Inter-Individual differences in regulatory strategies in infancy: A pilot study utilizing eye-tracking technology

by

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B.S., Kansas State University, 2014

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

School of Family Studies and Human Services
College of Human Ecology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2017

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Abstract

The mother-infant relationship affects the child's exploratory and separation behavior, how the child perceives strangers, and significantly impacts the conceptual framework of typical social relationships in the infant's brain. The purpose of this study was to examine infants' regulatory strategies, specifically, the relationship between the mother-infant dyad, and the infant's response to a stressful situation. Eight, 5-month-old infants and their mothers participated in the Face-to-Face Still-Face experiment and a play session to assess maternal sensitivity. Data from the mother-infant dyads were collected during each phase of the Face-to-Face Still-Face paradigm (i.e., play, still-face, and reunion). Maternal sensitivity was assessed using an adapted version of Ainsworth's four scales of maternal sensitivity. The infant's strategies for re-engagement with the mother were assessed using eye-tracking methodology to identify specific eye gaze behaviors used during each phase of the still-face experiment. The infants who had more sensitive mothers showed an increase in fixation duration during the reunion phase of the procedure, which could be indicative of a trusting relationship in which the child knows the mother is there to help them regain control of their emotions. Implications of these findings are discussed for the use of eye-tracking methodology as a more flexible and potentially more accurate measure of studying infants' patterns of ocular focus.

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Chapter 1 - Introduction

Consider the following scenario: A mother and her young child are in the grocery store doing his or her shopping. As they walk down the aisle, the child reaches for something that catches their attention. The mother looks at what the child is referencing, says no, and a temper tantrum commences. The mother uses multiple strategies to soothe the distressed and screaming child and bring him or her back to a happy calm state, but what exactly are these strategies the mother uses to calm her baby? How does this experience affect the child and their ability to soothe him or herself?

A child's ability to successfully recover after a stressful experience, or self-regulate, is a critical ability in human development. Experience plays a substantial role in mastery of the regulatory system. The child's interactions with the environment naturally provide small increments of stress in which the child learns to cope, building neural connections in the brain gradually preparing the child to accommodate more significant stressors (Fleming, O'Day & Kraemer, 1998). The maturation of biological systems in the brain, as well as socioemotional development, play a defining role in the efficiency of the self-regulatory system. These systems are extremely dependent on the experiences the child has with their primary caregiver (Feldman, 2009). The development of self-regulatory behavior is a process that begins early in development, with the biological foundation laid in utero and continuing to rapidly progress throughout the early childhood years (Braun & Bock, 2011).

The progression of the regulatory system is largely affected by experience, but where do caregiving and interactions fit into this developmental progression? Speculations about connections between maternal sensitivity and self-regulation have been measured with a variety of methodologies. This study will investigate the relationships between the sensitivity of the

mother to her young infant and the infant's ability to self-regulate after experiencing minor stress. Investigation will be completed with eye-tracking technology to capture gaze behavior during the self-regulatory task. This investigation will provide an alternate method for exploring attachment as well as self-regulation in infants.

Chapter 2 - Review of Literature

Theoretical Framework

Since 1980's researchers have examined the mother-infant relationship primarily through the paradigm-shifting work of John Bowlby and Mary Ainsworth. Bowlby (1958) investigated the reciprocal nature of the relationship between a mother and her developing infant, which resulted in theoretical implications that changed how infants were regarded as psychological beings. Prior to Bowlby's work, researchers drew heavily from behaviorism and attributed the infant's bond to their mother to the meeting of basic physiological needs, such as feeding and protection (Skinner, 1963). Bowlby proposed, however, that attachment is the resulting relationship between mother and infant, and the security of that relationship is based on the sensitivity and synchrony of behaviors between the mother and infant (1969).

Although the claims made by Bowlby (1958) began the initial shift in thought regarding the mother-infant relationship, his work was analyzed and validated through the empirical discoveries carried out by one of his team members, Mary Ainsworth. Bowlby (1958) proposed that infant development was not only dependent on biological predispositions, or instinctual behavior such as sucking, rooting, crying, but also a delicate interplay between environmental stimuli and the child's heritable traits (i.e., temperament). Bowlby identified five behavior patterns in *The Nature of the Child's Tie (1958)*, which he called observable patterns of behavior. These patterns were derived from Darwin's (1875) concept of species-specific behavior. Bowlby later generalized these as instinctual responses (1958). Although Bowlby's theory originates in Darwin's research in instinct, Bowlby proposed a different perspective to consider. Instinct, as Bowlby discussed, is the "driving force" (pg. 13) behind behavior, but instinctual responses are the observable behavior patterns that contribute to the development of an attachment with the

mother (1958). Through his observations of infant behavior, Bowlby (1958) postulated that the attachment relationship, environment, and biological instincts synthesize to create and support the child's developmental progression and formation of an internal working model. This working model is a neurological framework built upon experiences with the environment that guide and inform the development of future relationships and how those relationships function within dyads (Bowlby, 1969). This offered new insight regarding the progression of social and emotional developmental competence (1969). The model proposes that the infant's mental representations of the developing relationship serves as a basis for understanding, not only him or herself in relationship to the people around them, but with the surrounding environment as well. This internal model had three main components: 1) a model of others as trustworthy, 2) a model of self-value, and 3) and a model of self as an effective interaction partner (Bowlby, 1969). The internal working model is simply what constitutes a typical interaction for that child, highlighting the importance of the mother's role as the mediator between the child's development and the child's interactions with others in their surrounding environment. This became the foundation for the later development of attachment theory. This theory of attachment, although originating in socioemotional development, has certain constructs that rely on healthy brain development and the foundational circuits reinforced at the earliest stages of development.

Infant Development

The development of the human brain begins shortly after conception; the beginning of a long period of growth and maturity that continues through emerging adulthood (Braun & Bock, 2011). The typical progression of brain development begins in utero where the biological foundation for instinctual responses is laid (Sheridan & Nelson, 2009). The developmental

progression of self-regulation begins in the prenatal stage with brain development and continues into postnatal life, with interactions between biology and environment (Berger, 2011). Maturity of the brain stem, which accelerates at birth due to the need for sufficient respiratory, sleep, and heart rate function, lays the foundation for socioemotional functions in the first few critical months of life (Feldman, 2009). A biological/behavioral shift occurs between 3 and 6 months of age, where infants begin to show purposeful emotion and synchronous behaviors with their caregiver (Feldman, 2009). This is the beginning of what Bowlby describes as attachment in the making, and what Ainsworth observed in her Uganda study beginning with 8-15 week old infants (Ainsworth, 1967). These attachment-in-the-making behaviors continue to develop over the first year of life, but lay their foundation before 6 months of age (Ainsworth, 1967).

Some areas of the brain are more susceptible to experience than others over time, particularly the pre-frontal cortex and the limbic system. The prefrontal-limbic system is a set of structures in the brain that are not fully developed at birth due to the naturally shorter gestation periods in the human species (Braun & Bock, 2011). This makes it susceptible to extraneous factors during infancy, which means experiences from the environment play a pivotal role in shaping the brain and neural connections (Braun & Bock, 2011). Because these areas of the brain are immature at birth and are highly vulnerable to teratogenic agents and the quality of experiences, the concept of "sensitive" periods was created to acknowledge the extensive plasticity during this time.

A sensitive period of development may be an optimal window in development for a specific skill or concept to be learned or for a neural pathway to be built (Sheridan & Nelson, 2009). The first 5 years of life is spent forming these neural connections, and repeated exposure to experiences with their surrounding environment reinforce those neural connections (Zeanah.

& Zeanah, 2009). Limbic system circuits are responsible for the processing and competence of social and emotional functions, which can affect cognitive function if less than optimal neural circuits are repeatedly reinforced (Braun & Bock, 2011). Therefore, testing infants at five months of age allows researchers to capture the child's relationship immediately prior to the next socioemotional transition. Given brain plasticity and environmental influence during these early years play an important role in how the brain functions and develops, it is natural to posit that the ways in which the primary caregiver interacts with the infant has the potential to affect how this structure forms.

Maternal Sensitivity

The internal working model develops in the first year of life (Bowlby, 1969). The internal working model is the behaviors of the infant's mother, which evokes a learning process in the child about how relationships function on a typical basis. The internal working model sets the foundation for, and functions in relationship to, the development of attachment, specifically attachment-like behaviors (Rosenblum, Dayton, & Muzic, 2009). The progression of attachment relies heavily on the sensitivity of the mother to the infant's needs, creating a reciprocal relationship between the two. The infant relies on the mother to help regulate high states of affect within themselves, best supported by mother-infant synchrony (Feldman, 2009). The matching of behaviors between mother and infant, often referred to as synchrony, is the most salient of factors for building an attachment (Feldman, 2009). Communication of these needs is largely dependent on eye to-eye interactions (i.e., mutual gaze), gestures, and vocalizations. This give-and-take relationship reinforces and activates neural connections within the infant's regulatory system (Zeanah Jr.& Zeanah, 2009). The stimulation the child receives from his mother in the form of synchronous behaviors helps the infant's system return to normal affect (Schore,

2005).Ainsworth and colleagues identified three types of attachment security, along with specific criteria that warrant each classification. The first attachment type is secure, which means that the infant's mother is responsive, both physically and emotionally. She was able to meet the infant's needs while also building a strong, trusting emotional bond (Ainsworth & Bell, 1970). The second style is insecure-resistant. A child who has been classified as insecure-resistant had their basic needs met, yet the emotional availability of mother was inconsistent. This warrants behavior from the child that is very dependent and clingy, until engagement with caregiver occurs, then they withdraw their need for interaction (Ainsworth & Bell, 1970). A third attachment style is insecure-avoidant. An infant with an insecure-avoidant attachment will find some comfort and security in their caregiver, but will be mistrusting of the duration or occasion of emotional support. Insecure avoidant children usually avoid physical contact due to the mother's discomfort. This attachment style often comes from authoritarian styles of parenting. The last category, disorganized, was added by Mary Main in 1980 and describes a relationship in which the child is both frightened of their caregiver and their reactions, but still wanting them to serve as a secure base, creating very confusing and erratic behavior in the child. Children classified as disorganized are often regularly neglected, exposed to frightening behaviors, and/or abused (Main, 1980).

The development of infant attention begins with attention given to the eyes and mouth in the first 6 months. Although other features are considered when looking at the faces holistically, infants between 3 and 6 months of age tend to focus on the eyes before shifting to the mouth around 6 months (Wagner, Luyster, Yeon Yim, Flusberg & Nelson., 2013). This coincides with the developmental period in which infants begin emotional intentionality and sharing of emotional responses (Feldman, 2009). During this period in development, infants gain an

awareness of gaze directionality (Wagner et al., 2013). Repetition of responsive face-to-face interactions sets the foundation for the child's own regulatory processes (MacLean, Rynes, Aragon, Caprihan, Phillips, & Lowe, 2014). Maternal sensitivity is a vital component to the development of the whole child, including the brain, nervous system, and other socioemotional and cognitive factors. These influences impact how the child interacts and perceives the world around them. The infant's ability to use the skills they have gained from participating in sensitive caregiving routines and practices allow them to begin to apply those skills in difficult situations. The capability to calm in challenging situations is directly connected to one's self-regulatory system.

Infant Self-Regulation

Self-regulation, or the ability to control our own behaviors and emotions, is a task that begins developing in the earliest stages of life (Berger, 2011). The ability to self-regulate does not emerge independently, but is a process that is reliant on external relationships, such as the one the infant has with his mother. Infants enter the world with a dependency on their caregiver to meet their needs; this includes correct interpretation of signals displayed by the infant (Zeanah Jr. & Zeanah, 2009). Face-to-face interactions, and the utilization of eye-gaze with the infant is critical to the early development of self-regulation; these face-to-face interactions promote the use of eye gaze which can be effective in establishing synchronous co-regulation strategies (Johnson, Senju, & Tomalski, 2015). Synchronous behavior within the mother-infant dyad can include eye gaze, emotionality, verbalizations, gestures and arousal (Feldman, Greenbaum, & Yirmiya, 1999). Research provides strong evidence to suggest that that brain function changes with experience, and the interactions that follow these experiences are changed as well (Fleming, O'Day, & Kraemer, 1998). This occurs because of the rapid growth rate of neural connections

occurring during the first 3 years of development; if an experience is reinforced, that neural connection stays intact until it is no longer used (Zeanah Jr.& Zeanah, 2009). The malleability of neural mechanisms is also observed in the central nervous system. A concept called mirroring comes into effect and is part of the reason for the push for skin to skin contact with infants in their first moments, as well as first few months. Mirroring, or co-regulation, is the close physical contact used by caregivers to help the infant's nervous system to return to a neutral state after a stressor is presented (Geva & Feldman, 2008).

Like the infant brain, the nervous system is immature and needs outside resources to rebalance after disequilibrium (Rosenzweig, 1999). This skin-to-skin contact, and outside help for establishing equilibrium, shapes the child's regulatory system. The efficiency of the assistance the child receives from the mother mirrors onto the child's nervous system and the child begins building its own foundation based off experiences had, particularly those that occurred within the first two months of life (Rifkin-Graboli, Borelli, & Enlow, 2009). Research in memory and cognition also addresses responses to stress using averted gaze, as discussed by Doherty-Sneddon and Phelps (2005). In their study, they discuss the role of averted gaze as a way of coping with cognitive load, which may be attributed to stress, among other factors (2005).

Infant self-regulation, and the relationship that the primary caregiver plays in this process, has become a notable area of research in the last several years. Researchers have developed methodologies to measure infant's responses to stress, such as the Still-Face Paradigm (Tronick, Heidelise, Adamson, Wise & Brazelton, 1978). This method was designed to evoke infant responses to the neutral affect of their mothers' face and then observe the reunion upon return to typical interaction. This method for observing infant stress has been used for the past

several decades, with the more recent research in conjunction with other variables, such as maternal interactions (Lowe, MacLean, Duncan, Aragon, Schrader, Caprihan, & Phillips, 2011) and attachment (Braungart-Reiker, Zentall, Lickenbrock, Ekas, Oshio, & Planalp, 2013). These studies used the Still-Face Paradigm to evoke a stress response from the infant and assess that stress response in relationship to caregiver interactions. Lowe and colleagues (2011) coded mothers' and infants' affect qualitatively during the Still-Face Paradigm to assess the stress of the infant and the interaction style of the mother. Braungart-Reiker and colleagues (2013) observed infants in a longitudinal study with the Still-Face paradigm at 3, 5 and 7 months of age and Ainsworth's strange situation task at 12 and 14 months. During the first three visits for the participant, caregivers and infants were video-recorded during the Still-Face paradigm and researchers rated mothers on sensitivity using a Likert scale with 1, being no sensitivity and 5 being high sensitivity. This observed the affect of the parent, and how they chose to interact with their child in that moment. This could vary across the scale based on their composite score taken out of total amount of points available for their time frame (Braungart-Reiker et al., 2013).

Although both studies assess interactions styles and sensitivity of the mother or caregiver, neither focus on the response of the child in a quantitative, objective fashion. The results of the infant assessment in both studies were based on observed emotion (Braungart-Reiker et al., 2013; Lowe et al., 2011). By assessing eye gaze behaviors and look patterns using objective, electronic measures like eye-tracking during the Still-Face Paradigm, it would be possible to determine with a greater degree of accuracy on the direction of the child's gaze during a typical interaction with their caregiver, and how he or she copes with the neutral affect during the Still-Face portion of the procedure. Before the current study, the use of eye-tracking procedures had not been used to assess the look patterns of infants during this paradigm. Previously, the majority

of studies involving infant behavior and the Still-Face Paradigm have involved the use of the preferential looking procedure (Braungart-Reiker et al., 2013; Lowe et al., 2011). The father of visual preference procedures, Fantz, introduced this technique to quantify visual fixation (Fantz, 1965). The method of preferential looking uses small sets of stimuli to assess where a child looks according to interest, visual development and visual pursuit (Teller, 1979). The collection of data was completed by a person visually tracking where the infant looked and recording how long they stayed fixated and how many times they visited stimuli (Teller, 1979). Since data is collected by a human individual, there is the potential for error and/or bias. Technology enhanced eye-tracking is a better fit for this study because it employs truly objective methods for collecting data, making the quality and accuracy much higher.

The following research questions were tested: What is the extent of the association between maternal sensitivity and infant self-regulation among 5-month-old infants in the first stages of attachment? What look patterns are used to self-regulate during stress?

Chapter 3 - Methodology

Participants

For the purposes of the current study, researchers developed the following criteria to determine eligibility to participate in the study. Infants were between 19-23 weeks of age, born between 36-41 week's gestation, weighed between 5 and 10 pounds at birth, and were screened as typically developing. No criteria were set regarding ethnicity/cultural background, socio-economic status or age of mother. Consequently, these data were not collected.

Measures

Assessment of normative development. The Ages and Stages Questionnaire (Squires, Twombly, Bricker, & Potter, 2009) is a developmental screening tool that assessed the infant's meeting of developmental milestones in communication, gross motor, fine motor, problem solving and personal-social development. The possible answers to each of the questions were as follows: yes (score = 10), sometimes (score = 5), and no (score = 0). The scores are totaled for each section to determine whether the child is developing on a typical time frame or developmentally delayed in some domains. After scoring the ASQ, the scores are charted in the provided area at the end of the assessment, signifying whether the child falls into a typically developing range. In order to participate in this study, infants had to meet a minimum score criteria of 35 or above (Squires et. al, 2009).

Researchers used an adapted version of a pregnancy and birth history questionnaire from the Wisconsin Department of Children and Families. The questionnaire included a compilation of questions regarding prenatal care, delivery details, and after birth measurements such as height, weight, and head circumference. These questions were designed in order to determine risks associated with certain pre- or post-natal behavior or complications from the delivery

process. The researcher added an additional question related to a history of seizures, due to the light emissions from the eye-tracker. Although no cases have been recorded where the eye-tracker triggered a seizures, similar light in the environment had. The question was added by request of the IRB. The principle investigator administered the questionnaire verbally to the mother to ensure the questions were fully understood and the most accurate answer was provided. Responses to this measure indicated potential anomalies in development occurring prenatally or at birth, which may impact the infant's response to stimuli. Head circumference within typical range was a key criterion. Circumference below the typical range may suggest cognitive delays.

Maternal sensitivity. Maternal sensitivity was measured using an adapted version of Ainsworth's Maternal Sensitivity Scales (Ainsworth, Blehar, Waters & Wall, 1978). Ainsworth developed four scales that measured unique characteristics of maternal sensitivity. The four scales included the following: cooperation vs interference, sensitive vs insensitive, acceptance vs rejection of baby's needs, and physical & psychological availability vs ignoring and neglecting (Ainsworth et al., 1978). These scales originally offered a rating from 1 = *highly insensitive* to 9 = *highly sensitive*.

Ainsworth's original set of maternal sensitivity scales defines maternal sensitivity with four parts: awareness of the infants' signals, ability to interpret those signals, appropriately responding, and doing so in a timely fashion (Ainsworth et al., 1978). Interference was defined similarly with two main constructs: actual physical interference with the infants' activity and frequency of interruptions. Availability was the awareness the mother has of her baby, in addition to acknowledging and responding to the baby. Acceptance, as defined by Ainsworth, was the mothers' ability to acknowledge the infant's agenda and respect it, even if the agenda is

different than her own or evokes feelings of frustration and/or irritation within her. The ability to suppress these feelings and overcome with positive actions signifies acceptance. Overall, these scales were designed to measure the mother's interactions with her infant and the appropriateness of each interaction.

Ainsworth's original scales were adapted into a user-friendly format in which the characteristic behaviors of the mother in each individual rating were identified in each scale (see Appendix 1). These characteristic behaviors were extracted, resulting in a scoring guide, where behaviors could be rated on a scale from one to five for ease of scoring totals after observation. In these scales, 5 represents the highest sensitivity in each scale. As the numbers decrease, so does the sensitivity rating of the mother.

Observable patterns of attachment. Another measure of sensitivity within the dyad that was used were observable patterns of attachment behavior derived by Ainsworth (1967) from Bowlby's concept of instinctual responses in *The Nature of the Child's Tie* (1958). These patterns in infant behavior range from the beginning stages of development, up until a determination of attachment can be achieved, making some of the observable patterns unusable with this set of infants, given the age range from 19-23 weeks. The patterns of attachment behaviors used to assess infant patterns were tallied upon each occurrence for differential crying, differential smiling, differential vocalization, following, visual motor orientation, greeting through smiling, and lifting arms in greeting. These patterns occur before the age of 6 months, with the latter half discussed by Ainsworth (1967) developing after the six-month mark in development.

Eye-gaze duration and visit count. Infant self-regulation was measured using multiple measures including eye-gaze.. Eye-gaze data was collected using the Tobii TX300 apparatus.

The Tobii TX300 samples at a rate of 300hz. This instrument uses corneal reflection technology to determine point of gaze relative to a fixed point in space. For the current study, the eye-tracker was used in X-Mode, as opposed to T-mode. X-mode is a specific configuration that allows for the presentation of live stimuli. In this mode, a live scene was used. The stimuli presented (i.e., the child's mother) was located in the active display area. In order to capture the visual field, a scene camera was used to record the active display area.

Eye-gaze was operationalized in two measures: fixation duration and visit count. Fixation duration was the total amount of time spent looking in a designated area of interest (AOI). Visit count was the amount of times the individual visits the identified AOI within the amount of time data was being collected. To analyze the data collected for fixation duration and visit count, AOI were designated.

Procedure

The researcher invited participants via flyers through early childhood programs, parenting groups, and county and state early childhood organizations located in a mid-sized, Midwestern community in the central region of the U.S. Mothers contacted the researcher when interested and set up an appointment to start the process. At this first meeting mothers completed the Pregnancy and Birth History Questionnaire. Then, they completed the Ages and Stages. The instruments were scored immediately and the mother was informed whether she and her child qualified for the study. Mothers with infants who did not qualify were given a book and invited to participate in another study. Mothers and infants who qualified were immediately immersed into the procedures of the current study.

Physical design. The infant was seated in a Graco 5-in-1 infant highchair. The eye-tracker was placed in front of the infant on an adjustable desk. In order to determine the active

display area, the principal investigator created a simulation of the visual field using a hanging board. This represented where the stimuli (i.e., child's mother) would be located. The board was 22.5 in x 16.5 in size. The size was determined based upon calculations for the active display area with an additional 25% enlargement added to the parameters of the configured space. Five 3-inch holes were cut in the board to be used for calibration. After the calibration board was in place, the physical parameters of the eye-tracker were reported to the corresponding computer. The measurements from the eye-trackers angle and the angle of the hanging calibration apparatus were also recorded and reported in the software to ensure the most accurate representation of the area being sampled from.

Calibration. Calibration of the infant's eyes to the machine is necessary for a valid sample from the session. Calibration in this mode requires a person be situated behind the eye-tracker to help facilitate manual calibration. Manual calibration occurs without the presentation of calibration points on a monitor. To begin the calibration procedure, the researcher or assistant, positions themselves behind the calibration board with an attention getter for the infant to visually follow through the calibration procedure. The researcher attracts attention of the infant towards each of the 5 holes in the board. When moving from one hole to the next, the research team (person behind the board and person at the computer to advance the calibration screen) must operate in synchrony. The researcher standing behind the board verbally prompts moves from each hole once they observe the infant's attention captured in each space obtains this synchronous movement. The progression continues until the infant had looked at all five spots. Once calibration is complete the experimental procedure began.

The Still-Face paradigm (Tronick et. al 1978) is a strategy for inducing stress in a controlled situation so infant stress and recovery can be observed and/or assessed. Mother-infant

synchrony and the level of co-regulation the infant has experienced affects how they respond to stress, in this case, how the infant responds in the Still-Face paradigm (Tronick, et. al, 1978). The Still-Face paradigm employs three phases for completion: play, still-face, and reunion. The play phase is utilized for the mother to interact with her infant in her typical manner for the duration of 2 minutes. After the 2 minutes the mother shifts her gaze to a designated space 8 inches above the infant's head and looks with neutral affect for 90 seconds. Upon completion of the still-face phase, the mother reengages with her infant for a final 2 minutes as a reunion phase (Tronick et. al, 1978).

Eye-gaze behavior was collected during the Still-Face Paradigm using the Tobii TX300. During the Still-Face portion of the study, the mother was instructed to sit across from her infant. Researchers asked mom to interact with her infant as she typically would. After two minutes of interaction, the investigator informed the mother that she would be given a verbal prompt to shift her attention to a spot that is approximately 8 inches above the infant's head. The mother was then instructed to keep a neutral face showing no emotion or response to what the infant was doing. The mother was reminded that at the end of the 90 seconds, she must stay seated, even if her infant was distressed and crying. After 90 seconds, the mother was verbally prompted to resume the typical interaction pattern that she would use with her infant. She was reminded to try and calm and reengage with her infant without getting up and going over to her infant. At the conclusion of the Still-Face, mothers were encouraged to engage with their infants as they typically would.

After completion of the eye-tracking session, the mother and infant moved locations to a classroom setting for a 30-minute play session. Researchers recorded the play session using an electronic tablet set on a table in the room. Once in the classroom space, the investigator showed

the mother the materials that were available for use. The investigator encouraged the mother to play as she normally would in their home setting. At the completion of the maternal sensitivity observation session, the mother and infant were offered a choice of infant board book and then were free to leave.

After the video data were collected from the 30-minute play phase of the procedure, both the researcher and research assistant, according to the maternal sensitivity scales, coded the behaviors of the mother, as well as the observable patterns of attachment. The research assistant was trained on foundational knowledge in attachment, attachment behaviors, research methods and ethical considerations. After the training session was completed, reliability was established by coding three videos to assess interrater reliability for coding maternal sensitivity, which ranged from 80-100% accuracy. Measures and procedures were reviewed and approved by the Institutional Review Board at Kanas State University (#8292).

Data Analysis

Areas of interest. The area of interest, or AOI, was signified by a single rectangle placed around the mother. Because data was captured using a live scene, the designated AOI was not static. To properly code this area, the principal investigator advanced the video frame by frame moving the AOI with the mother, keeping her within the parameters of the area. The designated AOI area determines the location from which to collect data.

After this was completed each video was segmented. This included breaking down the video into the three phases: play, Still-Face, and reunion. The researcher coded the videos and time stamped at the end of each phase of the procedure. They were then segmented and the data in each segment was exported to excel for sums to be calculated for each participant and their session.

Individual scores on the Maternal Sensitivity scale were summed with a range between 0 (highly insensitive mother) and 20 (highly sensitive mother). In addition to maternal sensitivity, observable patterns of attachment-like behavior by the infant were summed. The first 6 patterns of behavior were used and tallied throughout the free play session video: Differential crying, differential smiling, differential vocalization, crying when the mother leaves, following, and visual motor orientation (Ainsworth, 1967).

Chapter 4 - Results

Eight infants, between 19-23 weeks of age (*M* = 22.75 weeks; 2 male), and their mothers (*M* = 34 years) participated. Four infants were excluded from participation: three due to failure to calibrate during the eye-tracking paradigm and one due to small head circumference. This left a final sample of four mother-infant dyads. Of the four participants who completed the study, 2 were male and 2 were female.

Due to the small sample size, data analyses were modified. The look times of fixation duration and visit count were summed separately for individual participants in each of the three phases of the Still-Face Paradigm: play, still face, and reunion. Within eye tracking procedures, fixation duration is operationalized as the sum of fixations within an AOI and is calculated in seconds (Tobii AB, 2016). Visit count was defined within eye tracking parameters as the total number of times an active AOI is visited within the specified time frame (Tobii AB, 2016; see Table 1). When examining Table 1 (see Appendix B), inter-individual differences may be observed by looking down the columns, where comparisons of fixation duration and visit count can be made. Intra-individual change can be observed moving across the table horizontally, exhibiting the patterns of looking and visits and how they change within each child's session.

The first mother-infant dyad (male, 23 weeks, second born; see Table 1) scored a maternal sensitivity rating of 20/20 with eight observable patterns of attachment behaviors. This assessment of attachment behaviors was the highest obtained of the 4 participants, suggesting that this infant-mother dyad displayed the most secure attachment-like behaviors during the observed 30 minutes. During the play phase of the Still-Face Paradigm, the amount of time spent looking (i.e., fixation duration) within the targeted AOI region (i.e., the space the mother occupied in the visual field) was 25.44 seconds. The infant left and then revisited this AOI area

20 times for the duration of this phase. During the Still-Face phase of the session, the fixation duration score decreased to 5.33 seconds out of the available 90 seconds, with the visit count decreasing to 10. The reunion phase yielded a fixation duration increase to 16.13 seconds out of the available 120 seconds, with a visit count of 6. Thus the fixation duration exhibited a "V" pattern (gradual return to pre-stress phase) while the visit count exhibited a downward trend post-stress. The eye gaze patterns exhibited during the Still-Face paradigm are consistent with what might be expected given the high maternal sensitivity rating and number of observable patterns of attachment. These patterns of eye gaze suggest that the infant's reaction to the stressful situation was to spend less time looking at mom while she displayed averted gaze. The infant also revisited mom's AOI area less often. After the still-face phase of the paradigm, the fixation duration increased. This change in focus suggests a possible willingness, on the child's part, to return their attention or interest back to the mother, after she had returned to typical interaction.

The second mother-infant dyad (male, 23 weeks, second born; see Table 1) scored a maternal sensitivity rating of 20/20 with six observable patterns of attachment behaviors. During the play phase of the Still-Face Paradigm, the amount of time spent looking (i.e., fixation duration) within the targeted AOI region was 57.79 seconds. The infant revisited this AOI area 12 times during the duration of this phase of the Still-Face paradigm. During the still-face phase of the session, the fixation duration score dropped to 28.39 seconds out of the available 90 seconds, with the visit count decreasing to 7. The reunion phase yielded a fixation duration increase to 37.87 seconds out of the available 120 seconds, with the visit count of 9. Participant two's fixation duration pattern were similar to participant one during each phase of the Still-Face Paradigm, that is the child exhibited a "V" pattern. However, this child's visit count pattern also

showed a “V” or a slight return to pre-stress phase post-stress suggesting that for this child, when mom looks away, the child looks away and when mom returns to normal, the child also seeks a return to “normal” or pre-stress.

The third mother-infant dyad (female, 23 weeks, second child; see Table 1) scored a maternal sensitivity rating of 18/20 with 4 observable patterns of attachment behaviors. During the play phase of the Still-Face Paradigm, the amount of time spent looking (i.e., fixation duration) within the targeted AOI region was 44.42 seconds. The infant revisited this AOI area 27 times during the duration of this phase of the Still-Face paradigm. During the still face phase of the session, the fixation duration score increased to 50.29 seconds out of the available 90 seconds, with the visit count decreasing to 17. The reunion phase yielded a fixation duration decrease to 42.23 seconds out of the available 120 seconds, with the visit count of 15. Fixation duration demonstrated an inverted “V” pattern and a gradual continuous decline in visit count suggesting that this child spent a longer time looking at the mom AOI area than the other participants. During stress, rather than shortening the attempts for visual engagement, this child spent a longer time looking at mother as if to try to seek her gaze again. Post-stress the child returned slightly below the initial pre-stress level. Like the pattern we see in participant one, participant three’s visit count pattern steadily decreased throughout the Still-Face Paradigm. This indicates that participant three visited the mother AOI area less often as the procedure progressed.

The fourth mother-infant dyad (female, 23 weeks, second child) (see Table 1) from a participant began with a maternal sensitivity rating of 18.5/20 with six observable patterns of attachment behaviors. During the play phase of the Still-Face Paradigm, the amount of time spent looking (i.e., fixation duration) within the targeted AOI region was 10.73 seconds. The

infant revisited this AOI area 34 times during the duration of this phase of the Still-Face paradigm. During the still-face phase of the session, the fixation duration score decreased to 7.14 seconds out of the available 90 seconds, with the visit count decreasing to 12. The reunion phase yielded a fixation duration increase to 9.17 seconds out of the available 120 seconds, with the visit count of 24. This child exhibited the familiar "V" pattern for fixation duration as well as the "V" pattern for visit count. However, duration for fixation duration was lower for this child than all other participants suggesting that participant four spent less time looking at the mom AOI area throughout all phases of the Still-Face Paradigm. Fixation duration decreased during stress increased again between the still-face and reunion (post-stress). Visit count also decreased during stress but then returned upward post-stress.

Table 1

Dependent Variables for Mother-Infant Dyads P1, P2, P3, & P4

	Self-Regulation						Maternal Sensitivity	
	Play		Still Face		Reunion		Sensitivity Rating	Patterns of Attachment
	FD	VC	FD	VC	FD	VC		
P1	25.44	20	5.33	10	16.13	6	20/20	8
P2	57.79	12	28.39	7	37.87	9	20/20	6
P3	44.42	27	50.29	17	42.23	15	18/20	4
P4	10.73	34	7.14	12	9.17	24	18.5/20	6

FD - Fixation Duration is the total amount of time spent looking in a designated area of interest in seconds.
VC – Visit Count is the amount of times the individual visits designated area of interest within the amount of time data was collected.
Sensitivity Rating - The total score of each participant out of the available 20.
Patterns of attachment - Represent a total score of the frequency of attachment patterns exhibited in the 30-minute play session.

Chapter 5 - Discussion

This study examined the relationship between maternal sensitivity and self-regulatory behaviors among 5-month-old infants after experiencing minor levels of stress. The Still-Face Paradigm is an opportunity to examine pre-attachment behaviors similar to the strange situation (Tronick, 1978). The Still-Face paradigm provides this similar task because of the three phases of dyadic interaction (Braungart-Rieker et al., 2013). Results of this study suggest that infants exhibit distinct patterns pre-stress to post-stress as indicated by how long they gaze at mother as well as the frequency with which they look at mother post-stress.

Two distinct patterns emerge in the data with regard to duration of gaze. In three of the four participants, infants declined in duration of time looking at their mother's face during stress and then returned to or nearly to pre-stress levels post stress. However, the fourth child demonstrated the opposite effect by looking longer at mother during still face or stressful phase of the paradigm. Two distinct patterns emerged with respect to visit count as well. In two infants, the number of times they looked at the mother declined not only during stress but continued during post-stress. In the remaining two, the number of times they looked at mother during stress declined but reversed post-stress, that is, they attempted to look at mother more frequently, similar to pre-stress. It is of interest to note that two infants show the same patterns in duration and count while two infants demonstrated the same visit count decline post-stress, but demonstrated opposite durations (one decreasing during stress and one increasing during stress).

The literature suggests that, when stressed, infants will avert their gaze as a method of coping (Doherty-Sneddon & Phelps, 2005). In one of the observed patterns of eye-gaze behavior, fixation duration increased and visit count decreased in participant 3 during the Still-Face phase of the paradigm. In the three cases where this pattern was inter-individually consistent, the same

three infants' mothers had higher maternal sensitivity ratings, as well as higher incidences of patterns of attachment behaviors. This could suggest a relationship between the sensitivity and synchrony of the dyad and the infant's ability to cope with a stressor in an effective way (Feldman, Greenbaum, & Yirmiya, 1999). Young infants whose mothers are more highly sensitive and who exhibit a higher incidence of patterns of attachment-like behaviors may be creating additional opportunities for social engagement and synchronous types of behavior.

Given that fixation duration is considered a measure of attention, it is interesting that in the three similar participants, fixation duration increased in the third phase of the session for two children. This increase in fixation duration between the Still-Face and the reunion phase could be attributed to the sensitivity of the relationship between the pair and the patterns of attachment behaviors (Lowe et al, 2011). After the stressor (i.e., Still-Face), the infant uses their external resource, their mother, to help bring themselves back to a calm state, in essence using her to self-regulate (Feldman, Greenbaum, & Yirmiya, 1999). This suggests that these infants may have had more opportunities for consistent caregiving experiences that include using their mother as a moderator for environmental stressors, as would be predicted if the child had regular access to sensitive and responsive caregiving experiences (Feldman, 2009). Given infants' preference for faces (Johnson, Senju, & Tomalski, 2015), it is known that infants will use increased mutual gaze between themselves and their mother to self-regulate (Lowe et al., 2011). In addition to the literature regarding the purpose of fixation duration, research currently suggests that when examining the visit counts of the infants, it is speculated that this could be a simplified version of the "check in's" (i.e., moving closer to mom periodically during exploration) done by older infants during secure base behavior (Ainsworth & Bell, 1970). This simply means that the child checks in with mom to make sure that she is still watching them, keeping them safe, and is close

by in case the child needs anything (Ainsworth, 1978). This is part of the development of patterns of attachment behavior.

In mother-infant dyad number three, several differences were observed in self-regulatory behavior and maternal sensitivity. For this mother-infant pair, the opposite pattern of look time and visit count was noted. Instead of fixation duration decreasing as expected, the fixation duration rose between the play phase and still-face phase. This is unique because this dyad also had the lowest maternal sensitivity rating and the least amount of pre-attachment behavior patterns. Drawing upon Bowlby's theory (1958), the data suggests that the increase in fixation duration may be attributed to the infants' exposure to incidences where their mother could not look at or pay attention to them (Braungart-Rieker, et. al, 2013). During instances where the child's mother is unavailable, the infant relies on mutual gaze as a means to re-engage with mom. When this does not occur, this is seen as a violation of expectations, which results in distress. In this instance the infant spent more time looking at their mother, which seems to suggest there is less distress. There was less movement and vocalizations observed as well during the Still-Face and reunion phases. Since the infant vocalized and showed little movement in response to the Still-Face, and a decrease was seen in fixation duration during the reunion phase, it is possible that it may be related to the lowered maternal sensitivity from their caregiver (Ainsworth, 1978). This type of behavior may have occurred because the baby was accustomed to periods of time where the mother was not emotionally or socially present, making their reaction to the stressor less evident, and opposite of what the other participants exhibited.

Results of this study revealed a patterned response across infants to mother's state of being. These results suggest that infants possess basic strategies to self-regulate emotions in response to a stressful situation and recover to a general state of well-being. Results also offer

evidence to suggest that the dyadic relationship may be related to the child's adaptive response to stress and that the rating of maternal sensitivity contributes to the strategies used to self-regulate. According to the Feldman (2006), maternal sensitivity is a key element in the development of synchronous behavior and self-regulation. This is consistent with the results of this study: the mothers who had the highest maternal sensitivity ratings had infants who used gaze patterns consistent with what the literature predicted (Lowe et. al, 2011). The infants who had more sensitive mothers showed an increase in fixations during the reunion phase of the procedure, which could be indicative of a trusting relationship in which the child knows the mother is there to help them regain control of their emotions.

Limitation of this study includes the small sample size; consequently, predictive statistical analyses could not be conducted as planned. Despite the small sample size, the current study served as an opportunity to take an in-depth look at the change in intra-individual patterns across segments, as well as the inter-individual differences between the participants. When considering future directions, a longitudinal design would support examination of change over time in relationship at 3 months, 7 months, and again at 12 months. These ages are significant because bio behavioral shifts (i.e., changes in developmentally driven behaviors) occur around these points in development (Rosenblum, Dayton, & Muzik, 2009). Assessment of pre-attachment behavior at each of these checkpoints, coupled with measurement of attachment style at one year of age, could give insights into the specific characteristics of a secure attachment and the process by which they emerge.

In the last 30 years, attachment and the styles that encompass this relationship have been assessed using similar methods (i.e., subjective measures of looking) during the Strange Situation. However, this method is successful in children beyond the age of 9 months, a method

for identifying attachment earlier in development is needed, particularly if intervention may be provided to support development of a secure relationship. This study uses eye tracking, in addition to sensitivity scales, to explore the eye behaviors that may be predictive of types of attachment. Although using eye tracking with infants has its challenges (e.g., identify one or two), the data, could lead to the identification of a new and more objective method for exploring attachment and self-regulation.

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Appendix A - Maternal Sensitivity Scoring Guide

Scoring Guide for Maternal Sensitivity

Kansas State University

IRB#8292

Participant Name _____ Date_____

Name of Coder_____

Category 1: Cooperation vs Interference					
	1	2	3	4	5
5. Conspicuously Cooperative					
a) Respect child as individual with needs b) Plans ahead to minimize interference c) Reads cues of child before interrupting play d) Seldom uses directive strategies, only when necessary & appropriate (highly spontaneous in play) e) Does not use physical force to intervene except in emergencies					
4. Cooperative					
a) Respectful of child as individual with needs b) Foresees less obstacles but still plans ahead to minimize interference c) Reads cues of child most of the time before intervening in play d) Uses some verbal directive strategies during interaction e) Rarely uses physical force to intervene/redirect					
3. Mildly Interfering					
a) Inconsiderate of baby's wishes and activities b) Frequently interferes instead of planning ahead c) Does not read child's cues before intervening d) Play strategies are more directive and eliciting than spontaneous e) Seldom uses physical force to intervene/redirect					
2. Interfering					
a) Little respect for baby's needs & wishes					

b) Frequently interferes physically and/or mildly, but with underlying motive (ex. Training) c) Does not read cues before intervening d) Little to no spontaneity in play, highly directive e) Uses direct, forceful, physical interference and/or frequent milder interferences to intervene/redirect					
1. Highly Interfering					
a) No respect for baby as individual b) Consistently interfere both physically and mildly, with no apparent underlying motive. c) Does not read cues d) Uses all directive, eliciting, controlling strategies during 'play'. e) Combines physical and mild interference consistently to intervene/redirect					
Category 2: Sensitive vs Insensitive					
	1	2	3	4	5
5. Highly Sensitive					
f) Highly attuned to cues, both obvious and subtle. g) Demonstrates understanding of cue, acknowledges needs h) Responds to needs and offers acceptable alternative if needed i) Timing of response if appropriate j) Uses variety of interaction strategies					
4. Sensitive					
f) Attuned to less obvious cues with inconsistent response to subtle cues (often due to distraction) g) Demonstrates understanding of obvious cues and acknowledges them h) Responds to cues appropriately with occasional mismatches i) Timing of response is appropriate but occasionally inconsistent j) Uses variety of strategies but situational mismatches occur					
3. Inconsistently Sensitive					
f) Intermittent attunement (often keen, but sometimes impervious) g) Demonstrates intermittent understanding of cues, both obvious and subtle h) Responds to cues with inconsistent appropriateness i) Timing of response is inconsistent (prompt and appropriate at times, slow and inappropriate at others) j) Uses appropriate strategies at least 50% of the time, but also utilizes inappropriate strategies					
2. Insensitive					
f) Preoccupied, therefore misses signals or ignores cues intentionally g) Demonstrates consistent misinterpretation of signals, or ignores					

them completely. h) Responds to baby's needs according to own perceptions, which are consistently inappropriate i) Timing of response is inappropriate and inconsistent j) Uses appropriate strategies when convenient based upon her perception					
1. Highly Insensitive					
f) Coincidental attunement to cues g) Does not demonstrate understanding of cues; baby not viewed as individual with own specific needs. h) Responds to cues when consistent with mom's own needs i) Ignores cues or delays response such that it is no longer needed j) Strategies used are inappropriate or fragmented and incomplete.					
Category 3: Acceptance vs Rejection of Baby's Needs					
	1	2	3	4	5
5. Highly Accepting					
k) Accepting of behaviors, even hurtful or irritating to mom. l) Acknowledges that baby has will of own, even when it opposes her will. m) Pleased with baby's interest in people and exploring the world around them. n) Shows respect for baby's anger o) May become briefly frustrated with baby's behavior, but is aware that the baby is not at fault.					
4. Accepting					
k) Generally accepting and loving with infrequent occurrences of irritation and resentment. l) Acknowledges baby's own will sometimes, but not in an obvious way. m) Is genuinely patient with baby and accepts demands n) Generally accepts baby's interests and exploration outside of her. o) Expressive of own feelings with baby, with little evidence for negative feelings of irritation and resentment.					
3. Ambivalent					
k) Positive overall feelings toward baby, with occasional inappropriate displays of hurt or resentment. l) Often perceives baby's choices as direct insult to her personally as a mother. m) May be impatient and irrational with baby at times, rejecting them when no longer compliant or endearing. n) May tease baby when upset, angry or otherwise difficult. o) Interactions are overall mutually enjoyable and positive, predominating over negative feelings or affect.					

2. Substantially Rejecting					
k) Clear rejection, or "putting away" of baby when not compliant. l) Dwells on bad points and problems caused by baby m) Says critical, uncomplimentary, nasty things to and about baby in their presence, but presenting in joking manner. n) Evident irritation and suffering attitude of patience, or obvious impatience. o) Marked negative underlying meaning is frequently displayed in interactions.					
1. Highly Rejecting					
k) Resentful, angry and rejecting feelings toward baby l) Openly voices her resentment of his presence m) Implies baby's significant interference in her life n) Often opposes baby's wishes, purposefully engaging in a challenge of power. o) May be positive aspects of relationships but are rare and isolated.					
Category 4: Physical vs Psychological Availability vs Ignoring and Neglecting					
	1	2	3	4	5
5. Highly Accessible					
a) Close enough to him to read cues and signals b) Alert to what he is doing and his whereabouts c) Can divide attention appropriately, always responding when needed d) Rarely, if ever, ignores and approach or demand made, even if she does not do exactly what the baby seems to want. e) Always acknowledges baby when entering or leaving the room.					
4.Usually Accessible					
p) Usually accessible psychologically q) Brief periods where other demands may prevent mom from knowing where and what baby is doing r) Does not divide attention smoothly, but rather switches from task to task. s) Is sometimes preoccupied with her own activities with baby's care, doesn't often acknowledge baby's wants. t) Seldom acknowledges baby when entering and leaving room, which may or may not happen frequently.					
3. Inconsistently Accessible					
p) Inconsistent with availability to baby q) Long periods of close attention, as well as long periods of obliviousness r) Easily preoccupied, in which she does not respond to baby's wants or cues					

s) Regular, prolonged periods of unavailability t) Often caught up in own preoccupation that mom seems to forget and ignore baby's cues and physical needs.					
2. Often Inaccessible, ignoring, or neglecting					
p) Occasionally responsive to implicit needs, but inaccessible more often than accessible q) Too preoccupied to notice baby's signals or notices them but does not respond r) Does not acknowledge baby when entering and leaving the room, no matter the circumstances s) If baby signals strong or persistent enough, mom will respond t) Actions reflect solely on her perceptions of what baby "needs".					
1. Highly inaccessible, ignoring or neglecting					
p) So preoccupied with own thoughts, simply does not notice baby q) Enters room without looking at or acknowledging baby's presence r) When not in her line of attention, mom appears to forget about baby's existence s) Responds to baby only when she deliberately turns attention to them. t) Interventions are characteristically at mom's own whim and convenience.					