CARDIAC PATTERNS DURING ANOTHER INFANT'S CRY SOUND IN NEONATES OF DEPRESSED MOTHERS

by

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Nancy Aaron Jones, Department of Psychology, and has been approved by the members of his supervisory committee. It was submitted to the faculty of The Charles E. Schmidt College of Science and was accepted in partial fulfillment of the requirements for the degree of Master of Arts.

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ABSTRACT

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Past research indicates there is a link between physiological responses and adaptive social responses to another individual's distress. Scholars have theorized that humans may be predisposed, both physiologically and behaviorally to responding to others, especially those who are in distress. Maternal depression has been associated with dysregulated emotional development and may possibly affect the physiological and behavioral responses of a neonate. The present research examined the relationship between neonates' physiological and behavioral responses to naturally generated (compared to artificial) stimuli of other neonates, as well as the role of maternal depression in the responses. Specifically, heart rate, heart period, and heart period variability were measured to assess the newborns' reaction to cries generated by both other newborns and digitally modulated sources. This study found that newborns of depressed mothers had higher heart period variability and showed less behavioral distress when hearing the cry of another infant.

CARDIAC PATTERNS DURING ANOTHER INFANT’S CRY SOUND FOR NEONATES OF DEPRESSED MOTHERS

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CHAPTER I

INTRODUCTION

Studies of newborns of depressed mother suggest that those infants are more likely to demonstrate negative affect and be less discriminating and less distressed in response to the cries of other newborns (Field, Diego, Hernandez-Reif, & Fernandez, 2007; Jones, 2012). Scientists have suggested that this behavior predicts a lack of empathy in children (Jones et al., 2000) and that it is related to the internalizing behaviors found in children of depressed mothers (Field et al., 1996; Young, Fox & Zahn-Waxler, 1999). Yet, to assess the social responses of newborns to the cry of other newborns, behavioral observation alone cannot provide comprehensive understanding of the responses, since newborn behavioral responses can be limited. The research shows that sympathetic and parasympathetic responses to another's distress may be a structural foundation that humans are born with, similarly to how humans are born with a stepping reflex but cannot walk upright until several months of age (Field & Diego, 2007; Martin & Clark III, 1982; Jones 2000). Heart period (HP) and heart period variability (HPV) have been shown to be a dependable and stable measure of autonomic nervous system response to stimuli and a measure which is related to the behavioral dimensions of reactivity and self-regulation (Bar-Haim, Marshall & Fox, 2000). It is theorized that newborns, hearing the cries of another infant, respond through an activation of the sympathetic nervous system and vocalize their response by crying (reactive crying). For these reasons, HP and HPV are viable measures for obtaining physiological response data from newborns.

Cardiac Measures

Heart rate is how many times the heartbeats per minute; HP is the inter-beat interval (the interval between heart beats), which we have measured in seconds. HPV is the frequency range of the mean heart periods, similar to the relation of a standard deviation to the mean. HPV is related to sympathetic and parasympathetic nervous system arousal (Grasso, Schena, Gulli & Cevese, 1997). High frequency, or large HPV is a sign of cardiac arrhythmia in which the heart beats are not occurring at normal intervals. This is associated with low parasympathetic nervous system control of the heart and dysregulation in rhythmic heart beats (Grasso et al. 1997). However, chronic low heart period variability has been shown to be a reliable measure of distress and pain (Yeragani, 2000; Papa et al., 2010; Roy, Boucher & Comtois, 2009). This measure, first theorized by Hon and Lee (1965), allows for the study of the relationship between the autonomic nervous system and the cardiovascular system. HPV also plays an important relationship in cognitive performance and prefrontal neural function (Thayer, Hansenm Saus-Rose & Johnsen, 2009). Thayer et al. found that manipulating HPV levels is associated with changes in performance on executive-function tasks. Thus, HPV can be used to gauge physiological responses of the nervous system due to stimuli.

Heart period has also been used to measure emotional development in infancy and childhood and has been theorized to be related to the behavioral patterns of reactivity (Fox, 1989; Porges, 1991, 1992, 1995; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996). Longitudinal studies of infants from 4 months to 48 months have shown that heart period increases steadily between these times. It is possible that the increase represents maturation in the parasympathetic nervous system (Bar-Haim, Marshall, & Fox 2000). Porges (1995) hypothesized that the developmental change in heart period reflects the growing ability to self-regulate emotions from infancy to childhood.

Research also shows that the changes in HPV through the first years of infancy continue to mirror behavioral traits across development (Calkins, Graziano, & Keane, 2006). Calkins and her colleagues (2006) demonstrated that children who are at risk for behavioral problems experience high frequency heart period variability during difficult tasks as opposed to children who are not at risk. The observation of high frequency HPV in at risk children could be important in identifying behavioral problems in children early enough so that those behavioral problems may be corrected through interventions. It should also be examined whether infants of depressed mothers experience high HPV during a reactive crying experiment as well which may provide a biological link between maternal influence on heart period and future behavioral problems in children.

Differences in psychophysiological systems between infants of depressed versus non-depressed mothers have been shown during the neonatal period (Jones, Field, Fox, Davalos, Lundy & Hart, 1998). Maternal depression has also been shown to exacerbate physiological and emotional dysregulation in infants. Infants of depressed mothers experience more negative facial expressions, lower activity levels, and fewer vocalizations (Field, 1995). Infants of depressed mothers have been observed to have lower parasympathetic activity and heart rate when reacting to the cry of another infant than infants of non-depressed mothers (Jones, 2012). For example, a previous study suggests that infants of depressed mothers do not exhibit the expected responses while hearing the cries of another infant suggesting behavioral dysregulation (Thompson, 1987). Collectively, the research suggests cardiac activity is important for infant growth and development and is related to maternal depression. Other studies also suggest that maternal depression and their infants' emotional and physiological dysregulation are linked (Jones, Field, Fox, Davalos, Lundy & Hart, 1998). For example, in a study where other risk factors (such as cigarette smoking, drug use, alcohol use, poor weight gain, income, and birth weight) were controlled for, the relationship between maternal depression scores and newborn excessive crying and inconsolability remained unchanged, with neonates' temperamental difficulty increasing in the direction of depression scores (Zuckerman, Bauchner, Parker, & Cabral, 1990). Very little research has been conducted on heart period variability and how it relates to empathetic behaviors in newborns. My study plans to looks at HPV as a measure of distress in newborns and how it differs between newborns of depressed and non-depressed mothers.

Empathetic Behaviors

Empathy advances group survival without overly compromising individual survival. As an evolutionary adaptation, the physiological aspects of empathetic behavior would be active before humans developed the necessary cognitive skills to understand why they should help others or make decisions based on altruistic concepts. As a biological function, empathy would be present at birth and would allow newborns to respond to the distress of other newborns (cry) with their own cry. Hoffman (1981, 2000) proposed that empathy is the psychological mechanism responsible for altruism and prosocial behaviors. He argues that empathy fits the evolutionary requirements of inclusive fitness theory and would have been selected for because it is flexible and remains under individual control while still promoting prosocial behavior. It is theorized that human beings respond physiologically to the distress of another similarly to the physiological responses to their own distress due to the evidence “mirror neurons” which are neurons that fire both when an individual experiences and event and witnesses the event occurring to another individual (Preston & deWaal, 2002). This would indicate that empathy, as well as being considered a cognitive function of a social species, is also a physiological response that is present during early development. The research indicates that helping others in distress can relieve one’s own physiological distress (Weiss, Boyer, Lombardo, & Stich, 1973).

The evidence that altruism is motivated by a desire for social approval is weak compared to the evidence favoring biological preparedness theories (Hoffman, 1981; Jones 2012). For instance, the frequency and speed of helping responses in emergency situations allows little time for consideration of social approval and instead supports neuro-physiological underpinnings for empathy (Van den Bos, Muller & Van Bussel, 2009; Piliavin, 1972; Piliavin, Rodin, & Piliavin, 1969). Numerous studies have now documented the apparent innate nature of empathic responding. To illustrate, in one study, adults with no prior experience with children (i.e., no children of their own and no professional exposure to or experience with children) exhibited greater physiological arousal to the cries of high-risk premature babies than to the cries of healthy infants (Zeskind, 1987). In addition, the participants, who had no knowledge of the infants’ medical risk status, indicated verbally that the cries of the high-risk group sounded like babies who were sick. Other studies have found that 2-month-old babies prefer looking at human faces instead of mannequins and other objects, (Langsdorf, Izard, Rayias, & Hembree, 1983), and that neonates can distinguish between human (Sagi & Hoffman, 1975; Simner 1971) and non-human (but physically equivalent) sounds (Martin & Clark, 1982). Taken together, these findings provide strong support for a bio-behavioral preparedness to form social relationships, and empathy, as we have already seen, is a necessary component of those relations.

Regulatory Behaviors in Infancy

Several authors concluded that reactive cries in newborn infants are a biologically predisposed precursor to empathy (e.g., Hoffman, 1975, 1981; Martin & Clark 1982). Research has shown that newborns cry in response to the sound of another infant's cry, but not in response to the sound of their own cry, of a synthetic cry, or to the cries of a chimp (Martin & Clark, 1982; Simner, 1971; Sagi & Hoffman, 1975). Studies have also documented that infants as young as one day old differ in their behavioral responses to the sound of another infant's cry (Dondi, Simion, & Caltran, 1999). The observation that neonates vary in their attention to cry sounds and distress reactions is inconsistent with earlier theories that reactive newborn cries were mere vocal imitations or reflexes (Hoffman, 1984). Instead, reactive cries are full-blown distress cries and serve as evidence that newborns are processing the cries of another infant in a manner that is qualitatively different than how they process other sounds. Furthermore, Dondi and colleagues (1999) demonstrated that this distinction is present during sleep states, indicating that conscious effort or attention is not necessary to process social stimuli. This evidence strengthens the claim that humans have the structural necessities to respond to others' distress, perhaps signaling a biological social connectedness.

Cardiovascular measures are reliable long-term predictors of socio-psychological health (Doussard-Roosevelt et al., 1997), and cardiac deceleration has been used as an indicator of sustained, other-oriented attention, even in the absence of a behavioral response, for almost fifty years (Lester et al., 1996). Heart-rate acceleration, on the other hand, indicates rejection of stimuli and defensiveness (Andreassi, 2000). Numerous studies have consistently demonstrated that in infants, heart-rate acceleration is correlated with distress and negative affect and that deceleration is correlated with visual fixation of new and complex stimuli (Langsdorf et al., 1983). Other studies have documented similar responses in adults (Zeskind, 1987).

These observations are congruent with the theory that individuals, including young infants, who are capable of regulating their own emotional arousal, will be able to focus their attentional resources on external stimuli in a more controlled manner, facilitating an appropriate behavioral response. This framework for evaluating cardiac reactivity is consistent with poly-vagal theory (Porges, 1986), as well as the general concept that regulation of emotional arousal requires considerable resources. Thus, infants who lack self-regulatory capacities as a matter of biological predisposition (i.e., who have a lower upper-limit activation band threshold) will need to recruit additional resources to self-regulate in the face of negative emotionally arousing stimuli. This will significantly reduce the resources available to formulate and implement appropriate behavioral responses.

Within this framework, Fox (1991) argues that, in infancy, the only feeling states that have emerged stem from a motivation to either approach and explore, or to flee and withdraw. Further support for this theory comes from animal behaviorists who assert that approach and withdrawal are the only underlying motivators of behavior in animals (Schneirla, 1957, 1959). This initial temperamental orientation in infants continues to be reinforced throughout development (Hoffman, 1981). Children who instinctively withdraw from novel stimuli miss opportunities for social interaction and develop both fewer self-regulatory and helping skills, creating a cycle of personal distress and learned helplessness. Likewise, children who have a tendency to approach and explore will develop better social skills and the connection between someone else's distress and their own will be strengthened, thus enhancing the frequency of helping behaviors. Empathic responding is a crucial component of social success. Biological predispositions may indicate an infant's capacity for empathy that can be measured physiologically and behaviorally at birth. In addition, maternal depression may impact the physiological and behavioral precursors to empathy development.

CHAPTER II

PURPOSE AND HYPOTHESIS

The purpose of this study is to examine whether newborns are biologically predisposed to respond to other infants in duress, a sign of social responsiveness. The study will use the monitoring of the infant's heart rate as well, using measures of heart rate variability to examine whether infants respond to another newborn's crying, or a digitally modulated cry. The study will also examine whether the infants of depressed mothers respond differently to another infant's cry than infants of non-depressed mothers.

Behaviors

I hypothesized that newborns of depressed mothers would vocalize less, spend less time in high agitated states and close their eyes or avert their gaze away from the stimulus during the natural cry condition than newborns of non-depressed mothers. Three repeated measures ANOVA were conducted to analyze the percent of time newborns of the different depression groups spent in in each sleep state, vocalizing, and gaze direction during the natural cry condition compared to the digitized cry condition (see page 15).

Cardiac Measures

I hypothesized that newborns would have lower heart period, (higher heart rate) during the natural cry condition than the tonic condition. A paired samples t-test was conducted to compare the means of the different conditions. However, Field et al.

(2007), found that newborns of non-depressed mothers experience a decrease in heart rate during the natural cry condition. A decrease in heart rate is an orienting response and it is found when newborns orient themselves to a new stimulus (Clifton, 1974; Field et al., 2007). The discrepancy is why HPV may be a better measure of distress than HP.

I hypothesized that newborns of non-depressed mothers would show lower heart period (higher heart rate) during the natural cry condition than newborns of depressed mothers. A repeated measures MANOVA was conducted to compare the depression groups across all three conditions (baseline, natural cry, digitized cry).

Previous research has shown that a sudden decrease in heart period variability is a good indication of pain and stress in newborns (Papa, Jonckheere, Logier, Kuissim Mathieu, Rakza & Storme 2010; Porter, Porges & Marshall, 1988). Based on prior theories of emotional dysregulation in newborns of depressed mothers and their inability to orient to another infant crying (Field et al., 2007; Jones, 2000), I hypothesized newborns of non-depressed mothers would show greater distress when hearing another infant crying and therefore respond with lower heart period variability during the natural cry condition. A repeated measures ANOVA was conducted to compare the heart period variability between the depression groups through the three conditions (baseline, natural cry, digitized cry). Follow up independent samples t-tests were conducted to compare the heart period variability during the baseline, the cry condition, and the digitized cry condition between each mood group.

Exploratory Analysis

Exploratory analysis was conducted using the measures: vocalizing, sleep states, gaze, self-soothing behaviors, and Brazelton scores. The interaction of these behavioral measures will heart period and heart period variability during the three conditions (baseline, natural cry, and digitized cry) was analyzed.

CHAPTER III

METHOD

Participants

This study used data collected in 2001. In total, 88 mothers and their newborns participated in the behavioral portion of this study, 39 mothers were classified as depressed and 49 mothers were classified as non-depressed. Forty-one mothers and their newborns participated in both the behavioral and the heart-rate acquisition portion of this study, 21 mothers were classified as depressed and 20 mothers were classified as non-depressed. Classification of depression is described later in this section and is based on CES-D scores. Mothers were recruited in their hospital rooms following uncomplicated vaginal (87%) or cesarean (13%) delivery of health, full-term infants. Mothers and newborns were tested 24 to 36 hours post-birth. Mothers were predominately middle-class women, with 70% Caucasian, 17% African American, and 4% Hispanic and 9% other racial and ethnic groups. Comparisons between the groups revealed no differences on demographics, newborn health status (see OCS and PCS scales below), and maternal medication intake during and after delivery and newborn age at testing.

Procedure

Initial interviews were conducted privately in mothers' hospital rooms and included the administration of the Center for Epidemiological Studies-Depression Scale (CES-D); the Obstetric Complications Scale and Postnatal Complications Scale (OCS &

PCS; Littman & Parmelee, 1978): a demographic and support systems inventory; and the first four questions of the Diagnostic Interview Schedule-Depression Module (DIS), which assess symtomology on the first two DSM-IV diagnostic criteria (i.e., depressed and/or irritable mood, and loss of interest in activities), one of which must be present for a Major Depressive Episode to be diagnosed (Robins, Helzer, Cottler, & Goldring, 1989). A second examiner who was blind to the mothers' depression status administered the newborn assessments. Since the dyads were rooming-in, these were conducted in the mother's presence with mothers instructed to minimize interactions with their newborn during testing.

The examiner administered the Brazelton Neonatal Assessment Scale (NBAS; Brazelton & Nugent, 1995). Afterward, while the newborn was in a quiet-alert state, a miniature tape player was placed in the crib approximately 6 cm from the newborn's head and newborns were exposed to two audio recordings. Each recording lasted 4 min. and was followed by a 1 min. inter-stimulus interval. Using a hand-held video recorder, the examiner videotaped the newborn during the auditory presentations. Each infant was exposed to both stimuli, which were presented using random assignment.

Heart Rate Acquisition and Coding

ECG activity was recorded in a subsample of infants (N=41) by placing three disposable electrodes on the infant's chest in a triangular arrangement. Two electrodes were placed at the top of the chest, over the heart and a third was placed on the back of the neck to serve as a ground. The heart rate signal was collected using a laptop computer and amplified by SA Instrumentation Bioamplifier. Continuous recording were made at a sampling rate of 1000Hz. A three to four minute baseline heart rate signal was recorded prior to the administration of the audiotaped stimuli.

Heart rate data were used to calculate mean heart period across the entire session. IBI analysis software was used to process the heart rate data and to calculate cardiac heart period activity at rest, and during the cry sounds. Heart rate files were manually edited for artifact to remove incorrect detection of the R-wave, to add in missing R-waves, and to remove movement artifacts. The inter-beat interval of sequential R-waves was calculated to the nearest millisecond. The data were analyzed using software developed by James Long Inc (2001).

Depression

The Center for Epidemiological Studies-Depression Scale (Radloff, 1977) is a 20-item self-report questionnaire for assessing depressive symptomatology, including items that are descriptive of symptoms of depressed mood, feelings of guilt, worthlessness, helplessness, hopelessness, loss of energy, and problems with sleep or appetite. The scale yields scores ranging from 0 to 60, and a score of 16 or greater on this scale has been shown to differentiate clinically depressed and non-depressed participants in a community sample (Myers & Weissman, 1980; Weissman, Sholomskas, Pottenger, Prusoff, & Loche, 1977). This instrument has been used extensively for research purposes including similar work on maternal depression (Dawson et al., 1999; Jones et al., 1997; 1998; Lundy et al., 1999).

The Diagnostic Interview Schedule assessed psychopathology based on criteria from the Diagnostic and Statistical Manual of Mental Disorder (American Psychiatric Association, 2004). It has good psychometric properties and can be administered by graduate students (Costello, Edelbrock, & Costello, 1985), as in the present research. This DIS is used widely by researchers interested in psychological disorders (Caspi, Moffit, Newman, Silva, 1996; Lundy et al, 1996; Lundy et al., 1999). All mothers were asked to exclude the day of delivery and the postpartum period in their responses.

To control for variation in perinatal symptoms that can be experience by mothers during and post-delivery, mothers answered questions on the Obstetric Complication Scale (OCS) and Perinatal Complication Scale (PCS) (Littman & Parmelee, 1978). The 41-item OCS quantifies obstetric complications by including items on the mother's medical history, gestation, labor, delivery and immediate postnatal health of the infant. The 10-item PCS quantifies complications during the postnatal period, by addressing infant respiratory problems, infections, temperature disturbances, feeding, and serious medical illness requiring surgery. Both scales consist of items answered by the mother (or confirmed by chart examination with the mother's permission), rated as optimal or non-optimal, and yields summary scores in which high scores index more optimal conditions. This information was used as a control measure, to confirm the optimal health status of the dyad.

To examine the newborn's responses to behavioral and reflex stimuli, a Brazelton exam was administered by examiners who were trained to .90 reliability before the study and whose reliability was checked periodically during the course of the study. In addition to providing an assessment of newborn behaviors, this assessment was instrumental in eliciting an alert state, which was necessary in order to begin presentation of the audiotapes.

Maternal Mood Groups

Group categorization for mothers was based on their self-reported symptoms on the CES-D and the DIS scales. The label of “depressed” was given to mothers who reached the cut-off of 16 or greater on the CES-D and had responses on the modified DIS indicating that they met at least one of the mandatory criteria items for diagnosis of a Major Depressive Episode. All mothers selected as part of the depressed mood group reported elevated depression symptoms prior to their newborn’s birth. The label of non-depressed mood was made when mothers had a score of 12 or less on the CES-D and mothers reported no previous depression diagnoses and no family history of affective disorders.

Sound Stimuli

The two auditory sounds consisted of an infant’s pain cry and a digitized sound. The pain cry represented sound with a negative emotional valence. It was obtained by recording a newborn’s cry during a heel stick procedure. The digitized sound was used as a neutral stimulus. The digitized cry, created an implemented by Simner (1971), was designed to reflect certain major parameters of the cry sound while being easily distinguished. The digitized cry is suppose to have the same qualities of a newborn’s cry, without any of the emotional valence. To compose the digitized sound, the original sound was intermixed with preset, 150-200 millisecond, and delay echoes. Added to that signal was a Flanger preset effect, resulting in a phase-shifted, and time delay effect. Additionally, there was a 3D echo chamber preset ambient metal room to give the sound greater spatial characteristics. Sound recordings were preset to sound levels between 83 to 85 decibels, using a sound level meter to confirm the level. Previous studies have shown the digitized cry to be a reliable neutral stimulus (Jones, 2012).

Behavioral Coding

Behavioral responses to the audio stimuli were recorded and coded, including newborn's state (scale of 1 - 7), vocal distress (scale of 1 - 6), self-soothing behaviors (1-4) direction of gaze (1-4), and body distress responses (1-5). The newborn's state scores ranged from 1 to 7 with lower scores reflecting sleep states, such as resting and drowsy and higher scores reflecting greater alertness to agitation (Brazelton & Nugent, 1995). Vocal distress was coded on a scale of 1 to 6, with higher scores indicating greater distress (modeled after Thompson & Lamb, 1984), and a score of one if they did not cry. Direction of gaze was coded 1-5 with lower scores meaning eyes closed or averting eyes from stimulus and higher scores indicating a gaze at the stimulus. The frequency of newborn-initiated regulatory behaviors were tallied, including hand swipes, hand/finger insertions, facial distress without vocalizations, yawns/coughs/ sneezes/hiccups, tongue protrusions (>4 at a time), pacifiers, and self- and other-soothing techniques. The behavioral responses reinforce the physiological data gathered by indicating the activation of the sympathetic nervous system and the parasympathetic nervous system. If the newborn's state is coded as a 7, then it is probable the infant's heart rate has also increased, demonstrating a reaction to the auditory stimuli. The newborn's behaviors were coded on a second-by-second basis and summed into total scores across each stimulus segment. The first 10 seconds of the sound presentations were not used to give the newborn time to hear the sound. Inter-observer reliability was assessed on 25% of the videotapes and reliability of measures was good (Cohen (1960) kappa ranged from .83 to

.95). Subsequent tests showed that there were no differences in the presentation order for the depressed and the non-depressed groups, $X^2(1,N=87)=.56$, $p > .05$.

CHAPTER IV

RESULTS

Behaviors

A repeated measures ANOVA was conducted to evaluate the hypothesis that newborns of depressed mothers will close their eyes or avert their gaze during the natural cry condition more than newborns of non-depressed mothers. There was not a significant interaction between depression groups, gaze, and cry condition. However there was a significant interaction between gaze and depression, $F(3,81)=77.23$, $p=.002$. Follow up *t*-tests reveal there was a significant difference in the percent of time spent with eyes closed, $t(83)=3.24$ $p=.002$. Newborns of depressed mothers spent a greater percent of time with their eyes closed ($M=73.51$, $SD=34.82$) during the natural cry condition than newborns of non-depressed mothers ($M=49.19$, $SD=33.80$). There was also a significant difference in percent of time spent gazing at the source of the natural cry stimulus, $t(83)=2.72$, $p=.008$. Newborns of non-depressed mothers spent a greater percent of time looking at the stimulus ($M=26.50$, $SD=26.23$) than newborns of depressed mothers ($M=11.37$, $SD=20.75$). There was also significant difference in newborn's closing their eyes during the digitized cry condition, $t(86)=3.82$, $p<.001$. Newborns of depressed mothers ($M=79.24$, $SD=32.11$) spent a greater percent of time with their eyes closed than newborns of non-depressed mothers ($M=51.13$, $SD=37.60$) during the digitized cry condition. There was also a significant difference in the percent of time spent gazing at the source of the digitized cry stimulus, *t*(86)=3.21, *p*=.002. Newborns of non-depressed mothers (*M*=28.28, *SD*=28.10) spent a greater percent of time gazing at the stimulus during the digitized cry than newborns of depressed mothers (*M*=9.66, *SD*=18.49).

To evaluate the hypothesis that newborns of depressed mothers would spend less time in agitated or alert states than newborns of non-depressed mothers during the natural cry condition, a repeated measures ANOVA was conducted to determine if there were differences in time spent in states of alertness during the cry condition between newborns of depressed mothers and non-depressed mothers. There was not a significant interaction between newborn state, depression group, and cry condition. However, there was a significant interaction between depression group and newborn state, *F*(6,78)=3.33, *p*=.006 (See Table 1). Follow up *t* tests reveal there was a significant difference in the percent of time spent in a deep sleep, *t*(83)=2.68, *p* < .01. Newborns born to depressed mothers spent a greater percent of time in a deep sleep state (*M*=32.60, *SD*=42.26) and a drowsy state (*M*=30.39, *SD*=21.64) than newborns of non-depressed mothers spent in deep sleep *(M*=10.80, *SD*=28.56), and drowsy sleep (*M*=12.64, *SD*=21.64). However, newborns of non-depressed mothers spent more time in an awake but no visible movement state (*M*=34.26, *SD*=32.03) than newborns of depressed mothers (*M*=15.80, *SD*=26.05) during the cry condition.

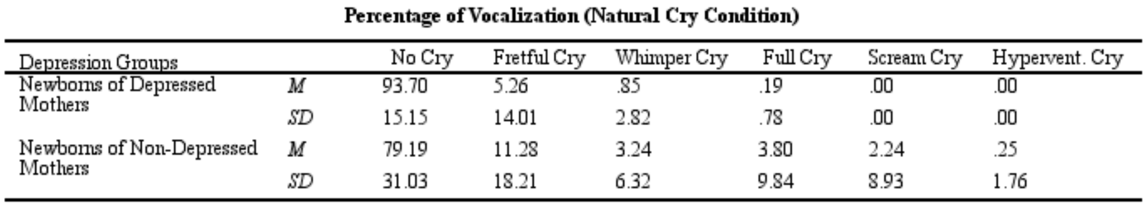
Table 1

Percent of Time in Newborn State (Natural Cry Condition)

Depression Groups		Deep Sleep	Drowsy Sleep	Awake/No Activity	Low Activity	High Activity	Low Agitation	High Agitation
Newborns of Depressed Mothers	*M*	42.26	30.39	26.05	22.35	9.33	22.34	16.35
	SD	32.60	25.10	15.80	9.36	1.63	11.07	4.43
Newborns of Non-Depressed Mothers	*M*	28.56	21.64	32.03	21.88	4.61	25.02	17.05
	SD	10.80	12.65	34.26	15.05	.79	19.31	7.15

A repeated measures ANOVA was conducted to evaluate the hypothesis that newborns of non-depressed mothers would vocalize for longer periods of time than newborns of non-depressed mothers during the natural cry condition. There was not a significant interaction between vocalization, depression groups, and cry conditions. However, there was a significant interaction between vocalization and depression groups, *F*(5,83)=2.69, *p*=.021. Follow up *t* tests reveal there were significant differences in percent of time spent vocalizing (See Table 2), *t*(83)= 2.60. *p* = .01. Newborns of depressed mothers vocalized less (*M*=93.70, *SD*=15.15) than newborns of non-depressed mothers (*M*=79.19, *SD*=31.03) during the cry condition. There was also a significant difference in the percent of time spent at full cry. *t*(83)=2.03, *p* = .05. Newborns of non-depressed mothers spent more time vocalizing at full-cry (*M*=.25, *SD*=1.76) than newborns of depressed mothers (*M*=. 00, *SD*=.00) during the cry condition.

Table 2



Percentage of Vocalization (Natural Cry Condition)

Depression Groups		No Cry	Fretful Cry	Whimper Cry	Full Cry	Scream Cry	Hypervent. Cry
Newborns of Depressed Mothers	*M*	93.70	5.26	.85	.19	.00	.00
	SD	15.15	14.01	2.82	.78	.00	.00
Newborns of Non-Depressed Mothers	*M*	79.19	11.28	3.24	3.80	2.24	.25
	SD	31.03	18.21	6.32	9.84	8.93	1.76

Cardiac Measures

To evaluate my hypothesis that newborns of non-depressed mothers would have lower heart period (higher heart rate) during the cry condition than newborns of depressed mothers, a repeated measures ANOVA was conducted. There were no significant differences in heart periods between the two groups and conditions. To evaluate my hypothesis that newborns would have lower heart period (higher heart rate) during the cry condition than the baseline heart periods, three paired samples t-tests were conducted. There were no significant differences between the conditions.

To evaluate the hypothesis that heart period variability would be lower during the cry condition versus the baseline condition, a repeated measures ANOVA was conducted to evaluate differences in the means between basal heart period variability, heart period variability during the cry condition, and the digitized cry condition. There was no significant difference between conditions. However, follow up *t* tests reveal there was a significant difference between the heart period variability during the digitized cry condition and the natural cry condition, *t*(29)=2.34, *p*=.03. Heart period variability was lower during the digitized cry condition (*M*=.06, *SD*=.05) than during the natural cry condition (*M*=.08, *SD*=.01).

Exploratory Analysis

Exploratory analysis was conducted because I was interested in how depression groups related to Brazleton scores. A general linear model was conducted to evaluate if there was a difference in Brazelton scores between the two depression groups. Maternal depression had a significant effect on the Brazelton Neonatal Assessment withdrawal score when controlling for self-soothing behaviors, *F*(3,84)=3.92, *p*=.01. Newborns of mothers with depression scored lower on the Brazelton-withdrawal (*M*=1.72, *SD*=1.60) than newborns of non-depressed mothers (*M*=2.26, *SD*=1.57).

At first glance the results would appear to show no statistically significant results for heart period and heart period variability, suggesting that these two measures are not indicative of a newborn's response to distress. However, several linear models controlling for self-soothing behaviors and sleep states were run because previous research suggests that self-soothing behaviors regulate reactivity in newborns (Crockenberg & Leerkes, 2004). Conducting a linear regression, self-soothing behaviors significantly predicted heart period variability during the natural cry condition. The regression analysis yielded a fit R^2_{adj}=.10. The overall relationship was marginally significant, *F*(1,26)=3.87, *p*=.06. The effect of self-soothing scores on HPV during the cry condition was also marginally significant, *t*(26)=1.97, *p*=.06, *b*=.37 (See Fig. 1). However, self-soothing behaviors did not predict heart period variability during the digitized cry condition. When controlling for self-soothing behaviors, there is a significant difference in basal heart period variability between newborns of depressed mothers and newborns of non-depressed mothers, *F*(2,23)=6.37, *p*=.02. Newborns of depressed mothers had lower basal heart period variability (*M*=.06, *SD*=.03) than newborns of non-depressed mothers (*M*=.08, *SD*=.03) (See Fig. 2). Additionally, there was also marginally significant difference in heart period variability during the natural cry condition between the two groups when self-soothing behaviors were controlled for, *F*(2,26)=2.72, *p*=.09 (See Fig. 3). Newborns of non-depressed mothers had lower heart period variability during the natural cry condition (*M*=.07, *SD*=.05) than newborns of depressed mothers (*M*=.10, *SD*=.10). There were no significant differences in HPV during the digitized cry conditions between the two groups when self-soothing behaviors were controlled for. Additionally, when controlling for basal heart period, self-soothing behaviors, and percentage time spent in awake states, there is a marginally significant difference in heart period between the newborns of depressed mothers and newborns of non-depressed mothers during the natural cry condition, *F*(8,13)=3.71, *p*=.08. Newborns of depressed mothers (*M*=.46, *SD*=.07) had lower heart period (higher heart rate) than newborns of non-depressed mothers (*M*=.48, *SD*=.05).

Several additional tests were conducted to analyze how the change in heart period (heart period during the natural cry, or digitized cry condition minus HP of the baseline condition) was related to different behavioral measures. Brazelton-motor scores significantly predicted the change in heart period from the baseline condition to the natural cry condition. The model yielded a low fit, R^2_{adj} =.19. The overall relationship was significant *F*(1,23)=6.34, *p*=.02 (See Fig. 4). The effect of Brazelton motor scores on change of heart period from basal to natural cry condition was significant, *t*(23)=2.52, *p*=.02, *b*= -.47. Brazelton motor scores also significant predicted the change in heart period from the baseline to the digitized cry condition. The model yielded a moderate fit, R^2_{adj} = .37. The overall relationship was significant, *F*(1,23)=14.33, *p*=.001. The effect of Brazelton motor scores on change of heart period from the baseline to digitized cry condition was significant, *t*(23)=3.79, *p* =.001, *b* = -.63. The amount of seconds spent in the highest agitated state was predictive of changes in heart period between the baseline condition and the natural cry condition. The regression yielded a low fit, R^2_{adj} = .27. The overall relationship was significant, *F*(1,22)=8.46. *p*=.008. The effects of time spent in the highest agitated arousal state on changes in heart period between the baseline and natural cry condition were significant, *t*(23)=3.06, *p* =.008, *b* =.55. Finally, Brazelton withdrawal scores were predictive of changes in heart period between the baseline and digitized cry conditions. The model yielded a low fit, R^2_{adj} = .19. The overall relationship was significant, *F*(1,27)=6.01, *p*=.02. The effects of Brazelton withdrawal scores on changes in heart period between baseline and digitized cry conditions were significant, *t*(27)=2.45, *p* =.02, *b* =.43.

CHAPTER V

DISCUSSION

These findings are congruent with previous research that suggests newborns of depressed mothers respond with less vocalized crying to the cries of another infant than their non-depressed mothers counterparts (Jones, 2012). During the study, newborns of depressed mothers spent the majority of their time with their eyes closed, in a deep sleep, not vocalizing while newborns of non-depressed mothers gazed longer at the source of the stimulus and vocalized. This is consistent with prior studies that newborns of depressed mothers are more withdrawn than newborns of non-depressed mothers, whereas newborns of non-depressed mothers are more inclined to respond to another newborn in distress in by being in distress themselves (Jones, 2012). One of Dondi and his colleagues' (1999) findings was that during sleep states, healthy newborns will still respond vocally and with more negative affect to the cry of another infant (Dondi et al. 1999). In this study, newborns of depressed mothers did not respond in a similar fashion to either stimulus. This would suggest that newborns of depressed mothers are indeed dysregulated in their emotional responses. As some suggest, this non-responsiveness to distress crying may indicate a later lack of empathy (Thompson, 1987).

The initial findings did not support our hypotheses that newborns of non-depressed mothers will have lower heart period variability during the natural cry condition than newborns of depressed mothers. This may be due to the small sample size of the subset population. It may also be due to extraneous factors such as how soon before the experiment the infant ate or slept. These two variables may play an important role in the development of heart rate and heart rhythm in newborns. However, the findings during the exploratory analysis suggest there is evidence for my hypotheses.

The findings of this study demonstrated that when controlling for self-soothing behaviors, infants of depressed mothers have lower base heart period variability than newborns of non-depressed mothers. Additionally, when hearing another infant cry, newborns of non-depressed mothers will have lower heart period variability than newborns of depressed mothers. A decrease in heart period variability has been documented as signs of distress, pain and depression (Yeragani, 2000; Papa et al., 2010; Roy, Boucher & Comtois, 2009). These studies hypothesized that it is an effective measure of pain in infants as well. In one study, circumcision in newborns was synchronous a drop in heart rate variability in healthy newborns (Porter, Porges & Marshall, 1988). The findings suggest that the drop in heart period variability in healthy newborns during the natural cry-condition is a distress/pain response to the cry of the other infant. Since newborns of depressed mothers did not demonstrate the drop in HPV, I am suggesting that these newborns are not experiencing the same distress that newborns of non-depressed mothers are experiencing. This is also supported by the fact that there were no differences in HPV between the two groups during the other conditions. It has been suggested that long-term low HPV is associated with depression and emotional attachment problems that one would find in newborns of depressed mothers (Izard, Porges, Maurice Haynes & Cohen, 1991). The findings in this study suggest that a drop in HPV accompanies brief instances of distress and pain, but healthy individuals return to normal levels once the instance is over. However, chronic low HPV would be observed in dysregulated individuals, which would explain why newborns of depressed mothers had lower base heart period variability than newborns of non-depressed mothers. These findings provide support for the theory that infants are predisposed to empathetically respond to the distress of another infants. However, infants of depressed mothers are dysregulated in this process and are at risk for behavioral problems and lack-of-empathy later in life.

These findings only occur when controlling for self-soothing behaviors in newborns. Since I found that the frequency of self-soothing behaviors is predictive of HPV during the cry condition, the data, and previous research indicates that newborns engage in self-soothing behaviors as a coping mechanism for distress (Kopp, 1989; Stifter & Braungary, 1995). This phenomenon can be seen in other studies where newborns of narcotic addicted mothers engage in self-soothing behaviors (Strauss, Lessen-Firestone, Starr & Ostrea, 1975). Although there were no significant differences between the two groups on frequency of self-soothing behaviors, the findings indicated that newborns of non-depressed mothers might perform more self-soothing behaviors than newborns of depressed mothers. Further research will have to be conducted to see if newborns of depressed mothers engage in more self-soothing behaviors when there is no stressful stimulus present than newborns of non-depressed mothers as an adaptive regulatory mechanism for distress. It is possible that self-soothing behaviors help regulate physiological distress, and the more distress an infant experiences, the higher the frequency of self-soothing behaviors. One theory as to why these self-soothing behaviors allow newborns to cope with distress is that skin-to-skin contact releases oxytocin, which is higher in mothers following delivery. Research in newborn/oxytocin relationships showed that distressed infants who received oxytocin release through contact were calmer when presented with distress (Matrhiesen, Ransjo-Arvidson, Nissen & Moberg, 2001). My study suggests that newborns are using their own skin-to-skin contact to cope with distress in the absence of another individual. Since frequency of self-soothing behaviors was not correlated with how old the newborns were, the findings suggest if self-soothing is learned, it must be in utero. However, these findings would suggest that coping with distress using self-soothing behavior is a response that is present at birth.

My hypothesis was that newborns of depressed mothers would have higher heart period than newborns of non-depressed mothers because higher heart period is associated with less distress (Adreassi, 2000). The findings showed the opposite effect which is consistent with previous research by Field et al. (2007), that newborns of depressed mothers had higher heart period (lower heart rate) during the natural cry condition than newborns of non-depressed mothers once time spent in sleeps states are taken into account (since a resting heart rate in deep sleep is lower than a resting heart rate while awake) due to an orientation effect. The discrepancy in heart period data is why HPV may be a more reliable measure of distress than HP. Further, as Brazelton motor scores increase in newborns, the change in heart period decreases (resulting in lower heart rate). Based other results reported here, this is expected because an increase in Brazelton motor scores is associated with greater control of motor muscles such as bring the hand to the mouth (Als, Tronick, Lester & Brazelton, 1977). Since gross motor skills are a prerequisite for self-soothing behaviors, it is expected that I would see fewer changes in in heart period from one condition to the next.

This study was limited in its ability to gather cardiac data from all the participants. Of the 147 mother-infant dyads that participated, cardiac data was only gathered from 44 of those participants. The study could further be enhanced by gathering cardiac data from all participants instead of only a subset. Future research should examine the frequency of regulatory behaviors in newborns on other measures of distress. Additionally, a study should be conducted to observe if newborns of depressed mothers engage in self-soothing behaviors more often than newborns of non-depressed mothers. This study should examine the newborns throughout the days to observe which stimuli evokes the highest frequency of self-soothing behaviors. Whether or not these self-soothing behaviors continue through childhood and adolescence and how it affects heart period and heart period variability should also be examined.

FIGURES

Fig. 1

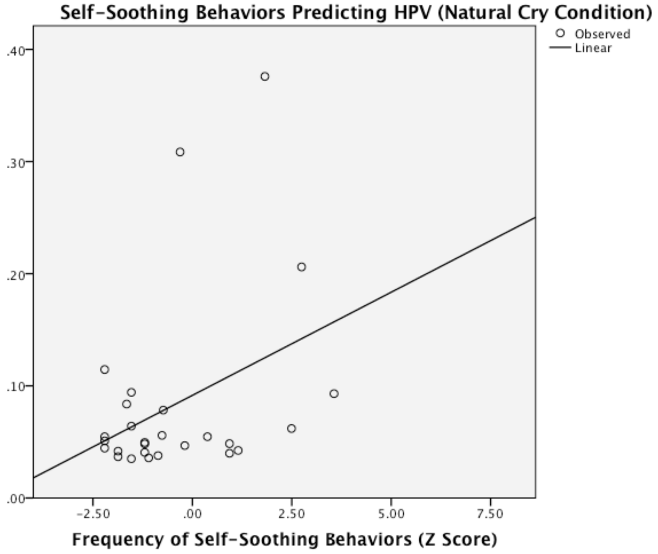


Fig. 2

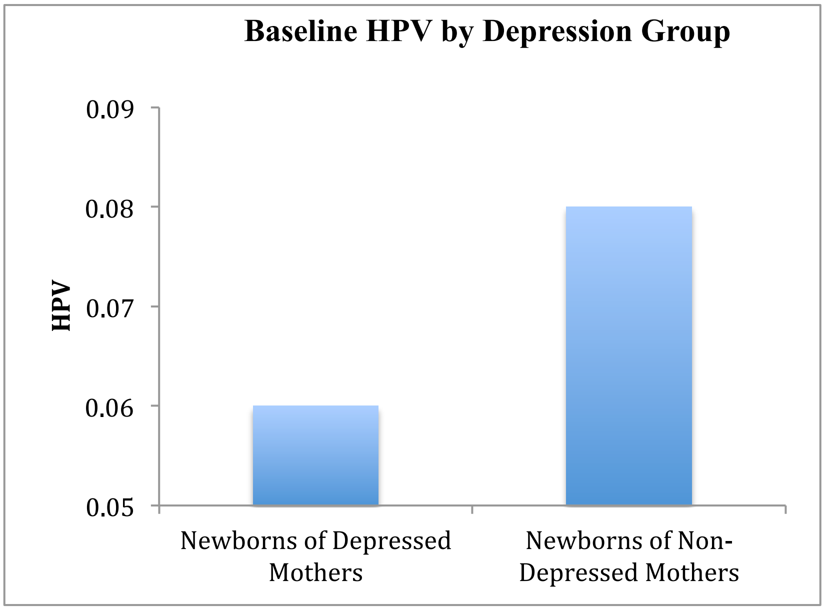


Fig. 3

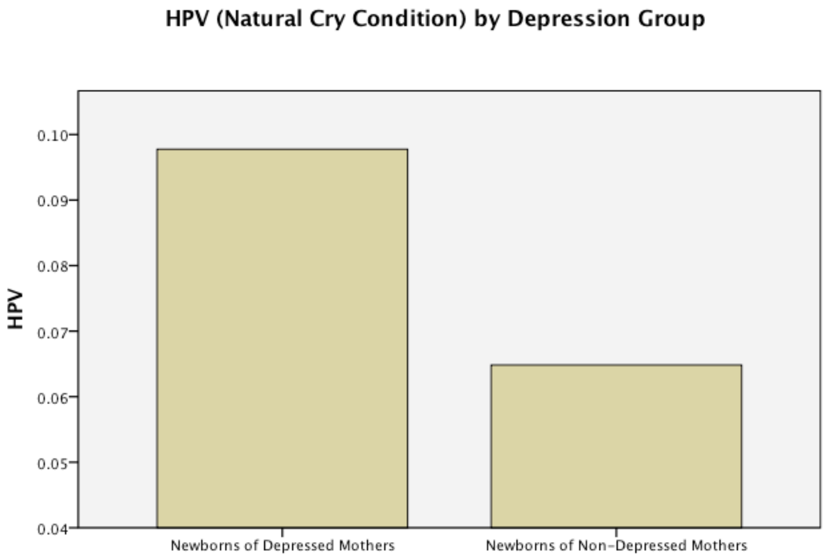
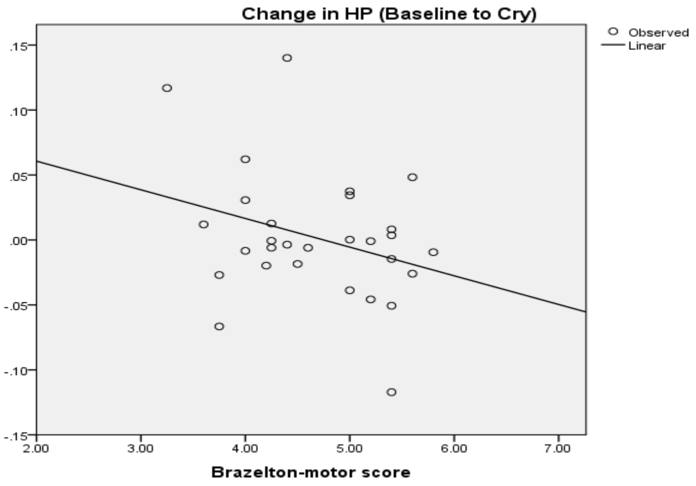
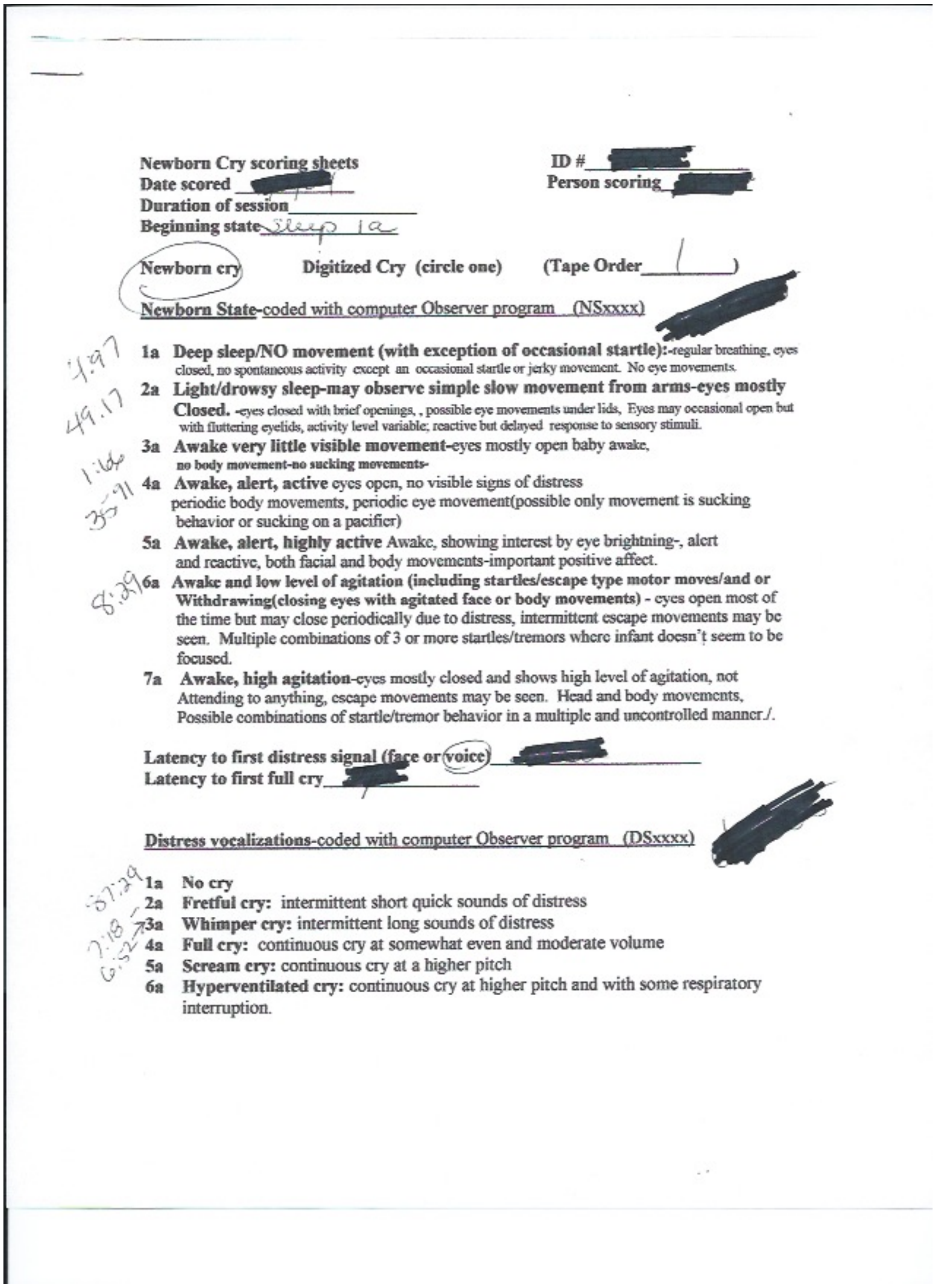

HPV (Natural Cry Condition) by Depression Group
HPV
0.10
0.09
0.08
0.07
0.06
0.05
0.04
Newborns of Depressed Mothers
Newborns of Non-Depressed Mothers

Fig. 4


Change in HP (Baseline to Cry)
Observed
Linear
.15
.10
.05
.00
-.05
-.10
-.15
2.00
3.00
4.00
5.00
6.00
7.00
Brazelton-motor score

APPENDIX

Behavioral Coding Sheet: Page 1



Newborn Cry scoring sheets **ID #** [redacted]
Date scored [redacted] **Person scoring** [redacted]
Duration of session____________
Beginning state Sleep 1a

[✓ **Newborn cry**] **Digitized Cry (circle one)** **(Tape Order** 1 **)**

Newborn State-coded with computer Observer program (NSxxxx) [redacted]

4:97 **1a Deep sleep/NO movement (with exception of occasional startle):**-regular breathing, eyes closed, no spontaneous activity except an occasional startle or jerky movement. No eye movements.

49.17 **2a Light/drowsy sleep-may observe simple slow movement from arms-eyes mostly Closed.** -eyes closed with brief openings, , possible eye movements under lids, Eyes may occasional open but with fluttering eyelids, activity level variable; reactive but delayed response to sensory stimuli.

1:16 **3a Awake very little visible movement-**eyes mostly open baby awake, **no body movement-no sucking movements-**

35.91 **4a Awake, alert, active** eyes open, no visible signs of distress periodic body movements, periodic eye movement(possible only movement is sucking behavior or sucking on a pacifier)

5a Awake, alert, highly active Awake, showing interest by eye brightning-, alert and reactive, both facial and body movements-important positive affect.

8:29 **6a Awake and low level of agitation (including startles/escape type motor moves/and or Withdrawing(closing eyes with agitated face or body movements)** - eyes open most of the time but may close periodically due to distress, intermittent escape movements may be seen. Multiple combinations of 3 or more startles/tremors where infant doesn't seem to be focused.

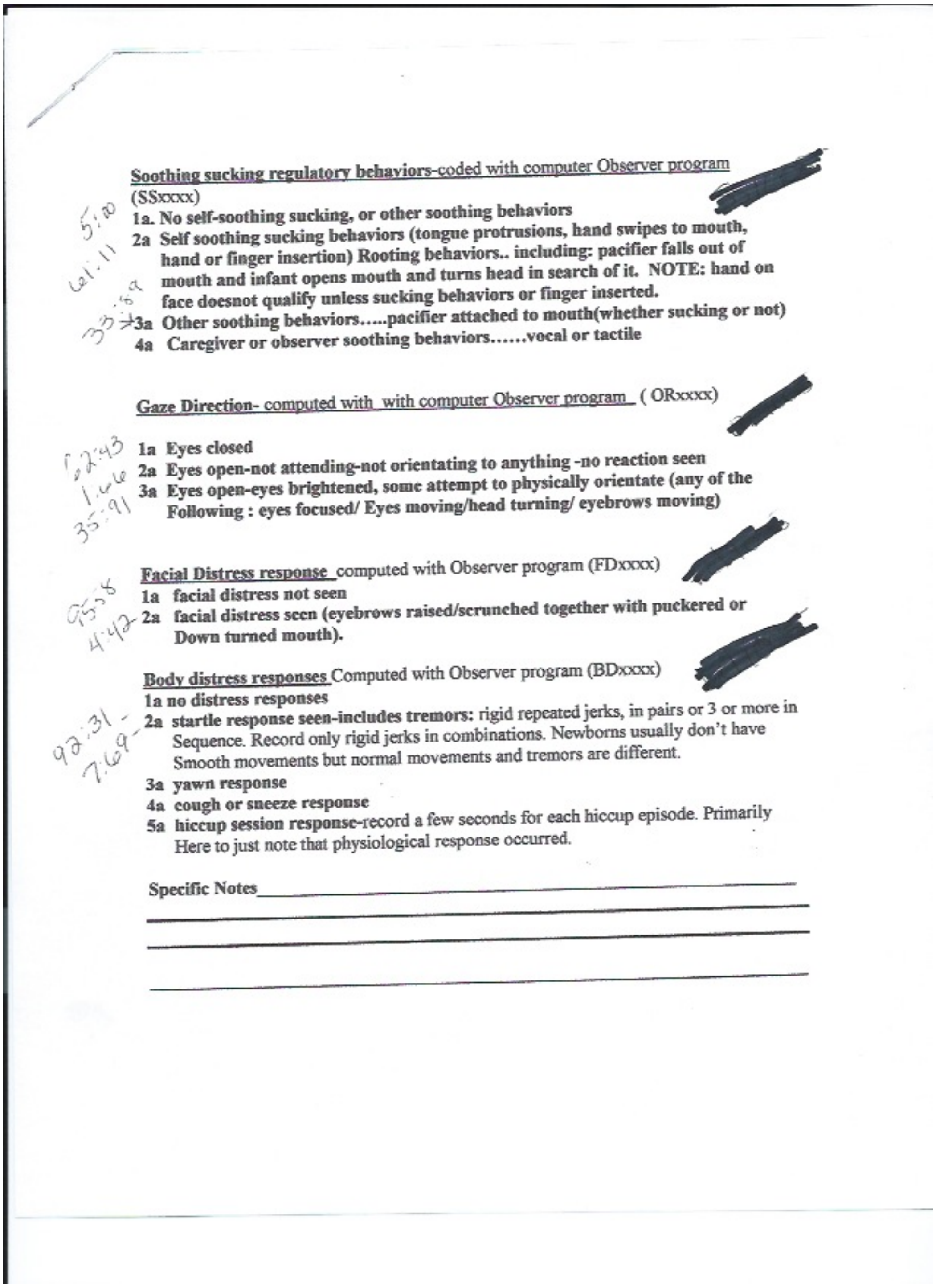
7a Awake, high agitation-eyes mostly closed and shows high level of agitation, not Attending to anything, escape movements may be seen. Head and body movements, Possible combinations of startle/tremor behavior in a multiple and uncontrolled manner./.

Latency to first distress signal (face or [✓ voice]) [redacted]
Latency to first full cry [redacted]

Distress vocalizations-coded with computer Observer program (DSxxxx) [redacted]

37:29 **1a No cry**
2a Fretful cry: intermittent short quick sounds of distress
7:18 **3a Whimper cry:** intermittent long sounds of distress
6:52 **4a Full cry:** continuous cry at somewhat even and moderate volume
5a Scream cry: continuous cry at a higher pitch
6a Hyperventilated cry: continuous cry at higher pitch and with some respiratory interruption.

Behavioral Coding Sheet : Page 2



Soothing sucking regulatory behaviors-coded with computer Observer program [redacted]

(SSxxxx)

5:20 **1a. No self-soothing sucking, or other soothing behaviors**

61:11 **2a Self soothing sucking behaviors (tongue protrusions, hand swipes to mouth, hand or finger insertion) Rooting behaviors.. including: pacifier falls out of mouth and infant opens mouth and turns head in search of it. NOTE: hand on face doesnot qualify unless sucking behaviors or finger inserted.**

33:89 **3a Other soothing behaviors…..pacifier attached to mouth(whether sucking or not)**

4a Caregiver or observer soothing behaviors……vocal or tactile

Gaze Direction- computed with with computer Observer program (ORxxxx) [redacted]

62:43 **1a Eyes closed**

1:66 **2a Eyes open-not attending-not orientating to anything -no reaction seen**

35:91 **3a Eyes open-eyes brightened, some attempt to physically orientate (any of the Following : eyes focused/ Eyes moving/head turning/ eyebrows moving)**

Facial Distress response computed with Observer program (FDxxxx) [redacted]

95:58 **1a facial distress not seen**

4:42 **2a facial distress seen (eyebrows raised/scrunched together with puckered or Down turned mouth).**

Body distress responses Computed with Observer program (BDxxxx) [redacted]

92:31 **1a no distress responses**

7:69 **2a startle response seen-includes tremors:** rigid repeated jerks, in pairs or 3 or more in Sequence. Record only rigid jerks in combinations. Newborns usually don't have Smooth movements but normal movements and tremors are different.

3a yawn response

4a cough or sneeze response

5a hiccup session response-record a few seconds for each hiccup episode. Primarily Here to just note that physiological response occurred.

Specific Notes____

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