The Pennsylvania State University

The Graduate School

College of the Liberal Arts

PARENTING SELF-EFFICACY, MOTHERS' EMOTIONAL EXPRESSIONS, AND FRONTAL EEG ASYMMETRY

A Thesis in

Psychology

by

Nastassia Josephine Hajal

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

August 2010

The thesis of Nastassia Josephine Hajal was reviewed and approved* by the following:

Pamela M. Cole
Professor of Psychology
Thesis Co-Adviser

Ginger A. Moore
Associate Professor of Psychology
Thesis Co-Adviser

Rick O. Gilmore
Associate Professor of Psychology

Susan Mohammed
Director of Graduate Training of the Department of Psychology
Associate Professor of Psychology

*Signatures are on file in the Graduate School.

Abstract

This study aimed to add to the literature on parent emotion. Specifically, it examined relations between parenting self-efficacy and physiological and behavioral measures of emotion in mothers of infants. Mothers' facial expressions of emotion and EEG asymmetry were examined while mothers watched videos of their own infants in a range of emotional situations. Greater parenting self-efficacy and more approach (as indexed by EEG asymmetry) were related to maternal positive expressions (joy) that were longer, more intense, and quicker to onset and peak, and negative emotional expressions (sadness and lip tension) that were shorter and slower to onset. Furthermore, parenting self-efficacy had a moderating effect on the relation between EEG asymmetry and some dynamic measures of maternal emotion. Specifically, for some measures of maternal joy, sadness, and lip tension, cohesion between measures of facial expression and brain activity depended on the level of parenting self-efficacy. Implications for future research on parental emotion will be discussed.

Table of Contents

List of Tables

List of Figures

Acknowledgements

This project would not have been possible without the guidance and support of many individuals. First and foremost I would like to thank my advisers, Drs. Pamela Cole and Ginger Moore, for their wisdom, mentorship, and enthusiasm over the past three years. Their guidance has been instrumental not only in this project, but in my overall growth as a researcher.

I am indebted to Drs. Douglas Teti and Mark Feinberg, Principal Investigators of the Minds of Mothers Study. Their willingness to let me participate in their vision has been a wonderful opportunity that is greatly appreciated. I would also like to thank Dr. Rick Gilmore, a member of my committee, for providing his time, thought, and ideas to this project.

This venture would not have been possible without the generous help of other students, as well: Anneliese Bass and Aleksandr Lewicki, who spent many hours on the painstakingly detailed task of facial coding, and Junyi Lin, who worked tirelessly to perfect the MATLAB programming necessary for my data analysis.

Finally, I would like to express my unending appreciation to my wonderful family. To my parents, Fady and Anne, my brother, Nicky, and my grandmother, Polly: your unconditional love, support, and faith in me is what has enabled me to reach my goals, and for that I am forever grateful.

Chapter 1. INTRODUCTION

Parental emotion is a growing topic of interest in the child development literature (Dix, 1991). The events and interactions characteristic of every day parenting both elicit emotion from parents and create opportunities to teach and socialize children about emotion expression and behavior. Therefore, the importance of the knowledge that can be gained from the study of parental emotion is twofold, with potential benefits for parents *and* for children. Parenting is an emotional experience (Dix, 1991) and likely influences a parent's well-being and mental health. For example, the inability to soothe a distressed infant may cause a sense of helplessness and sadness in the parent, while a toddler's temper tantrum is likely to evoke feelings of frustration, especially when the parent has other tasks to which attention needs to be paid. On the other hand, witnessing a child's joy often elicits happiness or contentment. The affective nature of parenting has important implications for child development, as well, as research has shown a link between parent well-being and child outcomes. Furthermore, a parent's emotional experience influences parental behavior, including the modeling of emotional behavior and the use of emotion in socializing children's emotional experience, expression, and regulation. Given that the development of emotional competence is considered a major milestone of early childhood (Calkins, 2004), the emotional aspects of parenting merit study. Thus, the study of emotion in caregiving is essential to the understanding of effective parenting and its impact on both parent and child.

One determinant of parent emotion is child emotion. A few recent studies have examined parental affective responses to child emotion (e.g. Strathearn, Li, Fonagy & Montague, 2008), particularly infant distress (e.g. Swain, 2008; Lorberbaum et al., 2002). It is important, however, to examine the way in which parental goals, motivations, and beliefs influence parents' emotional reactions, especially while in the presence of their children. Parental emotional reactions are influenced by parental goals, motivations, and beliefs, as well as the child's emotion and behavior. In particular, a sense of parenting self-efficacy, or, an individual's perception of her ability and competence in the parenting role (Bandura, 1982; Teti & Gelfand, 1991), may influence the quality of emotion that a mother expresses while witnessing her child's emotions. Therefore, an aim of the present study is to examine the relation between parental self-efficacy and emotional responses to infant displays of emotion.

In pursuing this question, it is essential to take on the issue of how best to assess parental emotion. Much emotion research is based on self-report of feelings or mood, although it is unlikely that all aspects of parental responses are available to conscious experience (Dix, 1991). Furthermore, self-report questionnaires or interviews administered at one point in time do not offer the opportunity to evaluate on-line parental emotion, which likely fluctuates continually in true caregiving contexts (see Dix, 1991). The proposed study takes a multimodal approach to assessing multiple aspects of the emotional experience of parenting in real time. By observing parental expressive behavior and measuring brain activity while mothers view emotion-eliciting video clips of their own infants (displaying happy, distressed, and neutral expressions), it is possible to shed light on the dynamic nature of emotion in the parenting of young children.

A Functional View of Emotion

Where does parent emotion come from? How does it serve the act of parenting? Drawing on work by Arnold (1960), Frijda (1986, 1988) puts forth a cognitive theory in which emotion is a response to stimuli perceived to have a bearing on an individual's concerns (i.e.

goals or motives). Emotions include subjective feelings of pleasantness or unpleasantness but are defined by appraisal and action readiness. As circumstances change, an individual's appraisal of those changes, relative to well-being, is paired with a specific pattern of action readiness (Frijda, 1988). Action readiness refers to the nature of the individual's preparedness to act in a particular manner, for example, to approach or disengage from the environment. This may refer to a readiness to engage in various types of behavior, including facial expressions of emotion or vocalizations. Both Arnold (1960) and Frijda (1986, 1988; Frijda, Kuipers & ter Schure, 1989) hold that particular patterns of appraisal and action readiness differentiate among the discrete emotions; in fact, we could not understand discrete emotional states without an understanding of action readiness. For example, few would argue that anger and sadness refer to two very different emotion states. However, without noting the differences in action readiness that accompany feelings of anger and sadness, they would simply fall together on the negative end of the pleasantness-unpleasantness spectrum. We cannot fully recognize the differences between anger and sadness until we consider the dissimilarities in action tendency associated with each: an angry person is likely to engage with her environment in order to change that which is threatening her concerns, while someone who is sad is more likely to withdraw and actually disengage from the environment that is housing lost goals.

Emotions may be elicited by internal or external changes, whether actual or expected. The type and strength of the subsequent emotion is influenced both by the degree of change that occurs and by the frame of reference against which it is evaluated. This frame of reference may be the environmental or situational context in which the change occurs, or it may be an expectation that the individual holds (Frijda, 1986, 1988). For example, a mother might have a very different reaction to her child's crying depending on context; she will likely be more inclined to feel concern and empathy if the child is crying after tripping and getting hurt versus during a temper tantrum at the grocery store. Similarly, a mother's beliefs or expectations about how her child behaves might influence her reaction to child cues. A mother who expects her child to be able to pick up toys independently will probably experience greater anger upon entering a messy playroom than a mother who believes that her child is too young to complete this type of task without assistance. Finally, a mother's beliefs or expectations about her own capabilities as a parent will likely have an impact on her immediate emotional reaction to a parenting situation. For example, the onset of illness in one's child is more likely to elicit anxiety in a mother who feels that she is not in control of the situation than in a parent who is confident that she will be able to effectively care for and restore her child's health.

Although felt action readiness is a reflection of actual state of behavioral readiness, emotions are processes at the level of goals and action *tendency* rather than of action itself (Frijda, Kuipers & ter Schur, 1989). Overt behavior such as facial expression and organized action reflect underlying emotion. Frijda (1986) notes that many of the expressive behaviors that accompany emotion experiences, including facial expression, have functional significance in the interest of meeting one's goals. Expressive behavior is the tangible expression of action readiness and operates via relational activity, which is activity that establishes or modifies the relationship between an individual and some aspect of the environment (Frijda, 1986). For example, anger is typically associated with a facial expression that includes tightness in the lips and furrowing of the brow; it is possible that these facial movements are one part of the general body tenseness that goes along with an angry individual's physical readiness to engage with the environment. Similarly, the eyes-wide-open expression that is associated with surprise and sometimes fear may have a functional role in that it allows the individual to be more alert to potentially threatening changes in the environment.

Frijda (1986), along with many theorists preceding him (i.e. Darwin, 1872), also highlights the importance of expressive behavior's communicative capacity; the face is, after all, the primary signal system for communicating one's emotions (Ekman & Friesen, 2003). To give just a few examples, expressive behavior can be used to elicit help from others (e.g. a distressed infant is more likely to obtain comfort from a caregiver if crying), to warn others of threat (e.g. a child who recognizes a fearful look on a trusted adult's face may become more cautious and alert of his surroundings), or to provide reinforcement in a positive social situation (e.g. smiling and nodding is likely to make a friend or peer continue in conversation). The signaling quality of emotion expression is particularly relevant in parent-child interactions when considering the socialization of emotion in young children.

Finally, the physiological arousal that goes hand in hand with the emotion experience can be seen to serve as the logistic support for the action readiness inspired by the emotion (Frijda, 1988; Frijda, Kuipers & ter Schur, 1989); for example, increased brain activity may serve to increase the intensity of an individual's felt anger, mobilizing that individual to engage with the environment in an attempt to reach a blocked goal. Emotion, then, can be conceptualized as a system that supports overt action in the service of an individual's concerns.

Parenting

In the early years of life, a child's world is shaped by his or her primary caregivers (Beardslee et al., 1983; Rogosch et al., 2004). Children are completely reliant on their caregivers for survival, especially as infants. In addition to ensuring safety, sustenance and shelter, adults are responsible for nourishing a child's psychological, social, cognitive, and emotional growth.

Although development across these domains is largely interconnected, this study was concerned with aspects of parenting and the parent-child relationship that ultimately influence children's emotional skills and functioning. Parents both influence and are influenced by their children's emotional development. One way in which parents are immediately ensconced in the emotional lives of their children is through the regulation of their children's emotions. Emotion regulation has been defined as the mobilization of intrinsic and extrinsic processes to monitor, evaluate, and modify emotional reactions and expressions in order to accomplish one's goals (Thompson, 1994). Although the ability to self-regulate emotion progresses over the course of early childhood, children are initially reliant on their caregivers to organize and guide their emotions (Kopp, 1989; Cole, 1994; Calkins, 2004; Tronick, 1989). Regulation of infant emotion may be seen as a first step in the emotion socialization process, which continues throughout childhood (Eisenberg et al., 1998).

In addition to being a major task of successful parenting (Thompson, 1994), managing and guiding infant emotion has implications for a mother's regulation of her *own* emotion, which, as noted above, may be particularly salient during parent-child interactions. In families with young children, conflictual parent-child interactions occur between 3.5 and 15 times an hour, with positive interactions occurring 2.5 times as frequently as negative interactions (Dix, 1991). From the perspective of the parent, constantly being on call to keep a child in emotional homeostasis can be an exhausting and emotionally draining endeavor. As a result, parental affect is inherently tied to all aspects of child-rearing, including teaching, regulating, and caring for a child (Radke-Yarrow et al., 1993). Dix's (1991) affective model of parenting integrates parent cognitions and emotions as a driving force for the affective quality of the parent-child relationship. Reflective of Frijda's theory of emotion (1986), Dix's model says that parents have concerns that they seek to promote during interactions with their children; these may be immediate (e.g., “I need to help the baby stop crying now”), or long term (e.g.“I want my baby to develop a strong sense of self”), or may be self-oriented (e.g.“I need to get the baby fed in the next 20 minutes so that I can get to work on time”). Because parents are invested in the outcomes of parent-child interaction, they respond emotionally to events that influence the realization of their concerns. If goals are blocked or lost, negative emotion results (such as anger or sadness, respectively); however, if goals are met, parents experience positive emotion (such as satisfaction, happiness, or contentment). Dix’s model states that parents try to organize interactions with their children in ways that increase the probability of parents’ concerns being met. As they continually assess the progress of the interaction, they adjust their behavior to meet the needs of the changing situation in hopes that their concerns will ultimately be met.

The specific emotion experienced in a given situation is partially the result of parental beliefs about whether or not a goal was met and why (Dix, 1991; Frijda, 1986, 1988). These beliefs may incorporate parents’ perception of the importance, stability, generality, and controllability of the outcome (Dix, 1991). The more important, stable, general, and controllable parents perceive a situation to be, the more intense the related emotion is likely to be, whether positive or negative. Additionally, since parenting is an ongoing cycle of old and new goals, it is likely that parents’ expectations of whether a future goal will be met, relative to its importance, stability, generality and controllability, is also a factor in determining the quality of the emotion experience. This study focused on mothers’ sense of their own control over the attainment of parenting goals, or parental self-efficacy, and its relation to parent emotion and behavior.

Parenting self-efficacy. An individual's motivation and behavior in any given situation is influenced by that person's sense of self-efficacy, or, perception of ability and competence in performing a particular task (Bandura, 1982; Teti & Gelfand, 1991). Self-efficacy has been likened to a sense of mastery or control over a particular set of circumstances. Although specific knowledge and skill sets play an essential role in the accomplishment of specific goals, self-referent thought (in this case, one's sense of self-efficacy) influences how such qualities relate to one's behavior (Bandura, 1982). An individual's sense of self-efficacy may vary across activities and situations (Bandura, 1982); thus, parenting self-efficacy refers to a mother's or father's judgment of his or her ability to perform competently and effectively in the parenting role.

The strength of one's sense of self-efficacy has implications for the degree to which one will persist in a difficult or taxing task. As noted, parenting a young child, especially when the aim is not simply controlling the child but teaching the child, can be such a task. Research has shown that individuals with low self-efficacy tend to put less effort into solving a problem and are likely to give up more easily than those with a strong sense of self-efficacy (Bandura, 1982); thus, percepts of self-efficacy influence action readiness and approach behavior. Furthermore, there is some evidence that an individual's sense of self-efficacy has a stronger impact on behavior than actual ability. In a study in which subjects completed a mastery task followed by a probe for self-efficacy, Bandura (1982) found that perceived self-efficacy was a better predictor of subsequent behavior than was a participant's actual performance on the task. Furthermore, a sense of self-efficacy in a certain situation heightens interest in that particular arena (Bandura, 1982). For example, a mother who feels that she is able to give her infant a bath without too much difficulty is more likely to come to enjoy this task than one who feels she cannot control her baby or keep him from crying during the process.

Bandura (1982) notes the dynamic interplay among self-referent thought, action, and affect, asserting that perceptions of self-efficacy impact emotional reactions *as well as* behavior. It is important to note that appraisals are key to both Bandura's theory of self-efficacy and Frijda's theory of emotion. According to Frijda, different states of action readiness, from which emotion stems, are elicited by different appraisals, which may take into account how an individual feels she can handle a specific situation (Frijda, 1988). As a result, an appraisal of uncontrollability may impact the action readiness and the emotion that eventually results from a meaningful event. It follows, then, that a person who appraises a situation as uncontrollable due to low self-efficacy is likely to experience a tendency to disengage from the environment, leading to sadness or another withdrawal-related emotion. Sense of self-efficacy, then, is intimately related to emotion experience. As an example, anxiety is not warranted in difficult circumstances when the situation, or aspects of it, can be prevented, ended, or made less intense (Bandura, 1982). As a result, if two individuals find themselves in the same ambiguous situation, but one has a higher sense of situationally-relevant self-efficacy, their action tendencies, and therefore their emotional experiences, should be different. The low-efficacy individual should appraise the situation as uncontrollable and therefore withdraw, potentially resulting in fear or anxiety. The person with a high sense of self-efficacy, however, should appraise the situation as within her grasp and therefore tend towards engagement with her environment.

Evidence for the link between self-efficacy and emotion has been found in the parenting literature, as well, and research has shown that mothers with lower percepts of parental self-efficacy experience stronger negative emotion during interactions with children (Dix, 1991). In a study by Bugental, Blue, and Lewis (1990), mothers with low perceived control over negative outcomes were more likely to display dysphoria both verbally and facially during interactions with children. Therefore, low self-efficacy was related to parent emotional behaviors during interactions with children—the increased expression of negative emotion and lack of positive emotion—which may further influence both the parent's and child's experience of the situation and ultimately socialization of child emotion.

It is also important to consider the role that child characteristics play along with percepts of efficacy on an individual's behavior (Bandura, 1982). In a caregiving context, child temperament and behavior may impact a mother's sense of efficacy and subsequent parenting behaviors (Donovan & Leavitt, 1992). For example, two new mothers may develop dissimilar senses of parenting self-efficacy as a result of each infant's unique disposition. If one woman's infant is easier to soothe than the other, it is possible that parental self-efficacy and ensuing parenting behavior will differ as a function of the responsiveness of the environment (here, the infant's soothability). In support of this, in a study of first-time mothers, Leerkes and Burney (2007) found that infant reactivity was associated with lower maternal self-efficacy.

At the same time, perceptions of self-efficacy may interact with child behavior and the parent's perception of that behavior, and further influence parenting. Bugental and colleagues (Bugental et al.,1993) conducted a study in which mothers with varying degrees of perceived control (PC) in the caregiving role helped a "child" (in reality they were interacting with a computer program) complete a maze over the computer. The child was either responsive (performance improved over the course of the training period) or unresponsive (performance became sloppier over time, suggesting he was not taking the adult's help and instruction into account). The authors measured maternal affect through the participant's listing of her thoughts, overall evaluation of the child, and the valence of the feedback given to the child during the training period. Physiological arousal was indexed by skin conductance, heart rate, and respiration. Although low-PC mothers showed fairly positive affect and low levels of arousal when interacting with responsive children, this group was characterized by increases in negative affect, heart rate and skin conductance when paired with an unresponsive child. High-PC mothers, on the other hand, responded to both child groups with an increase in positive feedback to the child over the session, and physiological arousal consistent with attention. It seems that when fears were confirmed by the environment, low-PC mothers were overtaken by negative affect and arousal (Bugental et al., 1993). High-PC mothers, on the other hand, were able to maintain an appropriate interactive style with the child regardless of the child's behavior.

Parenting self-efficacy and emotion dynamics. It is likely that mothers with varying levels of parenting self-efficacy differ not only in the valence of emotion typically experienced or expressed, but also in the quality of that emotion. For example, a mother with a low sense of self-efficacy may have negative emotions that are more intense and longer in duration than a mother with high parenting self-efficacy. How can we test these differences? The study of emotion dynamics, i.e. individual differences in the intensive and temporal qualities of emotional responses (Thompson, 1994), is a useful way to study emotion in the context of a continually changing interaction like that of a parent and infant. Both Thompson (1994) and Davidson (1998) cite qualities such as the intensity, persistence, modulation, onset and rise time, range, lability of and recovery from an emotional reaction as measurable characteristics that may differentiate between individuals. Thus, it is essential to study not just the presence or absence of an emotion, but rather to examine *how* that emotion is being experienced and expressed. The intensity and time course of an emotion has important implications for both the subjective experience of the emotion and for the quality of its behavioral output (e.g. facial expression).

It is likely that the intensive and temporal qualities of an individual's emotion experience vary depending on countless individual qualities, such as personality characteristics, the person's appraisal of the emotion-eliciting stimulus, the degree of felt action readiness, or the expectation of the ability to effectively cope with the situation at hand. Thompson (1994) argues that although the particular discrete emotion experienced (e.g. joy versus anger) forms a basis for the overall emotion experience, factors such as Duration (how long the emotional reaction lasted), Latency to Onset (how long it took for the reaction to begin following the stimuli presumed to have caused it), Latency to Peak (how long it took for the reaction to reach its peak intensity), and Recovery or Offset from Peak (how long it took for the individual to return to baseline after peak intensity), significantly color its overall quality. Following this notion, alterations in emotion experience are often applied to its dynamic characteristics; although emotion regulation sometimes influences the valence of an emotion expression, more often this process is used to modulate an emotion's dynamic properties, such as frequency, intensity or duration (Eisenberg et al., 1998; Thompson, 1994). Recent research has begun to shed light on specific individual differences in intensive and temporal dynamics of emotion, or, affective chronometry (Davidson, 1998). For example, in a series of three studies, Hemenover (2003) demonstrated that in response to negative stimuli, participants high in neuroticism increased the fastest and recovered the slowest in negative affect (as measured by the PANAS); the inverse was found for participants high in extraversion. Similarly, in response to positive stimuli, individuals high in neuroticism increased in positive affect the slowest and decreased the fastest; again, the inverse was found for participants high in extraversion. These particular studies' reliance on self-report measures of both personality and affect is a weakness in that method variance may have influenced findings. Furthermore, the relation between each personality category with general levels of positive or negative affect was not controlled. If extraverts are more likely to experience more positive emotion in general, for example, this may relation have had an impact on the group's rate of affect change. Still, such research supports the notion that variation across individuals in temporal aspects of emotional responding may be related to individual differences in characteristics such as personality and psychopathology, and further research is needed to elucidate these relations and their implications for emotional functioning and parenting.

Dynamic qualities also have important implications for emotion as a social communicative or signaling tool, which is particularly relevant in the case of child emotion socialization. For example, the meaning of an expressed emotion may be interpreted differently or express a different experience based on dynamic qualities such as Intensity, Duration, Latency to Onset, Latency to Peak, and Offset from Peak. In fact, some of the most informative aspects of emotion expressions are communicated through intensive and temporal qualities (Edwards, 1998; Thompson, 1994). For example, Edwards (1998) argues that from an evolutionary perspective, emotion expressions are more helpful if they convey more than the mere presence of a discrete emotion. This is because intensive and temporal cues enable an observer to assess the urgency and relevance of stimuli (Edwards, 1998). This may be particularly important during early childhood, when youngsters look to adults for social referencing. For example, the intensity of a mother's facial expression of fear will convey to her child how quickly he must act in reaction to the fear-evoking stimulus. Similarly, temporal cues may let an observer know whether an emotion is emerging or dissipating (Edwards, 1998), which may have relevance as far as response to the stimulus. Duration may also be functional in that a prolonged apex may facilitate an observer's recognition of another's emotion; for example, a longer facial expression of joy may increase the possibility that a child will recognize his mother's contentment in their interaction and incorporate this into his own self-concept. Eisenberg and colleagues (Eisenberg et al., 1998) assertion that it is not only the valence and type of parental emotion that moderates the degree to which socialization occurs, but the intensity of the expression as well, underscores the importance of qualitative dynamics of emotions. It can be argued that the specific temporal dynamics of parent emotion have a similar moderating effect on the socialization process. Similarly, Dunsmore and Halberstadt (1997) suggest that emotions have more impact on a child's schema formation when they are expressed in a way that is salient to the child, e.g. longer or more intense than usual.

This study tested whether a parent's sense of self-efficacy was associated with the intensive and temporal qualities of mothers' emotional reactions in the context of observing their own infants' emotions. More specifically, the Intensity, Duration, Latency to Onset, Latency to Peak, and Offset from Peak of mothers' facial expressions of emotion while viewing video clips of their infants in different emotional situations (e.g., happiness, distress, etc.) were examined. It was expected that mothers with a higher sense of parenting self-efficacy would have positive emotions that were expressed more Intensely and for longer Durations, with shorter Latencies to Onset and Peak, and longer Offsets from Peak than mothers with low-self efficacy. For negative parental emotional expressions, it was expected that lower self-efficacy mothers' expressions would be more Intense and longer in Duration, with shorter Latencies to Onset and Peak and longer Offsets from Peak than mothers with high self-efficacy.

Action Readiness and the Emotional Brain

In addition to the use of a second-by-second coding system to assess changes in mothers' nonverbal facial expressions of emotion, this study used electroencephalogram (EEG) measurement of prefrontal cortical (PFC) activity to obtain a neurophysiological measure of emotion and motivation. The motivational model of PFC activity makes affective neuroscience a logical arena in which to study an action readiness view of emotion from a neurophysiological perspective. Research has suggested that the PFC is involved in emotion and motivation processing, and its activity can be measured through EEG techniques detecting activity in the alpha range (8-13 Hz) (Coan & Allen, 2004). PFC activity can be measured through PET and fMRI techniques as well, however, temporal resolution tends to be finer using EEG (Harmon-Jones, 2007). While EEG detects electrical activation in the brain resulting from an increase in neuronal activity in certain areas, PET and fMRI both measure blood flow to brain regions recently involved in such activity. As a result, EEG measurement naturally taps into electrical activity in the brain closer to real time. Thus, in a study of the dynamics and moment-to-moment variations in emotion and related action tendencies, EEG may be the ideal technique.

Asymmetry between activity in the right and left side of the PFC is typically used as an index of emotion or motivation. Initially, researchers employing EEG methodology adhered to a valence model of PFC asymmetry (e.g. Dawson et al., 1997) (Harmon-Jones, 2007), positing that greater relative left-frontal activity is related to positive emotion, and greater relative right-frontal activity is related to negative emotion. This model seemed to be supported in various capacities: baseline frontal activity was found to be related to measures of trait affect (e.g. as measured by the PANAS; Tomarken et al., 1992), psychopathological conditions like depression (Henriques & Davidson, 1990) and social phobia (Davidson et al., 2000), and responses to emotion-eliciting stimuli (Allen, Harmon-Jones & Cavender, 2001; Davidson & Fox, 1989; Davidson et al., 1990) in the expected direction. Interestingly, Henriques and Davidson (1990, 1991) found that an individual's lifetime depression—regardless of current symptoms—predicts less relative right PFC activity than in individuals who have never been depressed. Additionally, EEG activation (i.e. change in EEG activity) in response to positive and negative stimuli (even when baseline activity is partialled out) has shown relations to greater relative left- and right-PFC activity, respectively (Wheeler et al., 1993).

Research has also emerged showing a relation between EEG asymmetry and measures of approach-avoidance trait behavior, indicating that greater relative left-frontal activity is related to approach tendency, while greater relative right-frontal activity is related to withdrawal (Davidson, 1998; Harmon-Jones & Allen, 1997). Initially, this *motivation model* was easily reconciled with the valence model because the only approach emotion considered in previous research was joy. Some researchers then referred to a *valenced emotion model* in which greater relative left-frontal activity was associated with positive, approach-related emotions, and greater relative right-frontal activity was associated with negative, withdrawal-related emotions. This conceptualization is problematic because it confounds motivation with emotion valence in that the only approach-related emotions considered are positive (joy), and all negative emotions considered are withdrawal-related (sadness, anxiety, fear). Harmon-Jones and colleagues (Harmon-Jones & Allen, 1998; Harmon-Jones & Sigelman, 2001; Harmon-Jones, 2003; Harmon-Jones et al., 2003) produced compelling evidence for the simple motivation direction model by showing that both state and trait anger, which is a negative emotion but also approach-related, is associated with greater relative left-frontal activity. Additionally, Sutton and Davidson (1997) showed that PFC asymmetry more strongly predicts self-report of behavioral inhibition and activation than positive and negative affect. Although there have been no studies to date examining EEG asymmetry of parents witnessing their children's emotions, some evidence for potential hemispheric asymmetry has arisen from fMRI studies of parenting. Lorberbaum and colleagues (Lorberbaum et al., 2002) found greater right hemisphere activity, especially greater right prefrontal activity, in response to an infant cry stimuli. Thus, at the present time, it seems that the motivation model of EEG asymmetry is the most plausible. The approach-avoidance dimensions upon which the conceptualization of EEG asymmetry has been based fit easily into Frijda's model of emotion and action readiness. While left PFC asymmetry seems to be higher when an individual is experiencing a greater readiness towards engagement with the environment (greater *approach tendency),* greater right PFC asymmetry seems to be related to disengagement from the environment (less *approach tendency*). As a result, EEG asymmetry can be conceptualized as a neurophysiological marker of action readiness. More specifically, it is representative of the neurophysiological approach tendency that an individual may experience in response to an emotion-eliciting stimulus.

It should be emphasized that PFC asymmetry itself is not necessarily what drives emotion processing; rather, the asymmetry that we can detect through EEG methodology is a marker for the neural activity that is related to this process (Cacioppo, 2004). What *do* we know about the specific functional role the PFC plays in the goal-oriented, action tendency processing of emotion? Davidson has theorized that one purpose of the PFC is to aid in maintaining representations of a goal state in working memory (Davidson, 1998, 2002, 2004; Davidson et al., 2000). As noted by Frijda, emotion organizes behavior toward the accomplishment of a goal. If the immediate achievement of these goals is not possible, an individual needs a way to preserve that goal in working memory until steps can be taken to achieve it—Davidson (2002) terms this the "affective working memory." Not surprisingly, the representation of a goal state in working memory is hypothesized to be implemented in the dorsolateral prefrontal cortex, which has primarily been indicated in cognitive processing. It is likely that the ventromedial sector of the

PFC is also involved in the anticipation of emotional rewards and consequences (Davidson, 2002).

It is important to keep in mind that the PFC is just one component of a much greater emotional system in the brain. The PFC itself is made up of various components, which, for the primate, have been subdivided into the dorsolateral, orbitofrontal, and ventromedial sectors (Davidson, 2002). EEG techniques measure only certain portions of the PFC—most likely the dorsolateral sectors (Davidson, 2004). Although the dorsolateral sector, as mentioned above, has been shown to be associated with cognitive processes, it seems to be the orbitofrontal cortex that is most engaged in emotion processing (Davidson, 2004). Interestingly, many fMRI studies examining parental responses to infant stimuli have found increased activation in the orbitofrontal cortex (for a review see Swain, Lorberbaum, Kose & Strathearn, 2008). It is important to keep in mind, however, that various parts of the PFC—and the rest of the brain, for that matter—are interconnected, and it is likely that multiple portions of the circuit comprised of the dorsolateral, orbitofrontal, and ventromedial sectors are involved in emotion processing. Furthermore, in considering a view of emotion that assigns a vital role cognitive processing (i.e. appraisal in Frijda's theory), it is important to consider the interaction of multiple brain structures, especially those that are involved in cognitive and emotion processing.

Implications for asymmetry as related to emotion dynamics. Davidson (1998) maps out several ways in which the PFC may influence the time course of emotional responding, or, emotion dynamics, with an emphasis on Offset from Peak. Larson and colleagues (2000) found that individuals with greater relative left-frontal asymmetry at baseline had a greater recovery of startle following the offset of a negative stimulus, suggesting that individuals with a greater tendency towards greater relative left-frontal asymmetry are more likely to recover quickly from negative affect. Research suggests that the amygdale, which have also been implicated in emotion (particularly fear and anxiety; Davis, 1992) may play a role in the interplay of the PFC and temporal dynamics of emotion. Research has suggested that the PFC and the amygdale work together; specifically, that one role of the PFC is to regulate the amygdale (Davidson, 2002, 2004). Structurally, the amygdale are a major target of neurons from some portions of the PFC (Davidson, 2004), and interaction with the PFC may foster habituation of the amygdale to negative stimuli (Davidson, 2002). The role of the PFC in both the maintenance, or Duration, of some emotions (by facilitating the affective working memory) and the Offset of others (by inhibiting the amygdale) demonstrate the basic manner in which the PFC may contribute to emotion dynamics. Furthermore, these contributions can be viewed as making up part of the emotion *regulation* component, which Davidson (1998) cites as an intrinsic part of emotional experience and behavior.

EEG and emotion expression. Coan and Allen (2004) provided evidence for a conceptualization of frontal EEG activation, i.e. change in EEG activity, as a mediator of emotional responding. This model suggests that a measurable change in frontal EEG asymmetry is necessary for a relation between a stimulus and an emotional response. Evidence in support of this model showed that participants who responded to an insult with higher relative left-frontal activity were more likely to report greater anger and aggression (Harmon-Jones & Sigelman, 2001). In other words, an increase in left-PFC activity was related to greater felt emotional response.

It is unlikely that EEG asymmetry is a perfect mediator of emotional responding (Coan & Allen, 2004); however, an emotional response might occur differently or at a lower level of intensity or duration if there is no change in EEG activity. So, to a certain extent, EEG activity may facilitate emotional responding (Coan & Allen, 2004). One study manipulated approach tendency to test its effects on left-PFC asymmetry, emotional responding, and behavior (Harmon-Jones et al., 2003). Participants consisted of a group of college students opposed to a tuition increase at their university. Half of the students were told that the university was definitely instating a 10% tuition increase in the next two years (anger-impossible condition), and the other half was told that the university was merely considering a tuition increase (anger-possible condition). Participants in the anger-possible condition were given the opportunity to sign a petition opposing the tuition increase. Although an increase in self-reported anger was seen across groups, only the anger-possible group evidenced left-PFC asymmetry. Furthermore, 80% of anger-possible subjects signed the petition, showing a tendency to engage with the environment in an attempt to effect change. Emotion and its link to left-PFC asymmetry may have a functional purpose in that it facilitates an individual's response to the situation at hand. First, it can be argued that the anger-possible groups' greater relative left-PFC asymmetry was reflective of action readiness, which, in this case, was a greater approach tendency. This increased neurophysiological approach tendency was associated with an increased likelihood to engage in behavior related to the emotional situation (signing the petition). Furthermore, in this particular paradigm, participants were unable to attempt to change the tuition increase until the study was over. This is consistent with Davidson's (2002) view of the meaning of hemispheric asymmetry in that it is possible that left-frontal asymmetry provides the physiological basis on which a goal can be maintained in memory.

It is interesting to note, however, that if there was little or no expectancy of success in correcting the tuition increase, approach tendency, as indexed by EEG asymmetry, was low or nonexistent. These results suggest that if an individual perceives little to no opportunity to alter the situation at hand, the reaction is more likely to be withdrawal-related, facilitating disengagement with the environment. How might this be related to parenting? Mothers with a low sense of parenting self-efficacy may be comparable to the "anger-impossible" group in the preceding study, in that they feel a reduced ability to affect change in parenting situations. This may then lead to a greater likelihood of emotional experiences that are both negative and withdrawal-related, such as sadness or anxiety. This study tested whether mothers with lower parenting self-efficacy would respond to child emotional cues with decreased left-frontal EEG activity, suggesting less neurophysiological approach tendency. Furthermore, it examined how the relation between maternal approach tendency and perceived parenting self-efficacy would influence the dynamic qualities of mothers' emotional expressions in response to their infants' emotion.

Parent Emotion and Approach-Oriented Caregiving

Given the emotionally evocative nature of parenting, it should be possible to increase our understanding of the emotional circumstances that lead mothers to approach or withdraw from their child's emotion. The optimal emotional stance of the caregiver of a young child is to respond to child negative emotion by reducing the child's distress and to child positive emotion by maintaining the state (Tronick, 1989). In both cases, the parent of the infant approaches the child to reduce or maintain child emotion. Ideally, then, infant emotion cues should result in a parent's greater relative left-frontal activity, indicating an approach-oriented action readiness, particularly if the context affords opportunity to approach. It can be argued that the degree to which a mother feels efficacious may influence the degree to which she feels she is able to respond appropriately to child emotion cues. For example, a mother low in parental self-efficacy may not be confident in her ability to effectively soothe her crying infant or to continue to engage her laughing toddler, decreasing the approach tendency she experiences when exposed to a child emotion stimulus. A mother high in parental self-efficacy, however, may perceive herself as fully capable of optimally regulating her child no matter what emotion he is expressing, and therefore may experience a high approach tendency when presented with such cues. Given that the motivational intensity of an individual's response to a given situation is likely related to the amount of frontal activation observed, (Harmon-Jones, 2007) it is possible that the amount of relative left- versus right-frontal activity a mother will experience when faced with an emotional cue from her infant will depend on how efficacious she views herself in the parenting role.

Coan and Allen (2004) provide evidence for the notion that frontal activation mediates the relation between an emotional stimulus and emotional response. In other words, frontal activation may be the mechanism through which an evocative stimulus leads to an individual's felt or expressed emotion. As a result, an emotional response might occur differently or at a lower level of intensity or duration if there is no change in EEG activity. Thus, this study predicted that a mother's sense of parenting self-efficacy would moderate the relation between maternal approach tendency (as measured by EEG asymmetry) and facial expression of emotion when witnessing her infant's emotions (see Figure 1.)

Drawing from the literature on emotion dynamics, this study examined specific temporal and intensive qualities of maternal emotion, such as Intensity, Duration, Latency to Onset, Latency to Peak, and Offset from Peak. Ekman (1984) notes that the strength of a stimulus is likely to be positively related to the Duration and inversely related to the Latency to Onset of an emotional response. As mentioned above, Davidson (1998, 2002, 2004) notes that one function of prefrontal activity may be to maintain behavioral reinforcement contingencies in working memory; in other words, increased frontal activity may lead to the greater Duration of an emotion expression over time. Another role of the frontal cortex may be to regulate negative affect via the amygdale. Both functions have implications for Duration and Offset from Peak of facial expressions of emotion. So, mothers who are highly efficacious and who experience increased approach-motivation in response to child cues will likely have positive emotional responses that are more Intense, shorter in Latency to Onset and Peak, and longer in Duration and Offset from Peak. Negative emotional responses in highly efficacious mothers will likely be of shorter duration than negative expressions in low-efficacious mothers. It is also likely that specific child behavior or cues (in the case of the current study, valence or intensity of infant expressed emotion) will influence maternal emotion expression. For example, a mother may have more doubt about her ability to regulate her infant's negative emotion than positive emotion. In this case, associations between EEG asymmetry and the dynamics of emotional expression may be more pronounced while the mother is viewing clips of her infant crying than smiling or neutral.

The intensive and temporal qualities of parent emotional responses that arise from child emotion events and the processes by which they occur certainly merit study, as it is likely that such events are associated with parent, and therefore child, well-being. This study examined each mother's neurophysiological approach tendency (via EEG asymmetry) and emotion expression in response to three videos of her own infant: one in which the infant was neutral, another in which the infant expressed happiness, and a third in which the infant showed signs of distress. It was expected that mothers' parental self-efficacy would have a moderating effect on the relation between neurophysiological approach tendency and observed expression of emotion.

Chapter 2. HYPOTHESES

1. It was hypothesized that dynamic qualities of maternal facial expressions of joy and sadness would vary based on infant emotion.
    a. *Infant happy condition.* In comparison to other conditions, it was expected that maternal joy expressions during the infant happy condition would be highest in duration, intensity, and time to offset from peak, and lowest in latency to onset and peak. It was expected that maternal sadness expressions during the infant happy condition would be lowest in duration and highest in latency to onset.
    b. *Infant distress condition.* In comparison to other conditions, it was expected that maternal joy expressions during the infant distress condition would be lowest in duration, intensity, and time to offset from peak, and highest in latency to onset and peak. It was expected that maternal sadness expressions during the infant distress condition would be highest in duration, intensity, and time to offset from peak, and lowest in latency to onset and duration.
    c. *Infant Neutral condition.* It was expected that latency to onset, duration, intensity, latency to peak, and time to offset from peak of facial expressions of emotion during the infant neutral condition would fall in between levels for infant happy and infant distress conditions. However, it was expected that dynamics of maternal emotion expression during the neutral condition would be closer to emotion expressed during infant happy than infant distress condition.
2. Given the paucity of research on lip tension, the dynamics of mothers' lip tension across conditions was examined in an exploratory fashion.

3. It was expected that the relation between approach tendency as measured by EEG asymmetry and infant stimulus condition would be moderated by parental self-efficacy, in that mothers with higher self-efficacy would consistently show greater relative left-frontal activity under all stimulus conditions. Mothers with lower self-efficacy would be expected to have the greatest relative left-frontal activity during the infant happiness condition and the lowest during the infant distress condition.
4. It was hypothesized that mothers' parenting self-efficacy and approach tendency would be related to the dynamic qualities of their facial expressions of emotions in the following manner:
    a. It was expected that maternal facial expressions of joy (an approach-related emotion) that were greater in intensity, longer in duration and recovery time, and shorter in latencies to onset and peak would be related to greater relative left-frontal asymmetry and greater parenting self-efficacy, while those that were lower in intensity, shorter in duration and recovery time, and longer in latencies to onset and peak would be related to greater relative right-frontal asymmetry and lower parenting self-efficacy.
    b. It was expected that maternal facial expressions of sadness that were lower in intensity, shorter in duration and recovery time, and longer in latencies to onset and peak would be related to greater relative left-frontal asymmetry, while those that were greater in intensity, longer in duration and recovery time, and shorter in latencies to onset and peak would be related to greater relative right-frontal asymmetry.

c. Given that analyses for maternal lip tension were exploratory, no specific predictions about the direction of the relation between maternal lip tension and EEG asymmetry were made.

5. Furthermore, it was expected that relations between temporal dynamics of emotion expression and approach tendency as measured by EEG asymmetry would be moderated by parenting self-efficacy in the following manner:

   a. It was expected that mothers higher in parenting self-efficacy would show greater relations between EEG asymmetry and dynamic variables related to joy expressions (indicating approach) and sadness (indicating empathy as well as approach) than mothers lower in parenting self-efficacy.

   b. It was expected that for mothers lower in parenting self-efficacy, expressions of joy would not be related to EEG asymmetry. For these mothers, expressions of sadness would be related to greater relative right-frontal activity.

Chapter 3. METHOD

Participants

Forty-eight mothers of 5- to 9-month-old infants agreed to participate in the current study; of these 48 women, 46 completed all home and laboratory visits. Recruitment strategies included newspaper ads, fliers, and use of the Penn State Child Study Center's Families Interested in Research Studies Database. Mothers lived in central Pennsylvania and identified as 90% Caucasian, 4% African American, and 6% Asian, Hispanic or bi-racial. All mothers lived with a partner, and 94% were married. Average family income was $73,021 a year (*SD* = $48,427). Maternal age ranged from 22 to 45 years (*M*=31, *SD*=5.2). In regard to parity, 46% of the participants were first-time mothers; of multiparous mothers, 40% had two children and 14% had three children. Recruitment was constrained to women who were right-handed (a standard of EEG research, given relations between handedness and neural organization), fluent in English, and living with their children. Exclusionary criteria included mothers whose infants were born very prematurely (< 32 weeks gestational age at birth) or had low birth weight, chromosomal abnormalities or significant perinatal complications (based on maternal report).

Procedure

Home visits. The first in-person contact was a home visit, during which infants were videotaped for the purpose of generating video clips of infant facial expressions that could be characterized as happy, distressed, and neutral. While the mother was out of sight, infants were videotaped while trained research assistants interacted with the infant using standard brief procedures known to elicit infant emotion. Specifically, to elicit infant happiness, a peek-a-boo task was used; if the child did not respond to this game, the assistant cooed and smiled at the infant. A gentle arm restraint task was used to elicit infant distress, and a clip of the infant during an emotionally neutral period was also taken from any point of the home visit. Once infant video clips were obtained, five 10-second clips (two happy, two distressed, and one neutral) were selected for a video presentation to be used at the lab visit. Clips were selected by choosing the two 10-second periods during which the each of the various emotions was best represented.

About a week after the first home visit, trained research assistants visited the home a second time; during this visit mothers completed a series of 15 questionnaires and a short interview. This study used the 13-item Sense of Competency subscale of the Parenting Stress Index (Abidin, 1983) as an index of parental self-efficacy. The Sense of Competency subscale has demonstrated good internal reliability (α=.74; Loyd & Abidin, 1985). Reliability of the scale for the current sample was very similar (α=.75) to that of the original sample. The Sense of Competency subscale includes items such as: "I feel capable and on top of things when I am caring for my child," and, "Since I brought my last child home from the hospital, I find that I am not able to take care of this child as well as I thought I could. I need help," (reverse-scored).

Laboratory visit. Within one week of the second home visit, mothers visited the Human Electrophysiology Facility at the Pennsylvania State University. During this visit, mothers were prepared for the EEG assessment. EEG data was collected with an Electrical Geodesics, Inc. (EGI) 250 Dense-Array EEG System. A non-abrasion method with a saline-based electrolyte solution was used for application of the net. The Geodesic sensor net was configured for 128 channels of data based on the International 10-20 System (Jasper, 1958). The 10-20 system determines electrode placement based on the distance of the line between standard points of measurement on an individual's scalp. For the placement of electrodes from the front to the back of the head, the distance between the nasion (the bridge of the nose) and the inion (the occipital protuberance, a bone that protrudes from the back of the head over the occipital area) is obtained.

For electrodes placed on the left and right sides of the head, the distance between the midpoints of the two ears is measured. The thirteen standard electrodes are then placed at distances of either 10% or 20% from each other, based on the total distance (in centimeters) from the inion to the nasion or the midpoint of the right ear to that of the left ear (Andreassi, 2000). The electrode placed at the midpoint of these two perpendicular lines (so exactly in the middle of the top of the head) is known as Cz. Electrodes were also placed on the supra- and sub-orbit of each eye in order to detect eye blink artifacts. Finally, electrodes were placed on the mastoid areas behind the left and right ears in order to compute a "linked ears" reference. This technique is often used in studies in which hemispheric asymmetries will be calculated because it allows for a bilateral referencing (Andreassi, 2000). During data acquisition, impedance was kept below 50,000 ohms, indicating good contact between the electrodes and the scalp. Signals were sampled at a rate of 250 samples per second.

Following electrode placement, mothers were seated in front of a computer display monitor with their heads resting on a chin rest approximately 61 centimeters from the monitor in order to limit head movement. Once the mother was comfortable, an 8-minute baseline procedure began (Tomarken et al., 1992). Baseline was divided into eight 1-minute trials, which consisted of 4 minutes total of eyes open (O) and 4 minutes total of eyes closed (C; order was C, O, O, C, O, C, C, O) while EEG was recorded continuously. This study used the average measure of baseline across eyes open and closed trials.

Following the baseline procedure, each mother watched a 15-minute video presentation, which consisted of a series of the 10-second infant emotion clips obtained during the home visit. EEG was recorded continuously during this viewing. Video presentations consisted of multiple displays of two joy clips, two distress clips, and one neutral clip. Each video clip was presented for 10 seconds and was offset by 15 seconds of a blank screen. The order of the happy, distress, and neutral video clips was counterbalanced within the video presentation, and each mother viewed the emotion clips in the same order. Each happy and distress clip was displayed 6 times (total of 12 clips for each) and the neutral clip was displayed 12 times. An Apple iSight digital video camera recorded mothers' facial expressions during the entire length of the video stimulus presentation. Additionally, a mirror was placed adjacent to mothers' faces that reflected the computer monitor's image to the iSight camera.

EEG data extraction, cleaning, and reduction. EEG recording requires the use of a reference point, which refers to an electrode placed in a relatively electrically inactive area of the body to serve as a comparison point for data collected from areas high in activity. In the current study, data were referenced to the Cz electrode during data acquisition. After acquisition, data were re-referenced and an average reference with Polar Average Reference Effect (PARE) Correction was computed. Since there is no *truly* electrically inactive point on the human body, researchers have suggested that an average reference be used. Proponents of this method assume that if there are enough electrodes placed over the head, the voltage across the entire scalp at any given moment will be zero (Cacioppo, Tassinary & Berntson, 2007). Average referencing should not be used if data is acquired from fewer than 20 electrodes (Cacioppo, Tassinary & Berntson, 2007); given that a 128 channel net was used in the current study, this method was an option. However, even with a high-density EEG net such as the one used in this study, activity on the bottom of the scalp was not adequately accounted for (since there are not as many electrodes on the bottom of the head as on the top). To address this, PARE correction was used, which uses spline interpolation to estimate activity at the bottom of the head (Junghoefer et al., 1999). This interpolation is then used to better determine the average reference.

Post-data acquisition, artifacts were screened and transits exceeding 200µv in 640 ms window size were considered data from a "bad" channel. Data from bad channels were then replaced with values interpolated from other channels with spherical splines. Finally, principal components analysis (PCA) was used to remove artifacts in continuous EEG data.

Given the interest in examining alpha asymmetry, which is typically detected in the 8-13Hz range, a bandpass filter of 1-30Hz was used (thus isolating activity within the 1-30 Hz range). Data were then divided into two-second epochs that were selected by a Hamming window. The purpose of a Hamming window is to decrease the contribution of the data at each end of an epoch, because the ends of an epoch may be subject to random frequencies resulting from the transition from one epoch to another (Cacioppo, Tassinary & Berntson, 2007). A result of the use of a Hamming window, however, is that good data may be lost at the end of each epoch. To resolve this issue, the final data used epochs that overlapped by 75%.

A Fast-Fourier Transform (FFT), which decomposes an EEG signal into its underlying sine waves, was used to obtain alpha power (which was considered to be the average power in the 8-13Hz range). The natural log was then taken of the alpha power score in each epoch. Alpha asymmetry scores were computed by taking the difference of the natural log-transformed scores for sites that have electrodes on both the left and right sides of the scalp. In the original 10-20 system, these sites would be F3 (left) and F4 (right); and F7 (left) and F8 (right). Since the current study collected data from 128 channels, averages were taken of each group of six electrodes surrounding F3, F4, F7, and F8 (F3: 19, 20, 23, 24, 27, 28; F4: 3, 4, 117, 118, 123, 124; F7: 26, 27, 32, 33, 34, 38; F8: 1, 2, 116, 121, 122, 123). The F3 and F4 sites are located just on either side of the line crossing from the nasion to the inion, and are considered mid-frontal sites. The F7 and F8 sites are out further on either side and are considered lateral frontal sites.

Alpha asymmetry scores were taken for each pair (F3/F4 and F7/F8), and computed by subtracting the average of the 6 corresponding log-transformed scores for each left site (F3 and F7) from the average of the 6 corresponding log-transformed scores from each right site (F4 and F8). Ultimately, higher asymmetry scores reflected relatively greater left-frontal activity. Composite asymmetry scores were calculated for *each* infant emotion clip (a total of 36) by averaging the asymmetry scores of its corresponding 2-second windows.

Facial Emotion Expression Coding and Data Reduction. Mothers' facial expressions were coded for muscular activity known to be indicative of emotion using a second-by-second following guidelines used by Cole and colleagues (2003). The occurrence of Joy, Sadness, Anger, and general Tension/Anxiety, were coded as occurring or not occurring in each 1-second epoch. If an emotion expression was judged to occur, it was rated for intensity on a scale of 1 (mild expression, involving a low level of muscular contraction) to 3 (full, intense involving multiple areas of the face contracted with greater effort). A binary emotion present/not present code was used when there was no indication of any emotion-related facial activity and these epochs constituted neutral epochs. Additionally, Lip Tension (pressing, tightening, or pursing of the lips in the absence of indicators of other another emotion) was noted. Emotion codes are not mutually exclusive; in other words, emotion blends may occur as specified by Ekman (2003).

Of all videos coded, only two mothers showed Anger expressions. Given the low frequency of Anger, which always occurred along with Lip Tension, the Anger code was collapsed into the Lip Tension code. Additionally, only one mother showed a Tension/Anxiety expression; furthermore, this expression was coded in the first few seconds of the video viewing period, before the first infant stimulus was presented. As a result, the Tension/Anxiety code was not used in analyses. Finally, only one mother showed more than a mild Sadness expression; as a result, Sadness was treated as a binary present/not present code in analyses.

Twenty-four percent of videos were double-coded for reliability. The overall kappa was acceptable ($\kappa = .70$). Kappas for each emotion expression ranged from .53-.86 (Joy $\kappa = .86$, Sadness $\kappa = .53$, Lip Tension $\kappa = .71$). In order to examine the cause of the low reliability for sadness, a portion of videos were consensus coded; it was determined that the master coder was accurate in coding sadness and that discrepancies were due to reliability coders' not identifying sadness at some points that it occurred. Finally, given that Joy could be coded as a mild, medium, or full expression, intra-class correlations (ICC) were computed for this code to check for reliability on coding of intensity. The ICC was good: .91.

In order to generate variables that capture dynamic changes in facial expressions of emotion (Thompson, 1994), MATLAB was used to create variables:

1. Latency to Onset (the number of seconds between the onset of a stimulus and the start of an emotion expression). If no emotion expression was present for a particular stimulus presentation, a score of 26 was assigned (given that there were 25 seconds between the start of each stimulus presentation, a true score of 26 would be impossible).
2. Duration (the number of seconds for which an expression lasts).
3. Intensity (the mean of intensity ratings for a given expression).
4. Latency to Peak (the number of seconds between the start of an emotion expression to the highest intensity of that expression).
5. Offset from Peak (the number of seconds between the highest intensity of the expression and the return to neutral).

Latency to Onset was calculated for each of the 36 stimulus presentations. Duration, Intensity, Latency to Peak, and Offset from Peak were calculated for each bout (a consecutive string of 1 second epochs in which an emotion expression was present) of emotion expressed. Separate scores were calculated for bouts of emotion beginning in infant neutral, happy, or distress conditions. The final variables used in analyses reflected means across all bouts (or all presentations, for the Latency to Onset variables) for each condition. Since there was no variation in intensity of Sadness or Lip Tension, only Latency to Onset and Duration variables were calculated for these emotion expressions.

Finally, in order to reduce the amount of missing data in final analyses, mothers were given a final average score of 0 or 26 (depending on the emotion dynamic) if they did not express an emotion during a particular condition. For example, if a mother did not express joy during any of the infant distress videos, she was given a score of 0 (for Duration, Intensity, and Offset from Peak) and 26 (for Latency to Onset and Peak) for her overall dynamic score for that condition (specifically, the mean Latency to Onset, Duration, Intensity, Latency to Peak, and Offset from Peak of joy expressions during the infant distress condition).

Chapter 4. RESULTS

Sample Characteristics Overview

Of the 46 mothers who completed the study, EEG data (n = 10), emotion expression data (n = 1), or both (n = 8) were unusable as a result of technical difficulties. One case was excluded due to outlying emotion expression variables. For the purposes of the current study, data from 26 mothers with complete EEG and emotion expression data were used. To check whether there were systematic differences between mothers with complete and partial data, one-way analyses of variance (ANOVAs) were conducted on demographic variables and parenting self-efficacy data. These analyses revealed no significant differences for mothers' age, target child age, target child sex, family income, or parenting self-efficacy (all F's < 1.5. p's > .10).

Descriptive Statistics, Zero Order Correlations and Hierarchical Multiple Regression Analysis Overview

First, an overview of descriptive statistics, correlation, and regression analyses is presented, followed by presentation of the results of tests of each hypothesis.

The descriptive statistics for the 26 mothers' demographic characteristics and parenting self-efficacy are presented in Table 1. In a separate table (Table 2), descriptive statistics for dynamic emotion expression variables as a function of infant stimulus condition are presented. Descriptive statistics for the EEG data are presented in Table 3. Individual electrode data for 1 mother were unavailable at the time of analysis, however, descriptive statistics for asymmetry scores reflect all 26 mothers with usable data. Finally, the correlation tables are presented in Tables 4, 5, and 6. As is often the case with emotion expression data, most of the dynamic emotion expression variables were skewed and kurtotic. In large part this was due to any given variable having a high number of zero scores. As a result, transformations of the data could not be used to improve the emotion expression variables' distributions. Therefore, Spearman's rho, which relates pairs of rank distributions, was used to present correlations among the variables of interest. Given that the direction of effects was predicted, one-tailed tests were used. It is noteworthy that 12% (n = 16) of the 135 correlations tested were significant ($p < .05$); an additional 14% (n = 19) approached significance ($p < .10$), with magnitudes ranging from .25 to .33, which suggests effects that may have reached significance with a larger sample. The number of significant relations is greater than would be expected by chance (5%; n = 7).

In order to test hypotheses 1-3, repeated measures ANOVAs were conducted to examine differences in maternal emotion expression and EEG asymmetry by condition. Finally, to test hypotheses 4 and 5, hierarchical multiple regression analyses were conducted.

Hypothesis 1a-c and 2 (exploratory): Maternal facial expressions will vary based on infant stimuli. It was expected that during the infant happy condition, maternal Joy expressions would be longest in Duration and Offset from Peak, highest in Intensity, and shortest in Latency to Onset and Peak, and that Sadness expressions would be shortest in Duration and longest in Latency to Onset. In the infant distress condition, it was expected that maternal Joy would be shortest in Duration and Offset from Peak, highest in Intensity, and longest in Latency to Onset and Peak, and that Sadness expressions would be longest in Duration and shortest in Latency to Onset. Given that analyses including Lip Tension were exploratory, the direction of effects by condition was not predicted. To test hypotheses, repeated measures ANOVAs were conducted. The specific means tested can be found in Table 2, along with other descriptive statistics. Bonferroni adjustments were applied in post-hoc tests of mean differences. Appropriate corrections (Huynh-Feldt or Greenhouse-Geisser) were used when assumptions of sphericity were violated.

The hypothesis that dynamics of maternal emotion expression would vary by stimulus condition was partially supported for maternal Joy and Sadness expressions; all significant relations were in the expected direction. For maternal Joy, infant stimulus conditions differentiated Latency to Onset, $F(1.71) = 29.05$, $p < .001$, $\text{eta}^2 = .54$ (all Mean (M) comparisons $p < .01$); Duration, $F(2) = 4.70$, $p < .05$, $\text{eta}^2 = .16$ (infant neutral greater than infant distress, $p < .05$); Intensity, $F(2) = 26.02$, $p < .001$, $\text{eta}^2 = .51$ (infant neutral and infant happy greater than infant distress, $p < .001$); Latency to Peak, $F(2) = 22.29$, $p < .001$, $\text{eta}^2 = .47$ (infant neutral and infant happy shorter than infant distress, $p < .01$). Differentiation by stimulus condition approached but did not reach significance for Offset from Peak, $F(1.5) = 3.47$, $p = .05$, $\text{eta}^2 = .12$. In summary, Latency to Onset differed across all three conditions; Duration and Intensity were significantly greater and Latency to Peak significantly shorter in the infant neutral and happy conditions than in the infant distress condition; and Offset from Peak did not differ across conditions.

For maternal Sadness, differentiation by stimulus condition approached but did not meet significance for both Latency to Onset , $F(1.06) = 3.45$, $p = .07$, $\text{eta}^2 = .12$; and Duration, $F(1.06) = 3.61$, $p = .06$, $\text{eta}^2 = .13$. For maternal Lip Tension, there were no infant condition effects, (all F's < 1).

Hypothesis 3: The relation between EEG asymmetry and infant stimulus condition would be moderated by parental self-efficacy. It was expected that mothers higher in parental self-efficacy would show greater relative left-frontal asymmetry across all infant stimulus conditions, while mothers lower in self-efficacy would show the greatest left-frontal asymmetry during the infant happy condition and the least in the infant distress condition. Given that EEG asymmetry was examined at both mid-frontal (F4/F3) and lateral-frontal (F8/F7) sites, separate analyses were conducted for each site pair. To test this hypothesis, repeated measures ANOVAs were conducted with EEG asymmetry entered as a within-subjects factor and parenting self-efficacy entered as a between-subjects factor (refer to Table 3 for specific means tested, along with other descriptive statistics). There were no significant differences in asymmetry scores across conditions for either site pair (all F's < 1), and no significant asymmetry by parenting self-efficacy effects (all F's < 1).

Hypotheses 4a and 5: Maternal Joy expressions will be related to parenting self-efficacy and EEG asymmetry, and relations between Joy expressions and EEG asymmetry will be moderated by parenting self-efficacy. Hierarchical multiple regression models were used to test the hypothesis that maternal Joy expressions would be related to parenting self-efficacy and EEG asymmetry. It was expected that maternal facial expressions of Joy (an approach-related emotion) that were longer in Duration and Offset from Peak, greater in Intensity, and shorter in Latencies to Onset and Peak would be related to greater relative left-frontal asymmetry and greater parenting self-efficacy, while those that were shorter in duration and Offset from Peak, lower in Intensity, and longer in Latencies to Onset and Peak would be related to greater relative right-frontal asymmetry and lower parenting self-efficacy. Furthermore, it was expected that the relation between EEG asymmetry and maternal Joy would be moderated by parenting self-efficacy.

A separate regression model was tested for each dynamic maternal emotion expression as the dependent variable. As EEG asymmetry scores were calculated for both mid-frontal (F4/F3) and lateral-frontal (F8/F7) site pairs, regressions were run separately for each site. Results from models including EEG asymmetry measured at the F4/F3 sites will be presented with a superscript "1," (^{1}) and those from models including EEG measured at F8/F7 will be presented with a superscript “2” (^{2}). In Step 1 covariates (number of children and baseline EEG asymmetry) that served as control variables were entered. The number of children was controlled for given its potential influence on parenting self-efficacy. Following Harmon-Jones and colleagues (Harmon-Jones et al., 2003), baseline EEG asymmetry was also entered as a covariate. In step 2 EEG asymmetry and parenting self-efficacy were entered. Finally, in step 3, the interaction between EEG asymmetry and parenting self-efficacy was entered. Given the skew and kurtosis of the emotion expression data, regression analyses were conducted following guidelines from Conover and Iman (Iman & Conover, 1979; Conover & Iman, 1981). All variables were rank transformed prior to entry into the equation; ties were handled by assigning average ranks (Iman & Conover, 1979). Using rank transformations, it was not necessary to center variables prior to entering the interaction term. Baseline data were unavailable for 1 mother, resulting in data from 25 mothers used in regression analyses.

Table 7 displays R^2, adjusted R^2, *F*-statistics, and effect sizes (Cohen’s f^2) for each of the Joy models, in addition to the beta weights for the two main effects (EEG asymmetry and parenting self-efficacy) and the interaction term in the final step of the model. Figures 1 and 2 illustrate significant interactions. First, significant main effects will be presented, followed by interaction effects. Finally, significant covariates will be discussed along with effects that were washed out upon entry of the interaction term.

Significant main effects were present in 6 out of 30 full models (20%); all effects were in the expected direction. Greater parenting self-efficacy was related to a longer Duration of Joy in the infant distress condition ($\beta = 1.11$, $p < .05$[1]), and longer Offset from Peak in the infant neutral ($\beta = 1.00$, $p < .05$[1]; $\beta = 1.08$, $p < .05$[2]), and distress conditions ($\beta = 1.12$, $p < .05$[1]). Greater approach tendency (as measured by EEG) was related to a higher Intensity of Joy during the infant neutral condition ($\beta = 1.25, p < .05^2$).

The interaction term was significant only in the model predicting Latency to Peak of Joy during the infant happy condition, suggesting that parenting self-efficacy moderated the relation between Latency to Peak of Joy and EEG asymmetry. In order to test hypotheses related to this interaction, mothers were divided into a low parenting self-efficacy group (n = 12) and a high parenting self-efficacy group (n = 13) by way of a mean split (a median split returned the same results as far as group membership). Regressions were then re-run for each group, with relevant covariates (number of children and baseline EEG asymmetry) entered in step 1 and EEG asymmetry entered in step 2. As expected, for mothers in the lower parenting self-efficacy group, Latency to Peak of Joy expressions was not related to EEG asymmetry ($\beta = -.13$, ns; $R^2 = .02$; Adjusted $R^2 = -.35$; $f^2 = .02$). For mothers in the higher parenting self-efficacy group, however, a shorter Latency to Peak was related to greater approach tendency ($\beta = -1.15, p < .01$; $R^2 = .62$; Adjusted $R^2 = .49$; $f^2 = 1.63$). Figures 1 and 2 illustrate this interaction.

The interaction term approached, but did not reach, significance in four other models predicting Intensity during the infant neutral condition in models for both EEG asymmetry sites, and the Duration and Offset from Peak during the infant distress condition. Probing of these interactions showed no significant predictors of Joy when the sample was split into low- and high- efficacy groups.

Covariates did not show consistent relations with maternal expressions of Joy. Baseline EEG asymmetry was not related to maternal expressions of Joy in any of the models tested. During the infant happy condition, number of children was the sole significant predictor of the

Latency to Onset of Joy expressions (β = -.46, $p < .05$[2]) and the Intensity of Joy expressions (β = .54, $p < .05$[1]; β = .46, $p < .05$[2]).

Because of the exploratory nature of this study and the small sample size it seemed worthwhile to consider main effects that were washed out when interaction terms were entered. There were two Joy models in which direct effects emerged in step 2 but became nonsignificant when the interaction term was entered in step 3. As expected, during the infant neutral condition greater parenting self-efficacy was related to a longer duration of Joy (β = .44, $p < .05$[2]), and during the infant happy condition, greater EEG asymmetry was related to a shorter Latency to Peak of Joy expressions (β = -.58, $p < .05$[2]). Additionally, it is worthwhile to note that there were some main effects that approached, but did not reach, significance (refer to Table 7).

In summary, higher parenting self-efficacy was related to longer Durations and Offset from Peak of Joy expressions, and greater approach tendency (as measured by EEG asymmetry) was related to greater Intensity and shorter Latency to Peak of Joy expressions. Furthermore, parenting self-efficacy moderated the relation between EEG asymmetry and Latency to Peak in the infant happy condition.

Hypothesis 4b & 5: Maternal Sadness expressions will be related to parenting self-efficacy and EEG asymmetry, and relations between temporal dynamics of Sadness expressions and EEG asymmetry will be moderated by parenting self-efficacy.

Hierarchical multiple regression models were used to test the hypothesis that maternal Sadness expressions would be related to parenting self-efficacy and EEG asymmetry, and that the relation between dynamics of Sadness expressions and EEG asymmetry would be moderated by parenting self-efficacy. The same procedures were used in setting up hierarchical multiple regression models for Sadness models as for Joy models. Table 8 displays R^2, adjusted R^2, *F*-

statistics, and effect sizes (Cohen's f^2) for each of the Sadness models, in addition to the beta weights for main effects and the interaction term in the final step of the model. First, significant main effects will be presented, followed by interaction effects. Finally, significant covariates will be discussed along with effects that approached, but did not reach, significance.

Significant main effects were found for 6 (50%) of the models. As expected, in the infant distress condition higher parenting self-efficacy was related to a longer Latency to Onset of Sadness ($\beta = 1.01$, $p < .05$[2]), and a shorter Duration of Sadness ($\beta = -1.06$, $p < .05$[2]). As for EEG asymmetry, a longer Latency to Onset of Sadness was related to greater approach tendency in both the infant neutral ($\beta = 1.28$, $p < .01$[1]) and infant happy ($\beta = 1.10$, $p < .05$[1]) conditions. For the infant distress condition a longer Latency to Onset of Sadness was related both to greater approach tendency ($\beta = 1.51$, $p < .01$[1]) and greater parenting self-efficacy ($\beta = 1.20$, $p < .01$[1]) and longer Duration was related to both less approach tendency ($\beta = -1.52$, $p < .01$[1]) and less parenting self-efficacy ($\beta = -1.16$, $p < .01$[1]).

Although the interaction term was not significant in any of the models, the potential interaction was probed for the one model (predicting Latency to Onset during infant distress) in which the interaction term approached significance. The same low- (n = 12) and high- (n = 13) parenting self-efficacy groups were used as in analyses for Joy. For mothers in both groups, a longer Latency to Onset of Sadness was associated with greater approach tendency. However, as expected, the relation for mothers in the high-efficacy group reached significance, ($\beta = 1.06$[1], $p < .05$; $F(3,12) = 2.06$, ns; $R^2 = .41$; Adjusted $R^2 = .21$; Cohen's $f^2 = .69$), while the relation for mothers in the low-efficacy group did not ($\beta = .79$[1], $p < .10$; $F(3,11) = 1.71$, ns; $R^2 = .39$; Adjusted $R^2 = .16$; Cohen's $f^2 = .64$).

Although number of children was not a significant predictor of Latency to Onset or Duration of Sadness, baseline EEG asymmetry was related to some dynamics of Sadness. Greater relative left-frontal baseline EEG asymmetry was related to a shorter Latency to Onset of Sadness in the infant happy ($\beta = -.72$, $p < .05$[1]) and distress ($\beta = -.54$, $p < .05$[1]) conditions and a longer Duration of Sadness in the infant distress condition ($\beta = .61$, $p < .05$[1]). In cases in which baseline EEG asymmetry was related to Sadness dynamics, however, these effects were not the sole significant predictors in the model. Rather, in all models, EEG asymmetry during the respective condition was significantly related to the Sadness dynamic in the expected direction. There were no predictors of Sadness whose significance was washed out when the interaction term was entered, however, there were some main effects that approached, but did not reach, significance (refer to Table 8).

Predictors of maternal Sadness were strongest and most consistent in the infant distress condition. However, as predicted, greater approach tendency and parenting self-efficacy were related to maternal Sadness expressions that were longer in Latency to Onset and shorter in Duration across conditions. Furthermore, as predicted, parenting self-efficacy moderated the relation between EEG asymmetry and the Duration of maternal Sadness expressions during the infant distress condition.

Hypothesis 4c & 5: Maternal Lip Tension expressions will be related to parenting self-efficacy and EEG asymmetry, and relations between temporal dynamics of Lip Tension and EEG asymmetry will be moderated by parental self-efficacy.

As for maternal Joy and Sadness expressions, hierarchical multiple regression models were used to test the hypothesis that maternal Lip Tension would be related to parenting self-efficacy and EEG asymmetry, and that the relation between dynamics of Lip Tension and EEG asymmetry would be moderated by parenting self-efficacy. Table 9 displays R^2, adjusted R^2, *F*-statistics, and effect sizes (Cohen's f^2) for each of the Lip Tension models, in addition to the beta weights for main effects and the interaction term in the final step of the model. Figures 3-6 illustrate significant interactions. First, significant main effects will be presented, followed by interaction effects. Finally, significant covariates will be discussed along with main effects that were washed out after entry of the interaction term, and those that approached, but did not reach, significance.

Main effects emerged in 9 (75%) of the models. In the infant neutral condition, greater parenting self-efficacy was related to a shorter Duration of Lip Tension expressions ($\beta = -1.01$, $p < .05$[2]). Greater approach tendency as measured by EEG was related to a longer Latency to Onset ($\beta = 1.22$ $p < .05$[1]) and a shorter Duration ($\beta = -1.34$, $p < .01$[1]) in the infant distress condition. Four other models showed significant main effects for both parenting self-efficacy and EEG asymmetry: for infant neutral and infant happy conditions, a longer Latency to Onset of Lip Tension was related to greater approach tendency (infant neutral $\beta = .94$[1], $\beta = 1.18$[2]; infant happy $\beta = 1.07$[1], all *p*'s < .05) and greater parental self-efficacy (infant neutral $\beta = 1.01$[1], $\beta = 1.10$[2]; infant happy $\beta = .74$[1], all *p*'s < .05). Finally, in the infant neutral condition, longer Duration of Lip Tension was related to less approach tendency ($\beta = -1.08$[1], $p < .05$) and less parenting self-efficacy ($\beta = -1.10$, $p < .01$[1] $p < .05$[2]).

There were two Lip Tension models (Duration and Latency to Onset during infant distress) for which the interaction term was significant. Probing of the interactions revealed systematic relations between EEG asymmetry and Lip Tension *only* for low-efficacy mothers; relations were in the expected direction. For mothers lower in parenting self-efficacy, a shorter Duration of Lip Tension was related to greater approach tendency as measured by EEG asymmetry (β = -.79, $p < .05$[2]; $F(3,11) = 2.85$, ns; $R^2 = .52$; Adjusted $R^2 = .34$; Cohen's f^2=1.08), however, there was no significant relation for mothers higher in self-efficacy (β = .54, ns[2]; $F(3,12) = 1.47$, ns; $R^2 = .33$; Adjusted $R^2 = .11$; Cohen's f^2= .49). A similar pattern emerged for the Latency to Onset of Lip Tension. For mothers lower in parenting self-efficacy, a longer Latency to Onset of Lip Tension was related to greater approach tendency as measured by EEG asymmetry (β = .68, $p < .10$[2]; $F(3,11) = 2.17$, ns; $R^2 = .45$; Adjusted $R^2 = .24$; Cohen's f^2= .82). It is of note, however, that this relation only approached significance. For mothers higher in parenting self-efficacy, there was no significant relation between EEG asymmetry and Latency to Onset of Lip Tension (β = -.04, ns[2]; $F(3,12) = .79$, ns; $R^2 = .21$; Adjusted $R^2 = -.06$; Cohen's f^2=.27). These interactions are illustrated in Figures 3-6.

The interaction term approached significance for models testing the Duration of Lip Tension (for both F4/F3 and F8/F7 EEG sites) during infant neutral, and at the F4/F3 site during infant distress. Given that nonsignificance might have been due to low power, interactions were examined for these variables. There were no effects in either self-efficacy group for Duration of Lip Tension when EEG asymmetry was measured at the F8/F7 site. However, relations found for the other two models showed the same pattern as the first two Lip Tension models tested: Duration of Lip Tension expressions were related to EEG asymmetry only for mothers in the low-efficacy group for both infant neutral (β = -.85, $p < .10$[1]; $F(3,11) = 1.48$, ns; $R^2 = .36$; Adjusted $R^2 = .12$; $f^2 = .56$) and infant distress (β = -.95, $p < .05$[1]; $F(3,11) = 2.58$, ns; $R^2 = .49$; Adjusted $R^2 = .30$; Cohen's f^2=.96), in that longer Durations of Lip Tension were related to relatively less approach tendency.

Although number of children was not a significant predictor of Latency to Onset or Duration of Lip Tension, baseline EEG asymmetry was consistently related to dynamics of Lip

Tension in infant neutral and infant happy conditions, in that greater relative left-frontal baseline EEG asymmetry was related to a shorter Latency to Onset and a longer Duration. In cases in which baseline EEG asymmetry was related to Lip Tension dynamics, however, these effects were not the sole significant predictors in the model. Rather, in all models, EEG asymmetry during the respective condition was significantly related to the Lip Tension, as well.

There was one Lip Tension model for which a direct effect emerged (in the expected direction) in Step 2 but became nonsignificant when the interaction term was entered. Greater Duration of Lip Tension during the infant happy condition was related to less approach tendency ($\beta = -.75$[1], $p < .05$) and less parenting self-efficacy ($\beta = -.56$, $p < .01$[1]). Finally, there were some main effects that approached, but did not reach, significance (refer to Table 9).

Because there has been very little research on Lip Tension, analyses of this facial expression in relation to approach tendency and parenting self-efficacy were exploratory. Results showed that greater approach tendency and parenting self-efficacy were related to maternal Lip Tension expressions that were longer in Latency to Onset and shorter in Duration across conditions. As predicted, parenting self-efficacy moderated the relation between approach tendency and the dynamics of maternal Lip Tension expressions during infant distress.

Chapter 5. DISCUSSION

Over the past 20 years, research on emotion and child development has begun to recognize parenting as an emotionally evocative experience (Dix, 1991; Radke-Yarrow et al., 1993). In spite of this recognition and the knowledge that a parent's emotional well-being has profound implications for child adjustment (e.g. Lovejoy, Graczyk, O'Hare, & Neuman, 2000), research on the emotional experiences of parents has been limited (Dix, 1991; Swain, 2008). This study sought to expand this small body of work by examining the impact of maternal beliefs (parenting self-efficacy) on real-time maternal emotional responses to infant emotions; specifically, on relations between emotional behavior (maternal facial expressions of emotion) and a neurophysiological mechanism proposed to underlie such behavior (frontal brain activity as measured by EEG asymmetry). Due to the well-established relation between EEG asymmetry and approach-avoidance emotions and behavior, EEG asymmetry was considered to be a neurophysiological marker of action readiness, which is an essential piece of the emotion process as espoused by functional theories of emotion (e.g., Arnold, 1960; Frijda, 1986). Specifically, greater relative-left EEG asymmetry indicated a greater approach tendency, while greater relative-right asymmetry suggested less approach tendency, or greater withdrawal. Overall, findings showed that mothers' parenting self-efficacy and neurophysiological approach tendencies while witnessing their infants' emotions were related to a wide variety of temporal and intensive qualities of maternal emotional expressions. In some cases, cohesion between measures of facial expression and neurophysiological approach tendency depended on the level of parenting self-efficacy.

Findings of the current study are consistent with past research showing that mothers of infants have measurable and systematic emotional responses to their own-infant cues (i.e. Swain, 2008). Furthermore, it is consistent with work (e.g., Strathearn, Li, Fonagy & Montague, 2008) showing that these reactions are specific to the state of the child: for example, in the current study mothers showed the quickest joy responses when their infants were happy and the slowest when their infants were distressed. Unlike some past work in this area (Strathearn, Li, Fonagy & Montague, 2008), however, the current study did not find differences in maternal brain activity as a function of infant emotion. Most work that has examined maternal brain activity in response to infant cues has used functional magnetic resonance imaging, though, and has focused on illuminating specific brain structures activated by parenting rather than action readiness or approach tendency. The current study is the first to date to examine maternal brain responses to infant cues using EEG, which indexes the brain response to evocative stimuli closer to real-time than does fMRI (Harmon-Jones, 2007). Given that emotions may occur on the order of seconds, EEG is a useful and more informative tool than fMRI when studying the *dynamics* of emotion, emotion expression, and associated action readiness in response to quickly changing stimuli. Since the parenting experience involves a continually changing emotional environment and requires quick responses to child cues, more research using methods that index affective responding close to real-time are needed in the study of parent emotion.

Although parenting self-efficacy did not show strong relations with a neurophysiological measure of approach tendency in response to infant emotion, it was related to maternal facial expressions of joy, sadness, and lip tension in response to a variety of infant emotional cues; specifically, higher parenting self-efficacy was related to greater positive emotion expressions and less negative emotion expressions. This finding is consistent with past research (Bugental, Blue, and Lewis, 1990) showing that mothers with low perceived control express greater verbal and facial dysphoria during interactions with children. Furthermore, past research has shown that women with greater self-efficacy are more able than those with lower self-efficacy to respond to children appropriately regardless of the state of the child (e.g. child behavior versus misbehavior; Bugental et al., 1993). The current study provided further support for this relation in that in the context of witnessing infant distress, high parenting self-efficacy was related to greater expressions of positive emotion and shorter expressions of negative emotion. For the negative emotions, maternal neurophysiological approach tendency was related to temporal qualities of emotion expression *in addition* to parenting self-efficacy. Given that parents' regulation of infant positive *and* negative emotion is a cornerstone of effective parenting (Tronick, 1989), it is reasonable to conclude that regardless of infant state, a more positive approach, along with the emotional behaviors that reflect this neurophysiological orientation, are an important part of optimal parenting. Results from the current study show that parenting self-efficacy may be an important component of a mother's ability to remain positive despite infant negative emotion. Furthermore, this study showed that relations between parenting self-efficacy and maternal emotional behavior can be seen in a variety of parenting-related situations, including when infants are not actually present. Given that parents are not always physically *with* their children, an understanding of parents' emotional reactions to infant cues even when not with the infant is important, as it may have implications for later parent-infant interactions. For example, a mother who responds to a reminder of her infant in a negative way may be more likely to have strained interactions when actually with her child.

Results of the current study are consistent with a wide variety of neurophysiological research (e.g. Davidson, 1998; Harmon-Jones & Allen, 1997) indicating that approach-related emotions are associated with greater relative left-frontal EEG asymmetry while withdrawal-related emotions are associated with greater relative right-frontal asymmetry. When standard baseline constructs (i.e. baseline EEG asymmetry) were controlled for, dynamics of joy and sadness expressions were related to EEG in the expected direction: greater joy was associated with greater approach, and greater sadness was associated with greater withdrawal. Maternal lip tension was included as an exploratory code of facial expression for emotion. Given that the range of behaviors included in the lip tension code (lip pressing, pursing, etc.) are reflective of facial muscle movements that are seen in both approach-related (anger) and withdrawal-related (anxiety) expressions, hypotheses were not made on the direction of effects. However, it seems that in this sample of mothers, maternal lip tension usually operated as a withdrawal-related emotion: the direction of effects across infant conditions were the same as sadness, in that greater lip tension was related to lower scores on EEG asymmetry (indicating less approach tendency). Interestingly, for the negative emotions examined, more robust relations were found between emotion expression, EEG asymmetry, and parenting self-efficacy for lip tension than for sadness. It is possible that the setting in which mothers were tested was not evocative enough to produce many full-blown negative expressions. First, mothers were viewing videos of their infants that had been recorded, on average, several days previously. Second, mothers were in a constrained and unfamiliar setting with an electrode cap on their head. They had been instructed to sit with their head positioned on a chin rest and to remain as still as possible. Indeed, less than 25% of the mothers expressed any sadness during the video viewing period, while almost every single mother exhibited at least some lip tension. The consistent and robust findings for lip tension suggest that in research in which stimuli may not be intensely evocative and/or in which constraints are set on mothers' body position (which may have implications for facial movement), it may be necessary and fruitful to examine lower-grade emotion expressions than are typically examined in emotion research.

The current study drew on work by Harmon-Jones and colleagues (Harmon-Jones et al., 2003) indicating that convergence between approach-related emotions and neurophysiological approach tendency (also measured by EEG asymmetry), are moderated by an individual's perception that he or she has the ability to have an impact on the environment. This phenomenon was tested in regard to parenting by examining the impact of mothers' sense of parenting self-efficacy. It can be assumed that mothers who have a high sense of parenting-self efficacy are more likely to feel capable of implementing change in parenting-related tasks (including successfully regulating their infants' emotions), while those low in self-efficacy are more likely to believe that they will be unsuccessful in such tasks. Drawing on past research (Harmon-Jones et al., 2003), it was expected that mothers with high, but not low, parenting-self efficacy would show relations between dynamic qualities of emotion expressions and neurophysiological approach tendency. Specifically, it was thought that for mothers with high self-efficacy, greater approach tendency would be related to greater joy expressions (specifically, expressions that were quicker to onset and peak, longer in duration and offset from peak, and more intense) and less negative expressions (specifically, expressions that were longer to onset and shorter in duration). It is important to note that of a multitude of models tested, significant interactions were found for only one joy and one sadness variable. However, given the small sample size of this study, it is noteworthy that some of the findings were significant. In the two models that did show significant interaction effects, the direction and strength of effects was as predicted. For mothers who were higher in self-efficacy, a shorter time to reach the peak of a joy expression was related to neurophysiological approach tendency. For mothers who were low in self-efficacy, there was no relation between time to reach peak intensity of a joy expression and approach tendency. For sadness, mothers in both low and high self-efficacy groups showed relations between the time to onset of a sad expression and approach tendency, however, relations were stronger for mothers in the high self-efficacy group. Furthermore, these relations were not due to differences in the expression of joy or sadness between low- and high- self-efficacy mothers. Both sets of results confirm hypotheses in that mothers who perceive a greater ability to parent competently show approach-related emotional behavior (a faster rise of joy and a slower onset of sadness) that is related to underlying neurophysiological approach tendency. It is possible that the increased approach-related brain activity that these mothers show serves to mobilize the mother for action, for example, by activating other brain areas to initiate a physiological process to facilitate action, by regulating the amygdale to inhibit an avoidance response, or by maintaining the goal state in affective working memory (as suggested by Davidson, 2002). Because of the small number of significant interactions found despite the large number of models tested, the generalizability of these results should be taken with caution. Still, given the exploratory nature of the study, the small sample size, and the lack of research in this area, these findings should be noted as preliminary and should encourage further empirical study.

Because it was unclear whether maternal lip tension would reflect an approach- or withdrawal-related emotion, the direction of effects was not initially hypothesized for self-efficacy as a moderator of the relation between lip tension and neurophysiological approach tendency. Given that lip tension seemed to relate to approach tendency in a similar way to withdrawal emotions, however, it would be reasonable to expect lip tension to behave similarly to sadness when examined in low and high parenting self-efficacy groups. However, unlike sadness, relations between maternal lip tension and approach tendency were found only for the low parenting self-efficacy group. One interpretation is that lip tension refers to something other than a withdrawal emotion. Some emotion researchers (Izard, Dougherty & Hembree, 1983;

Malatesta-Magai, 1991) have suggested that compression of the lips is made in an attempt to regulate anger. Furthermore, this expression has been observed in both infants and parents (Malatesta-Magai, 1991). Significant effects of neurophysiological approach tendency on lip tension in the low-efficacy mothers were present only during the infant distress condition (relations only approached significance for the infant neutral condition and were nonsignificant for the infant happy condition). It is possible that, due to a perceived inability to effectively regulate their infant's distress, low-efficacy mothers experienced feelings of anger upon viewing these videos. Given that anger is an approach-related emotion, less of an attempt to regulate this anger (operationalized as more lip tension) would lead to greater approach. Another possibility is that mothers' lip tension reflected the beginnings of action readiness, however, the failure of those muscle movements to grow into full emotion expressions reflected the mothers' being stuck between a preparedness to act versus not act. This state of being "caught in the middle" may be thought of as ambivalence, and is consistent with past research (Bugental & Shennum, 1984) showing that mothers low in perceived control were more likely to show mixed facial expressions of emotion toward their children. Given the paucity of research on lip tension, these interpretations are made with caution. Additionally, the constraints of the study should be taken into consideration: although a mother's initial response to the videos might have been to react to her child's emotion, she was in a room by herself, watching a video of her infant while hooked up to EEG equipment, which may have resulted in her feeling "stuck". Still, the consistent and significant results found for lip tension in this study suggest that further research on this subtle emotion expression and its implications for approach- versus withdrawal-related behavior is needed.

Although the majority of significant findings in the current study were in the expected direction, the large amount of nonsignificant relations cannot be ignored. It is possible that the low sample size contributed to the number of null findings; indeed, many of the models that were nonsignificant showed substantial magnitude of effects. However, knowledge can be gained upon examination of where effects were and were not found. For example, for maternal negative emotions, the fewer significant relations during infant neutral, and especially infant happy, conditions are not unexpected given that only the infant distress stimuli was designed to elicit negative maternal emotion. Indeed, more maternal sadness was seen during the infant distress condition (although differences across conditions only approached significance). When considered from this viewpoint, it is less surprising that the only interaction effects found for maternal negative emotions occurred during the infant distress conditions.

It is also notable that parenting self-efficacy and neurophysiological approach tendency were consistent significant predictors of joy only when intensity was considered (Intensity, Latency to Peak, and Offset from Peak). It is possible that the mere expression of joy upon viewing videos of one's infant is a common enough response that variability is present only when looking at the intensity of emotional reactions. Indeed, every mother in the study expressed at least some joy. This pattern of effects is consistent with recent work by Light and colleagues (Light et al., 2009), which showed evidence for a relation between low-level joy/contentment and greater relative-right frontal asymmetry (indicating less approach tendency). It is possible that when measuring joy using variables that do not take intensity into account (such as duration or latency to onset), relations between EEG asymmetry and joy are washed out because some of the joy expressions (those that are low-level) are relating to less approach, while other joy expressions (higher-level) are relating to more approach. Therefore, it is only when levels of intensity are parsed out that relations with approach are evident. These findings support those of Light and colleagues (2009), and suggest that emotion researchers must be aware of the nuances in the approach- versus withdrawal-relatedness of positively-valenced emotions.

This study differed from many others examining facial expression of emotion in that it empirically tested the temporal and intensive dynamics of emotion proposed by Thompson (1994), and written about by other researchers such as Davidson (1998) and Edwards (1998). Study findings support the notion that these dynamic variables warrant scientific attention and that research on emotion expression must go beyond consideration of amount of time spent in certain emotional expressions. For example, mothers' expressions of joy were most consistently related to parenting self-efficacy and neurophysiological approach tendency when variables considering intensity were tested. Additionally, latency to onset of negative emotion expressions were more consistently and strongly related to parenting self-efficacy and approach tendency even than duration of those expressions. Consideration of dynamics of parent emotion is important in increasing knowledge about such dynamics on both parent and child adjustment. For parents, increased knowledge about emotion dynamics can shed light on processes related to emotional well-being. For example, the decreased positive affect seen in depression and increased negative affect seen in both depression and anxiety (Mineka, Watson & Clark, 1998) may involve intensity of those emotions as well as frequency and duration over the course of daily life. The automaticity of fear responses seen in anxiety (McNally, 1995) likely has implications for the latencies to both onset and peak of fear or tension emotions. Finally, the time it takes for an individual to recover from an intense emotion expression (offset from peak) may be related to emotion regulation. Thus, the dynamics of parent emotion have implications for parent emotional adjustment and well-being, which then has an impact on child development.

It is been well established that even beyond the negative impact of parent mental health problems, parent emotion is formative for both long-term emotion socialization and shorter term social referencing. First, many researchers (e.g. Eisenberg et al., 1998) have noted the importance of temporal and intensive qualities of parent emotion expression in the socialization of child emotion knowledge and regulation. For example, it is likely that the degree to which emotional information is absorbed and retained is linked to the salience of the parent's emotional expression, including intensity and duration of those expressions (Eisenberg et al., 1998; Dunsmore & Halberstadt, 1997). Dynamic qualities of parent emotion also have implications for how a child learns about the surrounding environment in a social referencing capacity. For example, events that are paired with parent expressions of emotion that are longer in duration, more intense, or quicker may convey more relevance than those events to which the parent's emotional response is shorter or more muted. Overall, this study provides empirical support for the theory that it is essential to study the dynamic qualities of emotion.

It is important to note several limitations. Although EEG asymmetry can offer important information on approach and withdrawal tendencies closer to real time than many other techniques, there are drawbacks to this method. Given that asymmetry is computed by a difference score, the amount of overall brain activity is not apparent (Coan & Allen, 2004). For example, of two mothers with the exact same asymmetry score, one may have had a high degree of activity in both hemispheres whereas the other may have had very little. Generally, EEG has low spatial resolution. The current study measured activity over only a subsection of the brain, the prefrontal cortex, while fMRI studies of parental responses to infant cues suggests that many other structures, including the striatum, amygdale, and parts of the midbrain (for a review see Swain, Lorberbaum, Kose & Strathearn, 2007) lie on brain circuits that have been found to relate to parenting. Even within the prefrontal cortex (and even more specifically, the dorsolateral prefrontal cortex), however, the current study found some effects of location. Specifically, in some analyses different relations emerged depending on whether EEG asymmetry was measured at the mid-frontal (F4/F3) versus lateral-frontal (F8/F7) sites. Unfortunately, there has not been substantive systematic study on potential differences between asymmetry as measured at mid-frontal versus lateral-frontal sites (L. Gatzke-Kopp, personal communication, May 2010). Some studies record EEG at only one frontal site pair (for example, Davidson, Ekman, Saron, Senulis & Friesen, 1990; Fox & Davidson, 1987), while others measure asymmetry at multiple site pairs (Light et al., 2009) without much discussion of potential implications of site pair choice. Empirical work is needed to fully understand differences in EEG asymmetry at mid-frontal versus lateral-frontal sites. Furthermore, in order to increase specific knowledge of brain processes related to parent emotion, future research should seek to use combinations of methods that will increase overall spatial and temporal resolution, such as simultaneous recordings of EEG and fMRI.

Finally, there are some limitations of the methodology of this study. First, the sample size was small, and replication of findings in a larger sample is necessary. Also, although the overall inter-rater reliability for the facial expression coding data was acceptable, reliability for the specific sadness code was lower than ideal. Thus, results related to sadness should be interpreted with caution until they are replicated.

There were several procedural aspects of the study that must be considered. Mothers were physically restrained during the video viewing period in that they were wearing an electrode net, had their heads resting in a chin rest, and were asked to stay as still as possible. Given that approach is a key construct in this study, the fact that mothers were specifically asked to inhibit certain types of approach behavior is a limitation. Similarly, infants were not present during the stimulus presentation, thus, the findings' relation to actual parenting behavior is unclear.

Despite these limitations, research on parental emotion is still fairly new, and a greater basic understanding of parent emotion is needed. Additionally, as mentioned above, parents' emotional responses to memories or cognitive representation of their infants may have important implications for actual parenting behavior and warrant study. Finally, the establishment of the methods used in this study as related to parent emotion, even in the absence of the child, is promising for future research in this area.

Findings from this study have implications for clinical practice and application. Parenting self-efficacy was related both to maternal positive approach (regardless of infant state) and emotional expression that was supported by neurophysiological processes. These relations suggest that an increased sense of competency may be an essential precursor of optimal parenting, making it a worthwhile point for intervention. Interventions aimed at increasing parents' sense of self-efficacy could include both an education component on infant development and simple parenting techniques, and a cognitive-behavioral portion in which parents interact with their children while practicing increased awareness of their competence.

The current study contributes to a growing literature on parent emotion and provides evidence for a dynamic interplay between parental beliefs, emotion, and neurophysiological responding. It provides support for the significance of temporal and intensive qualities of emotion, and shows evidence for unique relations between dynamics of emotional expression and other constructs related to emotion and parenting. Furthermore, it suggests the importance of parenting self-efficacy in relation to parental responses to infant emotion, and thus shows potential for related clinical applications for parents and families. The knowledge gained from this study and other studies on parent emotion has important implications for both parent and child well-being, and will encourage future research in this domain.

References

Abidin, R.R. (1983). Parenting Stress Index. Charlottesville, VA: Pediatric Psychology Press.

Allen, J.J.B., Harmon-Jones, E., & Cavender, J.H. (2001). Manipulation of frontal EEG asymmetry through biofeedback alters self-reported emotional responses and facial EMG. *Psychophysiology*, 38(4), 685-693.

Andreassi, J. L. (2000). *Psychophysiology: Human Behavior and Physiological Response*. 4th Ed. Lawrence Erlbaum Associates: Mahwah, New Jersey.

Arnold, M. (1960). Emotion and Personality. Columbia University Press: New York.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, 37(2), 122-147.

Baron, R.M. & Kenny, D.A. (1986). The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology,* 51(6), 1173-1182).

Beardslee, W.R., Bemporad, J., Keller, M.B., & Klerman, G.L. (1983). Children of parents with major affective disorder: A review. *American Journal of Psychiatry,* 140(7), 825-832.

Bugental, D.B., Blue, J., Cortez, V., Fleck, K., Kopeikin, H., Lewis, J.C. & Lyon, J. (1993). Social cognitions as organizers of autonomic and affective responses to social challenge. *Journal of Personality and Social Psychology*, 64(1), 94-103.

Bugental, D.B., Blue, J. & Lewis, J. (1990). Caregiver beliefs and dysphoric affect directed to difficult children. *Developmental Psychology,* 26(4), 631-638.

Bugental, D.B. & Shennum, W.A. (1984). "Difficult" children as elicitors and targets of adult communication patterns: An attributional-behavioral transaction analysis. *Monographs of the Society for Research in Child Development,* 49.

Cacioppo, J.T. (2004). Feelings and emotions: roles for electrophysiological markers. *Biological Psychology,* 67, 235-243.

Cacioppo, J.T., Tassinary, L.G. & Berntson, G.G. (Eds.). *Handbook of Psychophysiology,* 3rd Ed. (2007). Cambridge University Press: New York.

Calkins, S.D. (2004). Early attachment processes and the development of emotional self-regulation. In Baumeister, R.F. & Vohs, K.D. (Eds.) Handbook of self-regulation: Research, theory, and applications, New York, NY: Guilford Press, pp. 324-339.

Coan, J.A. & Allen, J.J.B. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. *Biological Psychology,* 67, 7-49.

Cole, P.M. (1994). The Development of Emotion Regulation and Dysregulation: A Clinical Perspective. *Monographs of the Society for Research in Child Development, 59*(2-3), 25-52.

Cole, P.M., Teti, L.O. & Zahn-Waxler, C. (2003). Mutual emotion regulation and the stability of conduct problems between preschool and early school age. *Development and Psychopathology, 15,* 1-18.

Conover, W.J. & Iman, R.L. (1981). Rank Transformations as a Bridge Between Parametric and Nonparametric Statistics. *The American Statistician,* 35(3), pp. 124-129

Darwin, C. (1872). The Expression of Emotions in Man and Animals. London: John Murray.

Davidson, R.J. (1998). Affective Style and Affective Disorders: Perspectives from Affective Neuroscience. *Cognition and Emotion, 12*(3), 307-330.

Davidson, R.J. (2002). Anxiety and Affective Style: Role of Prefrontal Cortex and Amygdala. *Biological Psychiatry, 51,* 68-80.

Davidson, R.J. (2004). What does the prefrontal cortex "do" in affect: Perspectives on frontal EEG asymmetry research. *Biological Psychology,* 67(1-2), 219-233.

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A. & Friesen, W.V. (1990). Approach-Withdrawal and Cerebral Asymmetry, Emotional Expression and Brain Physiology I. *Journal of Personality and Social Psychology,* 58(2), 330-341.

Davidson, R.J. & Fox, N. A. (1989). Frontal Brain Asymmetry Predicts Infants' Response to Maternal Separation. *Journal of Abnormal Psychology,* 98(1), 127-131.

Davidson, R.J., Jackson, D.C. & Kalin, N.H. (2000). Emotion, Plasticity, Context, and Regulation, Perspectives from Affective Neuroscience. *Psychological Bulletin,* 126(6), 890-909.

Davis, M. (1992). The role of the amygdala in fear and anxiety. *Annual Review of Neuroscience*, 15, 353-375.

Dawson, G., Panagiotides, H., Klinger, L.G. & Spieker, S. (1997). Infants of depressed and nondepressed mothers exhibit differences in frontal brain electrical activity during the expression of negative emotions. *Developmental Psychology,* 33(4), 650-656.

Denham, S.A., Bassett, H.H. & Wyatt, T. (2007). The Socialization of Emotional

Competence. In Grusec, J.E. & Hastings, P.D., Handbook of socialization: Theory and research. New York, NY: Guilford Press, pp. 614-631.

Dix, T. (1991). The Affective Organization of Parenting: Adaptive and Maladaptive Processes. *Psychological Bulletin, 110*(1), 3-25.

Donovan, W.L. & Leavitt, L.A. (1992). Maternal self-efficacy and response to stress: Laboratory studies of coping with a crying infant. In Stress and Coping in Infancy and Childhood, Eds. Field, T.M., McCabe, P.M. & Schneiderman, N. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc. pp. 47-68.

Dunsmore, J.C. & Halberstadt, A.G. (1997). How does family emotional expressiveness affect children's schemas? *New Directions for Child Development, 77,* 45-68.

Edwards, K. (1998). The face of time: Temporal cues in facial expressions of emotion. *Psychological Science, 9*(4), 270-276.

Eisenberg, N., Cumberland, A. & Spinrad, T.L. (1998). Parental Socialization of Emotion. *Psychological Inquiry, 9*(4), 241-273.

Ekman, P. & Friesen, W.V. (1975, 2003). Unmasking the Face. Englewood Cliffs, NJ: Prentice Hall.

Ekman, P. (1984). Expression and the nature of emotion. In K.R. Scherer & P. Ekman (Eds.), Approaches to Emotion, Hillsdale, NJ: Erlbaum, pp. 319–343.

Frijda, N.H. (1986). The Emotions. Cambridge University Press: Cambridge.

Frijda, N.H. (1988). The laws of emotion. *American Psychologist,* 43(5), 349-358.

Frijda, N.H., Kuipers, P., ter Schure, E. (1989). Relations among emotion, appraisal, and emotional action readiness. *Journal of Personality and Social Psychology,* 57(2).

Harmon-Jones, E. (2003). Clarifying the emotive functions of asymmetrical frontal cortical activity. *Psychophysiology, 40,* 838-848.

Harmon-Jones, E. (2007). Asymmetrical Frontal Cortical Activity, Affective Valence, and Motivational Direction. In Harmon-Jones, E. & Winkielman, P. (Eds). Social Neuroscience: Integrating Biological and Psychological Explanations of Social Behavior, New York: Guilford Press, pp. 137-156.

Harmon-Jones, E. & Allen, J.J.B. (1997). Behavioral activation sensitivity and resting frontal EEG asymmetry: Covariation of putative indicators related to risk for mood disorders. *Journal of Abnormal Psychology,* 106(1), 159-163.

Harmon-Jones, E. & Allen, J.J.B. (1998). Anger and Frontal Brain Activity: EEG

Asymmetry Consistent With Approach Motivation Despite Negative Affective Valence. *Journal of Personality and Social Psychology, 74*(5), 1310-1316.

Harmon-Jones, E. & Sigelman, J. (2001). State Anger and Prefrontal Brain Activity: Evidence That Insult-Related Relative Left-Prefrontal Activation Is Associated With Experienced Anger and Aggression. *Journal of Personality and Social Psychology, 80*(5), 797-803.

Harmon-Jones, E., Sigelman, J.D., Bohlig, A. & Harmon-Jones, C. (2003). Anger, coping, and frontal cortical activity: The effect of coping potential on anger-induced left frontal activity. *Cognition and Emotion, 17*(1), 1-24.

Hemenover, S.H. (2003). Individual Differences in Rate of Affect Change: Studies in Affective Chronometry. *Journal of Personality and Social Psychology, 85*(1), 121-131.

Henriques, J.B. & Davidson, R.J. (1990). Regional brain electrical asymmetries discriminate between previously depressed and healthy control subjects. *Journal of Abnormal Psychology*, 99(1), 22-31.

Henriques, J.B. & Davidson, R.J. (1991). Left frontal hypoactivation in depression. *Journal of Abnormal Psychology,* 100(4), 535-545.

Iman, R.L. & Conover, W.J. The Use of the Rank Transform in Regression, *Technometrics*, 21(4), 499-509

Izard, C.E., Dougherty, L.M. & Hembree, E.A. (1983). A system for identifying affect expressions by holistic judgments (Affex). Newark, DE: University of Delaware, Instructional Resources Center.

Jasper, H.H. (1958). The 10-20 electrode system of the Inernational Federation. *Electroencephalography and Clinical Neurophysiology*,

Junghöfer M., Elbert T., Tucker, D.M. & Braun C. (1999). The polar average reference effect: a bias in estimating the head surface integral in EEG recording. *Clinical Neurophysiology,* 110(6).

Kopp, C.B. (1989). Regulation of distress and negative emotions: A developmental view. *Developmental Psychology, 25*(3), 343-354.

Larson, C. L., Ruffalo, D., Nietert, J. & Davidson, R. J. (2000). Temporal stability of the emotion-modulated startle response. *Psychophysiology*, 37, 92-101.

Leerkes, E.M. & Burney, R.V. (2007. The development of parenting efficacy among new mothers and fathers. *Infancy*, 12(1), 45-67.

Lorberbaum, J.P., Newman, J.D., Horwitz, A.R., Dubno, J.R., Lydiard, R.B., Hammer, M.B., Bohning, D.E., George, M.S. (2002). A potential role for thalamocingulate circuitry in human maternal behavior. *Biological Psychiatry,* 51, pp. 431-445.

Lovejoy, M.C., Graczyk, P.A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: a meta-analytic review. *Clinical Psychology Review, 20(5),* 561-592.

Loyd, B.H. & Abidin, R.R. (1985). Revision of the Parenting Stress Index. *Journal of Pediatric Psychology,* 10(2), 169-177.

Malatesta-Magai, C. (1991). Development of emotion expression during infancy: general course and patterns of individual difference. In J. Garber, & K. A. Dodge (Eds.), The development of emotion regulation and dysregulation (pp. 49-68). New York: Cambridge University Press.

McNally, R.J. (1995). Automaticity and the anxiety disorders. *Behavior Research and Therapy,* 33(7), pp.747-754.

Mineka, S., Watson, D. & Clark, L.A. (1998). Comorbidity of anxiety and unipolar mood disorders. *Annual Review of Psychology,* 49, 377-412.

Radke-Yarrow, M., Nottelmann, E., Belmont, B. & Welsh, J.D. (1993). Affective Interactions of Depressed and Nondepressed Mothers and Their Children. *Journal of Abnormal Child Psychology, 21*(6), 683-695.

Rogosch, F.A., Cicchetti, D., & Toth, S.L. (2004). Expressed emotion in multiple subsystems of families of toddlers with depressed mothers. *Development and Psychopathology, 16,* 689-709.

Sutton, S.K. & Davidson, R.J. (1997). Prefrontal brain asymmetry: A biological substrate of the behavioral approach and inhibition systems. *Psychological Science,* 8(3), 204-210.

Strathearn, L., Li, J., Fonagy, P. & Montague, P.R. (2008). What's in a smile? Maternal brain responses to infant facial cues. *Pediatrics,* 122(1), pp. 40-51.

Swain, J.E. (2008). Baby Stimuli and the Parent Brain: Functional Neuroimaging of the Neural Substrates of Parent-Infant Attachment. *Psychiatry,* 5(8), pp. 28–36.

Swain, J.E., Lorberbaum, J.P., Kose, S. & Strathearn, L. (2007). Brain basis of early parent-infant interactions: psychology, physiology, and in vivo functional neuroimaging studies. *Journal of Child Psychology and Psychiatry,* 3(4), pp. 262-287.

Teti, D.M. & Gelfand, D.M. (1991). Behavioral Competence among Mothers of Infants in the First Year: The Mediational Role of Maternal Self-Efficacy. *Child Development, 62,* 918-929.

Tomarken, A.J., Davidson, R.J., Wheeler, R.E. & Doss, R.C. (1992). Individual Differences in Anterior Brain Asymmetry and Fundamental Dimensions of Emotion. *Journal of Personality and Social Psychology,* 62(4), 676-687.

Thompson, R.A. (1994). Emotion Regulation: A Theme in Search of Definition. *Monographs of the Society for Research in Child Development*, *59*(2-3), 25-52.

Tronick, E.Z. (1989). Emotions and Emotional Communication in Infants. *American Psychologist, 44*(2), 112-119.

Wheeler, R.E., Davidson, R.J. & Tomarken, A.J. (1993). Frontal brain asymmetry and emotional reactivity: A biological substrate of affective style. *Psychophysiology,* 30(1), 82-89.

APPENDIX A

Tables

Table 1. Mean (M), Standard Deviation (SD), and Range of Demographic Characteristics and Parenting Self-Efficacy.

	M	SD	Min.	Max.
Mother's Age	31.04	5.20	22.00	45.00
Child Age (months)	6.94	0.81	5.57	8.67
Number of Children Mother Has	1.69	0.72	1.00	3.00
Mother's Highest Level of Education	4.62	1.44	2.00	8.00
Parenting Self-Efficacy	45.17	5.17	30.00	55.00
Family Income	$73,000	$48,500	$12,000	$300,000

Table 2. Descriptive Statistics: Temporal Dynamics of Maternal Facial Expression of Emotion.

	Condition													
	Infant Neutral				Infant Happy					Infant Distress				
	M	SD	Min.	Max.		M	SD	Min.	Max.		M	SD	Min.	Max.
Joy														
Latency to Onset	14.63	7.13	2.42	26.00	Latency to Onset	10.43	8.30	1.50	26.00	Latency to Onset	21.71	5.06	8.25	26.00
Duration	10.66	8.47	0	39.50	Duration	9.76	4.47	0.00	18.00	Duration	5.06	11.68	0.00	57.50
Intensity	1.02	0.23	0	1.29	Intensity	0.87	0.26	0.00	1.41	Intensity	0.44	0.36	0.00	0.99
Latency to Peak	2.33	5.59	0	26.00	Latency to Peak	5.65	5.29	0.00	26.00	Latency to Peak	15.10	8.76	3.33	26.00
Offset from Peak	8.63	6.71	0	29.86	Offset from Peak	8.33	3.91	0.00	16.92	Offset from Peak	4.49	11.48	0.00	57.00
Sadness														
Latency to Onset	25.68	0.86	22.42	26.00	Latency to Onset	25.83	0.49	24.08	26.00	Latency to Onset	24.54	3.50	10.42	26.00
Duration	0.33	1.30	0	6.50	Duration	0.17	0.71	0.00	3.50	Duration	0.97	1.85	0.00	6.00
Lip Tension														
Latency to Onset	23.61	3.32	13.67	26.00	Latency to Onset	23.77	2.73	15.58	26.00	Latency to Onset	23.83	3.42	14.50	26.00
Duration	0.72	0.73	0	2.82	Duration	0.78	1.04	0.00	4.09	Duration	1.05	1.16	0.00	4.50

Table 3. Mothers' Alpha Power and Asymmetry Scores by Condition.

		Condition											
		Infant Neutral				Infant Happy				Infant Distress			
		M	SD	Min.	Max.	M	SD	Min.	Max.	M	SD	Min.	Max.
Right Sites	F4	-0.27	1.22	-3.56	1.67	-0.31	1.22	-3.57	1.59	-0.28	1.20	-3.58	1.73
	F8	-0.22	1.56	-3.67	2.13	-0.26	1.55	-3.67	2.04	-0.25	1.52	-3.69	1.83
Left Sites	F3	.06	1.13	-3.11	2.24	0.02	1.13	-3.11	2.10	0.07	1.14	-3.13	2.29
	F7	0.32	0.99	-1.71	1.93	0.29	0.97	-1.80	1.79	0.32	0.97	-1.62	1.96
Asym-metry Score	F4/F3 Sites	-0.35	0.63	-2.26	0.56	-0.35	0.64	-2.33	0.58	-0.36	0.61	-2.37	0.56
	F8/F7 Sites	-0.54	1.20	-3.41	1.14	-0.55	1.20	-3.36	1.18	-0.56	1.19	-3.44	1.15

All alpha power values were log transformed (natural log).

Table 4. Correlations Among EEG Asymmetry, Temporal Dynamics of Facial Expression, and Parenting Self-Efficacy During the Infant Neutral Condition.

	Baseline		Infant Neutral		
	F4/F3 Asymmetry	F8/F7 Asymmetry	F4/F3 Asymmetry	F8/F7 Asymmetry	Parenting Self-Efficacy
Joy					
Latency to Onset	0.07	0.16	0.27†	0.10	-0.25†
Duration	-0.08	-0.12	-0.33†	0.08	0.19
Intensity	-0.21	-0.17	-0.17	-0.01	0.04
Latency to Peak	-0.20	-.36*	-0.24	-0.20	-0.04
Offset from Peak	-0.04	-0.09	-0.25	0.12	0.23
Sadness					
Latency to Onset	0.01	.40*	0.31†	0.32†	0.16
Duration	-0.06	-.35*	-0.13	-.37*	-0.11
Lip Tension					
Latency to Onset	-0.33†	-0.27	-0.15	-0.01	0.30†
Duration	.47**	0.27	0.26	0.15	-0.25†

Table 5. Correlations Among EEG Asymmetry, Temporal Dynamics of Facial Expression, and Parenting Self-Efficacy During the Infant Happy Condition.

	Baseline		Infant Happy		
	F4/F3 Asymmetry	F8/F7 Asymmetry	F4/F3 Asymmetry	F8/F7 Asymmetry	Parenting Self-Efficacy
Joy					
Latency to Onset	0.21	0.18	0.28†	-0.12	-0.14
Duration	-0.08	-0.10	-0.23	0.08	0.21
Intensity	-0.16	-0.18	-0.10	0.15	-0.01
Latency to Peak	-0.10	-0.04	-.34*	-.41*	0.18
Offset from Peak	-0.07	-0.07	-0.19	0.11	0.20
Sadness					
Latency to Onset	-0.14	0.29†	0.25	0.33†	0.07
Duration	0.09	-0.23	-0.07	-.35*	0.00
Lip Tension					
Latency to Onset	-.37*	-0.27†	-0.11	-0.22	0.04
Duration	.36*	.37*	0.07	0.20	-0.14

Table 6. Correlations Among EEG Asymmetry, Temporal Dynamics of Facial Expression, and Parenting Self-Efficacy During the Infant Distress Condition.

	Baseline		Infant Distress		
	F4/F3 Asymmetry	F8/F7 Asymmetry	F4/F3 Asymmetry	F8/F7 Asymmetry	Parenting Self-Efficacy
Joy					
Latency to Onset	0.21	0.19	.39*	0.31†	-0.24
Duration	-0.16	-0.09	-0.20	-0.30†	.31*
Intensity	0.02	-0.06	-0.09	-0.23	0.19
Latency to Peak	0.01	0.07	0.13	0.29†	-0.18
Offset from Peak	-0.16	-0.08	-0.18	-0.30†	.31*
Sadness					
Latency to Onset	0.07	.35*	0.30†	0.25	0.13
Duration	-0.05	-0.34†	-.33*	-0.29†	-0.17
Lip Tension					
Latency to Onset	-0.05	0.01	0.21	0.17	0.09
Duration	0.17	0.01	-0.19	0.01	0.03

Table 7. Hierarchical Multiple Regression Models Predicting Maternal Joy.

Condition	Dynamic Variable	EEG Asymmetry	Parenting Self-Efficacy	Interaction	R^2	Adj. R^2	f^2	F
Infant Neutral	Latency to Onset	.38	.02	-.16	.21	.01	.27	1.03
		-.19	-.26	.03	.20	-.01	.25	.98
	Duration	.25	.84†	-.93	.27	.08	.37	1.39
		1.01	.91†	-.60	.29	.10	.41	1.54
	Intensity	.70	.70	-1.20†	.25	.06	.33	1.28
		1.25*	.86	-1.20†	.27	.07	.37	1.37
	Latency to Peak	-.43	-.28	-.02	.14	-.09	.16	.63
		-.06	-.19	-.05	.18	-.03	.22	.85
	Offset from Peak	.44	1.0*	-.99	.29	.10	.41	1.54
		1.15†	1.08*	-.72	.36	.19	.56	2.13
Infant Happy	Latency to Onset	.66	.53	-.78	.22	.02	.28	1.09
		-.08	.20	-.50	.33	.15	.49	1.84
	Duration	.14	.45	-.53	.09	-.15	.10	.38
		.10	.003	.33	.14	-.08	.16	.63
	Intensity	-.31	-.62	.63	.24	.04	.32	1.20
		.27	-.24	.19	.31	.13	.45	1.71
	Latency to Peak	.27	.90*	-1.19*	.33	.16	.49	1.90
		-.04	.53	-.59	.28	.09	.39	1.46
	Offset from Peak	.24	.54	-.63	.10	-.14	.11	.42
		.13	.04	.30	.14	-.08	.16	.63
Infant Distress	Latency to Onset	.06	-.65	.65	.30	.12	.43	1.63
		.10	-.36	.16	.17	-.05	.20	.76
	Duration	.65	1.11*	-.96†	.33	.15	.49	1.83
		.45	.94†	-.80	.28	.09	.39	1.44
	Intensity	.02	.47	-.48	.16	-.06	.19	.72
		.04	.47	-.45	.21	-.01	.26	.98
	Latency to Peak	-.005	-.49	.55	.17	-.05	.20	.78
		.001	-.47	.50	.23	.03	.30	1.16
	Offset from Peak	.70	1.12*	-.96†	.33	.15	.49	1.85
		.43	.93†	-.80	.28	.09	.39	1.49

Note: Data in the top row for each emotion dynamic variable represents results when EEG asymmetry was measured at F4/F3 sites, while data in the bottom row shows results when EEG asymmetry was measured at the F8/F7 sites.
* $p < .05$; ** $p < .01$; † $p < .10$

Table 8. Hierarchical Multiple Regression Models Predicting Maternal Sadness.

Condition	Dynamic Variable	EEG Asymmetry	Parenting Self-Efficacy	Interaction	R^2	Adj. R^2	f^2	F
Infant Neutral	Latency to Onset	1.28**	.79†	-.47	.42	.27	.72	2.75*
		.74	.63	-.52	.29	.10	.41	1.54
	Duration	-.84	-.68	.61	.19	-.02	.23	.89
		-.83	-.60	.42	.35	.17	.54	2.01
Infant Happy	Latency to Onset	1.10*	.53	-.29	.34	.17	.52	2.0
		.61	.38	-.33	.15	-.07	.18	.67
	Duration	-.68	-.44	.43	.09	-.15	.10	.39
		-.65	-.33	.23	.18	-.04	.22	.83
Infant Distress	Latency to Onset	1.51**	1.20**	-.84†	.54	.41	1.17	4.37**
		1.02†	1.01*	-.78	.34	.16	.52	1.94
	Duration	-1.52**	-1.16**	.77	.55	.43	1.22	4.64**
		-1.12†	-1.06*	.85	.34	.17	.52	1.98

Note: Data in the top row for each emotion dynamic variable represents results when EEG asymmetry was measured at F4/F3 sites, while data in the bottom row shows results when EEG asymmetry was measured at the F8/F7 sites.

* $p < .05$

** $p < .01$

† $p < .10$

Table 9. Hierarchical Multiple Regression Models Predicting Maternal Lip Tension.

Condition	Dynamic Variable	EEG Asymmetry	Parenting Self-Efficacy	Interaction	R^2	Adj. R^2	f^2	F
Infant Neutral	Latency to Onset	.94*	1.01*	-.59	.44	.29	.79	2.99*
		1.18*	1.08*	-.74	.42	.27	.72	2.75†
	Duration	-1.10*	-1.10**	.99†	.51	.38	1.04	3.95*
		-1.17†	-1.10*	1.08†	.35	.18	.54	2.03
Infant Happy	Latency to Onset	1.07*	.74*	-.57	.55	.43	1.22	4.56**
		.77	.72	-.78	.38	.21	.61	2.29†
	Duration	-.80†	-.62	.09	.46	.31	.85	3.19*
		-.43	-.48	.20	.28	.09	.39	1.47
Infant Distress	Latency to Onset	1.22*	.82†	-.95	.26	.07	.35	1.34
		1.56*	1.13*	-1.37*	.28	.09	.39	1.46
	Duration	-1.34**	-.83†	1.06†	.35	.19	.54	2.09
		-1.42*	-1.12*	1.63**	.34	.17	.52	1.95

Note: Data in the top row for each emotion dynamic variable represents results when EEG asymmetry was measured at F4/F3 sites, while data in the bottom row shows results when EEG asymmetry was measured at the F8/F7 sites.
* $p < .05$
** $p < .01$
† $p < .10$

APPENDIX B

Figures

Figure 1. Theoretical Model.

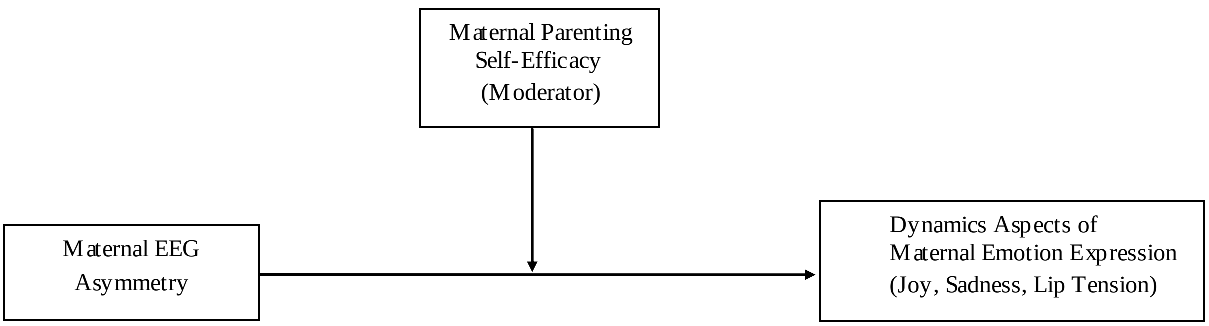
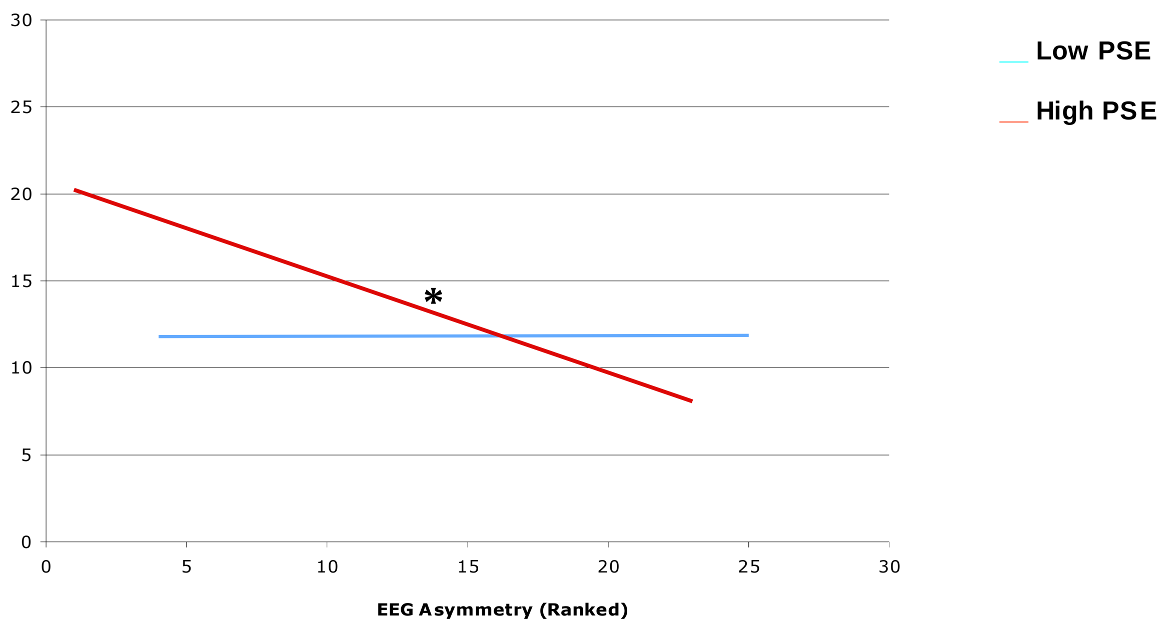
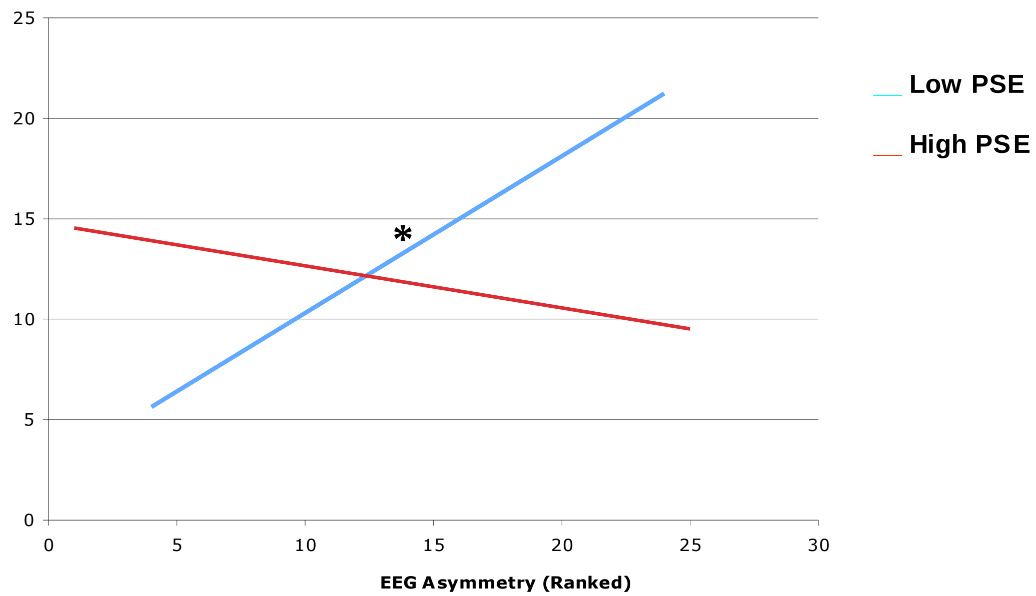


Figure 2. EEG Asymmetry as a Predictor of Latency to Peak of Joy Expressions During the Infant Happy Condition.



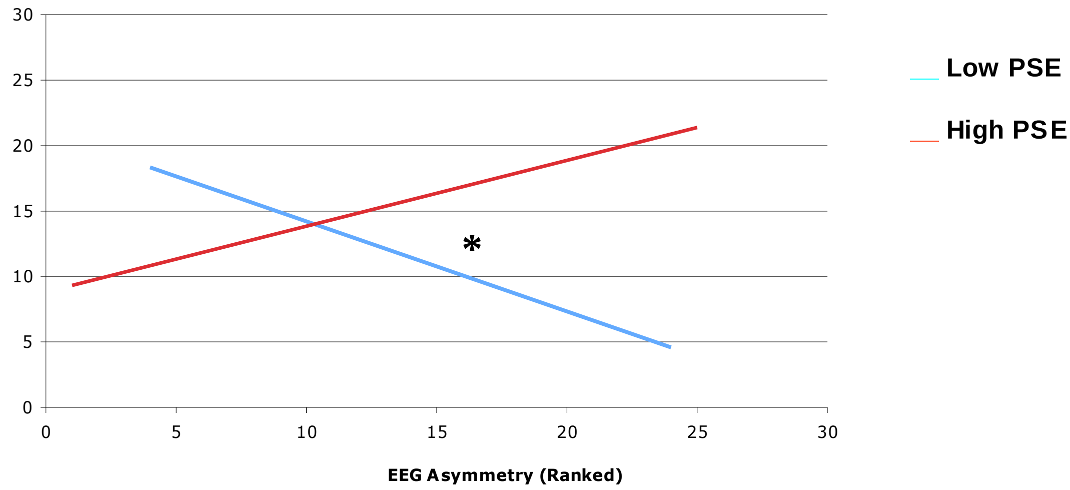
* $p < .05$

Figure 3. EEG Asymmetry as a Predictor of Latency to Onset of Lip Tension During the Infant Happy Condition.



* $p < .05$

Figure 4. EEG Asymmetry as a Predictor of Duration of Lip Tension During the Infant Happy Condition.



* $p < .05$

APPENDIX C

Minds of Mothers Study Emotion Expression Coding System

Based on the D.O.T.S. Emotion Coding System
Pamela M. Cole, Crystal N. Wiggins, Anna M. Radzioch, & Amanda M. Pearl

Emotions are coded second-by-second for the presence of target emotions and their intensity. Intensity of each emotion is coded on a 1 (minimal expression) – 3 (full expression) scale. Codes are not mutually exclusive (i.e., two different emotions can co-occur during the same second).

Happy - Joyful, excited, enthused, delighted, gleeful, pleasantly surprised

Facial Cues: Smiling, slightly or broadly, in which corners of mouth turn up, cheek area rounds up as muscle is contracted; smile may or may not be accompanied by crinkling around eyes, which often appears as brightness in eyes; forehead is smooth, brows may raise as in happy surprise.

Sad - disappointed, regretful, specific kind of unhappy, hopeless, dejected

Facial Cues: Lip corners may begin to pull down, bottom lip may appear loose as in a pout (*note: pouts may also contain cues of anger*), eyes may droop, brow may form an oblique shape (^).

Angry – frustrated, hostile, annoyed, irritated, mad

Facial Cues: Brow may be furrowed (but there must be additional cues to code as anger), eyes can be narrowed as in a “hard stare”, jaw clenched or set, mouth squared off if open, lips pressed or tightened if mouth closed.

Tension/Anxiety – nervous, tense, jittery, wary

Facial Cues: Brow may be furrowed, deepened; eyelids may be raised, eyes appear wider; lips may retracted (think of saying the word “eek” if you see a snake or insect; that is how the mouth retracts); there may be lip-biting, darting glances.

Lip Tension

Lip Tension was coded as either present or not present in a second. Lip Tension was coded when there was specific tensing of the muscles of the mouth and lips that was not captured above. These include lips being pressed together (as if making a drawn out "mmmmm" sound), tightened (the fullness of the lips is reduced, making them appear thinner) or pushed out (the mouth appears to pucker). NB: If other anger cues were present, anger trumped Lip Tension. A lip press was coded as Lip Tension only in the absence of other anger cues.