition, χ^2 analyses were conducted in which subjects were divided at the HR acceleration median value into two categories: those with responses of their total amount of HR acceleration greater than 171 and these with responses of their total amount of HR acceleration less than 171. No significant differences were found for main effects by cry type, $\chi^2(1) = .20$, $p < .95$ and personality type, $\chi^2(1) = .00$, $p < 1.00$. In addition, no significant interaction was found between personality and cry type, $\chi^2(3) = 2.00$, $p < .75$. The distribution of HR classification

of responses based on a median-split of the distribution are shown in Table 4.

While the χ^2 analysis supported the findings of the overall analysis of variance, the lack of finding reliable differences in the Newman-Keuls post-hoc comparisons may have been the result of the wide within-group variations in the scores. A test of the equality of variances indicated a significant difference between the variances of responses to high- and low-risk infant cries for introverts, F (19,19) = 4.43, $p < .002$, a significant difference between the variances of responses to high- and low-risk infant cries for extraverts, F (19,19) = 2.83, $p < .05$, and a significant difference between the variances of responses of extraverts and introverts to low-risk infant cries, F (19,19) = 6.18, $p < .002$. No significant differences were found between the variances of the responses of extraverts and introverts to high-risk infant cries, F (19,19) = 2.03, $p < .20$. In addition, a significant overall difference in variances was found across the four personality type-by-cry type cells.

Psychophysiological measures inherently have large variations in scores within individual subjects since heart rate may functionally range from 40 to 120 BPM per subject. This variability in the data of individual subjects may have compromized predicted results.

Discussion

The infant cry is a salient signal to the caregiving environment. Psychophysiological studies (e.g. Frodi, Lamb, Leavitt, Donovan, Neff & Sherry, 1978) have shown that different types of infant cries elicit different types of psychophysiological responses from the listener. These psychophysiological results may parallel previous findings in perceptual rating scale studies. The different types of responses may also reflect the personality characteristics of the listener. Eysenck's introversion-extraversion personality dimension in particular, regards different thresholds for psychophysiological activity as the foundation for the personality difference between introverts and extraverts. Past studies (e.g. Crider & Lunn, 1971) have suggested that introverts have a lower threshold for psychophysiological activity and react to a given stimulus with greater psychophysiological activity. Thus, introverts should respond with greater acceleration (representing a defensive response) than extraverts to the infant cry sound. Extraverts have a higher threshold for psychophysiological activity and as a consequence tend to "seek out" stimulation. Extraverts then, should respond with greater deceleration (representing an orienting response) than introverts to the infant cry sound. In addition it was predicted that both introverts and extraverts would respond with greater acceleration to the high- than low-risk infant cry, because of the extremely noxious sound of the high-risk infant cry.

No differences were found on several measures. Although studies have reported higher levels of heart rate variability in extraverts than in introverts (Thackray, Jones & Touchstone, 1974), and greater variability in responses to high- than low-risk infant cries (Zeskind, Huntington & Pocius, Note 1), no differences were found for total absolute HR change between extraverts and introverts or between high- and low-risk infant cries. Because the hypothesized differences between introverts and extraverts were in the acceleratory or deceleratory direction of HR change, total absolute HR change may not have been a useful indicator of personality differences. For instance, introverts and extraverts may have responded in different directions to the presentation of an infant cry sound, but with the same amount of change in each direction.

Deceleratory responses did not differ significantly between groups. Because this psychophysiological measure has been conceptualized as an orienting response, the results of this study suggest that both low- and high-risk infant cries were perceived as "aversive". Extraverts did not orient in their responses toward the stimulus as predicted, but rather did not differ reliably from the introverts. Thus, the hypothesis that extraverts would show a greater amount of orienting responding than introverts was not supported. An alternative interpretation may be that extraverts were still faced with what they perceived as a "tedious or boring situation", and hence responded to the situation by raising their arousal (HR acceleration) level.

Other measures did show an interesting pattern of reliable differences. The nonparametric analyses indicated that introverts responded with significantly greater acceleratory responses to high- than low-risk infant cries. Although no measure of perceptual ratings were administered, the evidence of greater "defensive" responding to high-risk infant cries supports the hypothesis that high-risk infant cries are perceived as more "aversive" than low-risk infant cries (Zeskind & Lester, 1978). Extraverts did not differ significantly in their responses to low- and high-risk infant cries.

The lack of a significant difference in acceleratory responding to low- and high-risk infant cries for extraverts and the significant findings that introverts do accelerate differently between cry types may be explained by several findings. First, Vingoe and Antonoff (1968) find that introverts are better judges of other individuals' traits than are extraverted subjects. This suggests that introverts are more "in tune" to the characteristics and behaviors of other individuals. This may be generalized to the introvert's perception of the infant cry. Although both extraverts and introverts may be making perceptual distinctions between these cry types, introverts may be responding with greater perceptual distance than extraverts between cry types. This may be reflected in their psychophysiological responses between high- and low-risk infant cries.

Second, one of the most robust findings in the current literature on personality traits is that the extraversion-introversion dimension is correlated with the repression-sensitization dimension (Morris, 1979).

These individuals are differentiated from one another on the basis of coping strategies to stress or negative emotion. Introverts tend to be sensitizers, which involves an "awareness of and reflection on internal, emotional and intuitive experiences" (Morris, 1979, p. 78). This suggests a heightened perception by the introvert of the qualities between different infant cry types, resulting in differential psychophysiological responding between cry types. Extraverts tend to be repressors which involves the tendency to deny emotional experiences. This suggests that extraverts will tend to repress their own emotional reactions when presented with the infant cry sound, reducing differential psychophysiological responding between cry types.

This heightened perceptual awareness may be aiding the introvert in performing a more "fine-grained" analysis of the perceived qualities of the infant cry type, resulting in a differentiation of psychophysiological responses between cry types. Extraverts, on the other hand, because of a less reflective nature may be responding with a more "coarse-grained" analysis of the perceived qualities of these infant cries, hence, no difference is found between acceleratory responses to high- and low-risk infant cries.

A second χ^2 analysis indicated that responses of greater acceleration to low-risk infant cries did not differ reliably between introverts and extraverts. This did not support the hypothesis that introverts should show more responses of greater acceleration than extraverts to both cry types.

Introverts gave more responses of greater acceleration to high-risk infant cries than extraverts; these results, however, did not differ reliably. Recent work based on Helson's (1964) classic theory of adaptation levels indicates that reliable differences may have been attenuated by the methodology of a between-groups design. Zeskind and Huntington (in press) found that, in comparison to a between-groups design, a within-groups method of cry presentation accentuated the perceptual distance among cry types. In particular, the "accentuation of perceptual distance between low- and high-risk infant cries resulted from a significant reduction in the perceived noxious quality of the otherwise aversive cry sound of the low-risk infant when it was directly compared to the unusually noxious cry of the high-risk infant" (p. 11). A between-groups design may have resulted in a "ceiling effect". Because introverts are more discriminating in their responses to different cry types than extraverts, the variation in responses to high-risk infant cries between introverts and extraverts may not have been lost if a within-groups comparison method had been used. This difference in perceptual style would have emphasized the perceptual distance between cry types. This would be reflected in a greater differentiation of psychophysiological responses for both introverts and extraverts. Introverts, however, would show greater discrimination between responses to cry types (e.g. greater acceleratory responses to high-risk infant cries) because of the introverts' heightened sensitivity to the qualities of these cries.

Interactions between the introversion-extraversion dimension and cry type in determining psychophysiological responses are not surprising. Many theorists (e.g. Endler & Magnussan, 1976) would argue that "trait" variables such as the introversion-extraversion personality dimension would interact with the situational variation (e.g. cry type) to influence the individual's behavior.

To summarize, the results of this study suggest that introverts give greater acceleratory HR responses to high-risk than low-risk infant cries, supporting previous findings that these high-risk infant cries are perceived as more "aversive" than low-risk infant cries (Zeskind & Lester, 1978). The finding that introverts discriminate in their responses between cry types while extraverts do not suggests that introverts' perceptions of cries in general may involve a "fine-grained" analysis of the cry's characteristics. Extraverts resort to a "coarse-grained" analysis of the cry's characteristics, thus reducing their discriminating responses between cry types.

Finally, a between groups design may have resulted in a "ceiling effect" in which variation in responses between introverts and extraverts to low- and high-risk infant cries, respectively, may have been attenuated.

Implications

Crying and its perception may be intimately involved in caregiver-infant interactions. In some cases, the cry of the infant may contribute to the development of abusive behavior on the part of the caregiver. A

crying infant increases the likelihood of agression, and interviews indicate that crying is often the eliciting stimulus for abuse (See Frodi & Lamb, 1980).

The evidence that introverts perceive cries in a qualitatively different manner than extraverts might also affect the caregiving relationship between the introverted or extraverted caregiver and the infant. Antisocial and aggression studies have shown that extraverts in general score higher on these characteristics than introverts (see Wilson, 1979). If crying increases the likelihood of agression, it seems plausible that extraverts rather than introverts would be more prone to developing into child abusers. It would be informative to study whether such a direct correlation exists between child abuse and neglect and extraversion.

The lack of differentiation among acceleratory responses to different cry types seen in extraverts are similar to the physiologically less sensitive responses given to different infant signals by child abusers (Frodi & Lamb, 1980). In addition, one of the strongest variables for the prediction of mothers at risk for child maltreatment is the mother's perception of the baby's temperament as being difficult at three months (Vietze, Altemeier, Falsey, Sandler & O'Connor, 1980). Mothers who describe their infants as "difficult" are also physiologically less sensitive to changes in infant expressions (Donovan, Leavitt & Billing, 1978). These similar response styles between extraverts and child abusers may be indicative of some of the underlying processes in the development of a potential child abuser.

Finally, anecdotal reports by parents of abused infants have often mentioned a "high-pitched" aversive cry sound typically emitted by the infant (Zeskind & Lester, 1978). The extremely aversive sound of the high-risk infant cry may serve to cause a deterioration in the caregiving situation between the parent and the infant eventually resulting in child abuse or neglect. For example, fetally malnourished infants tend to emit this "high-pitched" cry sound (Zeskind, 1981). In a longitudinal study Zeskind and Ramey (1978, 1981) found that maternal involvement with infants who were fetally malnourished would decrease over time. They speculated that "a fetally malnourished infant who is characteristically unresponsive and withdrawn may put off the caregiver in a nonsupportive environment in which the infant behaviors persist, thus exacerbating a cycle of nonsupportive infant and maternal interactive behaviors" (Zeskind & Ramey, 1981, p. 216). Thus, the extremely aversive sound of the high-pitched infant cry may serve to disrupt the cycle of supportive interactive behaviors between the infant and the caregiver.

Reference Notes

1. Zeskind, P. S., Huntington, L. & Pocius, K. E. Psychophysiological Responses to Low- and High-risk Infant Cries. In preparation.

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Table 1

Means and Standard Deviations for HR Change Scores

	Groups			
	High-Risk		Low-Risk	
Personality	Introverts	Extraverts	Introverts	Extraverts
Total Amount of Absolute HR Change				
X	439.4	439.1	389.7	422.5
SD	180.9	153.6	145.0	155.1
Total Amount of Deceleratory HR Change				
X	236.7	274.1	233.6	228.8
SD	161.0	147.7	152.8	112.9
Total Amount of Acceleratory HR Change				
X	202.65	164.9	156.0	193.7
SD	95.8	67.3	45.5	113.2

Table 2

Analyses of Variance of HR Change Scores

	Variance Source	df	F	p <
Analyses of Variance				
Total Amount of Absolute HR Change				
	Personality	1	.20	.65
	Group	1	.84	.36
	Personality by Group	1	.21	.65
Total Amount of HR Deceleration				
	Personality	1	.25	.62
	Group	1	.54	.46
	Personality by Group	1	.41	.52
Total Amount of HR Acceleration				
	Personality	1	.00	.99
	Group	1	.22	.64
	Personality by Group	1	3.88	.05

Table 3

χ^2 Distributions for Total Amount of HR Acceleration

	Personality Type			
	Extraverts		Introverts	
Cry Type	High-Risk	Low-Risk	High-Risk	Low-Risk
Amount of HR Acceleration				
⩽ 233	17	14	12	19
> 233	3	6	8	1*

	Cry Type			
	High-Risk		Low-Risk	
Personality Type	Extraverts	Introverts	Extraverts	Introverts
Amount of HR Acceleration				
⩽ 233	17	12	14	19
> 233	3	8	6	1

Note. * $p < .025$ with Yates' correction for continuity.

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