SALIVARY α-AMYLASE AND HEART RATE AS MARKERS OF AN INFANT'S EMOTIONAL CONTAGION RESPONSE USING MATERNAL FACTORS AS PREDICTORS

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NOMENCLATURE

HR	Heart rate
sAA	Salivary α-Amylase
BPM	Beats per minute
AAPI-2	Adult and Adolescent Parenting Inventory, Version 2
PSDQ	Parenting Styles and Dimensions Questionnaire
PSI/SF	Parenting Stress Index, Short Form
u/mL	Units per Mililiter
BS	Baseline

CHAPTER I

INTRODUCTION

In the field of psychological research, empathy is a topic that now generates interest, often due to its noted implications for prosocial development – specifically with helping behaviors (e.g., Barnett, Howard, Melton, & Dino, 1982; Moore, 1990; See Appendix A for Supplemental Literature and Theoretical Material). The vast majority of research on empathy, however, has been focused on older children, adolescents, and adults. This makes sense both developmentally and practically, as on one hand, empathy at this point can be studied in its "most developed" form and on the other, research with these populations is often easier than work with toddlers or infants. Even within these later ages, the characteristics and implications of empathy – or its absence – have been examined more thoroughly than its development. However, though at birth we seem to have the potential for empathy, that potential appears in no way a guarantee, and empathy appears to be too important to not examine its early development.

The definition of empathy has changed over time (Cozolino, 2006; Decety & Ickes, 2009; e.g., Kurdek, 1978; e.g., Moore, 1990) and continues to do so. Somewhat regardless of the definition chosen, however, lies the reality that almost every one of the characterizations that have been offered relate specifically to developed empathy because of their reliance on theory of mind, which refers to the ability to recognize that others have mental states that are often different from one's own as well as the ability to attribute those mental states to the appropriate individual (Baron-Cohen, 1991). Thus, a separate definition is needed to define the concept of empathy within infant populations. It is appropriate to note that most researchers do not consider it possible for "true" or "mature" empathy to be developed until egocentrism begins to decline – around the age of 3 years (Piaget, 1951) – and theory of mind begins to develop (Baron-Cohen, 1991). However, the precursors to this more mature empathy are apparent from birth in the ability to mimic (e.g., Sagi & Hoffman, 1976) and a rudimentary version of empathy that frequently involves an *internal* response is arguably present (Ungerer et al., 1990) despite the infant's limited empathic *external* responses. Perhaps, as is often the case in infant development, the developmental "groundwork" for empathy is being laid long before the behavior is fully visible. In light of this general consensus regarding the immaturity of empathy in infants, the term *emotional contagion* will be used in addition to the word *empathy* to reflect the construct in infants, though the terms *mimicry* or *emotional resonance* could also be substituted.

Thompson defines emotional contagion as "the sharing of the same emotion as a consequence of another's emotional display" (1987, p. 125). In infancy, emotional contagion is both sensitive and responsive to emotional cues exhibited by others (Ungerer et al., 1990), but due to the limited cognitive and physical abilities of infants, the external empathic response is also quite limited. For instance, the infant cannot offer aid or verbalize concern. In fact, during the first 6 months of life, the infant is largely unaware of the other's situation or even that there is another "self" involved (Hastings, Zahn-Waxler, & McShane, 2006). Yet, even here the infant is capable of imitating the emotional distress of another individual.

This earliest form of empathy is largely considered to act as a reflex, both automatic and involuntary (Roth-Hanania, Busch-Rossnagel, & Higgins-D'Alessandro, 2000), but to persist past this time in life and into adulthood while other components of empathy are developed (Preston & de Waal, 2002).

CHAPTER II

BRIEF REVIEW OF LITERATURE

Empirical Evidence for Emotional Contagion

Work examining emotional contagion in young infants has relied primarily on the contagious cry paradigm (see Simner, 1971). Such work has shown that infants as young as 18 hours will cry in response to hearing another newborn's cry (Martin & Clark, 1982), thus demonstrating an emotional contagion response. Additionally, while neonates will cry to other infants' cries, it has further been shown that they do not cry as much in response to a white noise recording, a computer synthesized cry (Martin & Clark, 1982; Sagi & Hoffman, 1976; Simner, 1971), or to the sounds of their own cries (e.g., Martin & Clark, 1982; Sagi & Hoffman, 1976; Simner, 1971). In addition to the contagious cry studies, work examining infant emotional contagion has been conducted by examining facial and postural mimicry in infants. For instance, early work by Meltzoff and Moore (1977, 1983) demonstrated that even infants less than 1 hour old are capable of imitating the facial expressions and manual gestures of others. Such findings have shown that this ability to mimic holds true whether the infant is familiar with the other or not (Meltzoff & Moore, 1992). Furthermore, Field, Woodson, Greenberg, and Cohen (1982) expanded on Meltzoff and Moore's (1977) work by demonstrating that infants possess the ability to distinguish between and imitate happy, sad, and surprised faces within only hours of birth. Data here showed that infants were able to discriminate among all three expressions and coded facial expressions of the infants showed their ability to imitate all three expressions displayed by the model.

Each of these reviewed studies of emotional contagion in early infancy focused exclusively on the neonatal period, outside of Meltzoff and Moore's (1992) work that did extend to 3 months of age. Recently, however, Geangu, Binga, Stahl, and Stiano (2010) examined the contagious cry phenomenon at older ages in 121 full-term infants. Here, infants were assessed at 1, 3, 6 and 9 months of age for facial distress and contagious crying. Not only was it found that infants at all four ages showed increased vocal and facial distress in response to the cry recording, but that their levels of distress did not significantly decrease with age or differ across genders.

Development of Emotional Contagion

It is necessary to point out that though empathy likely develops in a sequential pattern (see Roth-Hanania et al., 2000), the stages are not mutually exclusive, as each level builds or nests upon the previous ones (e.g., Hoffman, 1987). For instance, there are numerous examples of unconscious and conscious emotional contagion visible in adults (e.g., Dimberg, Thunberg, & Elmehed, 2000; Tiedens & Fragale, 2003; van Baaren, Holland, Kawakami, & van Knippenberg, 2004; van Baaren, Holland, Steenaert, & van Knippenberg, 2003; Wild, Erb, & Bartels, 2001), showing that emotional contagion specifically seems to persist even after additional empathy developments such as prosocial helping and sympathy are made.

However, while emotional contagion persists through development, outside of infancy high levels are likely not beneficial to either prosocial helping or general social functioning. The growing amount of literature suggests that the ability to "feel" what the other is feeling is necessary but not sufficient for reparative and prosocial behaviors to occur (e.g., Rieffe, Ketelaar, & Wiefferink, 2010). In fact, high levels of emotional contagion outside of early infancy have been shown actually to negatively relate to prosocial helping and general social functioning (e.g., Lovett & Sheffield, 2007; Rieffe et al., 2010). While both emotional contagion and sympathy are components of empathy, emotional contagion is developmentally egoistic, regardless of the developmental stage it is displayed in, and if prosocial behavior is elicited, it appears to regularly come from a drive to reduce one's own distress rather than from an attempt to aid another (Eisenberg & Fabes, 1990). In fact, within children and adults, an individual with high levels of emotional contagion (i.e., personal distress) will often resort to prosocial helping behaviors only if the other's distress is unavoidable (Szalvitz & Perry, 2010). On the other hand, if the other's distress can be avoided, individuals with high personal distress will often focus their energy on aiding themselves instead.

Maternal Influences on Emotional Contagion

During the first three years of life, the infant's development is influenced by two primary factors, first, normal biological developments – physical, cognitive, socio-emotional, and neurological – that are canalized (Waddington, 1942), that is, they proceed "as planned" in the absence of severe genetic abnormality or environmental insult, and second, the environment itself, which at this point in life is largely centered around the infant's interactions with his or her primary caregiver. These two influential factors are far from separate, however. In fact, evidence has shown specifically that parenting behaviors do affect an infant's biological developments and that such effects will often last into adulthood (e.g., Dawson, Ashman, & Carver, 2000; Propper & Moore, 2006). Now while emotional contagion responses may begin as reflexive (Roth-Hanania et al., 2000), empathy abilities are not automatic. Instead, there seem to be necessary social experiences for empathy to continue developing in children (Tucker, Luu, & Derryberry, 2005) in which such early infant experiences seem to form a "template" for later development. Numerous studies provide evidence that maternal interactions serve as predictors of how empathy is exhibited in older toddlers and children (e.g., Davidov & Grusec, 2006; Kiang, Moreno, & Robinson, 2004; Trommsdorff, 1991; Valiente et al., 2004; Zahn-Waxler, Radke-Yarrow, & King, 1979), but due to the age gap in the literature, a very limited amount of work has examined this relationship in infants.

One such study by Field et al. (2007) showed a difference in arousal between 14-day-old full-term newborns of non-depressed mothers and those of depressed mothers using a contagious cry paradigm. Results showed that infants of non-depressed mothers responded to the cry sounds of other infants with an arousal response whereas the newborns of depressed mothers did not show the same arousal response. An additional study examined the relations between maternal behaviors and empathy-related behaviors in older infants using a sample of full-term infants at 10 and 18 months of age (Spinrad & Stifter, 2006). Here, maternal responsiveness in mother-infant dyads was negatively predictive of the infants' levels of personal distress (i.e., emotional contagion) and positively predictive of their levels of concerned awareness (i.e., the degree to which the infant noticed and/or responded to the distress of another) using a distress simulation. To additionally note, two other studies have shown attention and arousal differences to faces viewed between infants of depressed and non-depressed mothers (Hernandez-Reif, Field, Diego, & Ruddock, 2006; Hernandez-Reif, Field, Diego, Vera, & Pickens, 2006).

If the infant and child work is integrated, the data show that maternal influences do appear to significantly impact empathy development during the initial infant stage of emotional contagion. Specifically, during the first 3 months, lower levels of maternal interaction, as would be found in infants with depressed mothers, seems to increase the level of arousal an infant experiences and decrease his/her perception of sad faces as novel stimuli (e.g., Field et al., 2007; Hernandez-Reif, Field, Diego, Vera, et al., 2006). Later in infancy, positive maternal interactions seem to be associated with a decrease in personal distress responses and an increase in prosocial behaviors (Spinrad & Stifter, 2006), a finding which appears to hold true in both toddlers and older children (e.g., Valiente et al., 2004; Zahn-Waxler et al., 1979).

Measurement of Emotional Contagion

In toddlers and children, the examination of emotional contagion and empathy has used constructed laboratory experiments (such as the Empathy Task, Frustration Task, and Theory of Mind Task), stories, pictures, and videos. Additionally self-report and parental report measures are used with children and adults (e.g., Cairns, Leung, Gest, & Cairns, 1995; Doherty, 1997; Mehrabian & Epstein, 1972; Rieffe et al., 2010). With infants, however, markers of the sympathetic nervous system (SNS) are commonly used to assess emotional contagion because of the arousal response that often occurs.

The use of heart rate (HR) as a measure of arousal or attentiveness in emotional contagion paradigms has been established (e.g., Liew et al., 2003; Zahn-Waxler, Cole, Welsh, & Fox, 1995). HR deceleration tends to be associated with taking in information from the environment, and thus often indicates an attentional phase, whereas HR acceleration has been associated more with stress, anxiety, or coping (Reynolds & Richards, 2008; Zahn-Waxler et al., 1995). In children HR deceleration accompanies prosocial behaviors and sympathy whereas HR acceleration is indicative of high levels of emotional contagion and/or personal distress (Eisenberg & Fabes, 1990; Field et al., 2007; Simner, 1971; Zahn-Waxler et al., 1995).

More recently, α-amylase derived from saliva samples has been shown to serve as a non-invasive measure of SNS activation because activation of the SNS increases salivary protein secretion (Gordis, Granger, Susman, & Trickett, 2006; Rohleder, Nater, Wolf, Ehlter, & Kirschbaum, 2004). As such, salivary α-amylase (sAA) can be used in similar ways as HR has been. However, the collection of sAA to assess SNS activation has one strong advantage over the more traditional psychophysiological assessments of the SNS, especially when it comes to work involving infants, and that is its ease of use. While other SNS measurements involve the attachment of electrodes (Hill-Soderlund et al., 2008), collecting a sample of sAA involves simply a swab in the mouth.

Though its ease of collection makes sAA attractive to infant researchers, there are important considerations for application in this population. Perhaps the most important of these is that sAA is not present in the saliva of newborns (Granger et al., 2006), which is thought to relate to the diets of infants (Sevenhuysen, Holodinsky, & Dawes, 1984). Alpha-amylase serves to break down starches and other consumed carbohydrates. Though it is synthesized and stored in the newborn's pancreas, it is not present in the duodenum until around 6 months of age, the age at which supplementary foods are suggested to begin (Riordan, 2004). Additionally, breast milk contains high amounts of α-amylase, thus offering an alternate method of starch digestion within the infant's digestive system rather than within its saliva.

In addition, though levels of sAA can be detected in infants as early as 2 months of age (Davis, Kanna, Marucut, Granger, & Sandman, 2007), sAA reactivity to stress has not shown to be evident until 6 months of age. Levels of sAA will rise sharply in the 0.9–1.9-year period, reaching maximum levels by 5 to 6 years of age (Granger et al., 2006), though remaining lower than those for adults until approximately 24 months of age (Davis et al., 2007). Davis and Granger (2009), in an exploration of the developmental trajectory of sAA, examined infants at 2, 6, 12, and 24 months of age using an inoculation at a well-baby exam. They showed that infant sAA begins to appear in infants between 2 to 6 months, increases in levels from 2 to 24 months, and that prestressor levels correlated with maternal sAA at 6, 12, and 24 months. Using the inoculation paradigm, reactivity in sAA was found at 6 and 12 months only. Additionally, it should be noted that sAA reactivity follows a short response pattern and thus is best sampled immediately following a stressor of at least 5 mins in length, as the greatest peak in sAA levels will be visible at that time, and that levels will return to their baseline state 10 min post-stressor (Davis & Granger, 2009).

While no specific data on sAA and empathy were found, several studies with adults and adolescents have shown that sAA increases in response to stressors in social and academic domains (e.g., Davis et al., 2007; El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008; Gordis et al., 2006). Using a social stressor paradigm with infants, however, Hill-Soderlund et al. (2008) examined whether sAA levels would be indicative of their attachment patterns. In a sample of 132 infants of an average age of 13.5 months and their mothers, vagal reactivity and sAA were assessed in infants using the Strange Situation Paradigm (SSP; Ainsworth, Blehar, Waters, & Wall, 1978) to investigate differences in physiological responses in a sample of insecure-avoidant and securely-attached dyads. Avoidant infants had higher sAA levels than those in the securely attached group. However, it should be noted that despite these findings, this early sAA work sampled the analyte 15 and 45 min following the SSP, when levels would have been returning to baseline states, rather than at the recommended 5 min post task time. This suggests that it is possible that even greater differences would have been visible if sAA had been sampled at a different interval and that baseline levels and reactivity levels may be sensitive to group differences.

In addition, infants with higher levels of positive behavioral reactivity who had highly sensitive mothers have been shown to demonstrate the lowest levels of sAA reactivity (Kivlighan, Granger, & Blair, 2007), with infants with the least sensitive mothers demonstrating the highest levels of sAA reactivity. In this study, 284 mother-infant dyads were tested when the infants were between 5 and 10 months of age. Forty-three percent of infants showed sAA elevation over their pre-task levels. In addition, mothers' and infants' sAA reactivity levels positively correlated with each other.

Studies using sAA (e.g., Davis et al., 2007; El-Sheikh et al., 2008; Gordis et al., 2006; Hill-Soderlund et al., 2008; Kivlighan et al., 2007), have shown the effects maternal influence has on infants' stress response systems. Specifically, highest elevations of sAA were shown in infants with the least responsive mothers, which is comparable to the HR work noted earlier which showed increased arousal in infants with less responsive mothers (Field et al., 2007). While no studies using sAA to assess empathy in an infant or child population were found, work with this method of measurement is consistent in its findings once methodological issues such as sampling time are accounted for. Specifically at least at older ages, 1) more negative mother-infant interactions positively correlated with higher baseline levels of sAA, and 2) more negative mother-infant interactions positively correlated with greater reactivity of sAA in response to a stressful event. Here, as in the HR work, at older ages in infancy, less reactivity would appear to be indicative of positive mother-infant interactions, though in contrast to the HR work, lower baseline states of these analytes could be viewed as indicative of positive mother-infant interactions (Eiden, Veira, & Granger, 2009; Grant et al., 2009; Hill-Soderlund et al., 2008; Kivlighan et al., 2007; Tu et al., 2007). Such work with infants has yet to be done, however.

Present Study

Current and suggested measurements of emotional contagion in infancy were discussed above. With regard to HR in children, HR deceleration and higher HR baseline states appeared to be indicators of empathy and HR acceleration and lower baseline states were presented as negative indicators of empathy (Eisenberg & Fabes, 1990; Zahn-Waxler et al., 1995). Additionally, sAA, a newer method of SNS assessment, was offered as a possible method of emotional contagion assessment due to its ease of use with an infant sample. The current body of literature has not examined sAA as a measure of emotional contagion in infants. Thus, the first purposes of the present study was to examine whether 1) sAA changes as a result of the emotional contagion paradigm and 2) whether sAA correlates with infant HR during such a paradigm. As was previously stated, HR acceleration in infants has been associated with an arousal response seen as a result of emotional contagion paradigms (Reynolds & Richards, 2008; Zahn-Waxler et al., 1995). It was expected that sAA would follow this same direction of activation. Therefore, regarding this first purpose it as hypothesized that baseline and reactivity levels of sAA would positively predict baseline and reactivity levels of HR, again using an emotional contagion paradigm.

Furthermore, evidence reviewed above suggests that maternal responsiveness appears to mold empathy development (Davidov & Grusec, 2006; Field et al., 2007; Hernandez-Reif, Field, Diego, & Ruddock, 2006; Hernandez-Reif, Field, Diego, Vera, et al., 2006; Kiang et al., 2004; Spinrad & Stifter, 2006; Trommsdorff, 1991; Valiente et al., 2004; Zahn-Waxler et al., 1979). More specifically, during an early stage of emotional contagion lower levels of maternal interaction or more negative maternal interaction appear to increase the level of arousal an infant experiences, while later in infancy and into childhood, positive maternal interactions seem to be associated with a decrease in emotional contagion responses and an increase in prosocial behaviors. This specific line of literature, however, has a primary limitation of a paucity of research that has examined infants between 3 and 9 months of age. In light of this, additional work on emotional contagion development and its relations to maternal factors needs explored further within this time period. Thus, the third purpose of the present study was to examine how emotional contagion relates to maternal factors in infants of this age. Here it was hypothesized that there would be a positive relationship between maternal factors and infants' emotional contagion responses.

CHAPTER III

METHODS

Participants

As part of a larger study examining infant nutrition and development, 36 mother-infant dyads were sampled. Mothers and infants (10 males, 26 females) were assessed when the infants were 3 and 6 months of age (+/- 2 weeks). All infants were primarily breastfed (< 28oz. formula/week) at the time of their 3-month appointment. Mothers were required to have single, full-term, non-complicated deliveries. Additionally, infants who weighed less than 6.5 lbs or more than 9.5 lbs at birth were screened from admission. Eight infants were delivered via C-Section.

Mothers ranged in age from 19 to 37 years (*M* = 28.28 years) but were not eligible for participation if they were under 18 years of age. Eighty-nine percent of mothers (*n* = 32) were Caucasian and 92% (*n* = 33) were married. The number of children per mother ranged from 1 to 3, with a mean of 1.47. Overall, the mothers were highly educated, with 25 (69.4%) having a graduate degree and only two mothers having no college education at all. Additionally, 15 (41.7%) of the mothers were unemployed at the time of the 3-month testing, with 4 (11.1%) working part-time, and 16 (44.4%) working full-time. One mother did not report employment data. The majority of mothers reported a household income over $60,000 (*n* = 16, 44%). Seven mothers (19.4%) reported a household income of $40,000 to 60,0000. Three, five, and three mothers, respectively, identified themselves as falling within the additional income categories ($25,001 to 40,000, $15,001 to 25,000, and under $15,000), resulting in an additional 11 mothers. Two mothers failed to provide income data. Finally, five (13.9%) of the mothers reported experiencing abuse from within their childhood homes and two (5.6%) reported experiencing abuse from outside of their homes as children; two of these mothers reported abuse from both environments.

Mothers were recruited from childcare and healthcare facilities associated with prenatal and postnatal care, by posting flyers for the experiment on the university campus and several public/private locations (e.g., community libraries, infant clothing and novelty retailers, infant and child interest organizations, and maternal service providers such as doula care and pregnancy spa services), by issuing a press release and advertisement within the local newspaper, and by sending letters to organizations that may have had an interest in the goals of the study. Mothers were paid $65 for their participation in the larger study to help defer the costs of travel. Participants received an honorarium of $40 for the 3-month visit and $25 for the 6-month visit. Additionally, students received 0.5 credits for every 0.5 hours spent in the study. All participants and data were treated in accordance with the university's Institutional Review Board.

Measures

Demographic questionnaire. At the initial 3-month appointment, a demographic questionnaire was used to gather general information about the mothers, infants, and pregnancies. This information included data on age, due date, gender, race, maternal education, maternal employment, income level, marital status, number of children, method of delivery, and maternal history of abuse.

Parenting risk. At the 3-month appointment risk levels of maternal attitudes were assessed using the Adult and Adolescent Parenting Inventory, version 2 (AAPI-2; Bavolek & Keene, 2005). The AAPI-2 is designed to assess the parenting and child-rearing attitudes of adult and adolescent parent and non-parent populations and includes a specific empathy subscale. Based on the known behaviors of abusive parents, responses to the AAPI provide an index of risk for practicing parenting behaviors known to contribute to the maltreatment of children. The present version (AAPI-2) is the revised and re-normed version of the original inventory first published in 1979 by Bavolek.

Responses to the AAPI-2 (Bavolek & Keene, 2005) are first converted to sten scores that compare the participant's responses to a normal distribution. Sten scores in the 1 to 3 range indicate high-risk parenting attitudes, scores in the 4 to 7 sten range indicate a moderate to average risk, and scores in the 8 to 10 sten range indicate a low risk. Five constructs are examined within the AAPI-2; a total score is not attained: A) Expectations of Children, B) Empathy Towards Children's Needs, C) Use of Corporal Punishment as a Means of Discipline, D) Parent-Child Role Responsibilities Children's Power, and E) Independence.

Item and factor analyses of the data generated from the field-testing of nearly 1,500 adults and adolescents from 53 agencies in 23 states formed the basis of norming and validating the AAPI-2 (Bavolek & Keene, 2005). As the AAPI-2 consists of two parallel forms, factor loadings obtained from the Factor Analysis and the corresponding correlations between the two forms ranging from .80 to .92 and between the constructs ranging from .75 to .49 strongly support the validity of the inventory. The Spearman-

Brown and the Cronbach estimates of internal reliability range from .80 to .93 on both Form A and Form B of the AAPI-2. Only Form A was used for the present study.

Parenting style. The Parenting Styles and Dimensions Questionnaire (PSDQ) is a 32-item questionnaire used to broadly assess parenting styles that may have an effect on children's behavioral outcomes and is based on the original, 62-item Parenting Practices Questionnaire (Robinson et al., 1995). Hart et al. (2000) differentiated between parenting practices and parenting styles by explaining that the former include strategies that parents use to obtain goals within particular contexts/situations, whereas the latter can be thought of as aggregate collections of behavior that are typical of parent-child interactions across many situations.

The PSDQ includes self-report and spousal-report items to capture similarities and differences between parenting styles within the home, although much less research has been done to solidify the psychometric properties of the latter (Winsler, Madigan, & Aquilino, 2005). Therefore, maternal self-report is the only scale used within the current study. Participants complete the questionnaire by answering statements about the frequency of particular parenting practices within the home on a 5-point Likert scale, ranging from 1 (Never) to 5 (Always). This yields three separate scale scores based on Baumrind's (1971) theory of parenting styles, including: authoritative, authoritarian, and permissive parenting styles (Robinson et al., 1995). Greater scale scores indicate a higher level of each particular parenting style. The 27-item authoritative scale includes the following subscales: warmth and involvement, reasoning/induction, democratic participation, and good natured/easy going; while the 20-item authoritarian scale includes subscales: verbal hostility, corporal punishment, non-reasoning/punitive actions, and directiveness; and the 15-item permissive scale includes the following subscales: lack of follow-through, ignoring misbehavior, and self-confidence (Winsler et al., 2005).

Research investigating the psychometric properties of the Parenting Practices Questionnaire has revealed that the measure has good internal consistency (Robinson et al., 1995). Further, the PDSQ has been successfully adapted and used within multiple cultures including: Chinese (Nelson, Hart, Yang, Olsen, & Jin, 2006; PDSQ), Russian (Hart et al., 2000; PDSQ), and African American (Coolahan, McWayne, Fantuzzo, & Grim, 2002), in addition to mainstream Euro-American culture.

Maternal stress. Given the influence stress can have on parenting behaviors, maternal stress was assessed using the Parenting Stress Index: Short Form (PSI/SF; Abidin, 1995a, 1995b). The PSI/SF is a shortened version of the original PSI and contains 36 items from the original 120 that are categorized into one of three subscales and a total score: Parental Distress (PD), Parent-Child Dysfunctional Interaction (P-CDI), and Difficult Child (DC). A Defensive Responding (DR) validity scale is also scored with values of 10 or below indicating defensive responding. Data indicating defensive responding were not used in analyses per scoring guidelines of the PSI/SF. Administration takes approximately 10 min and respondents answer by indicating their level of agreement with each item (strongly agree, agree, not sure, disagree, strongly disagree).

Internal consistency values using alpha coefficients are strong for the PSI/SF, ranging from .80 to .87 for the three subscales and .91 for Total Stress (Abidin, 1995b). Test-retest reliability over a 6-month test interval is also strong, ranging from .68 to .85

for the three subscales and .84 for Total Stress. Within a sample of 530 subjects, Total Stress scores on the PSI/SF and the PSI are shown to highly correlate ($r = .94$).

Materials

Infant cries. The audio from a video supplied by Nancy Eisenberg was used in the attempt to elicit a response from infants to the hearing of other infants' distress. The video has been used in previous research to evoke an empathy response in infants and had 50 sec of crying that began with the sound of a rattle to elicit the attention of the infant to the video. The crying portion was lengthened by looping this segment six times in order to provide a more appropriate timeframe for the salivary analyte to reach its peak level in response to the stimulus. This resulted in a final video that was 5 min in length. The audio was played through two speakers positioned directly in front of the infant, side by side of each other.

Procedure

The mothers and her infant visited the Developmental and Psychophysiology Laboratory at Oklahoma State University when the infant was both 3 and 6 months of age. The infant was placed into a stationary car seat and recording leads used to measure HR were placed onto the infant. A 2 min baseline period began during which HR data were collected. At this time, the mother or experimenter engaged the infant by quietly playing and talking with him or her. Attempts were specifically made to keep the infant from becoming aroused more than would be the infant's normal state. Following this initial period, the mother was asked to stand behind her infant, out of the infant's line of sight. The recorded crying was played through a computer's speakers and the infant video recorded during this period. The procedure was stopped if 1) the mother at any time requested a cessation of experimentation or 2) the infant cried consistently for 30s.

During the recorded cries, information was documented as to whether the infants were fussy at the visit as a whole, whether they appeared to be distressed with being positioned in the car seat, whether the infants cried during the recorded cries, and if mothers used any soothing methods during the cry recordings, though this data was not analyzed for the present study. Additionally, at a convenient time for the infant during the visit, mothers were administered all questionnaires.

Heart rate. At both ages, HR was derived from the electrocardiogram (EKG) and was recorded through two shielded electrodes placed in a triangular configuration on the infant's chest and abdomen. The electrodes were applied with tabs containing a moistened hypoallergenic gel designed to increase conductance of the signal from the heart. Although voltage was measured across the electrodes from the skin surface, no current ran from the equipment to the infant. The EKG data collected were digitized and stored. The EKG signals were amplified using a Biopac EKG100B amplifier with filters set at 1 Hz high pass and 100 Hz low pass and a gain of 2000. Using AcqKnowledge software (Biopac, Santa Barbara, CA), the EKG data were then transformed using a normalized cross correlation procedure and then manually edited for artifact. The change in the average HR of infants as beats-per-minute (BPM) from pre- to during-task was measured as an assessment of infant response to the recorded cries.

Salivary α-Amylase. At the 6-month visit, saliva was obtained by having infants suck on a long swab designed for the collection of saliva from children under the age of 6 years. The diameter of the swab is smaller for infants' mouths (8mm) and is durable to withstand chewing. All saliva samples were collected using kits from Salimetrics (State

College, PA). Saliva samples were taken shortly upon arrival and immediately after the 5 min cry segment. Such sampling intervals best reflect the activity of the SNS response to stressors (Davis & Granger, 2009). In order to control for how breast milk and other foods and beverages can affect the measurement of sAA in saliva, the infant was provided a small amount of water upon arrival and approximately 2 min before collecting a saliva sample. In addition, if infants ate or drank during their time in the laboratory, a second drink of water was given before beginning the auditory cries.

Following completion of data collection, samples were stored at -20°C until assayed. All samples were assayed for sAA at Oklahoma State University using commercially available kinetic reaction assay (Salimetrics, State College, PA). On the day of testing, saliva samples were centrifuged at 3000 rpm for 15 min to remove mucins. This assay uses 2-chloro-*p*-nitrophenol, a chromagenic substrate linked to maltotriose. The enzymatic action on this substrate yields 2-chloro-*p*-nitrophenol and was spectrophotomoetrically measured at 405 nm using a standard laboratory plate reader. Inter-assay variation (CV) was computed for the mean over average duplicates and values reported are represented in units per milliliter (u/mL).

CHAPTER IV

RESULTS

Descriptive Data of Measures

Descriptive statistics of all maternal measures (AAPI-2, PSI/SF, and PSDQ) were run and are reported in Table 1. It should be noted that some infants were missing HR and/or sAA data. Missing HR data were due to either experimenter error (n = 7 at 3 months baseline [BS]; n = 4 at 3 months during cries; n = 1 at 6 months BS) or excessive artifact from crying or movement or from general fussiness of the infant (n = 2 at 3 months BS; n = 2 at 3 months during cries; n = 1 at 6 months BS; n = 5 at 6 months during cries). Missing sAA data were due to experimenter error (n = 2 at 6 months for both BS sAA and post cry sAA). Because the calculation of HR and sAA difference required both data points to be present for HR or sAA, respectively, HR difference and sAA difference were not calculated on any infant missing one of the required two data points (n = 9 at 3 months for HR; n = 6 at 6 months for HR; n = 2 at 6 months for sAA). Those infants with missing data were not significantly different on any of the maternal variables from the rest of the sample when analyzed using independent samples t tests.

Gender Differences

Independent samples *t* tests were run at alpha levels of .05 to test for differences between genders on both HR and sAA measures as well as on independent variables (AAPI-2, PSDQ, and PSI/SF scale scores). While none of the independent variables or sAA showed differences between genders, a significant difference was found between male and female infants on their BS average HR at 6 months, with males (n = 13, M = 134.91 bpm) having lower BS HR than females (n = 21, M = 144.13 bpm), t (32) = 2.07, p = .047.

Hypothesis 1

The first purpose of the present study was to examine whether the cries did produce a change in HR and/or sAA. Separate dependent sample *t* tests were run at alpha levels of .05. There was no significant difference found between BS (M = 154.84 bpm, SD = 1.81) and during cry HR (M = 156.91 bpm, SD = 2.14) at 3 months, t (26) = -1.02, p = .318. Changes from BS HR (M = 138.93 bpm, SD = 2.31) and during cry HR (M = 143.18 bpm, SD = 2.18) at 6 months did approach significance, however, t (29) = -1.98, p = .058. Lastly, changes from BS sAA (M = 38.14 u/mL, SD = 19.83) to post-cry sAA (M = 52.24 u/mL, SD = 5.60) at 6 months did show a significant difference, t (33) = -3.67, p = .001, increasing from BS to post cry.

Hypothesis 2

The second purpose of the present study was to examine whether sAA correlated with infant HR during the emotional contagion paradigm. Here it was hypothesized that BS, post cry, and difference levels of sAA would correlate with BS, during cry, and difference levels of HR. A correlation matrix was used to examine for such relations (see

Table 2). Significant relations were found between HR difference at 6 months and both post cry sAA at 6 months (*r* = .43) and sAA difference at 6 months (*r* = .49). In both instances, greater increases in HR were related to higher post cry sAA values and greater increases in sAA, respectively.

Hypothesis 3

The third purpose of the present study was to examine how emotional contagion, as measured by HR and sAA, related to maternal factors in infants of this age. It was hypothesized that there would be a relationship between maternal factors and infants' emotional contagion responses such that positive maternal factors would predict emotional contagion responses.

Heart rate.

AAPI-2. A correlation matrix with HR and the AAPI-2 was used to assess relations between these variables (see Tables 3 and 4). No significant correlations were found between AAPI-2 data and HR measures at 3 or 6 months of age.

PSI/SF. A correlation matrix with HR and the PSI/SF was used to assess relations between these variables after excluding three PSI/SFs due to high levels of defensive responding (these same three participants were excluded from all analyses using the PSI/SF; see Tables 5 and 6). For 3 month HR data, significant correlations between the PSI/SF and HR values were found between HR difference and both parental distress (*r* = -.47) and total stress (*r* = -.60), with greater differences in HR between BS and during cry associated with lower levels of parental distress and total stress. Additionally, during cry HR averages approached significance in their relation to total stress levels (*r* = -.37, *p* = .058), with higher levels of during HR cries associated with lower levels of total stress. No significant relations were found between 6-month HR and PSI/SF data. Additionally, no significant differences in HR data were found between the mothers with high defensive responding and those without.

Based on the above significant relations, a linear regression equation was used in an attempt to predict 3-month HR difference. Due to the high correlation between parental distress and total stress ($r = .77$), only total stress was included in the regression analysis, $r^2 = .36$, ß = -.60, $p = .002$ (see Table 7).

PSDQ. A correlation matrix with HR and the PSDQ was used to assess relations between these variables (see Tables 8 and 9). A significant correlation was found between scores on the PSDQ Permissive Parenting subscale and BS HR levels at 3 months ($r = -.46$), where the higher the level of permissiveness, the lower the BS HR. Additionally, the correlation with Permissiveness and during cry HR approached significance ($r = -.35$, $p = .06$), with again, higher levels of permissiveness related to lower during cry HR averages. No other correlations with HR were found using the PSDQ.

Following up on the significant relation between Permissive Parenting subscale and BS HR level at 3 months, a linear regression equation was used in an attempt to predict 3-month BS HR with Permissiveness and was found significant, $r^2 = .21$, ß = -.46, $p = .018$ (see Table 10).

sAA.

AAPI-2. A correlation matrix with sAA and the AAPI-2 was used to assess relations between these variables (see Table 11). No significant correlations were found between AAPI-2 data and sAA measures at 6 months of age.

PSI/SF. A correlation matrix with sAA and the PSI/SF was used to assess relations between these variables (see Table 12). No significant correlations were found between PSI/SF data and sAA measures at 6 months of age.

PSDQ. A correlation matrix with sAA and the PSDQ was used to assess relations between these variables (see Table 13). Again, No significant correlations were found between PSDQ data and sAA measures at 6 months of age.

HR Development from 3- to 6-months

A correlation matrix was run to analyze relations between 3- and 6-month HR data (see Table 14). BS HR at 3 months was correlated with both during cry HR at 3 months (r = .48) and HR difference at 3 months (r = -.39), but was not correlated to any of the 6-month HR values. During cry HR at 3 months was correlated to HR difference at 3 months (r = .63) as well as to BS HR at 6 months (r = .37) and HR difference at 6 months (r = -.41). In addition, HR difference at 3 months was correlated to BS HR at 6 months (r = .41).

CHAPTER V

DISCUSSION

Hypothesis 1

The first purpose of the present study was to examine whether emotional contagion using the recorded cries did produce a change in HR and/or sAA levels. In contrast to previous work by Liew et al. (2003) and Zahn-Waxler et al. (1995), HR data showed no differences between BS and during cry rates at 3 or 6 months, though it is worth noting that the difference at 6 months did approach significance, with HR increasing from BS to during cry rates as well as that the 3-month HR did follow this same pattern of increasing in level from BS to during cry. sAA, however, did show a significant difference between BS and post cry levels, with sAA levels also following the same pattern as HR at 6 months, increasing from BS to post cry. Such results lend support to the use of sAA as a measurement of emotional contagion in infants at the age of 6 months and suggest that at this age, the developmental emotional contagion response appears to be an increase in SNS arousal, as indicated by greater levels of sAA and possibly HR.

It is hypothesized that as the infant's stress arousal system continues to mature from maternal interactions, that by a later age in infancy an inverse relationship might possibly be found between SNS measurements in response to the cries, however. Such a theoretical assumption would be supported by later work (e.g., Eisenberg & Fabes, 1990; Lovett & Sheffield, 2007; Rieffe et al., 2010) that shows less arousal in child populations as positively predictive of helping behaviors in empathy work. This pattern is thought to be indicative of an older infant or child who becomes aroused enough to attend to the cries but not so aroused as to become overly distressed by them.

One reason that HR data could have failed to show significant responses to the cries could be related to the underdevelopment of the SNS at 3 months of age and the large amount of artifact that was within the 6 month HR data. Here, it is worth noting that the HR data at 3 months was relatively free of artifact and thus did not require extensive editing. In fact, many of the HR files at 3 months had little to no artifact and were thus fairly easy to use and code. However, the HR data from the 6-month visit required large amounts of editing due to artifact produced by crying and movement, despite careful placement of the HR recording leads. In approximately half of these data files, editing of each heartbeat was required for at least 50% of the file, which is a possible limitation of the current study. With this in mind, such data might suggest that to assess emotional contagion at 6 months of age, due to the ease of use of sAA and its significant reactivity to the cries, and given the difficulty in analysis produced by large amounts of HR artifact, that sAA may in fact be a more appropriate method of measurement of emotional contagion in comparison to HR.

Hypothesis 2

The second purpose of the present study was to examine whether sAA correlated with infant HR during the emotional contagion paradigm. Here it was hypothesized that BS, post cry, and difference levels of sAA would correlate with BS, during cry, and difference levels of HR. From previous literature showing that HR is able to capture infant emotional contagion responses, it was thought that if such correlations between the two measures existed, that additional support would be given to sAA as a measure of emotional contagion in infants. Results showed that while some such relations were present, they were not uniform. Significant correlations were found between some of the 6-month HR variables and 6-month sAA data. Specifically, HR difference at 6 months was positively correlated to post cry sAA levels and greater differences in sAA. In other words, the more reactivity an infant had in HR to hearing the cries, the higher their sAA levels were following the cries and the greater reactivity they had in sAA in response to hearing the cries. No such relations existed between HR at 3 months and sAA at 6 months. Since results were able to establish that HR and sAA did correlate with each other at some points, with the knowledge that HR has been shown to capture infant emotional contagion responses, support has thus been given to sAA as a measure of emotional contagion in infants.

Again, given the changes in the SNS between 3 and 6 months of age (Davis et al., 2007), it is not altogether surprising that 3-month HR variables did not correlate with sAA at 6 months. Since sAA has not been shown to reach peak levels until childhood or even have reactivity to stressors until approximately 6 months (Davis et al., 2007; Granger et al., 2006), sAA at 3 months of age was not gathered. However, it might be appropriate to explore such relations in future studies given the correlations between HR data at 3 and 6 months to explore this null finding given the early state of infant sAA work. Taken in conjunction with sAA development and results from Hypothesis 1, a possible conclusion is that HR may be a more appropriate measurement method for emotional contagion at 3 months of age – due to its ease of coding and that sAA is undeveloped – even though it failed to show a significant reaction to the cries. Additional work is needed to determine whether HR or sAA is a stronger method of assessment in 6-month-old infants. These data could also suggest a developmental difference between younger and older infant samples in regard to their SNS or an inconsistency in the developmental trajectory of emotional contagion, though further examination is needed.

Replicating the present work with an older sample of infants, such as 9 or 12 month olds, would allow for a greater exploration of whether HR and sAA are indeed related to each other since both measurements are more stable at these later ages. Since there were not more correlations between the sAA and HR data here, however, the specific methodology used in the present study, as well as the use of sAA as a physiological measurement of emotional contagion, should be scrutinized for their validity, particularly since this is one of the first studies of its kind. It is also possible that by assessing HR differently, such as through heart rate variability measurement or by breaking the HR into coded segments of time (e.g., minute long pieces), it would allow the data collected to capture additional amounts of variance in emotional contagion.

Hypothesis 3

The third purpose of the present study was to examine how emotional contagion, as measured by HR and sAA, related to maternal factors in infants of this age. Based on previous research (e.g., Davidov & Grusec, 2006; Field et al., 2007; Kiang et al., 2004; Spinrad & Stifter, 2006; Trommsdorff, 1991; Tucker et al., 2005; Valiente et al., 2004; Zahn-Waxler et al., 1979), it was hypothesized that there would be a relationship between maternal factors from the AAPI-2, PSI/SF, and PSDQ and infants' emotional contagion responses, such that maternal factors would predict emotional contagion responses. The goal here was that if maternal variables were able to predict infants' emotional contagion responses to the recorded cries, that in the future, such information would possibly allow for identification of “at-risk” infants or even indicate that maternal attitudes, as assessed through self-report measures, could be used at times in place of or in addition to observations of mother-infant interactions.

In contrast to previous work, however, no significant correlations were found between sAA data at 6 months and the maternal measures. Likewise, in the examination of HR and maternal measures, no significant correlations were found with any of the 6 month HR data. However, the 3-month HR data did show significant correlations within both the PSI/SF (parenting stress) and the PSDQ (parenting styles) assessments, though not within the AAPI-2 (parenting risk). Out of the three HR variables (BS, during cry, and HR difference), when correlated to the PSI/SF, HR difference was significantly related and during cry HR approached significance. More specifically, HR difference and both parental distress and total stress were negatively correlated, where greater changes in HR, indicative of arousal or attention, were associated with lower levels of maternal stress. During cry HR averages approached significance in their relation to total stress levels, with higher levels of during HR cries associated with lower levels of total stress.

Again, looking at the HR variables, when correlated instead with the PSDQ, level of permissiveness was negatively related to BS HR and approached a significant relationship to during cry HR, where in both cases, the greater the level of permissiveness, the lower the HR averages at both times. Regression analyses did further suggest that total stress was negatively predicted by HR difference, accounting for a fairly large amount of variance within the data (36%). Lastly, HR also negatively predicted maternal permissiveness, though this time by BS levels. Here, BS HR accounted for 21% of the variance in maternal permissiveness. It should be noted here that an examination of the items included on the permissiveness subscale of the PSI/SF suggest that it could be thought of as more of a "disengaged" parenting style. From this perspective, the more disengaged the mother, the less aroused the infant became to the cries.

Such data might suggest that as was noted earlier regarding sAA at 6 months, an increase in HR is the typical emotional contagion response when infants are 3 months of age. Additionally, mothers who were more stressed and disengaged from, or less responsive to, their infants had infants who were less likely to become aroused by the cries. This pattern is supported by previous work by Field et al. (2007) with neonates of depressed mothers that showed mothers who were depressed had infants did not become aroused at the cries. Such patterns do contrast, however, with those seen at later ages in infancy that have shown evidence for reverse directions of such predictions (e.g., Hernandez-Reif et al., 2006; Hill-Soderlund et al., 2008; Kivlighan et al., 2007; Spinrad & Stifter, 2006), where greater maternal responsiveness or more secure attachment was shown to negatively predict arousal. Thus, as was discussed previously, it is highly likely that a developmental shift occurs during the first year of life in how infants respond to emotional contagion paradigms. Additionally, it is likely that such a move is due, at least in part, to their interactions with their mothers and the related development of their stress arousal systems. Furthermore, by examining the currently available data, it is thought that such a move happens between 6 and 10 months of age.

To summarize again the theory of how maternal interactions help the stress response system to develop, the metaphor of a dance will be used (see Appendix A for further elaboration). As the mother and infant attempt to "dance" in synchrony with each other, with each altering his or her behaviors and affect in response to the cues seen in the other, many "in step" moves are made which allow the infant to begin to trust that the world is a safe place in which his or her needs will be met. However, within this same dance, many "out of step" moves are also made, even by very attuned mothers. Such asynchronous moves create stress, and thus arousal, in the infant. When such small asynchronous movements are restored to synchrony, however, the mother teaches her infant that small stressors can be managed and that such events do not signal concerns of safety, thereby helping develop the infant's ability to tolerate stress and dampen arousal responses even in the face of stressors. When such asynchronous movements are not brought into synchrony, however, or are too numerous to allow the infant to reach equilibrium again before another asynchronous event occurs, the infant is not presented with this opportunity to learn and even minor stressors signal danger and the arousal response continues to escalate, as the infant has not learned how to dampen his or her stress response.

However, since little evidence was provided here that self-report maternal factors relate or predict infant emotional contagion, the use of maternal attitudes through self-report measures in such studies should be questioned. It is suggested that future research examine actual mother-infant interactions in addition to using self-report measures but it is also possible that by examining a more overt behavior, such as whether the infant cried in response to the emotional contagion paradigm, that differences in maternal attitudes would be captured.

The little evidence that was provided here, however, does suggest that the different measures of HR (i.e., BS, during cry, HR difference) might assess separate aspects of emotional contagion. Because in different analyses, each point of measurement was significant, it is suggested that the greatest amount of data would be gathered when they are used in conjunction with each other rather than individually. Later studies could explore whether physiological markers of emotional contagion – namely HR and sAA – are best viewed as indicators of a state or trait response. For instance, if BS responses of these measures were consistently better predictors, then it might be suggested that actually evoking emotional contagion, through a contagious cry paradigm for example, is not always needed to predict what the responses would be. Based on evidence here, though, it is likely that the BS and reactivity responses together would serve as better predictors of emotional contagion in infants.

It is also worth the reminder that the sample of mothers used within the present body of work was a largely homogeneous sample and not classified as an "at-risk" group, particularly as all of the infants were exclusively breastfed at the age of the 3 months. While there was still some variability in the maternal measures, it is possible that greater diversity of mothers would allow the sAA and HR variables to capture greater variability in emotional contagion responses and therefore result in findings that are more robust. It is arguable, then, that the patterns of data presented here are only likely to be more visible in a more heterogeneous sample. Regardless, future work in this area should try to sample a more diverse group of mother-infant dyads.

Development of HR

Another query of the present study was to examine how HR data between the ages of 3 and 6 months were related to each other given the paucity of literature on this period of development. The three HR variables were all related to themselves at each age, with positive relations between BS and during cry HR and between during cry HR and HR difference. Thus, the greater the BS HR, the greater the HR during the cries and the greater the HR during the cries, the greater the difference in HR was. However, BS HR at each respective age was negatively related to HR difference, where the lower the BS HR, the greater the HR difference. Such data do make some mathematical sense due to how the difference variables were calculated and also show consistency between HR within each of the respective ages.

Examinations of HR between the two ages showed first that none of the three HR variables at 6 months were correlated to BS HR at 3 months. However, BS HR at 6 months was positively correlated to both during cry HR at 3 months and HR difference at 3 months. Thus, the higher the BS HR at 6 months, the higher the HR had been during cries at 3 months and the greater the difference was in HR at 3 months. Additionally, HR difference at 6 months was negatively related to cry HR at 3 months, such that the lower the HR level was during the cries at 3 months, the greater the HR difference was at 6 months. This seems to suggest that higher arousal from stimuli, such as the emotional contagion, at an earlier age (e.g., 3 months) may develop into a higher BS arousal state at a later age (e.g., 6 months).

Suggestions for Future Studies

In addition to what has already been noted above, such as the great amount of HR artifact within the 6-month data and the homogeneity of the sample, the sample size itself should be increased in additional work and was likely too low to find smaller effect sizes in some of the analyses. Based on *post hoc* sample size analyses, suggested sample sizes from the present data suggest values ranging from approximately 30 to 80 dyads.

Furthermore, it is recommended that future work in this area examine sAA in conjunction with cortisol (see Appendix A), as recent research suggests that the interaction of the two analytes may serve as a greater predictor of behavior (e.g., Gordis et al., 2006), as activation of both the SNS and HPS axis could be assessed simultaneously. Consideration here must be made for timing of peak sAA and cortisol levels, however, as cortisol has been shown to peak at 15 min post stressor and sAA at only 5 min post stressor. Different sampling times from the infants would thus be needed.

Lastly, while the present study makes a theoretical attempt to show emotional contagion is related to later empathy, the data have not been attempted here. Longitudinal work should thus be done that extends what has been already completed to determine the predictive abilities of the emotional contagion data to actual empathy development in early childhood. Here, if sAA samples taken at a later age were shown to predict the children's responses to a simulated distress event, additional support for the use of sAA as a method of assessing empathic responses would be provided. Also, if the sAA samples taken during infancy were shown to predict the children's responses at this later age, evidence would be provided for developmental consistency between emotional contagion and more mature empathy. This would then offer support for emotional contagion as an early form of empathy. If such predictive capabilities were not demonstrated, however, such a conclusion still could not be discarded, as the non-significant result could simply have failed to capture the relationship between the earlier and later ages. This is especially true given the possibility that there may be different patterns in infancy than there are in later ages (e.g., Lovett & Sheffield, 2007; Rieffe et al., 2010).

Conclusions

In summary, given the importance of empathy, its development and the factors affecting it need to be better understood. Future work was suggested to examine the developmental trajectory from infancy to childhood to assess whether emotional contagion and empathy follow a consistent path. Additionally, further work examining the noted maternal influences on emotional contagion was suggested to understand how such effects occur. To take on such research endeavors as were noted above, an assessment method that is easier to use and less invasive than heart rate would be beneficial for work within an infant population. sAA was thus examined and suggested as such a possible measure for continued research within this field.

Based on the consistent findings such as those elaborated on earlier, there is little doubt to most researchers that the early environmental experiences of infants do play a key role in how emotional contagion and later empathy develop. Whether that role involves specific parenting behaviors, mother-infant synchrony, or early attachment experiences, it is no doubt important. While much work has been done trying to increase the empathy levels of children (e.g., Barak, Katzir, & Fisher, 1987; Dixon, 1980; Hughes, Tingle, & Sawin, 1981), it is possible that addressing emotional contagion may be a more beneficial and effective course and despite its limitations, the data offered here have helped provide information that fills in part of the currently missing age gap within this body of literature.

It is fortunate that empathy is now recognized as an important topic within psychological research. Understanding emotional contagion in infancy is important and the implications of finding early methods of intervention valuable. It seems possible that currently, our potential for empathy development is waylaid by influences within our environments, but if such a conclusion is accurate, perhaps with more understanding, knowledge, and action such an outcome would not have to be – and that aim reflects the purpose of studies such as this.

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APPPENDICES

APPENDIX A

Supplemental Literature and Theoretical Material

After decades of being seemingly ignored, the concept of empathy has finally gained a place as an issue of importance. Perhaps the attention is in part because America faces as a nation what current President Obama referred to as an "empathy deficit" (Organizing for America, 2008). It is likely that Szalavitz and Perry (2010) were correct when they wrote about how we live in a society that sees others' pain as entertainment with an ever increasing number of small threats to empathy, but perhaps they were also correct when they wrote that "empathy and the caring it enables are an essential part of human health" (p. 1).

As was noted earlier, in the field of psychological research, empathy is now a topic generating interest (e.g., Barnett et al., 1982; Moore, 1990) but little of the research in this area has focused on an infant population. Perhaps, however, it is in understanding the earliest beginnings of empathy development, before some researchers acknowledge its actual presence, that effective interventions can best be made. Again, while at birth we seem to have the potential for empathy, that potential appears in no way a guarantee, and empathy is too important to not examine one of the earliest impacts on development in infants – namely, mothers.

Though early infant empathy is thought to be reflexive, because of how biological developments and the mother-infant environment together shape the infant's development, it is likely that they also play an interactive role in shaping the development of the infant's empathic behaviors. This appendix is designed to supplement the literature and theoretical material thought to be relevant to emotional contagion. As such, first, more specific descriptions on empathy development in infancy will be given, including additional details from studies previously reviewed. Second, the effects that maternal interactions have on empathy development in infancy will be examined more thoroughly and with additional attention to other theoretical views. And third, methods of assessing infant empathy will be elaborated on, with additional details provided regarding the use of physiological measurements. Limitations of the current body of research in this area will also be discussed throughout.

Empathy Development

Definition of Empathy

As was previously noted, the definition of empathy has changed over time (e.g., Decety & Ickes, 2009; Moore, 1990) and continues to do so. Decety and Ickes (2009) suggest that the definitions that have been offered for empathy can fall into eight non-mutually exclusive categories: 1) knowing another's internal state, 2) adopting another's posture or matching the neural state, 3) coming to feel as another, 4) intuiting or projecting one's self into another's situation, 5) imagining how another is thinking/feeling, 6) imagining how one would think and feel in the other's place, 7) feeling distress at actually witnessing another's suffering, and 8) feeling for another person who is suffering, without the need for being present to view the other's distress.

In a previous overview of how the definition of empathy has changed, Moore (1990) noted the then current tendency to focus on the concept as an emotional response to another's emotion. Prior to Moore's observation and somewhat in contrast, Kurdek (1978) noted that focusing on empathy as an emotional response does not negate its cognitive underpinnings, specifically those that are social in nature. More recently, Cozolino (2006) offered his own definition of empathy in a text that addresses the recent recognition and inclination to recognize the psychobiological underpinnings of the process: "a hypothesis we make about another person based on a combination of visceral, emotional and cognitive information" (p. 203). Through these differing perspectives and the review of research literature that will be discussed presently, it becomes apparent that empathy is a complex process, and though often considered psychosocial in nature, would be best understood as something that involves social, emotional, cognitive, biological, and neurological components of a given individual. While this view broadens the information that remains unknown about empathy, it also allows for greater possibilities for avenues of intervention into a process that has important implications throughout the lifespan.

Each of these characterizations relate specifically to developed empathy because of their reliance on theory of mind, however, (see discussion to follow) and a separate, or perhaps multiple separate definitions from those offered above are needed to define the concept of empathy within an infant population. Eisenberg (Eisenberg et al., 1994), one of the researchers most involved in the examination of early empathy in toddlers and children, has defined empathy as "an emotional reaction that stems from the apprehension or comprehension of another's emotional state or condition and is similar to what the other person is feeling or would be expected to feel" (p. 76). Yet, even this definition assumes theory of mind and thus likely fails to capture the immaturity of what would be present within an infant population.

Most researchers do not even consider it possible for "true" or "mature" empathy to be developed until egocentrism begins to decline – around the age of 3 years (Piaget, 1951) – and theory of mind begins to develop. However, to reiterate this point form earlier, a rudimentary version of empathy that frequently involves an *internal* response is very present despite the infant's limited empathic *external* responses (see discussion to follow). In addition, as is often the case in infant development, it is likely that the developmental "groundwork" for empathy is being laid long before the construct is fully visible. This is why the term *emotional contagion* has been used in addition to the term *empathy* throughout this document. Emotional contagion is defined as "the sharing of the same emotion as a consequence of another's emotional display" (Thompson, 1987, p. 125). However, it is important to remember that the significant early developments of an empathy process that will be covered within this paper are strongly related to the more mature form that comes later, despite the terminology used (e.g., Cummings, Hollenbeck, Iannotti, Radke-Yarrow, & Zahn-Waxler, 1986). In fact, it is possible that emotional contagion could be a primary concern when examining empathy development because the infant brain is likely at a sensitive period for receiving input from the environment to further develop its empathic abilities (see discussion below).

Emotional Contagion and the Beginnings of Empathic Behaviors

As was previously noted, while most researchers do not consider empathy to be developed in infancy, the precursors to this more mature empathy are apparent from birth in the ability to mimic (e.g., Sagi & Hoffman, 1976) and that between ages 0 to 3 years, this rudimentary empathy is both sensitive and responsive to emotional cues exhibited by others (Ungerer et al., 1990). It was also noted that due to the limited cognitive and physical abilities of infants, the external empathic responses of infants are limited as they cannot offer aid or verbalize concern. Emotional contagion, the earliest empathy exhibited by young infants, reflects this developmental immaturity because though the infant is largely unaware of the other's situation (see discussion to follow on theory of mind or research such as that done by Baron-Cohen, 1991), or even that there is another "self" involved in the first 6 months of life (Hastings et al., 2006), the infant is capable of imitating the emotional distress of another individual (see examples below). Again, this earliest form of empathy is largely considered to act as a reflex, both automatic and involuntary (Roth-Hanania et al., 2000), but to persist past this time in life and into adulthood while other components of empathy are developed (Preston & de Waal, 2002).

At this point, it is worth admitting that the terminology involved in this area of research is inconsistent and at times simply confusing. Various theorists have not only used different terms from each other, but at times the same term to describe different phenomena. This has created some confusion in the conclusions that each then makes from their individual research as contradictions begin to appear that upon further scrutiny are often a result of jargon rather than data (for information regarding the history of the term "empathy" see Wispe, 1986). Here a balancing attempt will be made between clarity and consistency on one hand and respect to the individual researchers and their theories on the other.

Empirical evidence for emotional contagion in young infants. Previously mentioned, work examining emotional contagion in young infants has relied primarily on the contagious cry paradigm. This is where infants are presented with a cry to determine whether they respond with indications of arousal or distress of their own and thereby demonstrate emotional contagion in how they appear to imitate the distress of another. Here, studies reviewed briefly earlier will be presented in more detail. For instance, as one of the earliest examples of this work, Simner (1971), who was the first to demonstrate this capability in human infants, though not the first to try (i.e., Margaret

Blanton in 1917 and Buhler & Hetzer in 1928), showed that 2-day-old infants (mean age of 70 hours) would cry in response to hearing another newborn's cry. In his first experiment, 75 full-term infants (36 males and 39 females) were assigned to one of three equal groups: 1) the spontaneous newborn (5-days-old) cry, 2) a white-noise recording that imitated vocal frequencies, or 3) a control group that experienced no exposure to an auditory stimulus. All auditory stimuli and interactions with the infant were held constant across conditions. Cries were recorded by an observer and were defined as "an audible, intermittent vocalization accompanied by facial grimaces and increased motor activity lasting a minimum of 1-2 seconds" (p. 138). Heart rate data were also collected. Results showed that infants cried in response to the newborn cry, but not in response to the white noise or during the control condition, though autonomic arousal did seem to be produced by both auditory stimulus groups as indicated by the infants' increased heart rates.

In follow-up work, Simner (1971) played additional infants of the same age as in his original experiment either a recording of a natural cry (using a cry from a 5½-month-old infant) or a computer synthesized cry and compared their results to those from the infants who had listened to the newborn cry or been exposed to the control condition from the original experiment. Here, significant differences in the number of infants who cried were found between infants exposed to the newborn cries and those exposed to the cries either from the 5½-month-old infant or the control condition. Specifically, infants who had been exposed to the newborn cries were shown to cry more than those in the other conditions. Additionally, only the newborn cry produced a significant increase in crying in comparison to the control condition and also resulted in a greater length of crying when compared to the computer-synthesized cries. Thus, Simner's work showed that newborn infants not only exhibited more distress in response to natural cries than they did to silence or computer-generated cries, but that they did so specifically when the cries were from infants who were more comparable in age. Such a finding suggests the possibility that the distress experienced from an emotional contagion response in very young infants is greatest when the infant is more similar to the distressed other.

As a replication of Simner's study with a younger sample, Sagi and Hoffman (1976) were able to demonstrate this rudimentary empathic distress reaction to auditory stimuli shortly after birth (mean age of the infants was 34 hours old). Using the same newborn cry and synthetic cry audio recordings as Simner (1971) along with a control condition, Sagi and Hoffman (1976) demonstrated within 58 infants that the newborns would cry significantly more often to the natural cry than they would in response to either the synthetic cry or control conditions. This younger sample of infants did tend to cry less overall than did those in Simner's work, but the pattern was clearly replicated.

Additionally, with an even younger sample of infants (mean age 18 hours), Martin and Clark (1982) not only replicated the results of Simner (1971) and Sagi and Hoffman (1976), but also showed that infants were able to discriminate not only between an artificial and natural cry, but between the natural cries they were hearing. Here, infants in one experiment were shown to cry less or even cease crying when they were exposed to the sound of their own cries as opposed to the sound of another newborn's cries, to which they would cry more. Furthermore, in an additional experiment infants were shown to cry less both in response to the sound of an older infant's cries (11 months as compared to 40 hours) as well as to the cries of a newborn chimpanzee (16 days old). Such findings are similar to what was found in Simner's (1971) work.

Thus, by using the contagious cry paradigm, studies (e.g., Martin & Clark, 1982; Sagi & Hoffman, 1976; Simner, 1971) have shown that infants even as young as one day old do appear to display emotional contagion responses in reaction to hearing the cries of another infant as was indicated by cry patterns and changes in heart rate. In addition to the contagious cry studies, additional work examining infant emotional contagion has been conducted by examining facial and postural mimicry in infants. For instance, early work by Meltzoff and Moore (1977) demonstrated that infants are capable of imitating the facial expressions and manual gestures of others at both 12 and 21 days old, though only six infants were sampled in this particular study. Lip protrusion, tongue protrusion, mouth opening, and sequential finger movements were all mimicked by the infants after watching an adult model such actions.

Additional work by Meltzoff and Moore (1983) showed that the abilities to imitate the mouth opening and tongue protrusion gestures could be seen within 40 infants (range of age was 42 min to 71 hours, mean age was 32.1 hours) using the same paradigm as their 1977 study. A third study by Meltzoff and Moore (1992) sampled 32 infants when they were 6 weeks old and then again when they were between 2 and 3 months of age. Again, using the same experimental method as the previous studies, the infants were exposed to adults modeling the gestures of mouth opening or tongue protrusion. However, in this study, the infants were modeled one gesture by an unfamiliar actor and the other by their mother; counterbalancing was used in the presentation of gestures by both adults. Not only did these findings show that the infant's ability to mimic holds true whether the infant is familiar with the other or not but that the infant's ability to mimic extended to at least 3 months of age.

Field, Woodson, Greenberg, and Cohen (1982) expanded on Meltzoff and Moore's (1977) work by demonstrating that infants possess the ability to distinguish between and imitate happy, sad, and surprised faces within only hours of birth. Using 74 infants with a mean age of 36 hours, adults modeled happy, sad, and surprised facial expressions, and the infants' facial expressions and eye movements were coded. The visual habituation and dishabituation data suggested that the infants were able to discriminate among all three expressions and the facial codings of the infants showed their ability to imitate all three expressions displayed by the model.

Each of these reviewed studies of emotional contagion in early infancy focused exclusively on the neonatal period, outside of Meltzoff and Moore's (1992) work that did extend to 3 months of age. Recently, however, Geangu, Binga, Stahl, and Stiano (2010) reexamined the contagious cry phenomenon at older ages in 121 full-term infants. Though previously reviewed, their work will again be summarized here. Using a looped recorded cry from a 3-month-old male, infants were assessed at 1, 3, 6 and 9 months of age for facial distress and contagious crying. Not only was it found that infants at all four ages showed increased vocal and facial distress in response to the cry recording, but that their levels of distress did not significantly decrease with age or differ across genders. (One additional study by Field, Diego, Hernandez-Reif, and Fernandez [2007] will be reviewed later.)

Thus, the extant literature supports the presence of emotional contagion in infants between 0 to 9 months as displayed by contagious crying (e.g., Geangu et al., 2010; Martin & Clark, 1982; Sagi & Hoffman, 1976; Simner, 1971), mimicked facial and manual gestures (Meltzoff & Moore, 1977, 1983, 1992), and ability for facial expression discrimination (e.g, Field et al., 1982). However, the evidence in infants between 3 and 9 months is very limited and the bulk of the studies relied on coding observable behaviors (e.g., crying, imitating, eye movement) rather than assessing such behaviors physiologically, as could be done through heart rate or sucking.

Empirical evidence for empathy in older infants. Though the present research focuses on young infants, some studies that focus on older infants will also be reviewed. For example, in an examination of the emergence of prosocial behaviors within the developmental trajectory of empathy, Zahn-Waxler and colleagues (Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992) examined 27 infants (17 boys, 10 girls) from the time they were 12 months to 24 months of age. Through both maternal and experimental observations of the infants' responses to others' emotions, it was shown that prosocial behaviors emerged during the second year of life and increased in both frequency and variety during this time. Additionally, prosocial behaviors were shown to positively relate to the infants' expressions of concern and their efforts to understand the distress of others.

In another study, 184 pairs of both monozygotic and dizygotic twins were examined longitudinally at 14 months and 20 months of age (Zahn-Waxler, Robinson, & Emde, 1992). In the home as well as in the laboratory, the infants' responses to simulated distress by both the experimenter and the mother were video recorded and then later coded. For the distress situations, the experimenter pretended to either pinch her finger in a suitcase or bump into a chair and the mother pretended to either hurt her knee as she stood up from the ground or pinch her finger in a clipboard. At both 14 and 20 months of age, infants showed levels of emotional concern, attempted to understand the distress of others, and engaged in prosocial acts. Additionally, from 14 to 20 months of age levels of hypothesis testing and empathic concern actually increased with age, though all components showed stability over time. It is also interesting to note that within this twin sample, compared to previous research with singletons, these twins were less responsive in activities that required engagement with the other. This could suggest a possible delay in self-other differentiation within twin samples, though it is possible such a difference could be representative of a more global developmental lag that is often found in twins.

Also using a twin sample, Volbrecht and colleagues (Volbrecht, Lemery-Chalfant, Aksan, Zahn-Waxler, & Goldsmith, 2007) examined 584 twins (292 pairs) aged 12 to 25 months. Here, infants were assessed during four separated laboratory visits at 12, 19, 22, and 25 months using a temperament assessment of joy at the 12 month appointment (the peek-a-boo and puppet episodes from Goldsmith & Rothbart's [1999] Laboratory Temperament Assessment Battery; Lab-TAB) and episodes of simulated distress by the caregiver at the later three visits. During these visits, infants' behaviors were coded and mothers also completed assessments on infant temperament. Results showed that both the temperament pleasure episodes at 12 months and mothers' reports on infant temperament at this time significantly predicted prosocial helping and hypothesis testing seen in the laboratory observations at the later ages.

In contrast to the above experiments that each assessed infants' responses to the overtly displayed simulated distress of another, Vaish, Carpenter, and Tomasello (2009) explored whether 30 infants at 18 or 25 months of age were able to sympathize with someone in distress even if no emotional signals were given by that individual. Prosocial responses and patterns of looking were used to assess the infants' concern – specifically checking, concerned, and other looks. Exposing infants randomly to either a harm (where an adult was taking away or destroying a possession of another adult) or a neutral (an adult did something non-harmful to another adult) condition, it was shown that at both 18 and 25 months, infants showed concern for and prosocial behaviors towards the victimized adult in the harm condition, regardless of whether emotional signals were given. Additionally, levels of concern were positively correlated with prosocial behaviors. Such findings suggest that perspective-taking and concern for the "victim", as opposed to simple distress at the event, underlies the empathic responses of these infants even at such an early age in development.

Thus, such evidence within an older infant sample (12 to 25 months of age) shows the emergence of empathic behaviors – such as prosocial behaviors, expressions of concern, and efforts to understand others' distress – outside of the period specific to emotional contagion. As infants age, their abilities in perspective-taking and theory of mind develop, and as they do, room for reparative and prosocial behaviors is made. Work reviewed later will examine how emotional contagion continues in this stage of development and beyond, even as more mature behaviors are adopted.

Developmental sequence of emotional contagion. The research reviewed above provides empirical evidence for how the phenomenon of emotional contagion is displayed in infancy. Now, literature will be explored that examines the developmental theory thought to underlie this construct. Using a model of self-concept development (DesRosiers & Busch-Rossnagel, 1997) to theorize on empathy development, Roth-

Hanania et al. (2000) classify the stage in which emotional contagion begins as *global automatic and nonvoluntary empathy* where the infant (0-12 months) is without the full ability for self-differentiation. Self-differentiation refers to the ability to differentiate the self from another person and begins to develop around 6 months of age. Examples of behaviors that frequently occur within this period are contagious crying and mimicked facial expressions – both shown in the above literature.

It is thought that there are two substages within the stage of *global automatic and nonvoluntary empathy* (Roth-Hanania et al., 2000). The first occurs from birth to approximately 6 months of age and reflects the infants' limited understanding that they are different from their mothers. In other words, the infant at this time largely lacks self-other differentiation. The second substage occurs from approximately 6 to 12 months and refers to early differentiation abilities in which joint attention (i.e., attending to an object or action that the infant observes another attend to) plays an important role. Roth-Hanania et al. note that the developmental shift around 6 months of age corresponds not only to object permanence gain but with great increases in motor skills. In the research that will be proposed here, it is this time period of 0 to 12 months that falls within the proposed *global automatic and nonvoluntary stage* that will be examined in the greatest amount of detail.

Continuing, however, around 1 year of age the infant does gain the ability to attend to another's feelings (Hoffman, 1987), and by 18 months of age additional cognitive prerequisites for empathy are in place, allowing for "truer" empathic responses rather than for basic emotional contagion alone (Ungerer et al., 1990). These cognitive developments include aspects such as self-other differentiation and perspective-taking abilities (for a discussion on the effects the development of reasoning and perspective-taking possibly play in toddlers, see Wellman & Woolley, 1990). At this point, the infant is thought to recognize that it is another that is in distress, thereby displaying self-other differentiation, but to still assume that such a state is the same as his or her own due to the notable presence of egocentrism (Hoffman, 1987). Additionally, the empathic behaviors of infants will likely be demonstrated by concerned or imitating looks and comforting or early "helping behaviors" (i.e., prosocial action), but due to the continuation of egocentric thought, these instrumental helping behaviors are apt to take a visibly egocentric pattern. For example, the infants will behave in manners that would assist in the regulation of their *own* affective states, such as bringing the other individual *their own* mother or security object, rather than those that belong to the other individual. Thus, between 12 and 18 months of age, empathic abilities are often referred to as *egocentric empathy* (Roth-Hanania et al., 2000).

Between 18 and 24 months of age, empathy abilities are referred to as *prosocial-active helping* (Roth-Hanania et al., 2000). In this stage, infants are more actively able to make interventions on the behalf of others as a result of both increased cognitive and motor development. Such behaviors will be a continuation and a more matured form of those seen within the previous stage. For example, the infant would now bring a distressed other a tissue or the other's own mother, but yet is still largely acting to reduce his or her *own* distress by aiding the other. Then, by around 24 months of age, empathy abilities are referred to as *perspective-taking empathy* since infants are capable of expressing their emotions and empathic concern verbally (Roth-Hanania et al., 2000).

Previously, it was noted though empathy likely develops in a sequential pattern, the stages are not mutually exclusive, and a nesting metaphor was provided to illustrate the likely development of this construct (e.g., Hoffman, 1987). Additionally, evidence was provided showing that emotional contagion is very present even when more mature empathic behaviors have been developed (e.g., Dimberg et al., 2000; Tiedens & Fragale, 2003; van Baaren et al., 2004; van Baaren et al., 2003; Wild et al., 2001). Tucker, Luu, and Derryberry (2005) suggest that emotional contagion is further developed by way of sympathetic nervous system responses (see discussion to follow), that theory of mind is attained as part of a developmental sequence, and that only then is an individual capable of mature empathy.

It was also previously argued that while emotional contagion persists through development, outside of infancy it is likely *not* beneficial to either prosocial helping or general social functioning. The idea that the ability to "feel" for another may actually decrease helping behaviors is both interesting and relevant to the theory of empathy development (e.g., Lovett & Sheffield, 2007; Rieffe et al., 2010). Previously, this finding led to contradictory conclusions as to how empathy affected prosocial behaviors (e.g., Barnett et al., 1982; Coke, Batson, & McDavis, 1978; Feshbach & Feshbach, 1969; Findlay, Girardi, & Coplan, 2006), leading some to conclude that the two were unrelated (see Eisenberg & Fabes, 1990, for a discussion). But as was previously noted about the use of inconsistent definitions, earlier methods of assessing empathy frequently failed to separate out what is now referred to as *sympathy* from high levels of emotional contagion, also frequently termed *personal distress* within a population outside of infancy (Eisenberg, 2000).

As was described in detail earlier, while both emotional contagion and sympathy are components of empathy, emotional contagion is developmentally egoistic, regardless of the developmental stage it is displayed in, and *if* prosocial behavior is elicited, it appears to regularly come from a drive to reduce one's own distress rather than from an attempt to aid another (Eisenberg & Fabes, 1990). To restate what was earlier described, if I am unable to separate out your distress from my own, I will often choose to help myself rather than you – and that is assuming that in light of my own distress I have even been able to recognize that you too are suffering. In infancy, the development of the ability for self-regulation does appear to play a role in why one individual might become overwhelmed by the feelings of another when someone else does not (Okun, Shepard, & Eisenberg, 2000; Rothbart & Ahadi, 1994). Such a point will be key to the later discussion of the stress-arousal system in infants.

Theories of Empathy Development

Several theories of empathy development in adults and children have been offered that may or may not be applicable to infants (e.g., Barrett-Lennard, 1993; Wellman & Woolley, 1990). As was previously mentioned, during the first three years of life the infant's development is influenced by two primary factors that are closely interwoven with each other: normal physical, cognitive, socio-emotional, and neurological developments that are, overall, canalized apart from any major environmental deprivations; and the environment itself, which at this point in life is largely centered around the infant's interactions with his or her primary caregiver, most frequently the mother. Earlier, influential experiences with the mother were discussed. In addition to that, three other explanations of empathy development will be described separately here, none specific to any one theorist. First, an overview of mutual- and self-regulation will be provided with information given as to how these relate to empathy development. Second, an evolutionary theory will be offered, in part due to its ability to connect the environmental influences from the mother and the development of mutual- and self-regulation to the final explanation that will be offered – the neurological factors.

As one begins examining the development of empathy, it becomes clear that how and why empathy, or emotional contagion, begins to develop in infants is only recently becoming understood. Some researchers postulate that empathy has an evolutionary or biological basis (e.g., Brothers, 1990) while others hold that it is taught more by social learning (e.g., Kurdek, 1978). Such developmental theories will be discussed in more detail below, but it is arguable that the interaction of each of them best describes overall development, and thus they should not be considered singularly (e.g., Szalvitz & Perry, 2010).

Maternal Influences. While the environment encompasses many factors, as was previously noted, many of the aspects of infants' environments are centered on their interactions with their mothers. Thus, it will be maternal influences that will be focused on as the primary theoretical environmental influence. Specifically, the accumulating line of research suggests that maternal responsiveness seems to mold empathy development (e.g., Valiente et al., 2004; Zahn-Waxler et al., 1979). It should be noted that the role of fathers is likely important in the development of empathy, but the research in this area is still very limited (e.g., Kokkinaki, 2008), thus paternal roles will not be discussed here.

Now, one might question why environmental influences are relevant if emotional contagion is in fact reflexive or automatic (Roth-Hanania et al., 2000). Research that will be reviewed here suggests that though this is largely true, emotional contagion *is* additionally moderated by other influences, such as mother-infant interactions, and that such interactions appear to affect the continued development of empathy – a notable implication to the presently proposed research. As was previously suggested, empathy abilities are not automatic. Instead, there seem to be necessary social experiences for empathy to continue developing in children (Tucker et al., 2005) in which such early infant experiences seem to form a "template" for later development.

Before discussing the empirical findings, it should be said that one of the notable limitations to the current line of study, as it was in the literature that examined emotional contagion in infancy, is that there appears to be a gap in the ages that have been examined. The literature that was found almost exclusively examined either neonates or toddlers and children. There are almost no data on infants between 3 and 12 months of age. The known exception to this is the study done very recently and reviewed above by Geangu et al. (2010) in which contagious crying was shown in infants up to 9 months old. This has likely been done for methodological reasons and out of a lack of available assessment techniques, but still presents a limitation that the research studies proposed here aim to address.

Given the limited amount of data from an infant population and due to the evidence that maternal interactions do serve as predictors of how empathy is exhibited in older toddlers and children, some of these findings will be reviewed first. Each of the following studies provides evidence that mothers' behaviors do relate to empathic behavior in their children. In toddlers, for example, Zahn-Waxler et al. (1979) showed that in sixteen 1.5 to 2.5 year olds, maternal empathic caregiving did positively correlate to toddlers' prosocial behaviors in response to another's distress. Using in-home observations in which the mother acted as a confederate and observer, the toddlers were monitored on their reactions to a person in distress to events for which they were either the cause of the distress or a bystander to it. Mothers' empathic responses to the child in natural interactions were categorized into one of the following categories: Explanations, Suggestions for positive actions, Unexplained verbal prohibitions, Use of physical restraint, Use of physical punishment, Modeling of altruism to the victim, or Reassurance and support to own child. Results showed that children's reactions were significantly predicted by their mothers' responses. Specifically, within this age group, when the children were the perpetrators, mothers who responded with high intensity and clarity, often forcefully or with embellishment, were more likely to have children who then initiated reparative and altruistic behaviors. Mothers who modeled empathic behaviors in their interactions with their children were also more likely to have children who acted prosocially.

Kiang, Moreno, and Robinson (2004) supported the findings by Zahn-Waxler et al. (1979) showing that higher levels of maternal risk using the Adult and Adolescent Parenting Inventory (AAPI; See discussion below for more details; Bavolek, 1984) positively related to levels of empathic indifference shown by 21 to 24 month olds to their mothers' simulated distress. Within 175 (87 boys, 88 girls) high-risk (i.e., low-income, low education, without health insurance, mean age of mothers of 19.7 years) and racially diverse mother-child dyads, children's responses to their mothers' simulated distress events and mothers' responses then to their children were assessed. Mothers who had more negative expectations towards parenting, as measured by the AAPI, were less sensitive to their children, and their children showed more indifference to the mothers' distress. Inversely, children who had mothers who were more sensitive initiated more prosocial responses during the distress simulation. Thus, maternal interactions with and their attitudes towards their children do seem to affect empathic behaviors in the children.

Again with children, Valiant et al. (2004) showed that 214 (96 girls, 118 boys) children's (4.5 to 8 years old) levels of empathy were related to their parents' levels of expressivity. Children completed an empathy scale, viewed an empathy-inducing film and then rated their emotional reactions to the film. Mothers' levels of expressivity were assessed through observations with their children and by using Halberstadt's Self-Expressiveness in the Family Questionnaire (Halberstadt, Cassidy, Stifter, Parke, & Fox, 1995). Results showed that within this sample, the higher the level of parental *positive* expressivity, the lower the children's levels of personal distress and the higher their levels of sympathy. However, when *negative* parental expressivity was examined, children's levels of personal distress instead increased and their levels of sympathy decreased. These findings not only support the theory that maternal interactions do affect children's expressions of empathy, but also suggest, as was previously discussed, that high levels of personal distress should actually not be considered a positive addition to empathy outside of infancy.

In a different cultural population than was used in the previously described studies, Trommsdorff (1991) showed with 30 German kindergarten children that their levels of empathy served as predictors of maternal empathic responses. With children 5 to 6 years of age (15 boys, 15 girls), their empathy was rated using the ratings of their kindergarten teachers, who had been trained in assessing the child's behaviors for purposes of this experiment. The mothers completed a translated version of the Empathy Scale (Mehrabian & Epstein, 1972) and were also interviewed using a semi-projective test that described 12 conflicts between a mother and child in order to assess her reactions to the situations described. Results showed that mothers' levels of empathy were closely related to their children's levels, and that mothers of more highly empathic children had significantly higher levels of empathy themselves, showed more understanding for their children, and pursued more prosocial goals. In addition, the frequency of these mothers' articulation of prosocial goals and their understanding for their children were both positively related to the levels of empathy exhibited by their children.

Davidov and Grusec (2006) also demonstrated differences in children's socio-emotional functioning as a result of mothers' responsiveness to distress and levels of warmth. In their work, 106 mother-children dyads with 6- to 8-year-old children (50% girls) completed questionnaires and participated in a laboratory assessment. Fathers of 96 of the children were also assessed, but results will not be reported here. Mothers' responsiveness to distress was assessed using four measures, the Coping with Children's Negative Emotions Scale (Fabes, Eisenberg, & Bernzweig, 1990), the Responsiveness to Distress Scale derived from the Child-Rearing Practices Report Q-sort (CRPQ; Block, 1981), the Interpersonal Reactivity Index (Davis, 1980), and their described reactions to a 3min video displaying a parent-child conflict. Mothers' levels of warmth were assessed by use of a Warmth scale derived from the CRPR Q-sort, observer ratings, and a short essay over what it was like being the mother to their child. Children's abilities to regulate their emotions were assessed through maternal report with the Emotion

Regulation Checklist (Shields & Cicchetti, 1997). Their levels of empathy and prosocial behaviors were assessed through maternal report using the empathic and the prosocial response subscale from the conscience measure (Kochanska & DeVet, 1994), by teacher report using the Prosocial Behavior Questionnaire (Weir & Duveen, 1981), and by their responses to both the simulated pain of the experimenter and to peer distress vignettes using dolls and other props. Results showed that maternal responsiveness to distress positively predicted better negative affect regulation, empathy, and prosocial responding in the children. Maternal warmth was also found to relate to better regulation of positive affect. Additionally, children's negative affect regulation mediated between maternal responsiveness to distress and children's empathic responding. Such evidence not only provides additional support for maternal interactions affecting children's empathy, but also shows how such interactions play a role in children's self-regulation abilities, an important concept that will be discussed below.

Now moving from children's empathy development to the small amount of evidence from neonate samples that was earlier described, differences have been found in emotional contagion responses that varied by maternal influences. For instance, findings by Field et al. (2007) showed a difference between 14-day-old full-term newborns of non-depressed mothers (n = 20) and those of depressed mothers (n = 20). Infants were exposed either to recordings of their own cries or to recordings of cries from another infant in the study. Infants from depressed mothers would be presented a cry of an infant from a depressed mother and vice versa for infants from non-depressed mothers. Infant responses to the cries were assessed through heart rate and their number of sucks using a pressure transducer. Results showed that infants of non-depressed mothers responded to the cry sounds of other infants with reduced sucking and decreased heart rates, which is indicative of infant arousal and attention (see discussion on heart rate below). In contrast, the newborns of depressed mothers did not show a change in their sucking behaviors or heart rate at the cry sounds of other infants, perhaps demonstrating an inability to discriminate. However, because the infants that were presented with another infant's cries were grouped by depressed or non-depressed mothers so that only the cries they heard were cries from an infant who was similarly grouped, it is possible that an alternative explanation, such as novelty preference, is at issue within this study.

Though perhaps not as clearly related to emotional contagion development as the work done by Field et al. (2007), two other studies have shown attention and arousal differences to faces viewed between infants of depressed and non-depressed mothers (Hernandez-Reif, Field, Diego, & Ruddock, 2006; Hernandez-Reif, Field, Diego, Vera, et al., 2006). Attentional and arousal processes have been shown to relate to emotional contagion development (e.g., Eisenberg et al., 1994; Field et al., 1982; Simner, 1971). For instance, in the preceding reviewed study by Field et al. (2007), the differences in sucking and heart rate as responses to hearing the cries of another infant were discussed as indications of arousal and attention within the framework of emotional contagion. Thus, the differences in such processes as they relate to maternal depression will be presented here as possible examples of how emotional contagion might relate to maternal interactions.

For example, similar to the differences in arousal to auditory stimuli shown by Field et al. (2007), newborns of depressed mothers have also been shown to exhibit greater arousal and less attentiveness to faces viewed (Hernandez-Reif, Field, Diego, &

Ruddock, 2006). In 87 twelve-day-old full-term neonates, the Brazelton Neonatal Behavioral Assessment Scale (3rd ed.; Brazelton & Nugent, 1995) was used to assess infants' abilities to orient, their levels of alertness, and their state regulation. Overall, results suggest that neonates of depressed mothers oriented less well, particularly to faces, and were less alert. Additionally, their scores on the state regulation tasks showed higher levels of arousal, indicated by their responses to being held by the experimenter and their attempts to self-soothe by placing their hands into their mouths.

In full-term 3-month-old infants, too, infants of depressed mothers have shown to habituate more slowly to visual stimuli of happy and sad faces (Hernandez-Reif, Field, Diego, Vera, et al., 2006). Using 39 mother-infant dyads (*n* = 16 from depressed mothers), infants viewed video clips of "happy" and "sad" women. In the "happy" condition, the women smiled and used infant-directed speech patterns (i.e., exaggerated, high-pitched voices) and recited the phrases "Hello baby…look at me baby…that's a good baby…Can you smile for me?...That's a good baby" (p. 132). For the "sad" condition, the same phrases were recited, but the women did so in a monotone voice with flat facial expressions. One video was used as a habituation stimulus and the other as a dishabituation stimulus; order was reversed in half the infants to control for order effects. Average looking, habituation length, number of trials to reach habituation, average looking on the post-habituation trials, average looking on the novel trials, and a difference score were assessed by monitoring infant eye gaze. Novelty and familiarity preference for the infants was also assessed. Infants of depressed mothers took longer to habituate overall, specifically with the happy facial expression and were able to discriminate between the happy and sad conditions only if they had habituated to the sad video first. These findings suggest that these infants may not perceive the sad expressions as novel, and such a discrimination difference could impact their emotional contagion abilities.

One additional study that examined the relations between maternal behaviors and empathy-related behaviors in older infants used a sample of full-term infants at 10 and 18 months of age (Spinrad & Stifter, 2006). Here, maternal responsiveness in 98 mother-infant dyads was negatively predictive of the infants' levels of personal distress (i.e., emotional contagion) and positively predictive of their levels of concerned awareness (i.e., the degree to which the infant noticed and/or responded to the distress of another). Maternal responsiveness was assessed through a coded 15 min free-play period in the laboratory when the infants were 10 months old. At 18 months of age, the infants were assessed through a series of three distress simulations with two different examiners and the mother. The experimenter distress paradigms simulated a dropped basket of toys on the experimenter's toe and a crying baby doll, and the mother's simulation involved distress from injuring her finger with a toy hammer. Empathy-related responses were coded from a video recording following the session. Maternal responsiveness was shown to positively relate to the infants' levels of concerned awareness to all three simulations and to negatively relate to their levels of personal distress in the baby doll and mother simulations.

To once again summarize this material, maternal influences do appear to significantly impact empathy development during the initial infant stage of emotional contagion. During the first 3 months, a lack of maternal interaction, as would be found in infants with depressed mothers, seems to increase the level of arousal an infant experiences and decrease their perception of sad faces as novel stimuli (e.g., Field et al., 2007; Hernandez-Reif, Field, Diego, Vera, et al., 2006). Later in infancy, positive maternal interactions seem to be associated with a decrease in personal distress responses and an increase in prosocial behaviors (Spinrad & Stifter, 2006), a finding which further appears to hold true in toddlers and older children, as shown by the previous research reviewed (e.g., Valiente et al., 2004; Zahn-Waxler et al., 1979).

Mutual-regulation. Again, there seems to be a lack of research that has specifically examined how maternal interactions and infant empathy development affect each other between 3 and 10 months of age. One finding that could be added that helps close this gap in knowledge, though, is that infants (at least as young as 4 months) and children who are able to self-regulate tend to have lower levels of emotional contagion and higher levels of prosocial behaviors (e.g., Eisenberg, 2000; Rothbart & Ahadi, 1994). In light of this, this section will borrow from regulation and stress literature to make the argument that during the first year of life, maternal interactions help shape the infant's ability to self-regulate through an important mother-infant dance, so to speak. Additionally, it will be argued that if the mother and infant "dance in-step" with each other, that these interactions allow the infant to learn to self-regulate, which in turn allows for emotional contagion responses to decrease and prosocial empathy behaviors to appear.

Lines of research that have examined infants throughout their first years of life are those of mother-infant synchrony and mutual regulation. Mother-infant synchrony emphasizes the extent to which maternal affect is attuned to or matches the affect of the infant (Stern, 1977). The hypothesis regarding empathy development here is that the attunement of the mother to the infant facilitates the arousal of resonant affect within the infant. Mutual regulation emphasizes how mothers assist the infant in attaining and maintaining physiological homeostasis when the infant is too immature to do so on his or her own (Propper & Moore, 2006). Thus, mother-infant synchrony may be thought of as the process by which mutual regulation occurs.

Research in the area of mutual regulation likens these early interactions to a conversation or dance between the infant and caregiver and shows that such an attunement helps the infant's neurological system to develop and organize (Propper & Moore, 2006). Over time, the regulation strategies used by caregivers during their interactions with their infants are internalized by the infants to the point that the infants' own states will come to "match" the arousal responses of their caregivers and likely others in their environments. This process describes how an infant develops the ability for self-regulation out of mutual regulation (Stern, 1985). This attunement between mother and infant is both behavioral and physiological as a style of autonomic responsiveness and these effects will be long term (e.g., Perry & Pollard, 1998; Propper & Moore, 2006).

To elaborate further, infants rely heavily on their mothers and other caregivers to help regulate their own internal systems (Szalvitz & Perry, 2010). Neonates in particular depend on their mothers to help regulate their physical needs, such as body temperature and hunger, as well as their social and emotional needs. Imagine the following scenario that exhibits mother-infant synchrony and mutual regulation. An infant and mother are playing with each other. The infant smiles and coos and the mother smiles and talks back. The infant breaks eye contact and looks away, and the mother leans back slightly to give the infant both physical and emotional space. The infant reinitiates eye contact and moves his or her limbs and the mother leans back in, touching the infant and smiling. In such a scenario, the mother is in synchrony with the infant, allowing the infant to grow accustomed to becoming aroused and then calming down as is needed, thereby assisting the infant in regulating him or herself.

The effects of in- and out- synchrony interactions have been explored by use of the Still-Faced Experiment (see Tronick, 2007 for a review). Within this paradigm, adults are instructed to first engage in a normal interaction with an infant, and then to hold a still-face without talking or moving. Consistently, results show that the infants frequently first attempt to solicit attention during the still-faced section of the paradigm, and when that fails, look away, often displaying negative affect. Upon reunion, the infant frequently happily returns to engage with the adult, though is often more demanding in his or her interactions. Here, the infant is classically shown to be regularly distressed by an imbalance in the synchrony of the relationship and to find relief and pleasure when synchrony is restored.

However, despite the distress an infant is likely to feel from asynchronous interactions, it is important to recognize that a healthy level of arousal still can occur within these – as can a healthy level of stress, or what could also be called frustration. When the infant moves to change the pattern of behavior expected from the mother (i.e., from engagement to disengagement or vice versa), it is likely that even a very in-tune mother does not always immediately recognize the infant's signals. Not only is this to be expected, it is desired (Ham & Tronick, 2009). These minor stressors that occur within the mother-infant interaction in both moderation and rhythm and the reparation of such stressors help shape the stress system of the infant. In fact, Szalavitz and Perry (2010) claim that the "roots of empathy emerge from the soil of our stress response systems" (p. 15). The stress system appears to need such minor events to help shape it properly.

There is ample empirical evidence in both human and animal literature supporting the role that maternal responsiveness has on the infant (or offspring) stress system (e.g., Frigerio et al., 2009; Gunnar, Brodersen, Nachmias, Buss, & Rigatuso, 1996). For instance, using a rat model, pups with more responsive mothers were shown to have a stronger γ-aminobutyric acid (GABA-A) receptor system – which translates into a greater ability to slow the activation of the hypothalamic-pituitary-adrenal (HPA) axis (e.g., Frigerio et al., 2009), a major stress system which will be discussed below. At birth, human infants have a stress system that is responsive to even minor stimulations, such as dressing or diapering (Gunnar, 1998), but this is not true for all species. Rats in particular have a stress non-response period (Schapiro, 1962) during which they display a lack of corticosterone secretion, the physiological equivalent to cortisol in humans, in response to stressors. In human infants, there are also developmental differences within the responsiveness of the stress response system. Around 3 months of age there is an initial decrease in responsiveness and a second decrease that happens sometime before 12 months of age (Gunnar, 1998). Evidence does suggest that secure attachments between mother and infant do tend to serve as a buffer to the stress response system (see later literature on cortisol and alpha amylase). These infants are not only more able to self regulate, but they also have lower numbers of corticotropin-releasing hormone (CRH) receptors, an integral component of the HPA axis (see discussion to follow) that effects the ease of activation of the stress response system. In combination, these data suggest that having a more responsive mother may help develop an infant whose stress system not only takes more to activate but that is able to calm down more quickly.

In summary, for infant empathy development, what this dialogue of stress and regulation literature suggests is manifold. First, at least in part out of mother-infant interactions with specific regard to mother-infant synchrony and mutual regulation, infants' stress response systems develop, as do their abilities for self-regulation. Such findings have implications for assessing empathy development in infants that will be discussed later. Second, if such interactions are synchronous (i.e., the mothers are responsive to the needs of the infants), the infants' abilities for handling stress and their development of self-regulation will be positively strengthened, thereby lessening their levels of emotional contagion (i.e., personal distress) and likely increasing their abilities to first recognize the distress of another and then act sympathetically to relieve such distress. Third, if such interactions are out of synchrony – for instance the mothers are unresponsive, respond inappropriately, or are even absent – the infants' abilities for handling stress and for self-regulation will still be developed, but in such a way that could likely leave them with high levels of emotional contagion, thereby unable to recognize another's distress as easily and unable to respond as empathically. Thus, again, the role mothers play in empathy development appears to be of significant importance, here specifically as how such interactions appear to help develop the infants' abilities to self-regulate and handle stress.

Neurological Influences. Though this has been hinted at already throughout this document, infancy is a sensitive period for brain development. Changes in the infant brain, such as synaptic formation, myelination, and cortical organization, occur at a rapid pace during infancy and these changes occur largely without any "abnormally positive" environmental influences (Perry & Pollard, 1998). Environmental stimuli can affect normal development, such as has been found with work relating to infant nutrition and stimulation, but it is largely the case that environmental deprivations will have a much greater negative effect on development rather than positive influences playing a positive role (Propper & Moore, 2006).

Work examining infant neurological development has shown that alterations in synaptic formation and cortical organization can occur as a result of infant-parenting interactions (Dawson et al., 2000; Propper & Moore, 2006). Some theorists propose that in some ways, such findings are similar to enriched/impoverished environment work in how these normal interactions create the enriched environment that the infant brain needs to develop and that without such interactions (i.e., the impoverished environment) normal neurological development is hindered. In addition, epigenetic work now suggests that parenting influences have the potential to activate or inhibit gene expression (Propper & Moore, 2006). In a review of how parenting has shown to affect infant neurological development, Swain, Lorberbaum, Kose, and Stratheorn (2007) suggest in conclusion that "parenting behavior critically shapes human infants' current and future behavior" (p. 262). Based on the possibility of such programming effects, a brief neurological theory of empathy will be provided here. This is in no means exhaustive of the extensive amount of literature that has been published, but its aim is to highlight the importance of neural development in infancy rather than to describe its intricacies.

Rather recently, Tucker et al. (2005) noted that the evidence from the neurological fields has begun to provide an understanding of the neural mechanisms involved in the ability to empathize, though again, this literature has examined empathy primarily in adults, and thus its relevance to early empathy development in infants is currently unknown. Tucker et al. have also pointed out that the theoretical depth that is needed to integrate such findings is beyond what was previously hypothesized, and thus a complete working neurological theory of empathy has not been provided. While there have been some who have attempted such a model, at least for components of the process (e.g., Decety & Grezes, 2006; Decety & Ickes, 2009; Decety & Lamm, 2007; Gallese, Keysers, & Rizzolatti, 2004), the bulk of the research continues to remain domain specific, focusing on a single brain structure at a time.

From this literature, several areas of the brain have been identified as playing a role in mature empathy (e.g., Decety & Grezes, 2006; Decety & Ickes, 2009; Decety & Sommerville, 2003; Gallagher et al., 2000). Some of these areas – though not all – will be briefly delineated here, though descriptions of the neurological structures will not be offered. For example, Broca's Area is thought to have a function in frontal mirror neurons (Decety & Ickes, 2009). The superior temporal sulcus (STS) is thought to be involved with early visual description, imitation, and action feedback, with the STS and post parietal connections also influencing the abilities to predict sensations and plan imitative movements (Decety & Ickes, 2009). Kinesthetic aspects of face and body movements, as well as self-other differentiation, are thought to be controlled, at least in part, by the posterior parietal cortex, whereas the inferior parietal cortex and the prefrontal cortex in the right hemisphere assist in interpersonal awareness (Decety & Grezes, 2006; Decety & Ickes, 2009; Decety & Lamm, 2007). Both the anterior cingulate and the amygdala are attributed with the abilities to influence the processes involved with emotional relevance, physical pain, and social exclusion (Decety & Ickes, 2009). Internal and external experiences are thought to be bridged by the insula and focus on new stimuli and the redirection of attention by the primary sensory cortex. The paracingulate cortex seems to affect abilities for theory of mind and the orbital frontal lobe seems to be involved in emotional, though not cognitive, perspective taking (Decety & Ickes, 2009; Decety & Sommerville, 2003). Also, the Temporoparietal Junction (TPJ), currently thought to play one of the largest roles in empathy, works to compare signals that arise from self-produced actions to those from the environment (Decety & Ickes, 2009; Decety & Lamm, 2007; Gallagher et al., 2000).

Another limitation that should be noted from the neurological literature is that specificity of location varies from study to study. For instance, research with the TPJ (e.g., Decety & Grezes, 2006; Decety & Lamm, 2007) is newer and evidence regarding it was often previously attributed to the right parietal cortex (Decety & Sommerville, 2003). Thus, the literature on these structures will at times simultaneously overlap and conflict with one another. Additionally, the methodologies used in these studies have varied, both in design and instrumentation, though most have relied on Functional Magnetic Resonance Imaging (fMRI) and have had participants view faces (e.g., Wild, Erb, Eyb, Bartels, & Grodd, 2003). Also, some studies have looked at subjects with typical neurological features (e.g., Hynes, Baird, & Grafton, 2006) and others have examined those with atypical or empathy-eliciting features, such as those with lesions (e.g., Shamay-Tsoory, Tomer, Berger, & Aharon-Peretz, 2003; Stuss, Gallup, & Alexander, 2001), schizophrenia (e.g., Lee, Farrow, Spence, & Woodruff, 2004), or autism (e.g., Baron-Cohen et al., 1994).

Furthermore, the trend to examine the role specific locations, such as the TPJ or STS, have in empathy is likely overly simplistic. The brain operates as a holistic unit and the tendency to focus on one structure at a time may lead to inaccurate conclusions. To use an analogy, if a part of an automobile is not functioning correctly, it is highly likely that other components are also going to function differently or incorrectly as a result. However, attributing the outcome to what would be a secondary effect would lead to an incorrect conclusion about the cause of the automobile dysfunction. Similarly, looking at individual neurological structures, as opposed to the brain as a whole, could lead to inaccurate conclusions about the roles such structures play in empathy. For example, if differences in the TPJ using fMRI technology are shown in individuals with autism, perhaps it really is the TPJ that is originally different, or perhaps differences in receptors, neurotransmitter levels, or within another structure affected the TPJ. Either way, a primary limitation to this area of study is the lack of "whole brain" research and its focus on structure specific work.

It is possible that the different neurological areas that were just described could be involved in the different aspects or definitions of empathy noted earlier (Decety & Ickes, 2009). It is also possible that empathy development during infancy is in part driven by the development of these neurological structures, both individually and as interwoven systems. However, it would further appear in light of previous discussions that such developments are additionally influenced by maternal interactions – the effects of which often last into adulthood and as such should be considered within this light of influence (Propper & Moore, 2006). Regardless, the point remains that such work has yet to be done.

Evolutionary Theory. Though likely interwoven into the discussions of the other theories – namely maternal influences, stress and self-regulation, and neurological influences – an examination of empathy from a specifically evolutionary viewpoint was deemed appropriate. In part this is because many researchers have argued for the adaptive qualities of empathy from an evolutionary perspective (e.g. de Waal, 2005-2006). In a discussion regarding the evolutionary advantage of empathy, Dr. Mark Flinn, Professor of Anthropology at the University of Missouri, commented that empathy likely developed as a result of "an arms race in social tactics" (personal communication, November 12, 2010). The ability to empathize allows humans to not only read and predict the thoughts and actions of another, but to adjust our own behaviors based on our understanding of how others view us, thereby increasing the chance we will be perceived favorably. Such skills have likely been advantageous in the human species, which relies so heavily on social interactions for survival.

However, over the past few decades, evidence of empathy in other species has become increasingly noted (de Waal, 2005-2006). When Masserman and colleagues reported that rhesus monkeys refused to pull a chain that delivered food to themselves if doing so gave a shock to a companion, views on animal "empathy" began to change (Masserman, Wechkin, & Terris, 1964). Other species have regularly been shown to mimic one another, similar to emotional contagion in humans, and have an impulse to aid and care for offspring (Decety & Lamm, 2007) – aid that will regularly be extended outside the kin group and even to different species.

In light of the increasing amount of animal literature, de Waal (2005-2006) has suggested that rather than placing empathy as one of the highest abilities of human cognition, that it should be examined instead at a more basic level. He hypothesized that the development of empathy from an evolutionary perspective likely has its roots in the parental care behaviors of mammalian species. From this evolutionary perspective, human offspring who are cared for by multiple individuals – for instance in family groups, by neighbors, or in modern daycare settings – have a greater chance of survival. This is in contrast to a commonly held view that empathy developed out of the need to cooperate in times of war (Szalvitz & Perry, 2010). In comparison to other primates, such as chimpanzees or gorillas, humans are cooperative breeders. They do not simply tolerate other people, namely family members, helping with the care of their offspring but they actively solicit such help. Although currently in American society we often tend to place shame on mothers who share their responsibilities of childcare, unfortunately often viewing "daycare as a modern evil" (p. 179), this has not historically been the case with humans, and even now is not a global trend.

Additionally, de Waal (2005-2006) viewed the infant emotional contagion response as one of the signaling processes, like smiling or crying, that infants are able to use to initiate care-giving actions from others. The adaptive nature of empathy can also be viewed as having a role in inter-species cooperation, though admittedly a controversial concept within evolutionary theory. In this form, empathetic abilities allow one member of a species to comprehend the activities and goals of another member to produce effective cooperation. In addition, mutual aid among species members likely aids in the perpetuation of the genes (Decety & Ickes, 2009), where sometimes the most "fit" or reproductively successful are those who help when natural selection acts at the group level.

The nature of the self-regulation and stress systems can also be viewed from an evolutionary perspective, and as reviewed above, both appear to be necessary for empathy (Tucker et al., 2005). In parenting, empathic concern appears to be necessary and biologically encouraged, as evidenced by findings such as how infant-mother bonding appears to be mediated by opiate mechanisms. Here an underlying principle to remember, though certainly not unique to the evolution of these systems, is that individually we adapt to our environments, but the adaptations that allow us to survive in one environment may not allow us to thrive in another. As an infant, our stress system is developed (see discussion on the sympathetic nervous system and HPA-axis below), and as was discussed in the above sections, maternal interactions allow for that stress system to be ideally developed through a rhythm of small stressors (e.g., breaks in synchrony with mothers) followed by reparative behaviors (Tucker et al., 2005). Such an interaction is descriptive of mother-infant synchrony and mutual regulation, thus demonstrating a strong overlap of the constructs (see earlier discussion).

If, however, the stress an infant experiences is too great, the infant will develop a programmed stress response either of hyperarousal or dissociation (Perry & Pollard, 1998). With hyperarousal, the infant's baseline arousal state will be more exaggerated and sensitive, likely leading to higher and more persistent levels of emotional contagion. While a hyperarousal response is protective in the short term, often eventually eliciting the care of the mother through cries, body movements, and facial expressions, the long-term consequences of being in a consistently hyperaroused state are harmful to the body as whole (see work on allostatic load and Ganzel, Morris, & Wethington, 2010 for an integration of this work). Even more troublesome, however, is that if infants repeatedly adopt a hyperarousal response but are still unable to elicit needed care, they will eventually give up their attempts to connect with their caregiver. This form of defeat response can be seen in learned helplessness work (e.g., Maier & Seligman, 1976), and unfortunately in children is sometimes mistaken for resilience.

When such findings as those just discussed are combined with those previously described on how maternal interactions help to shape the stress response system (e.g., Gunnar et al., 1996; Gunnar, Hertsgaard, Larson, & Rigatuso, 1991), it could be argued that unresponsive, or even cruel parenting might be adaptive if the child was going to be raised in an environment where survival was at question (Szalvitz & Perry, 2010). Specifically, less empathic mothers might simply be better preparing their offspring for a stressful and shorter life. However, in our current society, such "survival" stressors are not often similar to the daily chronic stressors we face. Thus, rather than preparing our children for surviving in the world, we need to be preparing them to thrive in it. From such an evolutionary perspective, the earliest forms of empathy found in infants, namely emotional contagion, might be of specific interest (de Waal, 2005-2006). Not only is this because continued understanding of these early empathic responses will likely provide insight into the evolutionary development of the process, but because due to the neurological development and programming of brain structures and the stress system, it is also likely that this early time is when the greatest amount of intervention into empathy development can be made.

Measurement of Emotional Contagion

While the examination of emotional contagion in infants has primarily relied on physiological measurements and eye movements, though in toddlers, constructed laboratory experiments (such as the Empathy Task, Frustration Task, and Theory of Mind Task) are often used, and in children, stories, pictures, and videos have been utilized as well. Eisenberg and Fabes (1997) note that the conflicting data, particularly as it relates to prosocial behaviors, are likely due in part to the differences in assessment methods that have been used as well as the differences in operational definitions.

Parental Report

Though self-report and parental report measures are used with older children and adults (e.g., Cairns et al., 1995; Doherty, 1997; Mehrabian & Epstein, 1972) only recently has the first known parental report assessment for empathy been designed for toddlers and young children (Rieffe et al., 2010). The Empathy Questionnaire (EmQue) was based on Hoffman's (1987) theory of empathy development and thus consisted of three components of empathy that would be visible in toddlers and young children: Emotional Contagion, Attention to Others' Feelings, and Prosocial Actions. Parents are asked to focus on their children's behavior over the past 2 months and rate the degree that their children reflect a designated behavior on a 3-point scale (0 = never, 1 = sometimes, 2 = often). They are to respond to 20 questions such as "When another child cries, my child gets upset too" (Emotional Contagion), "My child laughs when another child laughs" (Attention to Others' Feelings), and "When another child starts to cry, my child tries to comfort him/her" (Prosocial Actions). The scale was tested with children aged 12 to 30 months of age and was shown to not only separate out the three assessed components, but to positively correlate with other parent report measures and laboratory tested child behaviors. Specifically, a simulated distress test and a frustration test (used with children aged 12-30 months old) and a theory of mind test (used with children aged 31-60 months old) were used to assess the validity of the EmQue. Additionally, a developmental trend was supported where children developed increased levels of Attention to Other's Feelings and then Prosocial Actions as they aged, though Emotional Contagion was not associated with age.

While the EmQue (Rieffe et al., 2010) bears promise for future work on assessing empathy in older infants, additional work is needed. Also, though it was not validated in infants under the age of one, future work could examine whether select items that were developmentally appropriate to the motor and cognitive skills of an infant under 1 year (e.g., "When another child cries, my child gets upset too") could be extracted and used to assess a younger population.

Assessment of the Sympathetic Nervous System

Previously discussed briefly, markers of the sympathetic nervous system (SNS) are commonly used to assess emotional contagion (Liew et al., 2003), particularly in infant populations where empathy scales or even maternal report measures are largely unavailable and impractical. Heart rate (HR) and sucking are the two modes frequently used, though skin conductance has also been used in older samples (e.g., Blair, 1999). Given the influence the stress system appears to play on emotional contagion (see previous discussion), markers of the SNS seem particularly relevant for such assessment. However, though physiological data are often considered to produce the most accurate results (Eisenberg & Fabes, 1990), there are disadvantages with them in regards to interpretation, and the same could be said for eye gaze as well. Each of these measures assesses constructs of arousal or attention, and though these in and of themselves are thought to point to emotional contagion, the evidence for that relies on results from infancy being used to predict empathic behaviors in childhood. Such a theoretical leap is great given the small amount of data currently available, and something the later proposed studies will attempt to address.

Heart rate and sucking. The reason SNS activity is utilized as a measure of empathy is because of the arousal response that often occurs when an empathetic behavior is elicited. This is because social stressors are primary activators of the stress response system, both in the SNS and hypothalamic-pituitary-adrenal (HPA) system. SNS activity results in a release of catecholamines that leads to HR differences, as well as differences in respiratory rate, blood flow, and blood glucose. The SNS response is commonly referred to as the "fight or flight" response and is activated more immediately and more often by daily stressors than the HPA axis.

As was described earlier, the use of HR as a measure of arousal or attentiveness in emotional contagion paradigms has been established (e.g., Liew et al., 2003; Zahn-Waxler et al., 1995). The difficulty begins, however, in how to handle differences in baseline state and in how to interpret the changes thought to be brought on by a stimulus (Eisenberg & Fabes, 1990). HR deceleration tends to be associated with taking in information from the environment, and thus often indicates an attentional phase, whereas HR acceleration has been associated more with stress, anxiety, or coping (Zahn-Waxler et al., 1995). Additional work with infant HR has shown that newborns display larger and longer HR decelerations when presented with novel stimuli, something that would be found with an unfamiliar cry as is commonly used in emotional contagion paradigms. Also, the magnitude of HR deceleration in infants is related to the novelty of the presented stimulus. Such findings are supported by work reviewed previously (e.g., Field et al., 2007; Simner, 1971).

To demonstrate, in infants with an average age of 70 hours in a study reviewed earlier, Simner (1971) showed that the neonates experienced increased HR when exposed to either recorded cries or white noise. Using both HR and sucking as markers of emotional contagion, Field et al. (reviewed earlier, 2007) showed decreased HR as well as reduced sucking rates in response to recorded cries within a sample of 2-week-old infants.

Interestingly, related to the associated negative consequences of emotional contagion outside of empathy that were discussed earlier, once the empathic components of sympathy and personal distress can be parceled apart in childhood, sympathy and higher levels of helping behaviors are associated with HR deceleration (likely other-focused attention) and personal distress and lower levels of helping behaviors are associated with HR acceleration (Eisenberg & Fabes, 1990). Eisenberg and Fabes found that while viewing a videotape of distressed children, HR deceleration in preschoolers (ages 46-70 months) was positively correlated with offering assistance to individuals when provided the opportunity to do so during the testing protocol. In contrast, HR acceleration was negatively correlated to helping behaviors within this particular sample.

Also in young children, Zahn-Waxler, Cole, Welsh, and Fox (1995) demonstrated that in 4- to 5-year-old children (31 girls and 51 boys), higher baseline HR and HR deceleration both positively predicted greater levels of empathic concern and prosocial behaviors, while lower baseline HR positively predicted greater levels of aggression and avoidance. Children’s levels of empathy were assessed through laboratory distress simulations and hypothetical simulations and their responses coded from video recordings. Thus, based on the literature reviewed, in children it appears as if HR deceleration is indicative of positive emotional contagion or empathy development. However, in infancy, such a conclusion should be considered carefully due to the scant amount of data within this age group.

Alpha Amylase. Though previously described, for purposes of continuity, data regarding α-amylase will be provided here again. Recently, α-amylase has been shown to serve as a non-invasive measure of SNS activation by way of saliva samples because activation of the SNS increases salivary protein secretion (Gordis, Granger, Susman, & Trickett, 2006; Rohleder et al., 2004). As such, salivary α-amylase (sAA) can be used in similar ways as HR due to the psychobiological nature of the arousal/stress response that was discussed earlier. However, the use of sAA to assess SNS activation has one strong advantage over the more traditional psychophysiological assessments of the SNS, especially when it comes to work involving infants, and that is its ease of use. While other SNS measurements involve electrodes and computerized recording apparatus (Hill-Soderlund et al., 2008), collecting a sample of sAA involves simply a cotton swab in the mouth.

Though its ease of use makes sAA attractive to infant researchers, there are important considerations for application in this population. Perhaps the most important of these is that sAA is not present in the saliva of newborns (Granger et al., 2006). This is thought to relate to the diets of infants (Sevenhuysen et al., 1984). Alpha-amylase serves to break down starches and other consumed carbohydrates. Though it is synthesized and stored in the newborn's pancreas, it is not present in the duodenum until around 6 months of age, the age at which supplementary foods are suggested to begin (Riordan, 2004). Breast milk, however, contains high amounts of α-amylase, thus offering an alternate method of starch digestions.

In addition, though levels of sAA can be detected in infants as early as 2 months of age (Davis, Kanna, Marucut, Granger, & Sandman, 2007), sAA reactivity to stress has not shown to be evident until 6 months of age. Levels of sAA will rise sharply in the 0.9–1.9-year period, reaching maximum levels by 5- to 6-years of age (Granger et al., 2006), though remaining lower than those for adults until approximately 24-months of age (Davis et al., 2007). Davis and Granger (2009), in an exploration of the developmental trajectory of sAA, examined infants at 2, 6, 12, and 24 months of age using an inoculation at a well-baby exam. They showed specifically that infant sAA develops between 2 to 6 months, increases in levels from 2 to 24 months, and that prestressor levels correlated with maternal sAA at 6, 12, and 24 months. Using the inoculation paradigm, reactivity in sAA was found at 6 and 12 months only.

Such findings are supported by Granger et al. (2006) who suggest that at early ages, individual differences in sAA levels may be regulated more by social relationships than physical stressors such as an inoculation. It is possible in light of this that sAA use in infants might have stronger implications in work involving social stressors rather than general stressors. If this is the case, there might be great applicability to emotional contagion work. Additionally, it should be noted that sAA reactivity is best sampled immediately following a stressor of at least 5 min in length, as the greatest peak in sAA levels will be visible at that time, and that levels will return to their baseline state 10 min post-stressor (Davis & Granger, 2009).

While no specific data on sAA and empathy were found, several studies with adults and adolescents have shown that sAA increases in response to stressors in social and academic domains (e.g., Davis et al., 2007; El-Sheikh et al., 2008; Gordis et al., 2006). Granger et al. (2006) were the first to use sAA as a SNS marker in infants, and found that infants showed cortisol (which will be discussed below) but not sAA reactivity to challenge tasks. It should be pointed out here that the methodology used did not involve a social stressor, which sAA reactivity is thought to capture best. Still, approximately 45% of the infants had a sAA rise greater than 10% in response to the tasks. In this same study, when using a preschool sample, approximately 40% of the children showed an increase in sAA greater than 10% in response to a separate series of challenging tasks.

Using a social stressor paradigm, Hill-Soderlund et al. (2008) examined whether sAA levels would be indicative of infant attachment patterns. In a sample of 132 infants of an average age of 13.5 months and their mothers, vagal reactivity and sAA were assessed in infants using the Strange Situation Paradigm (SSP) to investigate differences in physiological responses in a sample of insecure-avoidant and securely-attached dyads. The SSP was designed by Ainsworth, Blehar, Waters, and Wall (1978) in order to place children into attachment style categories and involves a series of separations and reunions between a caregiver, child, and stranger for a period of 30 min. Attachment styles were assigned by coding the infants' behaviors during the SSP from video recordings. Avoidant infants had lower mean values of respiratory sinus arrhythmia (RSA), which is a measure of HR variability during respiration, but greater RSA reactivity in response to the SSP. Additionally, these avoidant infants had higher sAA levels than those in the securely attached group. Hill-Soderlund et al. suggest that such findings indicate a greater allostatic load (i.e., the physiological results of exposure to chronic stress, such as immune suppression, [Ganzel et al., 2010]) within the avoidant infants. However, it should be noted that despite these findings, sAA was sampled 15 and 45 mins following the SSP, when levels would have been returning to baseline states, rather than at the recommended 5 mins post task time. This suggests that it is possible that greater differences would have been visible if sAA had been sampled at a different interval.

In addition, infants with higher levels of positive behavioral reactivity who additionally had highly sensitive mothers have been shown to demonstrate the lowest levels of sAA reactivity (Kivlighan et al., 2007), with infants with the least sensitive mothers demonstrating the highest levels of sAA reactivity. In this study, 284 mother-infant dyads were tested when the infants were between 5 and 10 months of age. Toy reach, mask, barrier, and arm restraint episodes from a laboratory infant temperament battery were used. Forty-three percent of infants showed sAA elevation over their pre-task levels. In addition, mothers' and infants' sAA reactivity levels positively correlated with each other.

Fortunato, Dribin, Granger, and Buss (2008) used a similar procedure as Kivlighan et al. (2007) with 111 toddlers with a mean age of 24 months. A series of modified tasks designed to elicit emotions from the Toddler and Preschool Laboratory Temperament Assessment Battery (LabTAB; Buss & Goldsmith, 2000) was completed within the laboratory and behaviors were then coded from video recordings (Fortunato et al., 2008). Saliva samples were appropriately collected for sAA prior to the task and immediately following. Pre-task levels of sAA were related to affective behaviors within this sample, where positive affect and approach correlated positively to sAA levels. Post-task levels were not shown to relate to affective behaviors, however. Such evidence suggests that an examination of baseline levels of sAA as well as its reactivity should be examined for what they might reveal.

In these studies using sAA (e.g., Davis et al., 2007; El-Sheikh et al., 2008; Gordis et al., 2006; Hill-Soderlund et al., 2008; Kivlighan et al., 2007), evidence was found for the effects maternal influence has on the stress response system of the offspring, as was discussed earlier. Specifically, highest elevations of sAA were shown in infants with the *least* responsive mothers, which is comparable to the HR work noted earlier which showed decreased arousal in infants with more responsive mothers (Field et al., 2007). However, an important distinction to remember between these two bodies of research is that the work summarized using HR utilized an empathy paradigm (i.e., exposure to stress of another) to elicit arousal, whereas the work with sAA was exclusively using paradigms that placed the participants themselves in the stressful situation. Particularly in an infant population, it is possible that the predictive directionality of maternal behaviors changes as a result. Therefore, in an empathy paradigm with sAA, it is still unknown whether greater changes in sAA would be found in infants with *more* responsive mothers.

Cortisol. The use of sAA was inspired by the widespread use of salivary cortisol, a salivary marker of the HPA axis which is a second stress system and different from the SNS. While both the SNS and HPA axis are activated by daily stressors and appear to respond best to psychosocial stressors (Flinn, 2006), the HPA axis remains in activation when exposed to extreme or prolonged stressors (Gordis et al., 2006). Such activation involves a hormone response cascade that has a primary role of modifying behavior in response to stressful or dangerous situations. HPA axis activation involves the initiation of corticotrophin releasing hormone (CRH) neurons located within the hypothalamus. This then leads to an increased production of a number of steroids, including various glucocorticoids. Thus, the end-product of HPA axis activation is the secretion of glucocorticoids such as cortisol into circulation (Risbrough & Stein, 2006). This process in turn activates the SNS. When the response is to a daily or mild stressor, the release of cortisol then follows a negative feedback inhibition loop and leads to the cessation of HPA axis activation and helps bring the system back to homeostasis. When the response is to an extreme or prolonged stressor, however, the HPA axis becomes disinhibited and therefore remains activated in an attempt to continue responding to the stressful event.

Chronically, exposure to either extreme stressors or prolonged exposure to moderate stressors have resulted in permanent increases in CRH levels, and changes in CRH receptors (Risbrough & Stein, 2006). Specific to the present work and reviewed previously, a difference in CRH receptors in infants was found by Gunnar (1998) in relation to attachment status, where securely attached infants had lower numbers of CRH receptors. Increased numbers of CRH receptors result in HPA axis activation that occurs in response to a lesser stressor (Risbrough & Stein, 2006). Additionally, basal CRH levels imply an increased HPA axis response to stress, which is likely to result in both exaggerated behavioral and physiological stress symptoms. To once again use a metaphor, if the HPA axis were a car, these two outcomes would result in an automobile that was both turned on more easily and that reached maximum speeds more rapidly. Thus, if such changes in CRH occur, cortisol would be secreted into the bloodstream more frequently.

Cortisol is a steroid hormone and glucocorticoid that is released into circulation by the adrenal gland and that is able to freely cross the blood brain barrier. Cortisol becomes active in multiple brain regions, including the amygdala and hypothalamus, but the behavioral modifying effects of the HPA axis are achieved by its interaction specifically on the amygdala, a primary emotion center of the brain. Like sAA, cortisol does follow a circadian rhythm that needs to be taken into account for analysis purposes (Rohleder et al., 2004), but unlike sAA, cortisol does not reach its peak levels until 20 mins post-stressor (Davis & Granger, 2009). Additionally, while use of salivary cortisol in infants has been done, Magnano, Diamond, and Gardner (1989) advise caution with this population due to the relatively high levels of cortisol that have been found in breast milk. They suggest continued use of salivary cortisol in breastfed infants with appropriate control measures to help ensure accurate results due to this possible contamination.

The only known study that has examined cortisol in relation to empathy was completed by Nakayma and colleagues using a young adult sample (ages 18- to 25-years of age; Nakayama, Takahashi, Wakabayashi, Ono, & Radford, 2007). Nakayama et al. examined empathy in males and females and found that males with higher levels of empathy had higher levels of cortisol as well. Unpublished results from this study further indicated a negative correlation between levels of empathy and levels of cortisol in females (T. Takahashi, personal communication, December 7, 2008).

Infant cortisol work has been done, however. For instance, in the Davis and Granger (2009) study reviewed earlier, the development of cortisol was examined in infants at 2, 6, 12, and 24 months of age using an inoculation at a well-baby exam. Here, cortisol levels were shown to increase at 2 and 6 months of age, but not at 12 and 24 months of age, again providing evidence to a stronger reactivity of cortisol to social stressors over physical stressors. Additionally, Eiden, Veira, and Granger (2009) examined infant cortisol reactivity in 7-month-olds. Approximately half of the infants ($n = 87$) had been exposed to cocaine prenatally while the others had not ($n = 81$). Infant reactivity and regulation were assessed by three episodes taken from LabTAB (Goldsmith & Rothbart, 1988) to assess anger/frustration (arm restraint), positive affect (puppet episode), and fear (scary masks). Cortisol samples were taken upon arrival, immediately following a 3 min habituation period, immediately following the tasks, and 20 min post task. Maternal caregiving behaviors were assessed by way of a behavior observation during a free play task and a structured interview. Results showed first that cortisol levels did differ between infants who had been exposed prenatally to cocaine and those who had not, with infants who had been exposed showing greater reactivity than those who had not. Second, maternal caregiving moderated between cocaine exposure and cortisol levels. Here, within the cocaine-exposed infants, greater caregiver instability was associated with higher basal cortisol levels. Differentially, among infants who had been exposed to other substances prenatally (e.g., tobacco, alcohol, marijuana), greater caregiver instability was associated with higher cortisol reactivity.

Somewhat more specific to the work at hand, 158 infants (103 pre-term infants and 55 full-term infants) were examined at 8 months of age within a laboratory setting (Tu et al., 2007). Levels of attention were measured by using a toy exploration session in which infants were presented with four toys consecutively with which to engage. Their levels of focused attention were defined as the quality of their visual examination of the toys from 1 (little or no investment in exploration of the object) to 5 (high levels of sustained and concentrated attention). Their mothers were assessed on their interactions with the infants during a play session in the laboratory and on their stress levels using the Parenting Stress Index (PSI; Abidin, 1995b). Infant salivary cortisol was collected only upon arrival. In infants whose mothers reported more stress on the PSI and displayed high interactive behaviors with their children, higher basal cortisol levels were associated with less focused attention. Here, though interactive parenting often serves as a buffer to stressors, it was shown that this effect seemed to be overridden when parenting stress was high. Drawing on the earlier discussion regarding mother-infant synchrony and mutual regulation, it is possible that an explanation for such a finding might involve a disruption in the mothers' abilities to remain in-synchrony with their infants. Specifically, though these mothers were interactive, their levels of stress might have affected their abilities for mutual regulation.

Additionally, in 88 mother-infant dyads (infants were 7 months of age), infants' salivary cortisol responses to the still-face procedure (described earlier) were examined in relation to maternal prenatal anxiety and caregiving (Grant et al., 2009). Salivary cortisol was sampled upon arrival to the laboratory and 15, 25, and 40 mins following the still-face procedure. After controlling for pre- and postnatal maternal depression and postnatal anxiety, an interaction was found between infants' cortisol responses and maternal prenatal anxiety as well as between infants' cortisol responses and maternal sensitivity. Maternal sensitivity did not appear to moderate between prenatal anxiety and infant cortisol response. Follow-up contrasts showed that infants with high sensitive mothers displayed little fluctuation in their levels of cortisol, while infants with low sensitive mothers increased in their levels between 15 to 25 mins post-test, the period of highest cortisol peak.

Within toddlers (mean age of 24 months), as was described above, Fortunato et al. (2008) used tasks from LabTAB (Buss & Goldsmith, 2000) to assess differences in cortisol and sAA based on affective behavior. Saliva samples were collected prior to the tasks and immediately following, thus missing the cortisol peak at 20 mins post-task. In spite of this, baseline cortisol levels were positively associated with intensity of negative affect and post-task levels were positively associated with both negative affect and withdrawal behaviors. Thus, infants with higher baseline and post-task cortisol levels displayed more negative emotions and/or more withdrawal. Given the methodological issue regarding timing of sampling, it is possible that additional differences would have been visible if samples were taken at the appropriate time.

To summarize these studies, maternal factors such as attachment, sensitivity, caregiving, and separation have been shown to relate to both baseline cortisol levels and cortisol responsivity in infants (e.g., Eiden et al., 2009; Fortunato et al., 2008; Grant et al., 2009; Tu et al., 2007), with more negative mothering behaviors associated with higher baseline levels and greater responsivity. However, when compared to sAA, there is some evidence that sAA may be a more sensitive measure of infant/child reactivity to daily stressors than salivary cortisol, as an indicator of the SNS rather than the HPA system (Granger et al., 2006). For instance, Mize, Lisonbee, and Granger (2005) showed that more children showed increases in sAA than they did to cortisol in response to the same battery of tasks.

In relation to maternal behaviors, perhaps a question to address would be whether multiple asynchronous interactions between mother and infant are experienced by the infant as individual daily stressors that might be best captured by sAA responsivity or as a series of prolonged stressors that would best make use of cortisol analysis. Regardless, both cortisol and sAA appear to be more sensitive to social stressors when working with children (Granger et al., 2006), increasing their application to empathy work. Based on these data, however, it might be suggested that together, salivary cortisol and sAA would provide a more complete understanding of infants' emotional contagion responses (e.g., Gordis et al., 2006).

Summary of SNS measurements. In summary, given the previously proposed relationship between empathy development and the stress response system, the use of salivary analytes such as cortisol and sAA that are reflective of either HPA axis or SNS activation would possibly allow for reliable, easy to use methods of assessing emotional contagion response behaviors. While the traditional psychophysiological measures of the SNS such as heart rate and sucking are the only ones that have previously been examined with relation to emotional contagion, it is suggested that the markers of salivary cortisol and sAA be examined within this context.

While no studies using sAA or cortisol to assess empathy in an infant or child population were found, work with each method of measurement is consistent in its findings once methodological issues such as sampling time are accounted for. Additionally, this body of reviewed literature suggests a difference in how baseline levels and reactivity are related to outcomes. The heart rate literature suggests, at least in childhood, that 1) sympathy and higher levels of helping behaviors are positively associated with HR deceleration (e.g., Eisenberg & Fabes, 1990; Zahn-Waxler et al., 1995), 2) personal distress and lower levels of helping behaviors are positively associated with HR acceleration, 3) higher baseline HR is positively associated with greater levels of empathic concern and prosocial behaviors, and 4) lower baseline HR is positively associated with greater levels of aggression and avoidance. Therefore, HR deceleration and higher HR baseline states might be viewed as positive indicators of childhood empathy and HR acceleration and lower baseline states might be viewed as negative indicators.

Similar patterns, at least in reactivity, were found in both sAA and cortisol work when the literature relating to maternal interactions with infants and toddlers was examined (Eiden et al., 2009; Grant et al., 2009; Hill-Soderlund et al., 2008; Kivlighan et al., 2007; Tu et al., 2007). Regarding both analytes, 1) more negative mother-infant interactions positively correlated with higher baseline levels of sAA and cortisol, and 2) more negative mother-infant interactions positively correlated to greater reactivity of sAA and cortisol in response to a stressful event. Here, as in the HR work, *less* reactivity would appear to be indicative of positive mother-infant interactions, though in contrast to the HR work, *lower* baseline states of these analytes could be viewed as indicative of positive mother-infant interactions.

Thus, while there has been convergence shown between various measures of empathy response utilized up until this point, namely verbal self-report, facial expression, and change in HR in young children (Anastassiou-Hadjicharalambous & Warden, 2007), additional research should examine whether there is also convergence between HR changes and both salivary cortisol and sAA. It is recommended that if these salivary analytes are used for this purpose that they be examined in conjunction with each other, as recent research suggests that the interaction of the two may serve as a greater predictor of behavior (e.g., Gordis et al., 2006).

Cultural and Gender Limitations

One of the limitations that have yet to be addressed is the possible variance in empathy development between genders and possibly across cultures. Almost all of the work that was found on empathy development was completed within the United States, though one study was completed in Germany (Trommsdorff, 1991) and another in China (Wellman, Fuxi, Liu, Liqi, & Guoxiong, 2006). It is possible that cultural differences would affect empathy development. For instance, in the Wellman et al. (2006) study, Chinese children differed from English-speaking children in their earliest understanding of cognitive mental states. Also, drawing from the evolutionary theory that was discussed, it is possible that what would be considered "disadvantageous" maternal interactions within the U.S. culture would be advantageous in another – particularly one with increased dangers. Thus, work across cultures needs to be completed. Additionally, there is mixed evidence within children (it has largely remained unexamined within infants) of whether empathy differs between genders (e.g., Feshbach & Feshbach, 1969; Hodges & Klein, 2001; Warden & Mackinnon, 2003). A more thorough investigation of such a finding is called for.

Summary

In summary, the above literature review specifically attempted to describe how empathy develops in infancy, with regard to progression and influences, and discussed methods of assessing infant empathy, proposing that sAA and salivary cortisol be examined as new assessment techniques. It was acknowledged that while mature empathy is not developed until later in childhood, that emotional contagion, a rudimentary version of empathy involving at least an internal response, is likely laying the developmental "groundwork" and has shown to relate to the more mature empathy that comes later (e.g., Cummings et al., 1986). Based on such evidence, it does appear as if there is likely a consistent developmental trajectory for empathy, though the discussed age gap in the literature makes this a preliminary conclusion.

Multiple examples of emotional contagion were provided (Field et al., 2007; Field et al., 1982; Geangu et al., 2010; Martin & Clark, 1982; Meltzoff & Moore, 1977, 1983, 1989, 1992; Sagi & Hoffman, 1976; Simner, 1971) and interesting evidence suggested that while emotional contagion appears to continue throughout the lifespan, that outside of infancy, it does not appear to be a particularly positive aspect of empathy (Vaish et al., 2009; Volbrecht et al., 2007; Zahn-Waxler, Radke-Yarrow, et al., 1992; Zahn-Waxler, Robinson, et al., 1992). Specifically, emotional contagion appears insufficient for reparative and prosocial behaviors to occur (e.g., Rieffe et al., 2010), and higher levels outside of infancy actually negatively relate to prosocial helping and general social functioning (e.g., Lovett & Sheffield, 2007; Rieffe et al., 2010). Thus, since emotional contagion is developmentally egoistic, which is appropriate for an infant, if prosocial behavior is elicited, it appears to regularly come from a drive to reduce one's own distress rather than from an attempt to aid another (Eisenberg & Fabes, 1990).

Additionally, four overlapping theories were discussed of how emotional contagion and empathy develop, namely, neurological and evolutionary factors, maternal influences, and influences of mutual- and self-regulation and the stress response system.

The importance of the infant's neurological developments with regards to empathy development were highlighted, specifically as the data suggested that parenting behaviors were able to shape such developments (e.g., Swain et al., 2007), and the adaptive qualities of empathy from an evolutionary perspective were also given (e.g., de Waal, 2005-2006). With regard to maternal influence, evidence was provided to suggest that maternal responsiveness does seem to mold empathy development (Davidov & Grusec, 2006; Field et al., 2007; Hernandez-Reif, Field, Diego, & Ruddock, 2006; Hernandez-Reif, Field, Diego, Vera, et al., 2006; Kiang et al., 2004; Spinrad & Stifter, 2006; Trommsdorff, 1991; Valiente et al., 2004; Zahn-Waxler et al., 1979). More specifically, during an early stage of emotional contagion a lack of maternal interaction appeared to increase the level of arousal an infant experiences, while later in infancy and into childhood, positive maternal interactions seem to be associated with a decrease in emotional contagion responses and an increase in prosocial behaviors.

This specific line of literature, however, had a primary limitation of there being hardly any material that examined infants between 3 and 9 months of age. In light of this, related work in the areas of mutual- and self-regulation and mother-infant synchrony was explored. Here, the importance of synchronous mother-infant interactions was presented with relation to mutual regulation and the role these interactions play in helping shape the infants' later abilities to self-regulate was discussed (Perry & Pollard, 1998; Propper & Moore, 2006; Stern, 1977, 1985). Then, data were provided that suggested the ability to self-regulate allows for emotional contagion responses to decrease and prosocial empathy behaviors to appear (e.g., Eisenberg, 2000; Rothbart & Ahadi, 1994). Additional material reviewed suggested that if mother-infant interactions were out of synchrony, that the infants' abilities for handling stress and for self-regulation would be developed in such a way that could likely leave them with high levels of emotional contagion, thereby unable to recognize another's distress as easily, and unable to respond as empathically (Szalvitz & Perry, 2010; Tronick, 2007). Thus, this area of research offers a possible mechanism for how mothers are influencing their infants' emotional contagion responses, providing support for the claim made by Szalavitz and Perry (2010) that the "roots of empathy emerge from the soil of our stress response systems" (p. 15).

Furthermore, current and suggested measurements of emotional contagion in infancy were discussed. The recently developed Empathy Questionnaire (EmQue) was presented as the only known parental report measure available for a younger population (Rieffe et al., 2010). Traditional markers of the SNS were reviewed given their ability to assess the levels of arousal and attention elicited through emotional contagion paradigms. With regard to HR in children, HR deceleration and higher HR baseline states appeared to be indicators of empathy and HR acceleration and lower baseline states were presented as negative indicators of empathy (Eisenberg & Fabes, 1990; Zahn-Waxler et al., 1995). Additionally, sAA, a newer method of SNS assessment, and salivary cortisol were offered as possible methods of emotional contagion assessment due to their ease of use with an infant sample. Though the current body of literature has not examined either of these salivary analytes as methods of empathy assessment in infants, examination of the literature related to maternal interactions with infants and toddlers showed that similar to HR work, *less* reactivity appeared to be indicative of positive mother-infant interactions, though in contrast to the HR work, *lower* baseline states of these analytes appeared to indicate positive mother-infant interactions (Eiden et al., 2009; Grant et al., 2009; Hill-Soderlund et al., 2008; Kivlighan et al., 2007; Tu et al., 2007).

Lastly, given the implications of emotional contagion development and the important role that early mother-infant experiences seem to have on such developments, it is important to note that in our society, almost nothing is taught about child development, even less on infant development, and hardly anything on the social needs of infants. Though research has strongly indicated that training in empathy can be effective within children (Brehm, Powell, & Coke, 1984; Frey, Nolen, Van Schoiack-Edstrom, & Hirschstein, 2005; Perry, Bussey, & Freiberg, 1981), college students (Barak, Katzir, & Fisher, 1987), teachers (Warner, 1984), and adults (Galinsky & Moskowitz, 2000; Higgins, Moracco, & Danford, 1981), the need for such training goes largely unrecognized.

APPENDIX B

Tables

Table 1

Descriptive statistics of all maternal measures

		N	Min	Max	*M*	*SD*
AAPI-2*						
	Expectations of Children	36	2	10	5.69	1.69
	Empathy Towards Children's Needs	36	1	10	6.11	1.88
	Use of Corporal Punishment as a Means of Discipline	36	1	9	5.33	1.85
	Parent-Child Role Responsibilities	36	4	10	6.44	1.70
	Children's Power and Independence	36	4	10	7.36	1.66
PSI/SF						
	Defensive Responding	36	8	31	14.42	4.66
	Parental Distress	32	11	52	24.34	7.56
	Parent-Child Dysfunctional Interaction	32	12	41	19.28	7.24
	Difficult Child	31	13	37	22.16	6.16
	Total Stress	31	21	90	59.61	18.36
PSDQ						
	Authoritarian	35	3.67	4.93	4.39	0.34
	Authoritative	35	1.00	2.08	1.43	0.27
	Permissive	35	1.20	2.80	2.00	0.42

* *On the AAPI-2, scores of 1-3 indicate a high level of risk, 4-7 a moderate level, and 8-10 a low level.*

Table 2

Correlations between HR and sAA

		BS sAA	Post Cry sAA	sAA Difference
BS HR at 3 Mos	Pearson Correlation	-.258	-.191	-.075
	Sig. (2-tailed)	.212	.359	.722
	N	25	25	25
During Cry HR at 3 Mos	Pearson Correlation	-.180	-.147	-.057
	Sig. (2-tailed)	.358	.455	.774
	N	28	28	28
HR Difference at 3 Mos	Pearson Correlation	.042	-.024	-.071
	Sig. (2-tailed)	.842	.907	.735
	N	25	25	25
BS HR at 6 Mos	Pearson Correlation	.120	-.003	-.107
	Sig. (2-tailed)	.511	.989	.559
	N	32	32	32
During Cry HR at 6 Mos	Pearson Correlation	.183	.281	.241
	Sig. (2-tailed)	.341	.140	.207
	N	29	29	29
HR Difference at 6 Mos	Pearson Correlation	.129	.430*	.491**
	Sig. (2-tailed)	.514	.022	.008
	N	28	28	28

**Correlation is significant at the .05 level.*

*** Correlation is significant at the .01 level.*

Table 3

Correlation matrix of HR at 3 Months and AAPI-2

		BS HR	During Cry HR	HR Difference
Expectations of Children	Pearson Correlation	-.011	-.074	-.070
	Sig. (2-tailed)	.955	.699	.730
	N	27	30	27
Empathy Towards Children's Needs	Pearson Correlation	-.018	.175	.151
	Sig. (2-tailed)	.930	.356	.451
	N	27	30	27
Use of Corporal Punishment as a Means of Discipline	Pearson Correlation	-.004	-.039	-.083
	Sig. (2-tailed)	.983	.837	.681
	N	27	30	27
Parent-Child Role Responsibilities	Pearson Correlation	-.179	.000	.099
	Sig. (2-tailed)	.370	.999	.623
	N	27	30	27
Children's Power and Independence	Pearson Correlation	-.099	.033	.166
	Sig. (2-tailed)	.623	.864	.407
	N	27	30	27

Note: Baseline (BS), Heart rate (HR)

Table 4

Correlation matrix of HR at 6 Months and AAPI-2

		BS HR	During Cry HR	HR Difference
Expectations of Children	Pearson Correlation	-.245	-.145	.078
	Sig. (2-tailed)	.163	.438	.683
	N	34	31	30
Empathy Towards Children's Needs	Pearson Correlation	-.116	-.175	-.036
	Sig. (2-tailed)	.512	.346	.851
	N	34	31	30
Use of Corporal Punishment as a Means of Discipline	Pearson Correlation	-.031	-.154	-.036
	Sig. (2-tailed)	.862	.409	.851
	N	34	31	30
Parent-Child Role Responsibilities	Pearson Correlation	.005	-.073	-.173
	Sig. (2-tailed)	.978	.697	.362
	N	34	31	30
Children's Power and Independence	Pearson Correlation	-.164	.075	.085
	Sig. (2-tailed)	.354	.687	.657
	N	34	31	30

Table 5

Correlation matrix of HR at 3 Months and PSI/SF

		BS HR	During Cry HR	HR Difference
Parental Distress	Pearson Correlation	.156	-.296	-.473*
	Sig. (2-tailed)	.465	.133	.020
	N	24	27	24
Parent-Child Dysfunctional Interaction	Pearson Correlation	-.162	-.060	.043
	Sig. (2-tailed)	.450	.766	.841
	N	24	27	24
Difficult Child	Pearson Correlation	.061	-.212	-.315
	Sig. (2-tailed)	.776	.289	.133
	N	24	27	24
Total Stress	Pearson Correlation	.213	-.369	-.601**
	Sig. (2-tailed)	.317	.058	.002
	N	24	27	24

* *Correlation is significant at the .05 level.*

** *Correlation is significant at the .01 level.*

Table 6

Correlation matrix of HR at 6 Months and PSI/SF

		BS HR	During Cry HR	HR Difference
Parental Distress	Pearson Correlation	-.111	-.202	-.099
	Sig. (2-tailed)	.561	.311	.630
	N	30	27	26
Parent-Child Dysfunctional Interaction	Pearson Correlation	.004	-.117	-.210
	Sig. (2-tailed)	.982	.561	.303
	N	30	27	26
Difficult Child	Pearson Correlation	-.253	.004	.286
	Sig. (2-tailed)	.186	.985	.166
	N	29	26	25
Total Stress	Pearson Correlation	-.258	-.057	.254
	Sig. (2-tailed)	.176	.783	.220
	N	29	26	25

Table 7

ANOVA Model for HR Difference at 3 Months and PSI/SF Total Stress

Model	Sum of Squares	DF	Mean Square	F	Sig.
Regression	1023.36	1	1023.36	12.45	.002
Residual	1808.01	22	82.18		
Total	2831.37	23			

Table 8

Correlation matrix of HR at 3 Months and PSDQ

		BS HR	During Cry HR	HR Difference
Authoritarian	Pearson Correlation	.063	.066	.068
	Sig. (2-tailed)	.759	.734	.742
	N	26	29	26
Authoritative	Pearson Correlation	-.281	-.041	.164
	Sig. (2-tailed)	.165	.831	.424
	N	26	29	26
Permissive	Pearson Correlation	-.461*	-.348	.020
	Sig. (2-tailed)	.018	.064	.924
	N	26	29	26

**Correlation is significant at the .05 level.*

Table 9

Correlation matrix of HR at 6 Months and PSDQ

		BS HR	During Cry HR	HR Difference
Authoritarian	Pearson Correlation	.108	.147	-.117
	Sig. (2-tailed)	.549	.438	.545
	N	33	30	29
Authoritative	Pearson Correlation	-.008	-.077	-.064
	Sig. (2-tailed)	.967	.687	.742
	N	33	30	29
Permissive	Pearson Correlation	.076	.246	.113
	Sig. (2-tailed)	.674	.190	.558
	N	33	30	29

Table 10

ANOVA Model for BS Heart rate at 3 Months and Permissiveness from PSDQ

Model	Sum of Squares	DF	Mean Square	F	Sig.
Regression	466.70	1	466.70	6.46	.018
Residual	1733.44	24	72.23		
Total	2200.15	25			

Table 11

Correlation matrix of sAA and AAPI-2

		BS sAA	Post Cry sAA	sAA Difference
Expectations of Children	Pearson Correlation	-.108	-.101	-.051
	Sig. (2-tailed)	.544	.570	.773
	N	34	34	34
Empathy Towards Children's Needs	Pearson Correlation	-.163	-.189	-.131
	Sig. (2-tailed)	.356	.283	.461
	N	34	34	34
Use of Corporal Punishment as a Means of Discipline	Pearson Correlation	-.117	-.223	-.221
	Sig. (2-tailed)	.510	.204	.209
	N	34	34	34
Parent-Child Role Responsibilities	Pearson Correlation	-.257	-.131	.036
	Sig. (2-tailed)	.142	.459	.838
	N	34	34	34
Children's Power and Independence	Pearson Correlation	.004	-.113	-.168
	Sig. (2-tailed)	.981	.524	.342
	N	34	34	34

Table 12

Correlation matrix of sAA and PSI/SF

		BS sAA	Post Cry sAA	sAA Difference
Parental Distress	Pearson Correlation	-.182	-.248	-.193
	Sig. (2-tailed)	.337	.187	.307
	N	30	30	30
Parent-Child Dysfunctional Interaction	Pearson Correlation	.034	.054	.047
	Sig. (2-tailed)	.857	.776	.805
	N	30	30	30
Difficult Child	Pearson Correlation	.054	.055	.030
	Sig. (2-tailed)	.779	.778	.876
	N	29	29	29
Total Stress	Pearson Correlation	-.008	-.030	-.036
	Sig. (2-tailed)	.968	.877	.854
	N	29	29	29

Table 13

Correlation matrix of sAA and PSDQ

		BS sAA	Post Cry sAA	sAA Difference
Authoritarian	Pearson Correlation	-.133	-.230	-.212
	Sig. (2-tailed)	.460	.199	.237
	N	33	33	33
Authoritative	Pearson Correlation	.045	.076	.069
	Sig. (2-tailed)	.802	.676	.704
	N	33	33	33
Permissive	Pearson Correlation	.123	.148	.106
	Sig. (2-tailed)	.494	.410	.556
	N	33	33	33

Table 14

Correlation Matrix Between HR at 3 and 6 Months

		During Cry HR at 3 Months	Difference in HR at 3 Months	BS HR at 6 Months	During Cry HR at 6 Months	Difference in HR at 6 Months
BS HR at 3 Mos	Pearson Correlation	.475*	-.386*	-.013	-.102	-.272
	Sig. (2-tailed)	.012	.047	.950	.652	.221
	N	27	27	26	22	22
During Cry HR at 3 Mos	Pearson Correlation		.628**	.371*	-.024	-.409*
	Sig. (2-tailed)		.000	.047	.911	.042
	N		27	29	25	25
Difference in HR at 3 Mos	Pearson Correlation			.406*	.159	-.156
	Sig. (2-tailed)			.040	.479	.488
	N			26	22	22
BS HR at 6 Mos	Pearson Correlation				.541**	-.525**
	Sig. (2-tailed)				.002	.003
	N				30	-.272
During Cry HR at 6 Mos	Pearson Correlation					.431*
	Sig. (2-tailed)					.017
	N					30

**Correlation is significant at the .05 level.*
***Correlation is significant at the .01 level.*

APPENDIX C

Institutional Review Board Approval

Oklahoma State University Institutional Review Board

Date: Tuesday, December 11, 2007

IRB Application No AS0783

Proposal Title: Maternal Dietary Nutrients and Neurotoxins in Infant Cognitive Development

Reviewed and Processed as: Expedited (Spec Pop)

Status Recommended by Reviewer(s): Approved Protocol Expires: 12/10/2008

Principal Investigator(s

David Thomas	Tay Seacord Kennedy
215 N. Murray	312 HES
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

VITA

Stephanie Grant

Candidate for the Degree of

Doctor of Philosophy

Dissertation: SALIVARY α-AMYLASE AND HEART RATE AS MARKERS OF AN INFANT'S EMOTIONAL CONTAGION RESPONSE USING MATERNAL FACTORS AS PREDICTORS

Major Field: Lifespan Developmental Psychology

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Lifespan Developmental Psychology at Oklahoma State University, Stillwater, Oklahoma in July, 2011.

Completed the requirements for the Master of Science in Psychology at Oklahoma State University, Stillwater, Oklahoma in December, 2009.

Completed the requirements for the Master of Arts in Marriage and Family Therapy at Southern Nazarene University, Bethany, Oklahoma in May, 2006.

Completed the requirements for the Bachelor of Science in Psychology at Southern Nazarene University, Bethany, Oklahoma in 2004.

Experience:

Candidate for Licensure as a Professional Counselor
Pediatric Inpatient Therapist, Shadow Mountain Behavioral Health Systems
Graduate Teaching and Research Assistant, Oklahoma State University
Assistant Professor of Psychology, Southern Nazarene University
Coordinator of the Student Advising Center, Oklahoma Wesleyan University

Professional Memberships:

Society for Research in Child Development
American Psychological Society

ADVISER'S APPROVAL: David G. Thomas

Name: Stephanie Grant Date of Degree: July, 2011

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: SALIVARY α-AMYLASE AND HEART RATE AS MARKERS OF AN INFANT'S EMOTIONAL CONTAGION RESPONSE USING MATERNAL FACTORS AS PREDICTORS

Pages in Study: 132 Candidate for the Degree of Doctor of Philosophy

Major Field: Lifespan Developmental Psychology

Scope and Method of Study:

Empathy generates interest due to its implications for prosocial development. Work in this area examining infant populations is limited, specifically between 3 and 9 months of age, however, in part due to difficulties in measurement. While mature empathy is not developed until a later age, a rudimentary version of empathy referred to as emotional contagion (EC) does appear to be present. One purpose of the present study was to examine whether a recent form of measurement of the sympathetic nervous system (SNS) called salivary α-amylase (sAA) could be used in addition to heart rate (HR) as a method of assessing EC in 3 and 6 month old infants. Furthermore, evidence reviewed suggests that maternal responsiveness appears to mold empathy development. Infants and their mothers ($N = 36$) visited the laboratory when the infants were 3 and 6 months of age. Mothers were assessed through self-report measures on parenting risk, parenting stress, and parenting styles at the 3-month visit only. At both visits infants were played a 5 min recording of another infant crying. During this time, HR data was collected and sAA (6 month visit only) from infant saliva was collected before and after the cries played.

Findings and Conclusions:

Results showed that both HR (non-sig.) and sAA levels (sig.) increased in response to the cries. Such results lend support to the use of sAA as a measurement of EC in infants at the age of 6 months and suggest that the developmental emotional contagion response appears to be an increase in SNS arousal. Relations between HR and sAA, while present, were not uniform. HR difference at 6 months was positively correlated to post cry sAA levels and greater differences in sAA. Few relations were found between HR at 3 months and maternal factors and no significant correlations were seen with maternal factors and sAA or HR at 6 months. Greater changes in HR were associated with lower levels of maternal stress and level of permissiveness was negatively related to baseline HR. Data presented might suggest a developmental difference between infant ages concerning their SNS or an inconsistency in the developmental trajectory of emotional contagion. Limitations and suggestions for future research were also discussed.

ADVISER'S APPROVAL: David G. Thomas