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Does Infant Temperament and Parental Involvement Influence Infant Cardiac Physiological Regulation?

Mary Richter
Western Kentucky University, mary.richter15@gmail.com

DOES INFANT TEMPERAMENT AND PARENTAL INVOLVEMENT INFLUENCE INFANT CARDIAC PHYSIOLOGICAL REGULATION?

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Diane M. Lickenbrock, Ph.D.

Digitally signed by Diane M. Lickenbrock, Ph.D.
Date: 2020.04.15 11:40:31 -05'00'

Dr. Diane Lickenbrock, Director of Thesis

Madole, Kelly

Digitally signed by Madole, Kelly
Date: 2020.04.06 11:20:32 -05'00'

Dr. Kelly Madole

Andrew Mienaltowski

Digitally signed by Andrew Mienaltowski
DN: cn=Andrew Mienaltowski, o=Western Kentucky University, ou=Psychological Sciences, email=drmski@wku.edu, c=US
Date: 2020.04.06 12:09:54 -05'00'

Dr. Andrew Mienaltowski

Cheryl D Davis

Digitally signed by Cheryl D Davis
Date: 2020.04.16 08:20:07 -05'00'

Dean, The Graduate School Date

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Mary Richter May 2020 37 pages

Directed by: Diane Lickenbrock, Kelly Madole, and Andrew Mienaltowski

Department of Psychological Science Western Kentucky University

The ability to self-regulate allows infants to stay at a baseline level during periods of stress (Porges, 1995). Baseline respiratory sinus arrhythmia (RSA) may be used as an indicator of self-regulation and how well an individual can respond to changes in the environment (Stifter & Corey, 2001). Differences in infant temperament can influence a child's ability to self-regulate (Dale et al., 2011), but moderators of this relationship have not been thoroughly examined in the literature. Parents who are more involved might have more opportunities to teach children important regulatory strategies (Blandon et al., 2010). The current study examined the association between parental involvement, infant temperament, and infant baseline RSA with mothers and fathers. Infant temperament and parental involvement were measured via parent-report when infants were 4 months old, and baseline RSA was measured at 8 months of age. Multiple regression analyses were used to test whether parental involvement acted as a moderator and whether there were differences between mother-infant and father-infant dyads.

Findings revealed differences in mother versus father predictors of infant baseline RSA. For mothers, a significant Infant Surgency X Maternal Play interaction was revealed; such that infants of mothers who were low involvement increased in their baseline RSA as their surgency increased. For fathers, a significant main effect of father care was found such that infants with highly involved fathers had higher baseline RSA. In

conclusion, parents may influence their child's ability to self-regulate based on their level of involvement. Findings have important implications for parenting interventions.

Introduction

The ability to self-regulate, or competency to voluntarily initiate and suppress behaviors and emotions in order to control reactions (Eisenberg, Hofer, Sulik, & Spinrad, 2013), is a vital tool that allows an infant to stay at a baseline level during periods of stress (Porges, 1995). The greater the ability to self-regulate, the better social and emotional outcomes an infant will have (Smith, Hastings, Henderson, & Rubin, 2019). Self-regulation may be measured in multiple ways, including physiological regulation (Smith et al., 2019). As an infant undergoes changes in his or her level of environmental stress, his or her heart rate changes in response to this stress (Porges, 2007). However, individual differences in temperament are an important factor to consider when evaluating how effectively a child can self-regulate (Dale, O'Hara, Schein, Inserra, Keen, & Flores, 2011). An infant's temperament may dictate how he/she behaviorally, emotionally, cognitively, and physiologically responds to his/her environment (Shiner et al., 2012). In addition, parents may display important regulation strategies that children observe and model (Blandon, Calkins, Keane, & O'Brien, 2010). The current study examined how infant temperament and parental involvement influence infant cardiac physiological regulation.

Cardiac Physiology

One method of measuring and assessing self-regulation is by evaluating aspects of physiological regulation. This type of self-regulation is related to the parasympathetic nervous system, which is the division of the human nervous system that acts to calm the body down after a stress response or keeps the body at a baseline level (Porges, 1995). The parasympathetic nervous system acts on the heart by decreasing heart rate after a

threat has been encountered. As threats increase, this control over the heart decreases. In other words, the parasympathetic nervous system's control over the heart can be thought of as a brake that gets released when a threat is encountered. This brake remains released as additional threats are encountered (Porges, 2007).

One way to assess the effects of the parasympathetic nervous system is through respiratory sinus arrhythmia (RSA), which measures the variability in a person's heart rate as it corresponds to the respiratory cycle (Porges, 2007). When the parasympathetic nervous system exerts a strong brake on heart rate, RSA is high; when the brake is weak, RSA is low (Porges, 2007). Baseline RSA describes the potential of an individual to respond to changes in the environment and is often seen as a trait-like entity (Stifter & Corey, 2001). Higher levels of baseline, or resting, RSA typically are associated with approach behavior and positive outcomes such as better attentional control, positive expressions of emotion, the ability to moderate negative moods (Healy, 2013), better emotional regulation, and higher social competence (Li, Deater-Deckard, Calkins, & Bell, 2017). One study showed that children with higher baseline RSA levels were at a lower risk for developing internalizing and externalizing problems when exposed to negative family environments, such as an environment with a high level of marital conflict (El-Sheikh, Harger, & Whitson, 2003). Thus, high baseline RSA may act as a protective factor (Viana, Palmer, Zvolensky, Alfano, Dixon, & Raines, 2017).

In contrast, low baseline RSA has been linked to aggressive behavior across age groups (Li et al., 2017), weaker emotional regulation, and more extreme emotional reactions (Buss, Goldsmith, & Davidson, 2005). Children with low baseline RSA are extremely attentive to their environments and are often overly vigilant for potential

threats (Viana et al., 2017). In addition, they may cope less effectively with actual problems that arise in their environments resulting in higher anxiety (Healy, 2013; Viana et al., 2017). Schmitz, Kramer, Tuschen-Caffier, Heinrichs, and Blechert (2011) found that children ages 8-12 years who showed symptoms of social anxiety disorder had lower RSA than children in a control group (Healy, 2013). Thus, low baseline RSA may act as a risk factor (Viana et al., 2017).

Compared to the adult nervous system, the infant nervous system is immature and still developing. Infant heart rate is often higher, there is less heart rate variability, and RSA is typically lower in young infants than adults (Porter & Dyer, 2017). As the nervous system develops, RSA values approach adult levels with developmental stability often seen between the ages of 3 and 6 months of age (Porter & Dyer, 2017). The maturation of the parasympathetic nervous system is closely linked to infants' abilities to regulate their states and emotions (Blandon et al., 2010) and subsequent positive developmental outcomes, such as better academic and social skills (Buss, Davis, Ram, & Coccia, 2018). Even though the infant physiological system is still developing, it is important to study RSA in infants to gain an understanding of how different factors may affect physiological functioning in infants (Burgess, Marshall, Rubin, & Fox, 2003) and subsequent child outcomes.

Infant Temperament

Individual differences in temperament might influence a child's ability to self-regulate, including physiological regulation (Dale et al., 2011). *Temperament* has been defined as relatively stable characteristics of an individual that arise early in life and contribute to affectivity, activity level, self-regulation, and attention (Shiner et al., 2012).

Though it was once believed that temperament was stable across the lifespan, later research showed that as biological systems mature, and new skills are acquired to inhibit behavior, the expression of an infant's affect and his or her emotional reactivity may change (Rothbart, 2011). Evidence also shows that the environment is influential on temperament. Therefore, both biological and environmental factors affect an individual's temperament throughout the lifespan (Rothbart, 2011).

One component of temperament is surgency, which describes how likely a child is to experience high levels of positive emotionality and actively engages with and explores his or her environment (Blandon et al., 2010). Children who are rated high in surgency often display characteristics such as high activity level, tendency to approach novel items, and positive affect (Hong et al., 2015). These children often prefer to engage with toys that provide high-intensity pleasure, such as toys that light up or make noise, and they are generally social and may be highly vocal (Putnam, Rothbart, & Gartstein, 2008).

Studies have found both positive and negative developmental outcomes related to children high in surgency (Blandon et al., 2010). The ability to actively engage the environment as well as the tendency towards positive affect may be beneficial developmentally; however, the tendency to approach novel items has been linked to frustration and aggression particularly when children's goals are blocked (Blandon et al., 2010). In addition, evidence has shown a link between surgency and self-regulation. Infants who display greater approach tendencies and higher levels of positive affect are more likely to have a lower inhibitory control later in life (Blandon et al., 2010). This is related to the fact that children rated high in surgency are also rated high in impulsivity (Putnam et al., 2008). If children cannot regulate their high approach tendencies and

high-intensity positive emotions, they may be at risk for disruptions in social interactions and behavior problems (Blandon et al., 2010). These children may also be at risk for internalizing and externalizing symptoms (Stifter, Putnam, & Jahromi, 2008).

In contrast to children high in surgency, children low in surgency display low approach tendencies to novel items and people. Rather, they are extremely cautious around new people and events and may even be apprehensive (Bassett, Denham, Fettig, Curby, Mohtasham, & Austin, 2017) which can lead to the development of anxiety particularly in social contexts (Hipson & Sequin, 2015). Children low in surgency are shy, socially withdrawn, and tend to observe new people from a distance (Bassett et al., 2017). Developmentally, these can lead to overly vigilant behaviors and a heightened responsivity to socializers' behaviors (Bassett et al., 2017). They may also be at a higher risk for internalizing problems (Dollar & Stifter, 2012).

Temperament is an important factor to assess because it might be associated with an individual's physiological functioning, such as RSA (Li et al., 2017). However, research is greatly lacking in this area (Blandon et al., 2010). One study found that higher levels of surgency were associated with greater baseline RSA at age 7 years (Blandon et al., 2010). Research has found that surgency early in life interacted with RSA to predict surgency several years later (Blandon et al., 2010; Li et al., 2017). For children with large increases in baseline RSA across time points, surgency was highly stable. On the other hand, for children with small increases or decreases in baseline RSA, surgency was only moderately stable (Li et al., 2017). In addition, children who were high in baseline RSA at two years of age were more likely to have high levels of surgency at seven years old (Blandon et al., 2010). Therefore, this research suggests that there is a link between

temperament and cardiac physiology in young children (Li et al., 2017). However, more research needs to be done on potential mediators and moderators of this relationship, which the current study attempted to examine.

Parental Involvement

Parental involvement is essential for infant development with greater levels of parental involvement leading to increased positive child socioemotional and cognitive outcomes (Pleck, 2010). For example, children with more highly involved parents tend to have an internal locus of control later in life and perform better academically (Williams & Radin, 1999). Furthermore, early involvement may influence later parent-child relationships, including attachment (Lickenbrock & Braungart-Rieker, 2015; Planalp, Braungart-Rieker, Lickenbrock, & Zentall, 2013), as well as a child's ability to self-regulate (Blandon et al., 2010). Young children's ability to regulate their reactivity levels during challenging situations may be influenced by their parents displaying regulatory strategies that infants learn through observation (Blandon et al., 2010). Morris, Criss, Silk, and Houltberg (2017) found that children learn emotional strategy use by modeling parental behaviors. Studying how child temperament and parent involvement contribute to changes in an infant's self-regulatory ability may give insight into factors that may aid or inhibit an individual's proper development (Blandon et al., 2010).

Although mothers and fathers each contribute to a child's development in important ways, mothers and fathers interact differently with children (Lickenbrock & Braungart-Rieker, 2015; Planalp et al., 2013). Mothers are more likely to engage in caregiving activities, such as feeding and bathing, whereas fathers are more likely to engage in play activities, such as rough-and-tumble activities (Lewis & Lamb, 2003).

Research has suggested that father's rough-and-tumble play styles may contribute to a healthy development of emotion regulation in young infants (Pleck, 2007). On the other hand, because the types of activities fathers engage in typically require greater motor skills, fathers tend to be more involved with older children (Mehall, Sprinrad, Eisenberg, & Gaertner, 2009). Due to this difference in parental involvement types between the two parents, both mothers and fathers will be examined in the current study to see if there are any contrasting results.

Despite these known differences in mother and father involvement, the examination of how each parent's involvement interacts with infant surgency to produce different child outcomes has not been well studied (Blandon et al., 2010). Therefore, the current study bridged this gap in the literature by looking at the interaction between infant surgency and parental involvement and how that interaction affects infant cardiac physiological regulation with mothers and fathers.

Current Study

The current study evaluated the relationship between infant temperament and parent involvement and its impact on infant physiological regulation. Temperament has been identified as an important influence on the ability to self-regulate (Dale et al., 2011), including physiological regulation such as RSA (Li et al., 2017). Of all the factors of temperament, surgency has been one of the least studied (Blandon et al., 2010). Although temperament has been linked to RSA (Blandon et al., 2010; Li et al., 2017), moderators of this relationship have not been highly examined. This study attempted to remedy that gap by examining parental involvement as a potential moderator. Parental involvement has also been linked to infant regulation ability (Blandon et al., 2010). However, fathers

have been underrepresented in parenting research (Doyle, Weller, Daniel, Mayfield, & Goldston, 2016), therefore the present study included both maternal and paternal involvement to examine potential differences in infant regulation ability in mother-infant and father infant dyads (Blandon et al., 2010). Research evaluating factors that may influence infant regulation is vital due to the positive outcomes, including social and emotional outcomes, which have been associated with greater self-regulation (Smith et al., 2019).

In the current study, the relationship between infant temperament and parental involvement on infant cardiac physiological regulation was examined in mother-infant and father-infant dyads when infants were 4 and 8 months of age. These ages were chosen because they are some of the earliest known ages at which RSA can be measured accurately in infants due to their developing cardiac systems (Porter & Dyer, 2017). To control for the natural development of the cardiac system in infants, RSA was measured at the 8-month time point while controlling for RSA at 4 months. Overall, there were 2 hypotheses for the current study, please see them outlined below.

Hypothesis 1: Parental involvement as a Moderator. The first hypothesis was that parental involvement would act as a moderator between infant surgency and infant RSA baseline at 8 months (See Figure 1 for expected results). This is based on the suggestion that infants learn control strategies from their parents (Blandon et al., 2010; Morris et al., 2017).

Hypothesis 1A. First, it was expected that infants who are high in surgency and have parents high in parental involvement at 4 months would show high baseline RSA at 8 months of age. High baseline RSA would suggest that children are better able to

regulate themselves, which would be expected in parents who are highly involved and around their infant more to demonstrate these control strategies (Blandon et al., 2010).

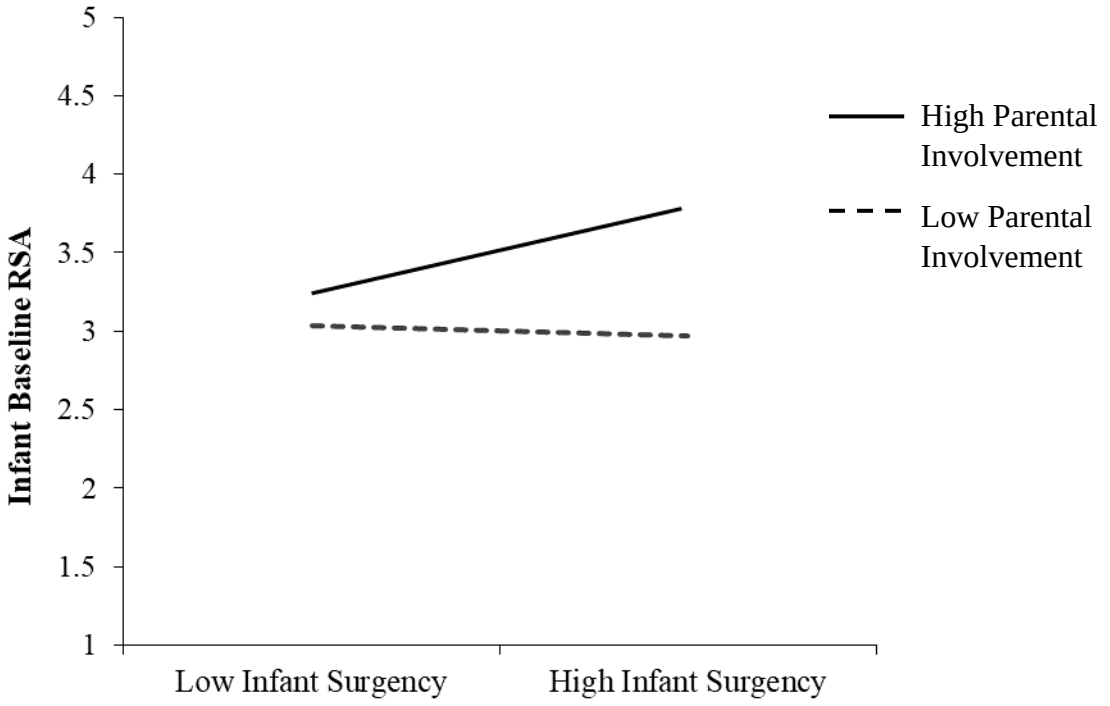

Figure 1. Graph of parental involvement by infant surgency

Hypothesis 1B. Second, it was predicted that infants who are high in surgency and parents are low in parental involvement at 4 months would have lower baseline RSA at 8 months of age. Because the parents are not involved and around their infants as much, those infants do not have as many chances to learn regulatory strategies from their parents (Blandon et al., 2010). Thus, their baseline RSA would remain lower.

Hypothesis 1C. Similar to Hypothesis 1A, it was predicted that infants who are low in surgency and have parents who are high in parental involvement at 4 months would show a high baseline RSA at 8 months of age. Due to the fact that their parents are

highly involved, these infants were expected to have an increased opportunity for potentially learning regulatory strategies from mothers and fathers (Blandon et al., 2010). However, because they are lower in surgency, they are most likely already better at self-regulation compared to infants higher in surgency. Therefore, children low in surgency will show less of an effect with parental involvement than infants high in surgency.

Hypothesis 1D. Fourth, it was predicted that infants who are low in surgency and have parents who are low in parental involvement at 4 months would show a lower baseline RSA. Due to the fact that the parents are not as involved, these children would not have many opportunities for learning regulatory strategies that would increase baseline RSA (Blandon et al., 2010).

Hypothesis 2: Parent Differences. The second hypothesis is that there would be differences in the expected results with maternal involvement and paternal involvement. Mothers and fathers interact differently with children (Lickenbrock & Braungart-Rieker, 2015; Planalp et al., 2013), and fathers typically do not become highly involved until children are older (Mehall, Sprinrad, Eisenberg, & Gaertner, 2009). Therefore, due to these differences in maternal and paternal involvement, the moderation effect of parental involvement on surgency and infant cardiac physiological regulation may be different between the two parents. However, this hypothesis was exploratory.

Method

Participants

Families were recruited as part of a larger longitudinal study involving 4, 6, and 8-month-old infants with a sample size of 91 families (mother, father, infant). The majority of infants were male (59.3%). Only data from the 4 and 8-month visits were

used in this study. The study occurred at a large state university campus located in a mid-sized, Southeastern city. Recruitment occurs through flyers, tabling at family events, and through mailing letters to families who publish their birth announcements in the local newspaper. The larger longitudinal study has received Institutional Review Board approval (See Appendix A). All families who participated received $20 in compensation at each visit.

To be included in this study, infants met the age criteria of 4, 6, and 8 months (+/- 14 days). Both parents were able to participate in the study at all time points, and they both must read and understand English. The mother must have had a healthy pregnancy and delivery with no birth complications, and the infant must have been full-term (gestational age ≥ 37 weeks; birth weight ≥ 5.5lbs). In addition, the family did not plan to move out of the area in the next six months.

The majority of parents were European American (mothers: 91.2%; fathers: 89%). Mothers were on average 30.44 years of age (*SD* = 5.26; range = 19 to 44). Fathers were on average 32.14 years of age (*SD* = 6.35; range = 19 to 55). The majority of parents (95.7% of mothers and 86.9% of fathers) reported finishing at least some college. The distribution of the remaining education levels completed are as follows: 3.3% of fathers completed some high school, 3.3% of mothers and 8.8% of fathers completed high school, and 1.1% of mothers and 1.1% of fathers completed trade school. The majority of parents worked a full-time job (51.6% of mothers and 86.8% of fathers). The distribution of the remaining employment levels are as follows: 15.4% of mothers and 6.6% of fathers worked part-time, 24.2% of mothers and 3.3% of fathers were unemployed, and 7.7% of mothers and 3.3% of fathers reported other employment circumstances. The majority of

families were middle class (62.7% reported an income of $45,000-$104,999). The distribution of the remaining income levels is as follows: 4.4% reported less than $15,000, 6.6% reported $15,000-$29,999, 11% reported $30,000-$44,999, 6.6% reported $105,000-$119,999, 8.8% reported an income greater than $120,000. The living arrangement of families were as follows: 91.2% married and living together, 7.7% unmarried and living together, and 1.1% of families were single.

Attrition was moderate (24.2%) from the first time point (4 months) to the last time point (8 months). Statistical comparisons between the families that had complete data (n = 69) from the total sample (n = 91) along different demographic variables revealed no significant differences between the families that had complete data and the families who dropped out of the study.

Procedure

Informed consent was obtained at the commencement of the first visit with both parent signing the consent forms and one parent provided consent for the infant to participate. Prior to each lab visit, mothers and fathers were mailed a packet of questionnaires assessing infant temperament and parental involvement that they were told to complete and bring with them to each laboratory visit. In addition, at the beginning of each laboratory visit, mothers and fathers answered questions related to demographic information. During the laboratory visit, mothers and fathers also completed another packet of questionnaires that further assess parental involvement. Each laboratory visit lasted two hours on average, which is typical with infant studies considering infants may need to take breaks for feedings and diaper changes.

Mothers and fathers individually completed the Still-Face Paradigm (SFP; Tronick, Als, Adamson, Wise, & Brazelton, 1978) with his/her child, and the parent that went first with his/her infant will be randomly assigned. Cardiac data was obtained from the mother, father, and infant during this procedure using an impedance monitor (Mindware Technologies, Gahanna, OH). This monitor measures heart period and impedance. Seven electrodes were placed on the mother, father, and infant. Two electrodes were placed on the right and left side clavicle, one electrode was placed in the middle of the torso by the diaphragm, two were placed above each hip bone, and two were placed on the back of the body by the neck and small of the back. The first parent entered the observation room with his/her infant and was instructed by the primary experimenter to be seated and to place the infant on his/her lap, and the primary experimenter left the room. A three-minute cardiac physiology reading was taken. The experimenter watched in a separate room through a one-way mirror with the secondary experimenter.

Immediately following the baseline measurement, the primary experimenter returned, helped place the infant in a highchair facing the parent, provided instructions for the SFP and then left the room. A cheat sheet was on the wall for parents to refer to should they forget the experimenter's instructions. The SFP consists of three episodes: play, still-face, and reunion that each last 90-seconds. An electronic doorbell signaled the beginning of each episode. For the play episode, the parent freely interacted with the child without toys. For the still-face episode, the parent sat back and looked at the child with a blank face. No interaction with the child occurred during this time. For the reunion episode, the parent interacted with the child again. A doorbell rang at the end of the

reunion episode signaling the end of the SFP. Immediately following the SFP, the primary experimenter returned to the room and instructed the parent that he or she may take his orher child out of the highchair and place him or her back in the parent's lap for another three-minute baseline (recovery) measurement. During this period, the parent held the child quietly in their lap for another 120 seconds. After the first series of baseline, SFP, and recovery tasks were completed and the infant was in a calm/neutral state, the second parent repeated the same series with the infant.

Measures

Infant Behavior Questionnaire- Revised (IBQ-R; Gartstein & Rothbart, 2003). The IBQ-R was used to assess infant temperament. Both mothers and fathers independently completed this assessment, which consists of 191 items focusing on the emotional and behavioral responses of infants to different situations. In total, 14 dimensions of infant temperament are assessed (Perry, Dollar, Calkins, & Bell, 2018) including approach, vocal reactivity, high intensity pleasure, smile and laughter, activity level, perceptual sensitivity, sadness, distress to limitations, fear, falling reactivity, low intensity pleasure, cuddliness, duration of orienting, and soothability. Responses were recorded on a 7-point Likert scale ranging from 1 (*never*) to 7 (*always*) with an eighth option for *does not apply*. An example of a question on the survey would be "*When introduced to an unfamiliar adult, how often did the baby cling to the parent"*. The scales on the IBQ-R measure three different dimensions of temperament: negative affectivity, surgency, and effortful control (Li et al., 2017). The dimensions of activity level, high-intensity pleasure, perceptual sensitivity, positive anticipation, smiling and laughter, and vocal reactivity all fall under the factor of surgency. Falling reactivity, fear, distress to

limitations, and sadness correspond to the factor of negative affectivity. The dimensions correlated with orienting include duration of orienting, low-intensity pleasure, cuddliness, and soothability (Putnam, Rothbart, & Garstein, 2008). Since its development, the IBQ-R has demonstrated reliability and validity, which is supported by the results from numerous research studies (Bridgett, Gartstein, Putnam, McKay, Iddins, Robertson, Ramsay, & Rittmueller, 2009). For the current study, only the infant surgency factor score was used (Mother-report $\alpha = .73$; Father-report $\alpha = .75$). Mother- and father-report of infant surgency was moderately correlated ($r = .30$, $p < .05$), therefore, the scores were averaged. Another study found that mother and father reports of temperament were also moderately correlated and averaged the scores together to create a more comprehensive measure of temperament (Jessee, Mangelsdorf, Shigeto, & Wong, 2011). Higher scores mean higher infant surgency.

What I Did With My Baby Checklist (Lickenbrock & Braungart-Rieker, 2015; Planalp, Braungart-Rieker, Lickenbrock, & Zentall, 2013). Parental involvement was measured using a diary-like checklist known as the What I Did With My Baby Today Checklist. This self-report questionnaire was completed by each parent to measure parental involvement. The survey assesses the amount of time each parent was available, playing with, or otherwise caring for their infant within a 24-hour period. Fathers and mothers chose a day that reflected their typical schedule/routine and checked off different childcare and play/interaction events with their infant. Two sets of behaviors were included in this checklist, care (six items) and play (four items). The care items included changing diapers, feeding, bathing, soothing, and waking up for the infant at night. The play items included active or calm playing, teaching, and going on outings. Proportion

scores were created for each set of behaviors (care/play) separately for mothers and fathers. Higher proportion scores indicate more care or play behaviors. Reliability scores cannot be calculated since this is a checklist and not all items are checked by each parent (Planalp et al., 2013).

Infant Cardiac Physiology. Respiratory sinus arrhythmia (RSA) was measured using electrocardiography data during the baseline. Trained research assistants manually inspected the data files for artifacts using MindWare Heart Rate Variability (HRV version 3.0.25) software (Buss et al., 2018). This software calculated RSA values for each of the six 30-second segments. Those values were averaged over the six segments to get one RSA value per infant.

Coders were trained to edit HRV data files until they achieved sufficient reliability (interclass correlations (ICCs) ≥ .80). To avoid bias, coders were not allowed to edit infant data from both parents in one age group. Coders overlapped by coding 28% of the overall 4 month data and 30% of the 8 month data. Average ICC was .97 for 4 month infant baseline RSA with mothers, .98 for 4 month infant baseline RSA with fathers, .98 for 8 month infant baseline RSA with mothers, and .97 for infant baseline RSA with fathers. Baseline RSA values were highly correlated between mothers and fathers at both the 4-month ($r = .57$, $p < .05$) and 8-month ($r = .64$, $p < .05$) time points, therefore the infant's baseline scores with mothers and fathers were averaged. Higher baseline scores indicate a stronger capacity to respond to the environment when environmental challenges are encountered.

Results

Results are presented in two sections. The first section details descriptive statistics and preliminary analyses (zero-order correlations, tests for covariates, etc.). The second

section describes the results from the first hypothesis, which examined whether parental involvement acted as a moderator between infant temperament and infant baseline RSA. This section also covers differences seen between maternal and paternal results (Hypothesis 2).

Descriptive Statistics and Preliminary Analyses

Means, standard deviations, skewness, and kurtosis of the study variables are presented in Table 1. All variables were normally distributed. Analyses between the study variables and infant gender, parent age, parent ethnicity, parity, parent order, family income, and marital status resulted in no consistent patterns of significant findings. Therefore, no covariates were included in subsequent analyses.

Table 1.

Descriptive Statistics

	n	Min	Max	*M*	*SD*	Skewness	Kurtosis
Surgency	84	3.15	5.55	4.18	.53	.14	-.21
Father Care	81	.00	1.00	.52	.19	-.45	.41
Father Play	82	.00	1.00	.55	.27	-.31	-.55
Mother Care	83	.33	1.00	.72	.14	-.09	-.29
Mother Play	83	.25	1.00	.70	.21	-.08	-.80
Infant RSA4	81	.50	4.98	3.06	.90	-.48	.55
Infant RSA8	63	1.91	5.70	3.57	.77	.29	.19

Note: Surgency: Infant Surgency at 4 months Averaged Across Mothers and Fathers; Father Care: Father Care at 4 months ; Father Play: Father Play at 4 months; Mother Care: Mother Care at 4 months; MotherPlay: Mother Play at 4 months; Infant RSA4: Infant Baseline RSA at 4-Months Averaged Across Mothers and Fathers; Infant RSA8: Infant Baseline RSA at 8-Months Averaged Across Mothers and Fathers

Zero-order correlations among variables are presented in Table 2. Father care involvement at 4-months was significantly correlated with infant baseline RSA at 8-months with more highly involved fathers having infants with higher baseline RSA. Correlations for mother measures were non-significant.

Paired t-tests revealed differences between maternal and paternal involvement for both play and care. Mothers were involved more in play activities compared to fathers (t (80) = -4.00; p <.05; Mother Play: M = .69, SD = .21; Father Play: M = .55, SD = .27. Mothers were also more involved in care activities compared to fathers (t (80) = -7.91; p < .05; Mother Care: M = .72, SD = .15; Father Care: M = .52, SD = .19).

Table 2.

Correlations Among Variables

	1.	2.	3.	4.	5.	6.	7.
1. Surgency	1.00	.08	.21	.12	.14	-.05	.17
2. Father Care	.08	1.00	.29**	.08	.02	.03	.32*
3. Father Play	.21	.29**	1.00	.13	.12	.22	.01
4. Mother Care	.12	.08	.13	1.00	.20	.13	-.02
5. Mother Play	.14	.02	.13	.20	1.00	.08	-.14
6. Infant RSA4	-.05	.03	.22	.13	.08	1.00	.12
7. Infant RSA8	.17	.32*	.01	-.02	-.14	.12	1.00

Note: Surgency: Infant Surgency at 4 months Averaged Across Mothers and Fathers; Father Care: Father Care at 4 months; Father Play: Father Play at 4 months; Mother Care: Mother Care at 4 months; Mother Play: Mother Play at 4 months; Infant RSA4: Infant Baseline RSA at 4 months Averaged Across Mothers and Fathers; Infant RSA8: Infant Baseline RSA at 8 months Averaged Across Mothers and Fathers; *p < .05, **p < .01

Parental Involvement as a Moderator

The first hypothesis states that parental involvement would act as a moderator between infant temperament and infant physiological regulation. To test this hypothesis, a hierarchical multiple regression model was conducted with infant surgency and parental involvement at 4 months as the predictors and infant baseline RSA at 8-months as the outcome. Baseline RSA at 4 months was entered as a covariate. Due to a small sample size, mother and father analyses were kept separate, which is similar to previous studies with comparable sample sizes (Lickenbrock & Braungart-Rieker, 2015; Jessee et al., 2011). The first step included the main effects of infant surgency, parental involvement (mother involvement, father involvement), and baseline RSA at 4-months. The second

step included the main effects and the 2-way interactions between infant surgency and parental involvement (surgency X maternal involvement, surgency X paternal involvement). The variables were mean centered to help with interpreting results, and any significant interactions were examined one standard deviation above and below the mean (Aiken & West, 1991).

Table 3.

Infant Surgency and Maternal Involvement at 4-months Predicting Infant Baseline RSA at 8-months

Model	Variables	Mothers: 4 Months→8 Months				
Play		*B(SE)*	*df*	*F*	R^2	ΔR^2
I.			3	.18	.09	
	Surgency	.36 (.20)				
	Mother Play	-.69 (.48)				
	Infant RSA4	.17 (.13)				
II.			4	2.93*	.19	.09
	Surgency	.38 (.19)				
	Mother Play	- .68 (.46)				
	Infant RSA4	.16 (.12)				
	Surg. X M. Play	-1.95 (.81)**				
Care						
I.			3	1.08	.06	
	Surgency	.31 (.20)				
	Mother Care	-.21 (.77)				
	Infant RSA4	.14 (.13)				
II.			4	.88	.06	.01
	Surgency	.31 (.21)				
	Mother Care	-.30 (.79)				
	Infant RSA4	.13 (.13)				
	Surg. X M. Care	-.84 (1.51)				

Notes: Surgency: Infant Surgency at 4 months Averaged Across Mothers and Fathers; Mother Care: Mother Care at 4 months; Mother Play: Mother Play at 4 months; Infant RSA4: Infant Baseline RSA at 4-Months Averaged Across Mothers and Fathers; *$p < .05$, **$p < .01$

The second hypothesis states that there would be differences in the effect of parental involvement on infant temperament between maternal and paternal involvement.

This hypothesis was tested by running separate multiple regression models for maternal versus paternal data.

Infant Surgency - Maternal Involvement. As can be seen in Table 3, results from the first step testing for main effects of infant surgency and mother play involvement were non-significant. The second step that included the two-way interaction resulted in a significant two-way interaction between infant surgency and mother play involvement (See Figure 1), 95% CI [-3.57, -.33].

Simple slopes analyses were run to probe this interaction one standard deviation above and below the mean and revealed a significant effect for mothers who were low in play involvement. More specifically, results revealed that infants who were high in surgency and had mothers low in play involvement had higher baseline RSA at 8-months (*B*= .81, *SE*= .27, $p < .01$) than those low in surgency. No significant main effects or interactions were found with mother care involvement.

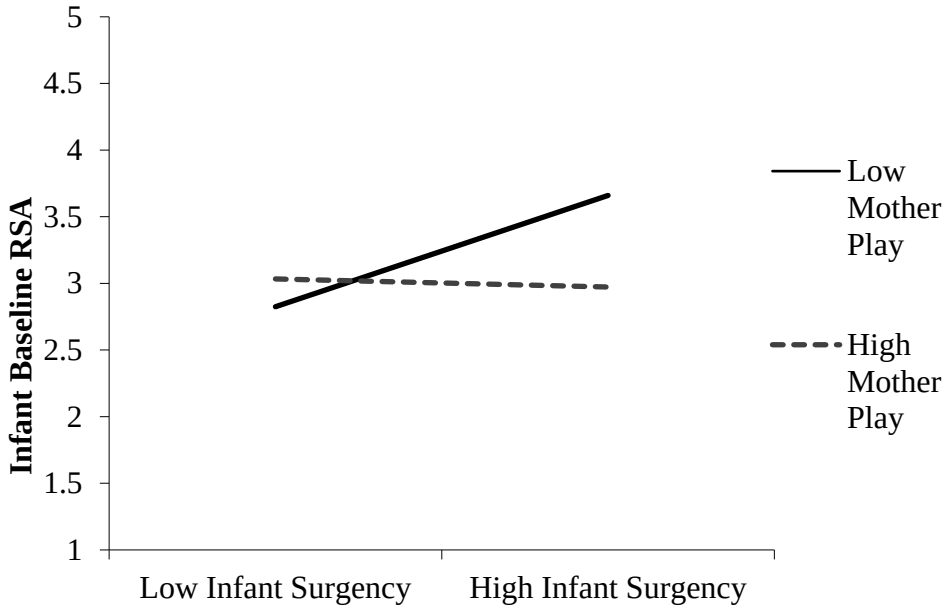

Figure 2. Graph of mother play involvement by infant surgency interaction.

Infant Surgency – Paternal Involvement. As can be seen in Table 4, the test of infant surgency and father care involvement revealed a significant main effect of father care involvement such that fathers who were higher in care involvement had infants who had higher baseline RSA. The second step revealed only the same significant main effect of father care involvement (95% CI [.10, 2.23]). No other significant effects were found for father involvement.

Table 4.

Infant Surgency and Paternal Involvement at 4-months Predicting Infant Baseline RSA at 8-months

Model	Variables	Fathers: 4 Months→8 Months				
Play		*B(SE)*	*df*	*F*	R^2	ΔR^2
I.			3	.98	.06	
	Surgency	.32 (.21)				
	Father Play	-.20 (.39)				
	Infant RSA4	.14 (.13)				
II.			4	.73	.06	.00
	Surgency	.32 (.21)				
	Father Play	-.21 (.41)				
	Infant RSA4	.14 (.15)				
	Surg. X F. Play	-.08 (.82)				
Care						
I.			3	2.62	.13	
	Surgency	.23 (.19)				
	Father Care	1.20 (.54)*				
	Infant RSA4	.09 (.12)				
II.			4	2.70*	.18	.04
	Surency	.24 (.19)				
	Father Care	1.16 (.53)*				
	Infant RSA4	.10 (.12)				
	Surg. X F. Care	-1.82 (1.12)				

Notes: Surgency: Infant Surgency at 4 months Averaged Across Mothers and Fathers; Father Care: Father Care at 4 months; Father Play: Father Play at 4 months; Infant RSA4: Infant Baseline RSA at 4-Months Averaged Across Mothers and Fathers; *$p < .05$, **$p < .01$

Discussion

The current study sought to examine how infant temperament and parental involvement influence infant cardiac physiological regulation. This study is unique in that it examines the role of both mothers and fathers in developmental literature. Most studies just examine the maternal role, and a general lack of paternal presence in the infant development literature (Lewis & Lamb, 2003). In addition, there is a lack of studies regarding surgency in infant temperament literature (Blandon et al., 2010) so this study attempted to fill that gap. Hierarchical multiple regression analyses were conducted to test the hypotheses that parental involvement would act as a moderator between infant temperament and infant baseline RSA and that there would be differences seen between maternal and paternal involvement. A significant interaction was found between infant surgency and maternal play involvement such that infants who were higher in surgency and had mothers who were low in play involvement had higher baseline RSA. A significant main effect was found for paternal care involvement such that fathers who were higher in care involvement had infants with higher baseline RSA.

RSA Correlation

One particularly interesting finding regarding the correlations is lack of a significant correlation between baseline RSA at 4 months and baseline RSA at 8 months. A lack of correlation between infant RSA at 4 months and infant RSA at 8 months may be explained by fluctuations in the cardiac system in infants of this age (Porter & Dyer, 2017). Other studies have also found low to moderate correlations between earlier baseline RSA values and later baseline RSA values such that baseline RSA at 5 months was only moderately correlated with baseline RSA at 10 months (r = .30; Perry, Dollar,

Calkins, & Bell, 2018). Yet another study found no correlation between 6 month and 12 month baseline RSA (r = .03; Putnam & Stifter, 2002). Therefore, the lack of a significant correlation between baseline RSA at 4 months and baseline RSA at 8 months has been found in other studies and is to be expected.

Infant Surgency X Maternal Play Interaction

The significant interaction between surgency and maternal play involvement is counter to the study's hypothesis. It was hypothesized that infants who were high in surgency and had mothers who were low in involvement would have lower baseline RSA as these mothers would not have as many opportunities to teach their children important regulatory skills (Blandon et al., 2010). In light of the findings, high surgency in children could act as an enhancing factor when paired with low maternal play involvement as these children had a high potential to respond to changes in the environment, and other groups of children did not. High surgent children are high in activity level and positive affect (Hong et al, 2015), which could mean that they are better able to engage their environments on their own without maternal play support (Blandon et al., 2010).

This finding also supports the differential susceptibility theory (Ellis et al., 2011). This theory states that some individuals are more susceptible than others to both negative as well as positive environments (Ellis et al., 2011). Infants who are high in surgency might react to a low maternal play environment differently than other children. In addition, it may be the case that children who are both very high and very low in surgency react differently to stressful situations than children who have moderate levels of surgency (Blandon et al., 2010). Yet another study found that children who were more emotionally reactive, such as those who are high in surgency, did not seem to be

susceptible to differences in parenting (Slagt et al., 2019). Future research should aim to probe this interaction further and test other temperament factors to see if the response from maternal play involvement is similar or different.

These results are in opposition to a previous study that found that infants who were high in surgency had mothers who played more with them (Planalp et al., 2013). This study also found that infants low in surgency had mothers who exhibited high care involvement, whereas the current study did not find any significant relationship between infant surgency and maternal care. It is interesting to note that both the current study and the Planalp et al. (2013) study used the IBQ-R and the What I Did with My Baby Checklist to measure infant temperament and parental involvement. However, Planalp and colleagues only had mothers report on infant temperament, and the present study had both parents report. In addition, Planalp et al. studied infants from 3 months of age through 20 months of age, whereas the current study only assessed families when infants were 4 and 8 months old. Perhaps important changes occur somewhere between 8 and 20 months. In addition, play was controlled for in care analyses and care was controlled for in play analyses (Planalp et al., 2013), which the current study did not do. Due to these discrepancies, additional studies are needed to examine the interaction between surgency and maternal involvement at different ages.

One shortcoming of the current study is that maternal sensitivity/intrusiveness was not taken into account. These parenting quality components could also interact with temperament to affect infant regulation (Planalp et al., 2013). Sensitivity is a rating of the parent's awareness to the infant's emotions and ability to adapt to changes in the infant's emotions (Lickenbrock & Braungart-Rieker, 2015). Research has shown that mothers

display greater sensitivity to infants who are low in surgency (Planalp et al., 2013). In contrast to sensitivity, intrusiveness is an exertion of control over the infant (Perry et al., 2018). Perhaps no effects were seen with high maternal play involvement because too much play or play that is too intense could become intrusive and prohibit the child from developing a sense of autonomy (Perry et al., 2018). This might lead to aggressive, negative behavior and low baseline RSA in infants (Perry et al., 2018). Future studies should include parental sensitivity and intrusiveness in order to examine how those aspects of parenting may interact with infant temperament to affect infant cardiac physiological regulation.

Main Effect of Paternal Care

The main effect of paternal care on infant cardiac physiological regulation is in agreement with previous studies that have found more highly involved parents have more opportunities to teach their children important regulatory strategies (Blandon et al., 2010). Past research has also highlighted this positive effect of father care. Fathers who are high in care involvement with infants have children who do better in school and are more successful in spousal relationships later in life (Lewis & Lamb, 2003). However, other studies have not found this main effect of paternal care (Planalp et al., 2013). A lack of a significant finding with father play could be because fathers are not typically as involved in play activities until children are older due to the restrictions in infant motor development (Mehall et al., 2009). Future studies should focus more on fine-grained paternal involvement activities. Care and play activities could be broken down further into individual tasks to gauge if there is a specific activity that enhances infant regulatory ability.

It is important to acknowledge that this study is not able to disentangle the extent to which both genetics and environment are associated with infant physiological regulation. Parents with high baseline RSA might also be better caregivers due to their greater ability to respond to potential challenges in the environment (Stifter & Corey, 2001). This physiological advantage might be passed on genetically to their offspring and might explain the main effect seen between paternal care involvement and infant baseline RSA. However, it could also be the case that parenting behaviors serve as a direct environmental influence on infant physiological regulation (Moore, 2009). Future research should account for different environmental factors, such as parent anger (Moore, 2009), that could affect infant physiological regulation.

Limitations, Future Directions, and Implications

This study has several limitations that must be noted. One limitation of this study is the small sample size. Due to the small sample, mother and father involvement data were kept in separate models, and as a result hypothesis two (comparing mothers and fathers results) was not statistically examined. Different patterns in outcomes between parents do not necessarily indicate the ability to make direct comparisons between mothers and fathers. Future studies should aim to have larger sample sizes to increase statistical power. Generalizability of the results is also an issue as the majority of parents were married and living together. This study did not account for differences in involvement levels between single-parent and two-parent households. For fathers who are the primary caregiver, their involvement level may differ considerably from mothers (Lewis et al., 2009).

Even though the study was multi-method due to inclusion of both questionnaires and the laboratory assessment of physiology, response bias when utilizing questionnaires is a potential limitation. It is important to note that the present study had both parents independently rate their infant's temperament, the scores were moderately correlated, and the alphas were acceptable. Future studies could also combine questionnaire data with observational forms of temperament to achieve higher validity in ratings of infant temperament. Parental involvement could also be measured using methods that assess involvement beyond just a one-day rating. Interviews could be conducted from multiple family members about the average involvement of a parent over time (Williams & Radin, 1999). Even though the checklist asked about the hours the parent was available to the infant over the course of the day, it did not ask parents how many times a day they engaged in those specific parenting activities and did not cover the full range of possible care and play activities. Therefore, a more complete, comprehensive measure of parental involvement may be needed in order to more fully access parental involvement.

Researching how infant temperament and parental involvement interact could further understanding of how parents can influence their child's development. Previous research has shown that different temperament styles in infants might require parents to interact with their infants in different ways to best support their infant's temperament style (Planalp et al., 2013). Findings from the current study could inform the development of further interventions with both mothers and fathers that increase their awareness of how not only their actions but also their infant's temperament might affect infant regulation. This study also adds to the literature regarding the link between infant temperament and physiology.

Conclusions

Overall, this study extends the literature on the link between children's temperament and regulation by focusing on the possible moderator of parental involvement. This study showed that infants who are high in surgency and have low maternal play involvement may have an enhanced potential to respond to environmental challenges as they have higher baseline RSA than other groups of children. Also, fathers who engage in more care activities have infants who have a greater potential to respond to challenges in their environments than infants with fathers low in care involvement. Taken together, these results underscore the importance of parental influence on temperament and regulation.

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Appendix A

IRB Approval Form

WESTERN KENTUCKY UNIVERSITY

Institutional Review Board
Continuing Review Report

If this is your third year for your Continuing Review Request, please complete a e
Otherwise; DO NOT include the complete application in describing modifications and requests for additional time to collect data.

Name of Project: The Development of Emotion Regulation Within the Parent-Infant Relationship: Intrinsic and Extrinsic Predictors
Name of Researcher: Diane M. Lickenbrock, Ph.D.
Department: Psychological Sciences

How many total subjects have participated in the study since its inception? # 91

How many subjects have participated in the project since the last review? # 7 new families (7 others finished up study)

Is your data collection with human subjects complete? ☐ **Yes** ☒ **No**

1. Has there been any change in the level of risks to human subjects? (If "Yes", please explain changes on a separate page). ☐ Yes ☒ No

2. Have informed consent procedures changed so as to put subjects above minimal risk? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

3. Have any subjects withdrawn from the research due to adverse events or any unanticipated risks/problems? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

4. Have there been any changes to the source(s) of subjects and the Selection criteria? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

5. Have there been any changes to your research design that were not specified in your application, including the frequency, duration and location of each procedure. (If "Yes", please describe on a separate page). ☐ Yes ☒ No

6. Has there been any change to the way in which confidentiality of the Data is maintained? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

7. Is there desire to extend the time line of the project? ☒ Yes ☐ No
On what date do you anticipate data collection with human subjects to be completed? 10/31/2020

The laboratory location has changed from Gary Ransdell Hall 3064 to Kelly Thompson Hall 4063. The research protocols are the same; it's just that we're now in a new location. Lab phone number is still the same; however PI no longer has phone in office (changed office phone number to lab phone number).

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Approval - 10/23/2019
End Date - 10/23/2020
Full Board
Original - 2/28/2013